TransGrid

Maintaining reliable supply to Bathurst, Orange and Parkes areas

RIT-T – Project Specification Consultation Report

Region: Central West New South Wales

Date of issue: 17 March 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 Bathurst, Orange and Parkes areas of Central West New South Wales (NSW). Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

As set out in our 2020 Transmission Annual Planning Report (TAPR), the latest demand forecasts indicate that electricity demand is expected to increase substantially in the Bathurst, Orange and Parkes areas going forward.[1] This is mainly due to expected demand growth of some existing large mine loads in the area, the planned connection of new mine/industrial loads and general load growth around Parkes, including from the NSW Government's Parkes Special Activation Precinct (SAP).[2]

TransGrid's power system studies forecast that the expected load growth in the Bathurst, Orange and Parkes areas will reach voltage stability and thermal limits of the 132 kV supply network in the Central West area if action is not taken.

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 Central West NSW in light of the significant projected load growth

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.[3] 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.[4]

TransGrid undertook planning studies that show that the current Central West 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, our planning studies show that the increased demand will also lead to thermal constraints in the Central West region of NSW, particularly during times of low renewable generation dispatch in the region.

If the longer-term constraints associated with the load growth in the Bathurst, Orange and Parkes areas 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 Central West NSW with forecast demand increases.

[1] TransGrid, *2020 Transmission Annual Planning Report*, p. 40, available at: https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2020%20Transmission%20Annual%20Planning%20Report.pdf

[2] https://www.nsw.gov.au/snowy-hydro-legacy-fund/special-activation-precincts/parkes-special-activation-precinct

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

[4] 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 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.

Each of the credible network options outlined in this PSCR requires a new 330/132 kV substation near Orange and a 132 kV line to Orange North to provide the required supply capacity to meet the forecast load growth in Bathurst, Orange and Parkes areas. While the expected timing of this new substation differs between options and scenarios, on account of the interaction with the other option components, TransGrid expects that this substation will be included in each option at some point in the assessment period. This new substation near Orange and 132 kV line to Orange North is estimated to cost between $162 million and $198 million.

Aside from the new 330/132 kV substation near Orange, the credible network options differ by where, how and when new capacity is added to the Central West region in the near-term. In particular, TransGrid currently considers there to be four broad types of credible option, which cover:

- a new 132 kV line between Orange and Parkes;
- a new 330 kV line between Orange and Parkes;
- dynamic reactive support at Orange and Parkes for as long as it can meet forecast demand, following which a new 132 kV line between Orange and Parkes is required; and
- batteries to provide both load reduction and dynamic reactive support, following which a new 132 kV line between Orange and Parkes is required.

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 our long-term planning for the area and each involves a series of investments over the next twenty years. 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);
- configuration of existing or expected renewable generators in the area to provide fast-acting reactive support;
- bulk or aggregated energy storage systems, e.g.:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage;

  – pumped hydro; and
> 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 should 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.

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 TransGrid is 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 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.

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 17 June 2021.

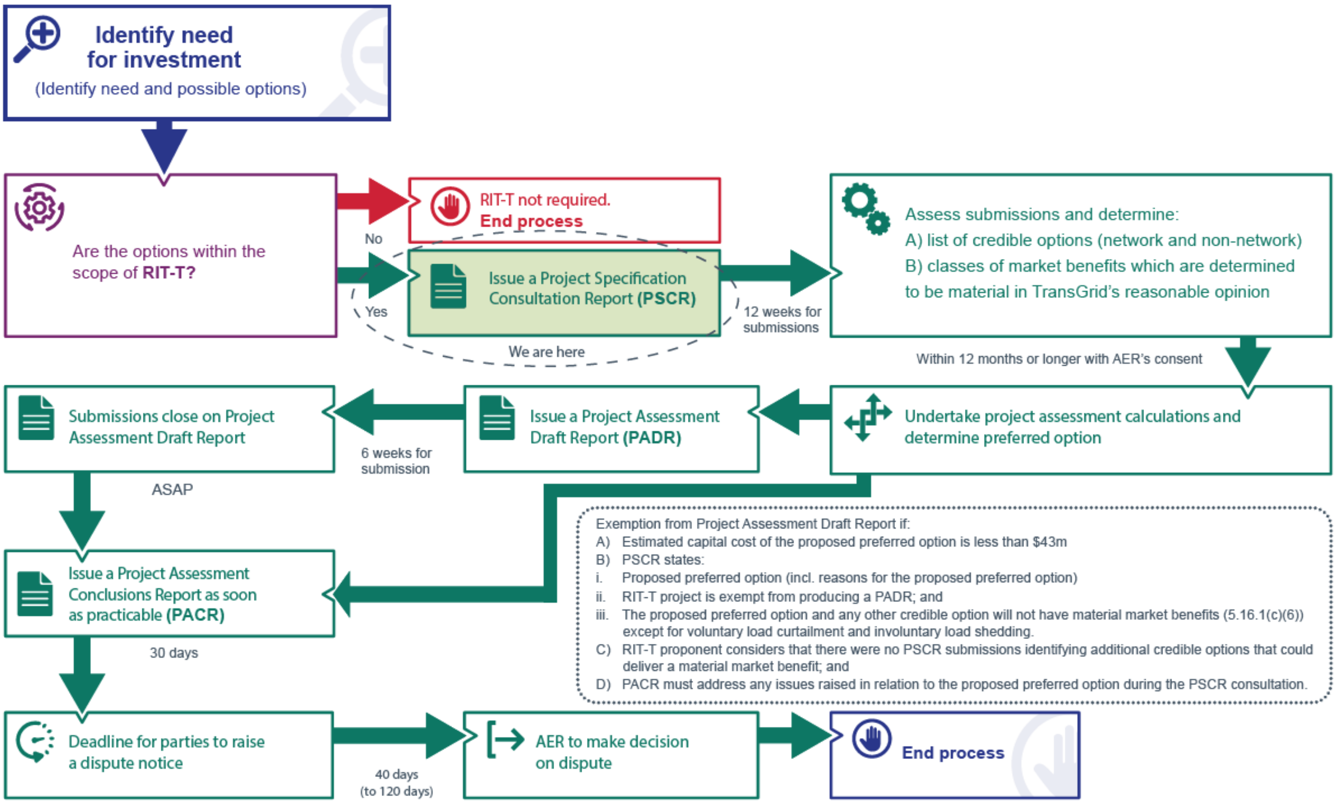
Submissions should be emailed to TransGrid's Regulation team via regulatory.consultation@transgrid.com.au.[5] In the subject field, please reference 'PSCR Maintaining reliable supply to Bathurst, Orange and Parkes areas.'

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 mid-2021.

[5] 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[6]



6 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 Orange and Parkes areas of Central West New South Wales (NSW). Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

As set out in our 2020 Transmission Annual Planning Report (TAPR), the latest demand forecasts indicate that electricity demand is expected to increase substantially in the Orange and Parkes areas going forward.[7] This is mainly due to expected demand growth of some existing large mine loads in the area, the planned connection of new mine/industrial loads and general load growth around Parkes, including from the NSW Government's Parkes Special Activation Precinct (SAP).[8]

TransGrid's power system studies forecast that the expected load growth in the Orange and Parkes areas will reach voltage stability and thermal limits of the 132 kV supply network in the central west area if action is not taken.

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.[9] 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.[10]

TransGrid undertook planning studies that show that the current Central West 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 Central West region of NSW, 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 taken (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.

7 TransGrid, *2020 Transmission Annual Planning Report*, p. 40, available at: https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2020%20Transmission%20Annual%20Planning%20Report.pdf

8 https://www.nsw.gov.au/snowy-hydro-legacy-fund/special-activation-precincts/parkes-special-activation-precinct

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

10 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.

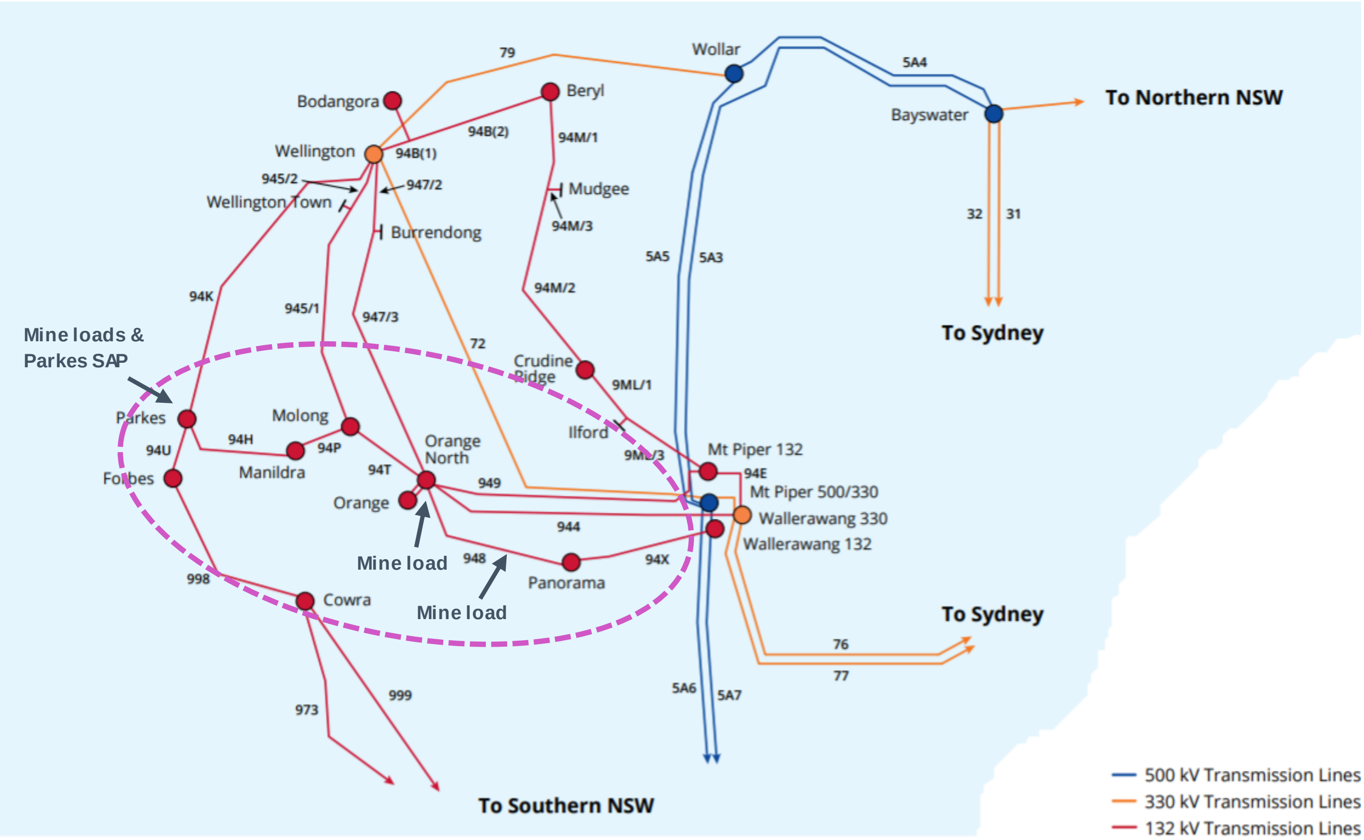
Together with this document, TransGrid has also released an Expression of Interest (EOI) to provide additional detail on the technical requirements for non-network options and seek submissions from proponents of these options.

2. The identified need

2.1 Background

The current Central West NSW electricity transmission network is shown in Figure 2-1 below. The area relevant for this RIT-T is around Bathurst, Orange and Parkes and is circled below. The indicative location of key forecast electricity loads that are discussed in this PSCR (and are publicly announced) are also shown with arrows.

Figure 2-1: Central West NSW transmission network



Electricity demand in Central West NSW is forecast to increase significantly over the next ten years, primarily due to:

> expected demand growth in some existing large industrial loads (the names, locations and loads have been redacted due to confidentiality reasons);

> planned connections of new industrial loads, i.e. McPhillamy's mine[11] and Sunrise mine;[12] and

> the NSW Government's Parkes Special Activation Precinct (SAP).[13]

11 https://www.regisresources.com.au/McPhillamys-Gold-Project/mcphillamys-gold-project.html
12 https://www.cleanteq.com/sunrise-project/
13 https://www.nsw.gov.au/snowy-hydro-legacy-fund/special-activation-precincts/parkes-special-activation-precinct

These loads are located around the Bathurst, Orange and Parkes areas and 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.[14] 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.[15]

TransGrid undertook planning studies that show that the current Central West 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, our planning studies show that the increased demand will also lead to thermal constraints in the Central West region of NSW, particularly during times of low renewable generation dispatch in the region.

If the longer-term constraints associated with the load growth in Bathurst, Orange and Parkes areas 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 Central West NSW 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 our 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 existing and expected new mining loads in the area;
> general system demand in Central West NSW; 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 existing and expected new mining loads

Essential Energy forecasts increased load from some of the existing large industrial loads in the area going forward. The specific details regarding the mines, locations and load forecasts has been redacted from this PSCR due to confidentiality reasons.

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

[15] 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.

In addition, going forward, two further mines are expected to connect in the region in the next few years:

- McPhillamy's gold mine;[16] and
- CleanTeQ Sunrise Nickel-Cobalt-Scandium mine.[17]

These loads are located, or expected to be located, around Bathurst, Orange and Parkes in the Central West region.

Please note that specific load information for each of the expected mines has not been presented in this PSCR due to this information being commercially sensitive.

2.3.2 General system demand in Central West NSW

General system load growth is expected in the Parkes area as a result of the Parkes SAP, which is a planned development by the NSW Government to develop Parkes as a business hub over the next 20 years. It is expected that this project will result in a further 60-94 MW of load growth in the Parkes area over this period, which compares to other expected general load increases of around 12 MW over the same period.

Additional general system load growth is also expected at Orange but is not as high as for Parkes. For example, TransGrid's forecast indicates general load increases of around 18 MW for Orange by 2040.

The four figures below present the actual 2019, as well as the forecast future, load duration curves (LDCs) and demand limits for the Parkes 66 kV and 132 kV Bulk Supply Point (BSP), as well as the Panorama 66 kV BSP (located in the Bathurst area). The LDCs represent the net demand (i.e., total demand minus total renewable generation) and show the significant increase in demand going forward, as well as how the voltage limits are expected to be exceeded an increasing percentage of the year if action is not taken.

16 https://www.regisresources.com.au/McPhillamys-Gold-Project/mcphillamys-gold-project.html

17 https://www.cleanteq.com/sunrise-project/

Figure 2-2: Forecast LDCs and demand limits for Parkes 66 kV and 132 kV, actual 2019 and forecast to 2030 under the central scenario

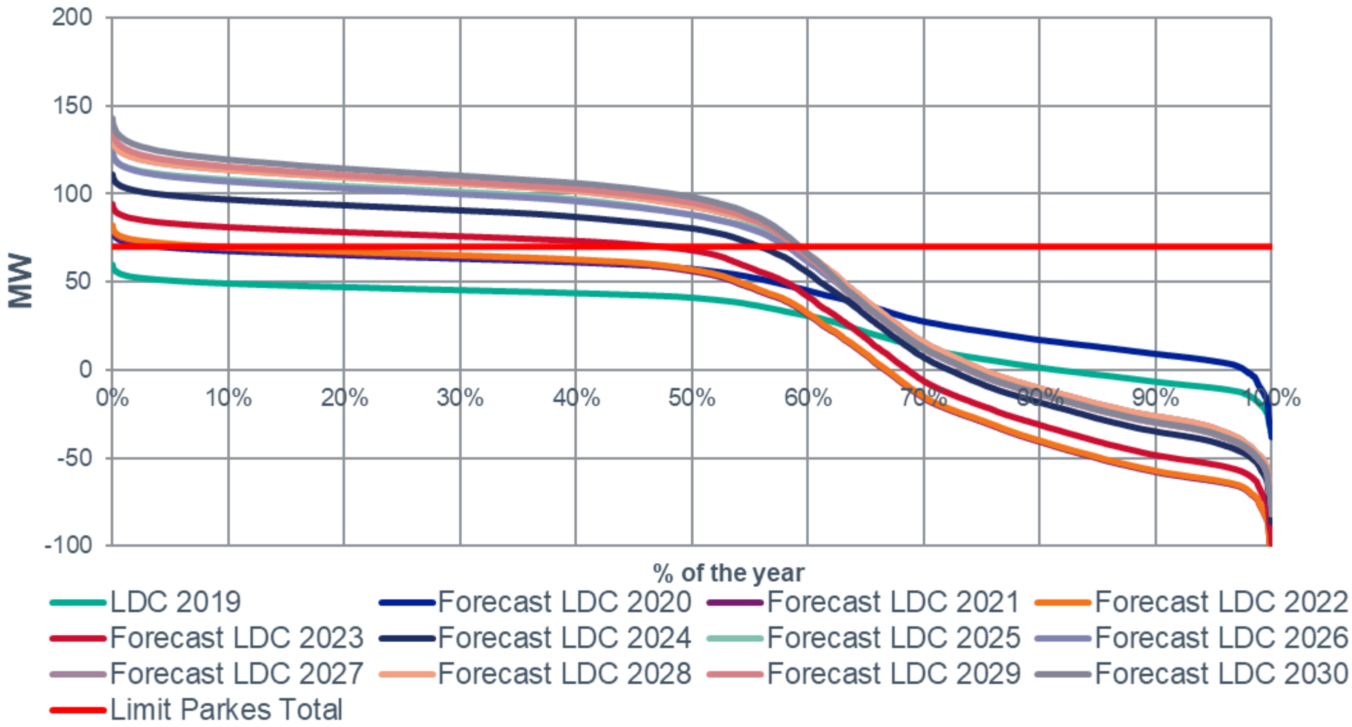


Figure 2-3: Forecast LDCs and demand limits for Parkes 66 kV and 132 kV, forecast 2031 to 2040 under the central scenario

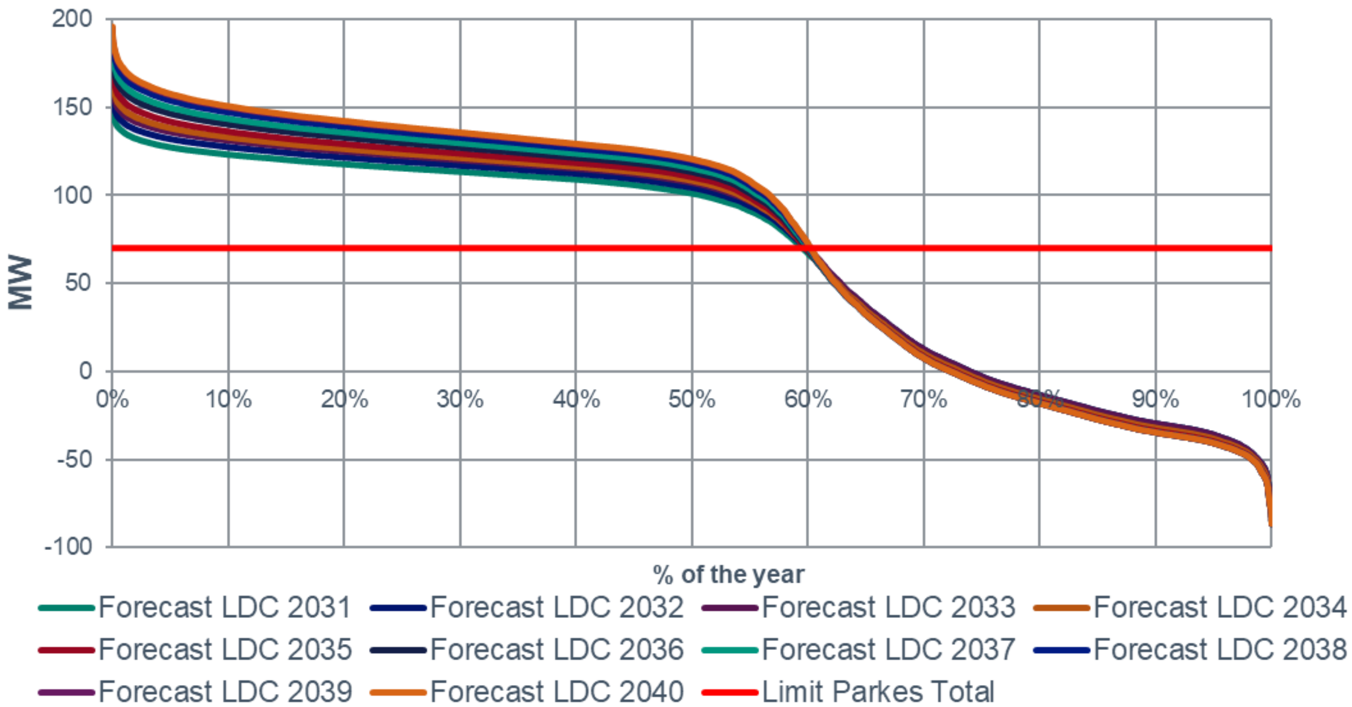


Figure 2-4: Forecast LDCs and demand limits for Panorama 66 kV (inc. McPhillamy's mine), actual 2019 and forecast to 2030 under the central scenario

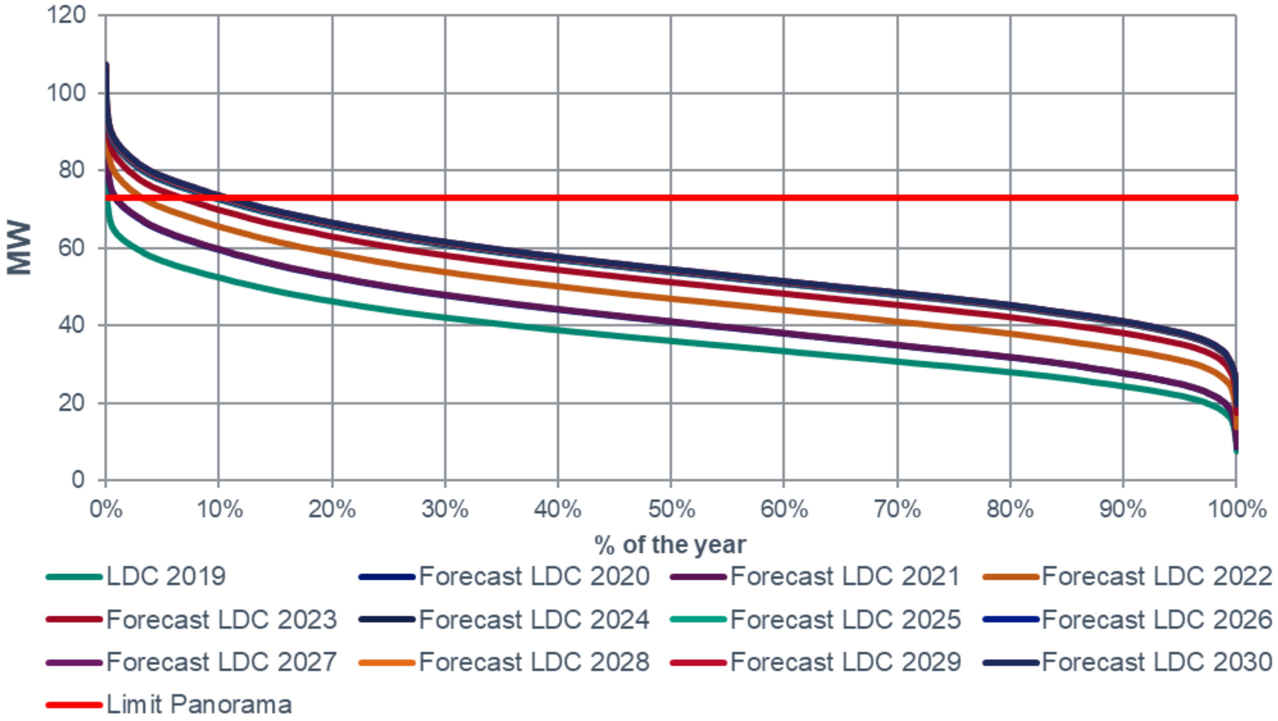
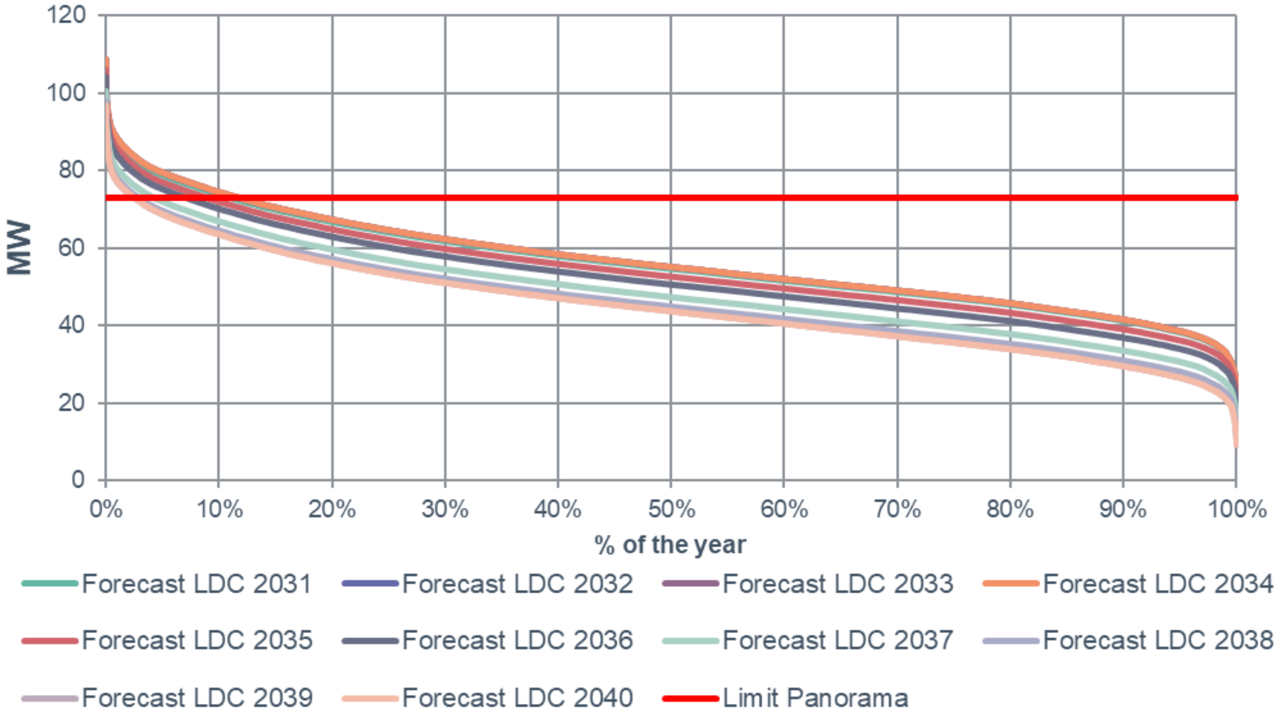


Figure 2-5: Forecast LDCs and demand limits for Panorama 66 kV (inc. McPhillamy's mine), forecast 2031 to 2040 under the central scenario



2.3.3 Renewable generation in the region

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

There are a number of in-service and planned renewable generator connections in the Central West region, particularly around Parkes. Table 2-1 summarises these systems.

Table 2-1: Current and planned renewable generation in the Central West region

Generating System	Connection location	Capacity (MW)	Status
Parkes Solar Farm	Parkes 66 kV Busbar	50.5	In service
Manildra Solar Farm (EssE)	Manildra 11 kV Busbar	50	In service
Goonumbla Solar Farm	Parkes 66 kV Busbar	70	Commissioning
Suntop Solar Farm	Line 94K (Wellington – Parkes tee Suntop Solar Farm)	150	Committed
Molong Solar Farm	Molong 66 kV Busbar	30	Committed
Jemalong Solar Farm (EssE)	West Jemalong 66 kV Busbar	50	Committed
Flyers Creek Wind Farm (EssE)	Orange North 132 kV	138	Advanced*
Quorn Park Solar Farm (EssE)	Parkes 132 kV	80	Advanced*

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

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 account of in-service, commissioning and committed renewable generation in assessing the identified need for this RIT-T.

While TransGrid is currently working with the NSW Government to plan new transmission infrastructure for the development of Australia's first coordinated REZ in the state's Central West Orana region, new renewable generation connecting to this REZ will not have a material impact on the identified need for this RIT-T as it is outside the area in which the limits are observed.

2.3.4 Forecast voltage and thermal limits if action is not taken

A number of under voltage conditions and voltage step change violations (i.e., greater than the required 10 per cent) have been identified at various locations under (N-1) contingency and outage conditions.

Figure 2-6 and Figure 2-7 show voltage limits for Orange and Parkes considering the peak demand that can be supplied without resulting in network voltages below 0.9 pu, under system normal and under (N-1) contingency conditions.

Figure 2-6: Peak demand forecast and voltage limit for the Orange area

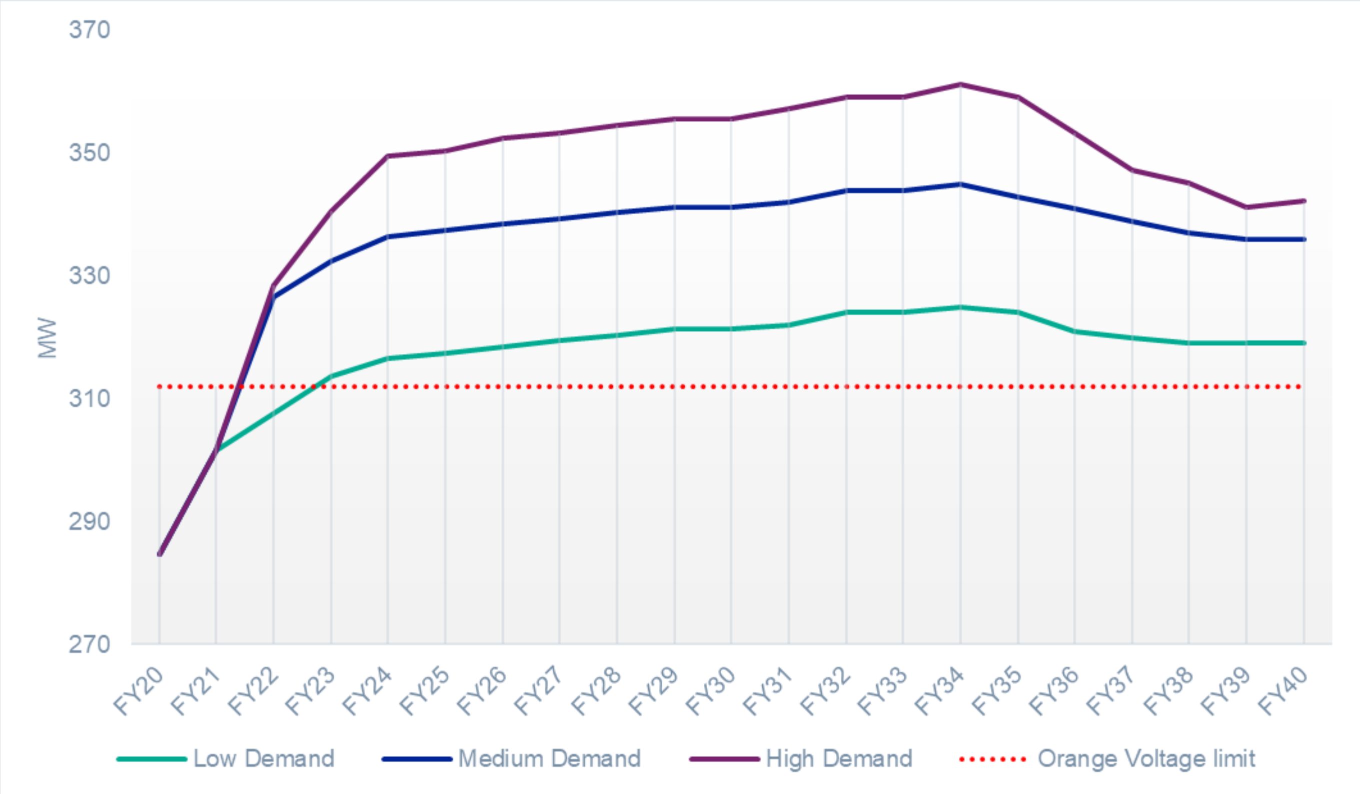
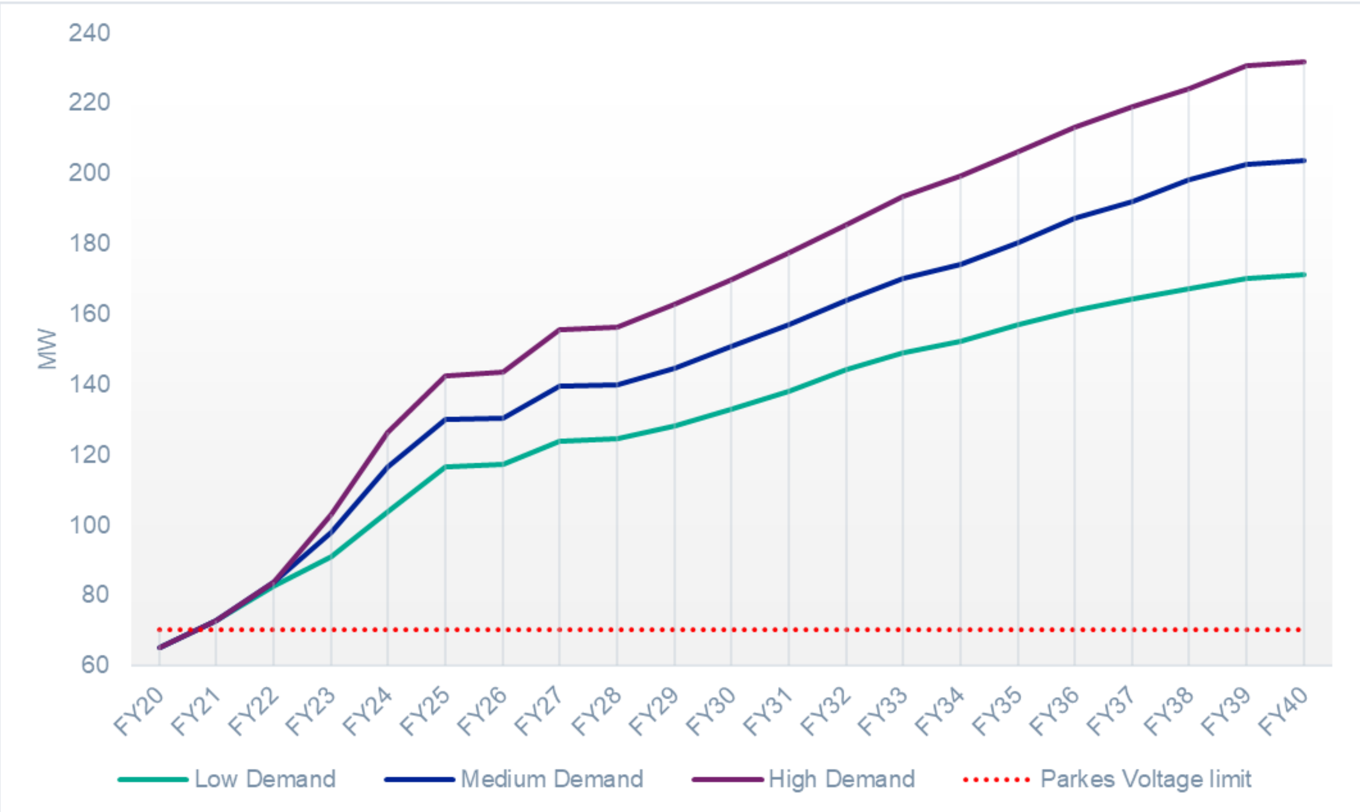
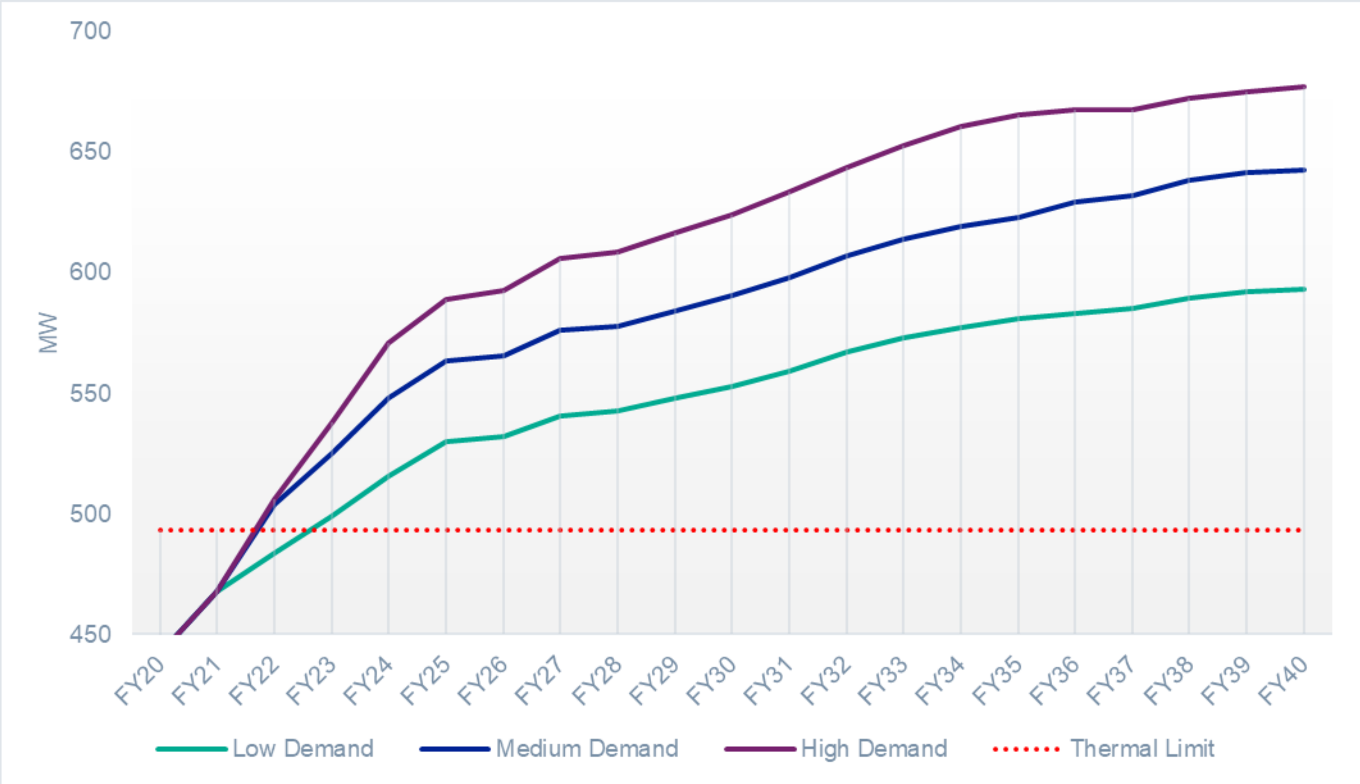


Figure 2-7: Peak demand forecast and voltage limit for the Parkes area



In addition to the longer-term voltage constraints identified above, the increased demand will also lead to thermal constraints, particularly at times of low renewable generation dispatch in the Central West region. This thermal supply limit is shown below against the backdrop of the expected future load in the area.

Figure 2-8: Peak demand forecast and thermal limit for the Central West area



In calculating the limits, it is assumed that four capacitor banks will be installed in Orange North, Panorama and Parkes as part of separate TransGrid projects.

In addition, the thermal limit is derived based on the thermal limitation of the two 330/132 kV transformers at the Wellington 330 kV substation for the (N-1) contingency/outage of one of the transformers. Specifically, the increased demand in the Bathurst, Orange and Parkes area could lead to a thermal limitation of each Wellington transformer for the loss of one transformer, particularly at times of low renewable generation dispatch in the Central West region of NSW. The options outlined in this PSCR have been designed to also alleviate this constraint.

2.3.5 Reactive power margin shortfalls if action is not taken

TransGrid's system studies also indicate that the voltage constraints will result in a reactive margin shortfall around the Orange and Parkes/Panorama areas after 2022 if action is not taken. As per the requirement under Clause S5.1.8 of the NER, a minimum reactive power margin of 1 per cent of the maximum fault level has to be maintained at each location. Accordingly, the minimum reactive power margin required at the Panorama 66 kV BSP and Parkes 132 kV BSP are 12.3 MVAr and 10.1 MVAr, respectively.

As shown in Table 2-2, a reactive power margin short-fall (in red) is projected at the Parkes 132 kV and Panorama 66 kV BSPs, under (N-1) contingency conditions, after 2022. The projected reactive power margin shortfall is in line with the projected voltage stability issues after 2022.

Table 2-2: Reactive power margin at the Parkes 132 kV and Panorama 66 kV Bulk Supply Points

Bulk Supply Point	Contingency	Required min Q Margin as per NER (MVAr)	Q Margin in 2021 (MVAr)	Q Margin in 2022 (MVAr)	Q Margin in 2024 (MVAr)
Panorama 66 kV	TL 94X	12.3	48	14.4	-74
Parkes 132 kV	TL 94K	10.1	19.7	8.67	-100

While TransGrid projects that there will be reactive margin shortfalls if nothing is done, these are considered a secondary concern to the forecast voltage and thermal constraints. Specifically, the voltage constraints are expected to be the first constraint to reach and, if resolved, will fully resolve the subsequent reactive power margin shortfall as well.

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.[18] This will include any credible options that are put forward by proponents in response to this PSCR.

The credible options outlined in this PSCR were developed as part of TransGrid's long-term planning for the area and each involves a series of investments over the next twenty years. 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. 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.

TransGrid considers that each of the credible network options outlined in this PSCR require a new 330/132 kV substation near Orange and a 132 kV line to Orange North to provide the required supply capacity to meet the forecast load growth in Bathurst, Orange and Parkes areas going forward. While the expected timing of this new substation will differ between options and scenarios, on account of the interaction with the other option components, TransGrid expects that the cost of this substation will be included in each option at some point in the assessment period. This new substation near Orange and 132 kV line is estimated to cost between $162 million and $198 million.

Aside from the new 330/132 kV substation near Orange, the credible network options differ in the near-term by where, how and when new capacity is added to the Central West region. In particular, TransGrid currently considers there to be four broad types of credible option, which, outside of the common new substation at Orange, cover:

- a new 132 kV line between Orange and Parkes;
- a new 330 kV line between Orange and Parkes;
- dynamic reactive support at Orange and Parkes for as long as it can meet forecast demand, following which a new 132 kV line between Orange and Parkes is required; and
- batteries to provide both load reduction and dynamic reactive support, following which a new 132 kV line between Orange and Parkes is required.

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. While only the near-term stages of each option are summarised in this table, each option section beneath the table outlines the later stages for each option that will be included in the RIT-T economic evaluation.

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

Table 3-1: Summary of the credible options

Option	Description	Estimated capex ($2020/21)	Expected timing (central load forecasts)
Option 1 – A new 132 kV line between Orange and Parkes			
1A & 1B	New Orange 330/132 kV substation and a 132 kV line to Orange North New 132 kV line from Orange New substation to Parkes	$162-198m for the substation and line to Orange North $168-206m for the line to Parkes	2024-25 for the substation 2025-26 for the line to Parkes
1C	2 x 40 MVA synchronous condensers at Parkes 132 kV New Orange 330/132 kV substation and a 132 kV line to Orange North New 132 kV line from Orange 330/132 kV to Parkes	$113-139m for the synchronous condensers $162-198m for the substation and line to Orange North $168-206m for the line to Parkes	2022-23 for the synchronous condensers 2024-25 for the substation 2025-26 for the line to Parkes
Option 2 – A new 330 kV line between Orange and Parkes			
2	New Orange 330/132 kV substation and a 132 kV line to Orange North New 330 kV line from Orange New substation to Parkes	$162-198m for the substation and line to Orange North $351-429m for the line to Parkes	2024-25 for the substation 2025-26 for the line to Parkes
Option 3 – Dynamic reactive support at Orange and Parkes for as long as it can meet forecast demand, following which a new 132 kV line between Orange and Parkes is required			
3A	New 132 kV synchronous condensers at Panorama (50 MVA) and Parkes (3*35 MVA) New Orange 330/132 kV substation and a 132 kV line to Orange North) New 132 kV line from Orange 330/132 kV to Parkes	$242-296m for the synchronous condensers $162-198m for the substation and line to Orange North $168-206m for the line to Parkes	2022-23 for the synchronous condensers 2024-25 for the substation 2026-27 for the line to Parkes
3B	New 132 kV SVC at Panorama (50 MVA) and 132 kV synchronous condensers at Parkes (3*35 MVA) New Orange 330/132 kV substation and a 132 kV line to Orange North New 132 kV line from Orange 330/132 kV to Parkes	$239-293m for the SVC and synchronous condensers $162-198m for the substation and line to Orange North $168-206m for the line to Parkes	2022-23 for the SVC and synchronous condensers 2024-25 for the substation 2026-27 for the line to Parkes

Option	Description	Estimated capex ($2020/21)	Expected timing (central load forecasts)
3C	New 132 kV STATCOM at Panorama (50 MVA) and 132 kV synchronous condensers at Parkes (3*35 MVA) New Orange 330/132 kV substation and a 132 kV line to Orange North New 132 kV line from Orange 330/132 kV to Parkes	$242-296m for the STATCOM and synchronous condensers $162-198m for the substation and line to Orange North $168-206m for the line to Parkes	2022-23 years for the STATCOM and synchronous condensers 2024-25 for the substation 2026-27 for the line to Parkes
Option 4 – Batteries to provide both load reduction and dynamic reactive support, following which a new 132 kV line between Orange and Parkes is required			
4	New 20 MW (40 MWh) battery and 132 kV synchronous condensers at Parkes (2*35 MVA), and 30 MW (60 MWh) battery at Panorama New Orange 330/132 kV substation and a 132 kV line to Orange North New 132 kV line from Orange 330/132 kV to Parkes	$297-363m for the synchronous condenser and batteries (comprised of $113-138m for the two synchronous condensers, $76-96m for the Parkes battery and $104-128m for the Panorama battery) $162-198m for the substation $168-206m for the line to Parkes	2022-23 years for the synchronous condensers and batteries 2024-25 for the substation 2026-27 for the line

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); > configuration of renewable generators to provide fast-acting reactive support; > bulk or aggregated energy storage systems, e.g.: – sealed batteries; – flow batteries; – concentrated solar thermal with storage; – compressed air storage; – pumped hydro; and > 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 proxied as two per cent of the total capex, this will be reviewed 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:[19]

[19] AER, *Regulatory Investment Test for Transmission Application Guidelines*, August 2020, p. 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 Bathurst, Orange and Parkes areas are unresolved, there is expected to be significant interruption of supply to loads in the area under 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 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., it is estimated that these will exceed $6 billion by 2025 under the central demand forecasts[20] 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 is consistent 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.[21]

3.2 Option 1 – A new 132 kV line between Orange and Parkes

In the near-term, as summarised in Table 3-1 above, Option 1 involves constructing the following in conjunction with a new 330/132 kV substation near Orange and a 132 kV line to Orange North:

> a 132 kV line from Orange New substation to Parkes (Option 1A and Option 1B); or

> synchronous condenser at Parkes 132 kV (Option 1C).[22]

[20] 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.

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

[22] Option 1C is designed to test the net benefits of providing dynamic reactive support at Parkes early in the assessment period, given the lead times of a new substations and transmission lines.

Table 3-2 summarises the various longer-term stages to the Option 1 variants.

Table 3-2: Summary of the longer-term stages of the Option 1 variants

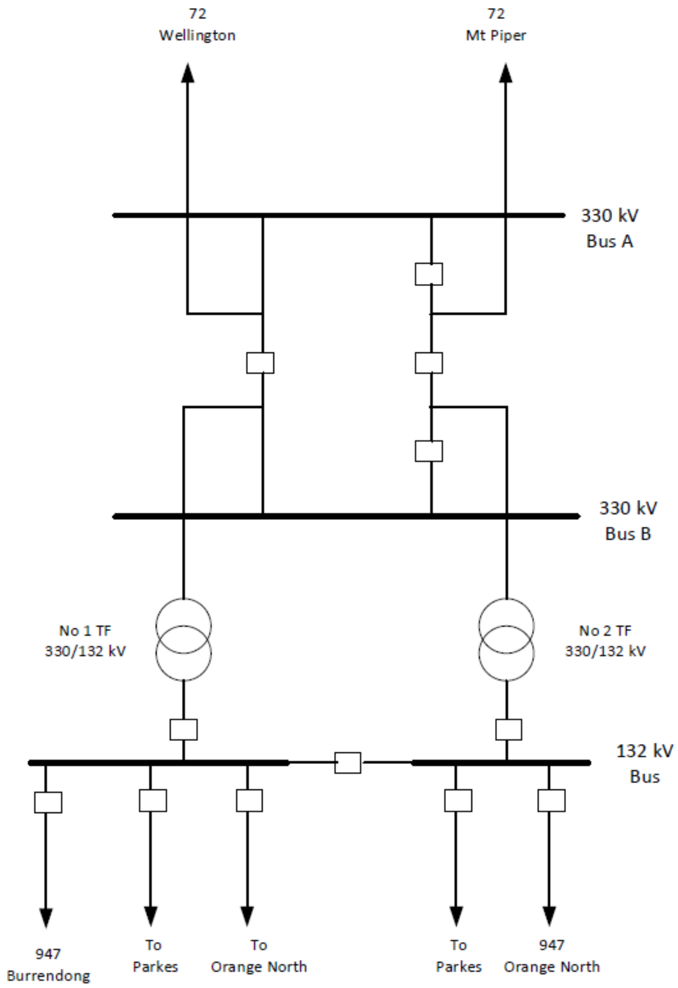
Stages	Estimated capex ($2020/21)	Expected timing (central load forecasts)		
		1A	1B	1C
Second new 132 kV line from Orange 330/132 kV substation to Parkes substation	$86-106m	2028-29	2031-2032	2033-34
Additional 2 x 40 MVA synchronous condensers at Parkes 132 kV	$113-139m	2033-34	2028-29	-
Additional 40 MVA synchronous condenser at Parkes 132 kV	$50-62m	2036-37	2036-37	2036-37

The establishment of a new Orange 330/132 kV substation in the near-term involves:

> a cut-in to Line 72 (Wellington to Mt Piper 330 kV);
> a cut-in to Line 947 (Orange North to Wellington Tee Burrendong)
> two new 330/132 kV transformers (375 MVA);
> a new 132 kV Line to existing Orange North substation; and
> a new 132 kV bay (and a circuit breaker) at the existing Orange North 132 kV substation.

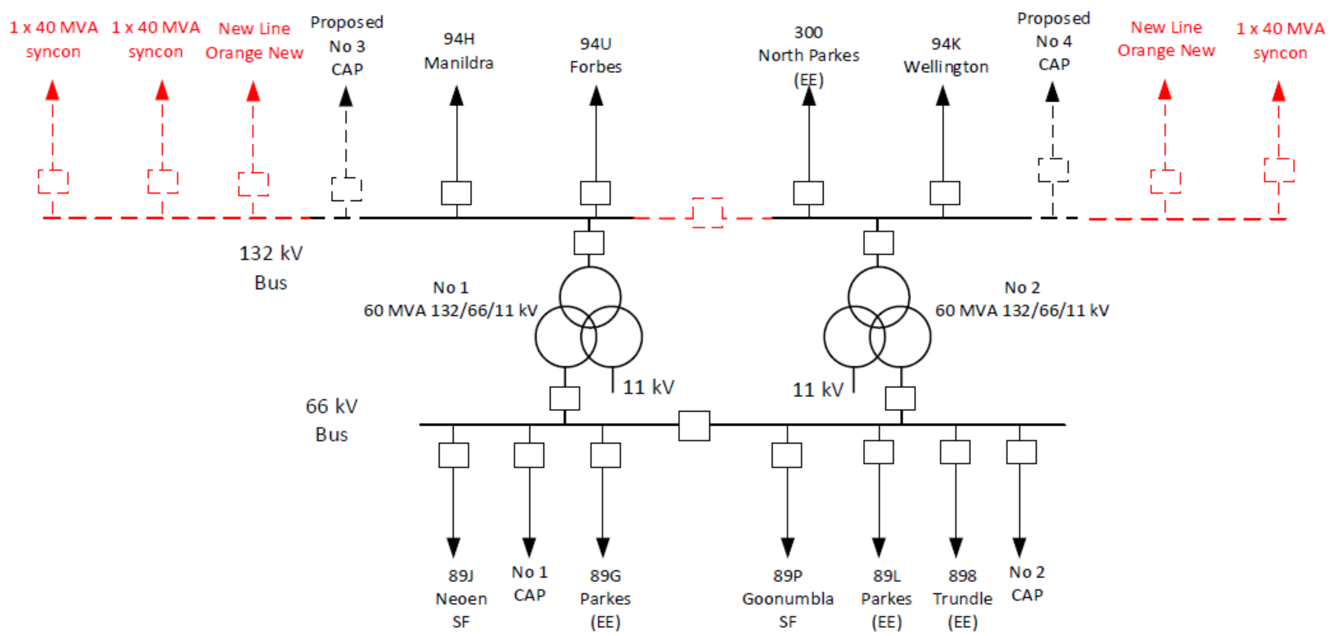
An indicative ultimate layout for the new Orange 330/132 kV substation under the Option 1 variants is shown in Figure 3-1.

Figure 3-1: Indicative Orange new 330/132 kV substation layout under the Option 1 variants



An indicative ultimate layout for the Parkes 132/66 kV substation under the Option 1 variants is shown in Figure 3-2.

Figure 3-2: Indicative Parkes 132/66 kV substation layout under the Option 1 variants



Option 1C is expected to be able to be commissioned earlier than Option 1A and Option 1B in the near-term and so is expected to provide a greater reduction in expected unserved energy compared to base case. TransGrid will assess the extent of this difference, as well as any differences in system strength provided and relieving of the identified thermal constraints, as part of the PADR.

3.3 Option 2 – A new 330 kV line between Orange and Parkes

In the near-term, as summarised in Table 3-1 above, Option 2 involves constructing the new Orange 330/132 kV substation as well as a 330 kV line from Orange New substation to Parkes.

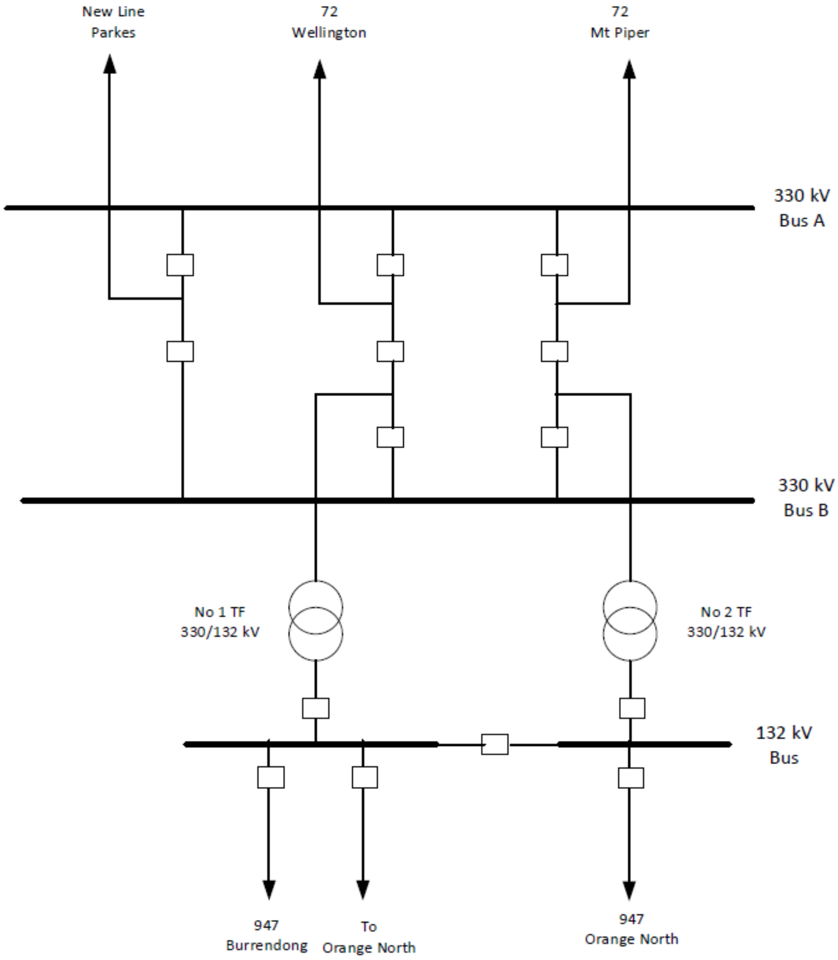
Table 3-3 summarises the longer-term stage to Option 2.

Table 3-3: Summary of the longer-term stages of Option 2

Stage	Estimated capex ($2020/21)	Expected timing (central load forecasts)
New 330 kV line from the new Parkes 330/132 kV substation to the Wellington 330/132 kV substation	$301-367m	2033-34

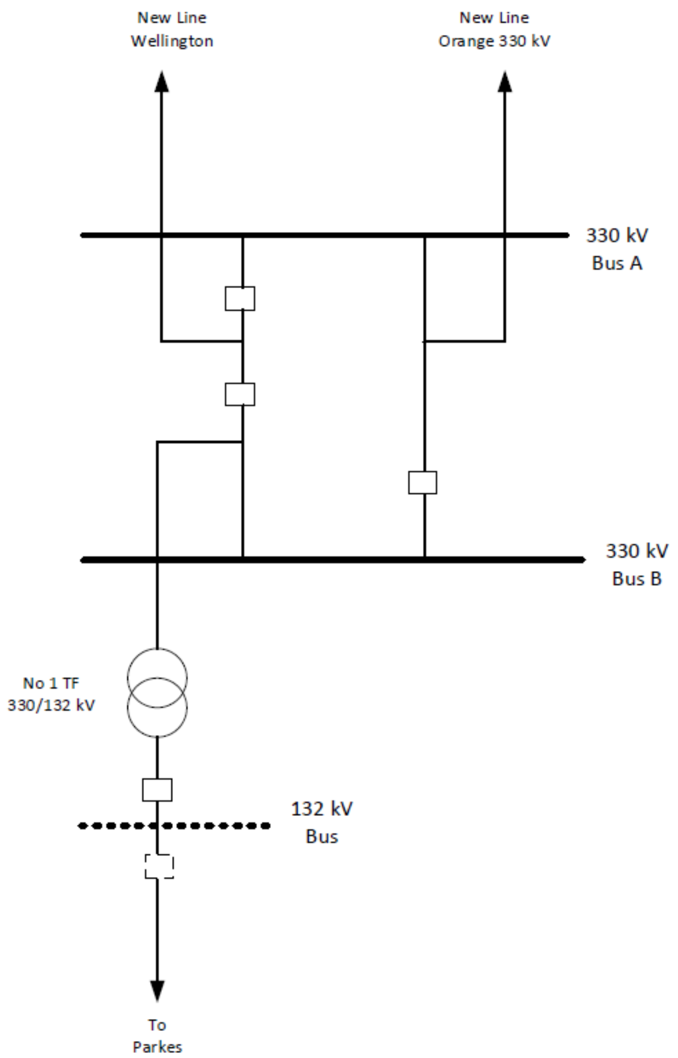
An indicative ultimate layout for the Orange 330/132 kV substation under Option 2 is shown in Figure 3-3.

Figure 3-3: Indicative Orange New 330/132 kV substation layout under Option 2



To facilitate the new 330 kV line from Orange 330/132 kV substation to Parkes 330/132 kV substation, it is proposed to construct a new Parkes 330/132 kV substation with a short line to the existing Parkes 132/66 kV substation. The indicative layout for the Parkes 330/132 kV substation is shown in Figure 3-4.

Figure 3-4: Parkes new 330/132 kV substation layout



The 330 kV line from Orange New substation to Parkes is a key difference between Option 2 and the Option 1 variants.

3.4 Option 3 – Dynamic reactive support at Orange and Parkes for as long as it can meet forecast demand, following which a new 132 kV line between Orange and Parkes is required

In the near-term, as summarised in Table 3-1 above, Option 3 involves one of the following ahead of constructing the new Orange 330/132 kV substation and a new 132 kV line from Orange 330/132 kV to Parkes:

> 132 kV synchronous condensers at Panorama (50 MVA) and Parkes (3*35 MVA) (Option 3A);
> a 132 kV SVC at Panorama (50 MVA) and a 132 kV synchronous condenser at Parkes (3*35 MVA) (Option 3B); or
> a 132 kV STATCOM at Panorama (50 MVA) and 132 kV synchronous condenser at Parkes (3*35 MVA) (Option 3C).

An SVC is a dynamic reactive power support device, which is capable of providing fast dynamic reactive power support. SVCs generally consist of a combination of thyristor controlled and thyristor switched reactors; and thyristor switched capacitors. SVC capability increases and decreases with the square of the operating voltage level. For example, a reduction in the operating system voltage to 90 per cent would reduce SVC capability to 81 per cent.

A STATCOM is also a dynamic reactive support device with a better dynamic performance compared to an SVC. STATCOMs are a current controlling device and the reactive power capability increases and decreases linearly with operating voltage. For example, a reduction in operating system voltage to 90 per cent would reduce STATCOM capability to 90 per cent. STATCOMs are considered more robust during low voltage conditions compared to SVCs.

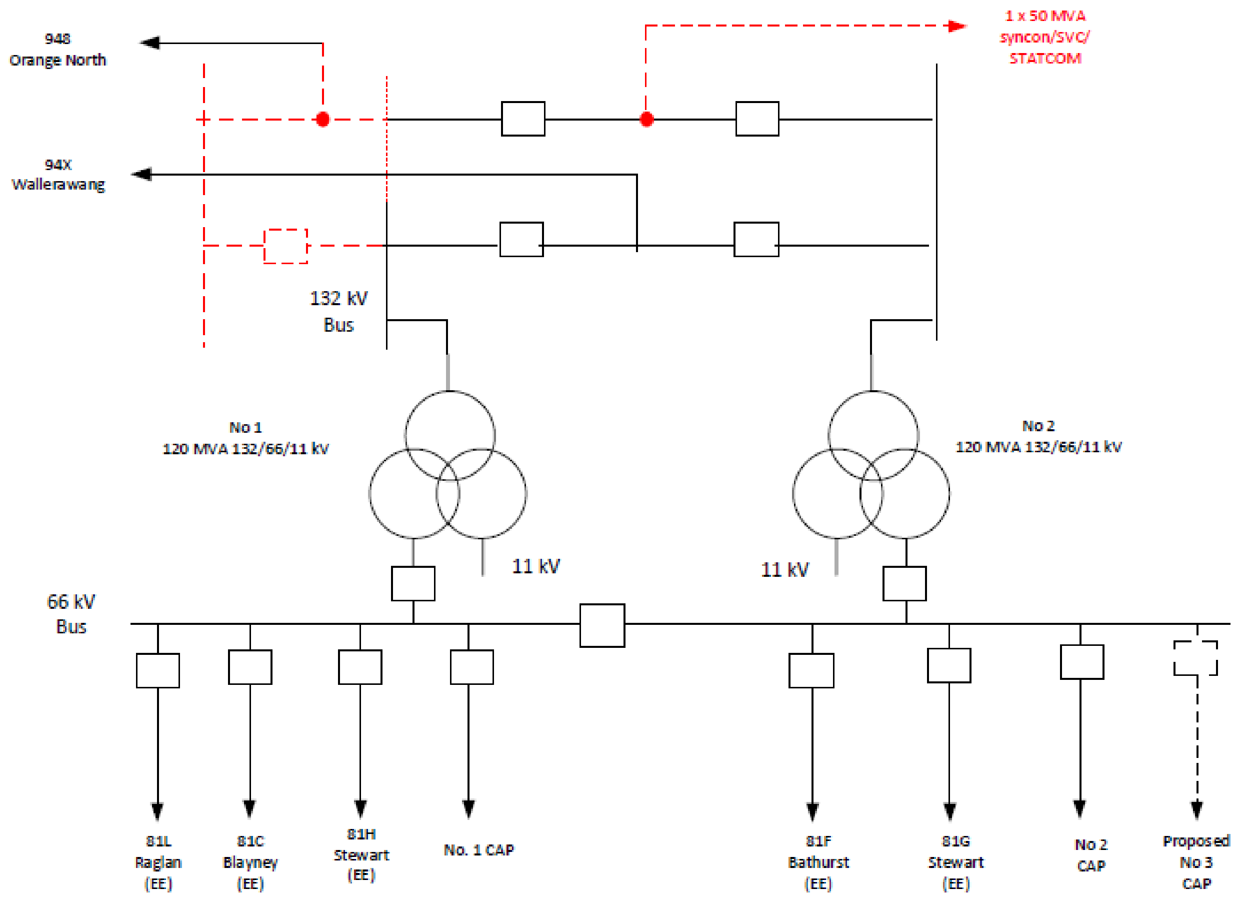
Table 3-4 summarises the common longer-term stage to the Option 3 variants.

Table 3-4: Summary of the longer-term stage of the Option 3 variants

Stages	Estimated capex	Expected timing (central load forecasts)
Second new 132 kV line from Orange 330/132 kV substation to Parkes substation	$86-106m	2033-34

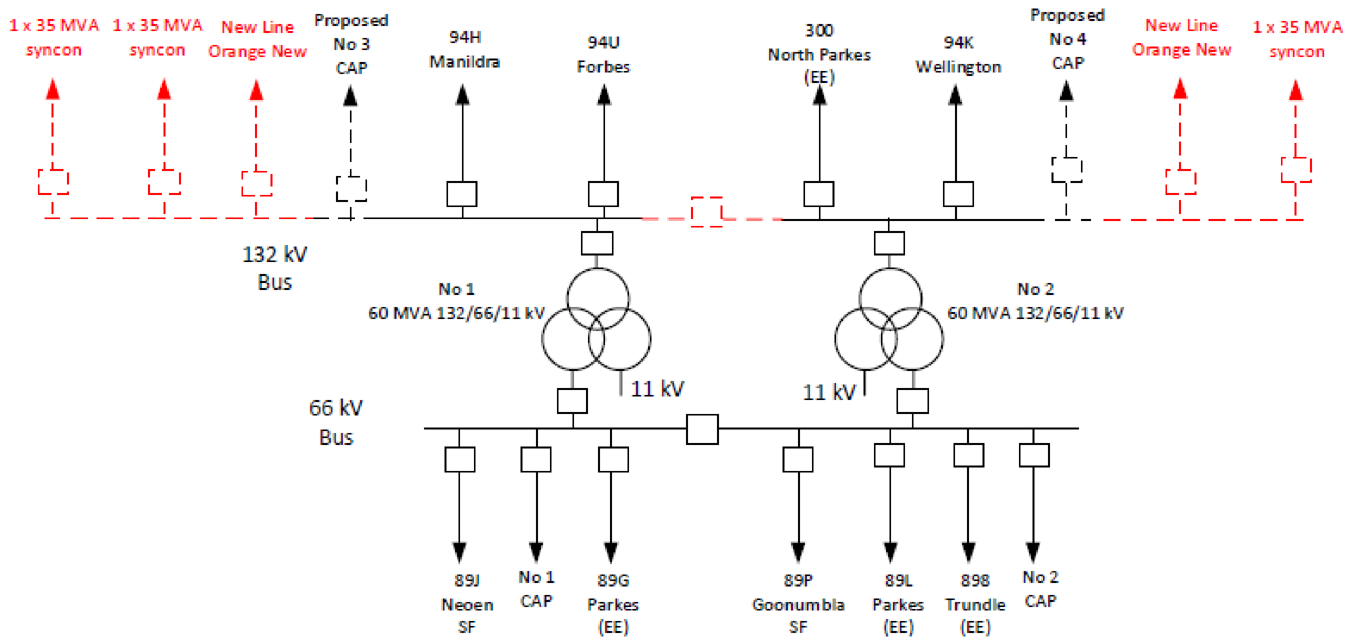
An indicative ultimate layout for the Panorama 132/66 kV substation under Option 3 is shown in Figure 3-5.

Figure 3-5: Indicative Panorama 132/66 kV substation layout under Option 3



The indicative layout for the Parkes new 132/66 kV substation is shown in Figure 3-6.

Figure 3-6: Parkes new 132/66 kV substation layout



3.5 Option 4 – Batteries to provide both load reduction and dynamic reactive support, following which a new 132 kV line between Orange and Parkes is required

In the near-term, as summarised in Table 3-1 above, Option 4 involves the following investments ahead of constructing the new Orange 330/132 kV substation and a new 132 kV line from Orange 330/132 kV to Parkes:

> a 20 MW (40 MWh) battery and 132 kV synchronous condensers (2*35 MVA) at Parkes; and

> a 30 MW (60 MWh) battery at Panorama.

Batteries can generally be used for a number of grid support services. In this application, it is expected that the batteries will output both active and reactive power. The batteries can hold charge (MWh) and reserve power capacity (MVAr) ready to be discharged on a single credible contingency at times of high demand and low renewable generation. The batteries can also provide MVAr output at all times to provide dynamic reactive support, to maintain voltage stability during system disturbances.

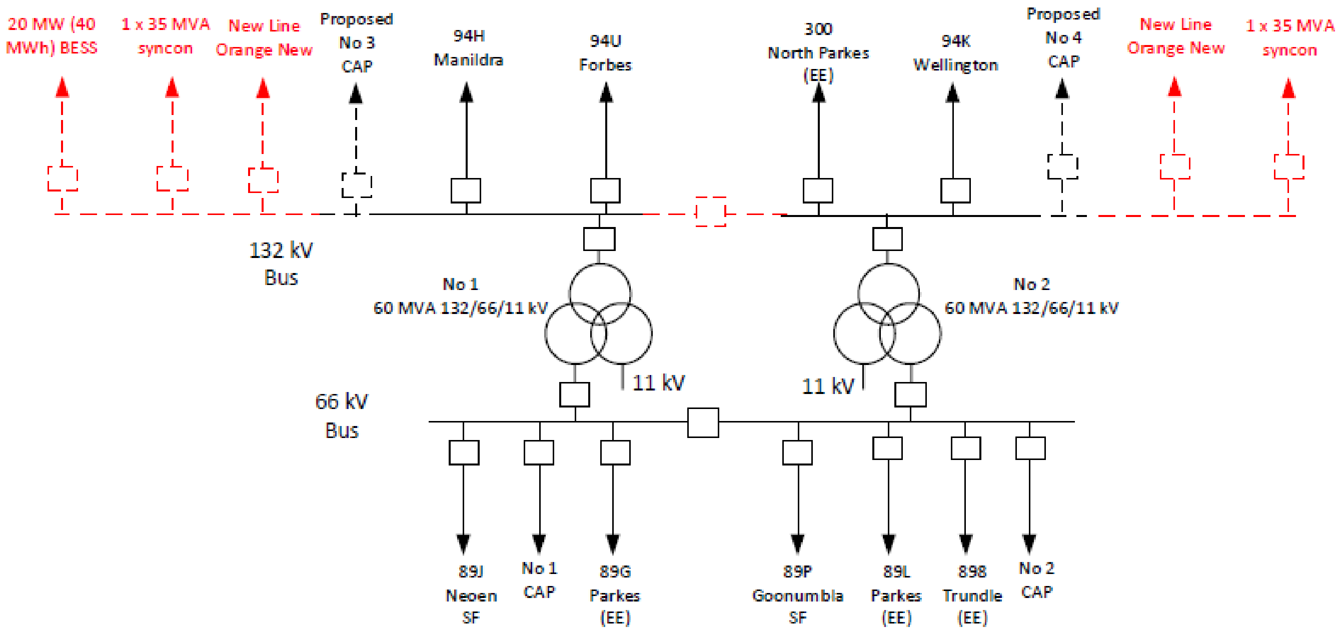
Table 3-5 summarises the longer-term stage for Option 4.

Table 3-5: Summary of the longer-term stage of Option 4

Stages	Estimated capex	Expected timing (central load forecasts)
Second new 132 kV line from Orange 330/132 kV substation to Parkes substation	$86-106m	2033-34

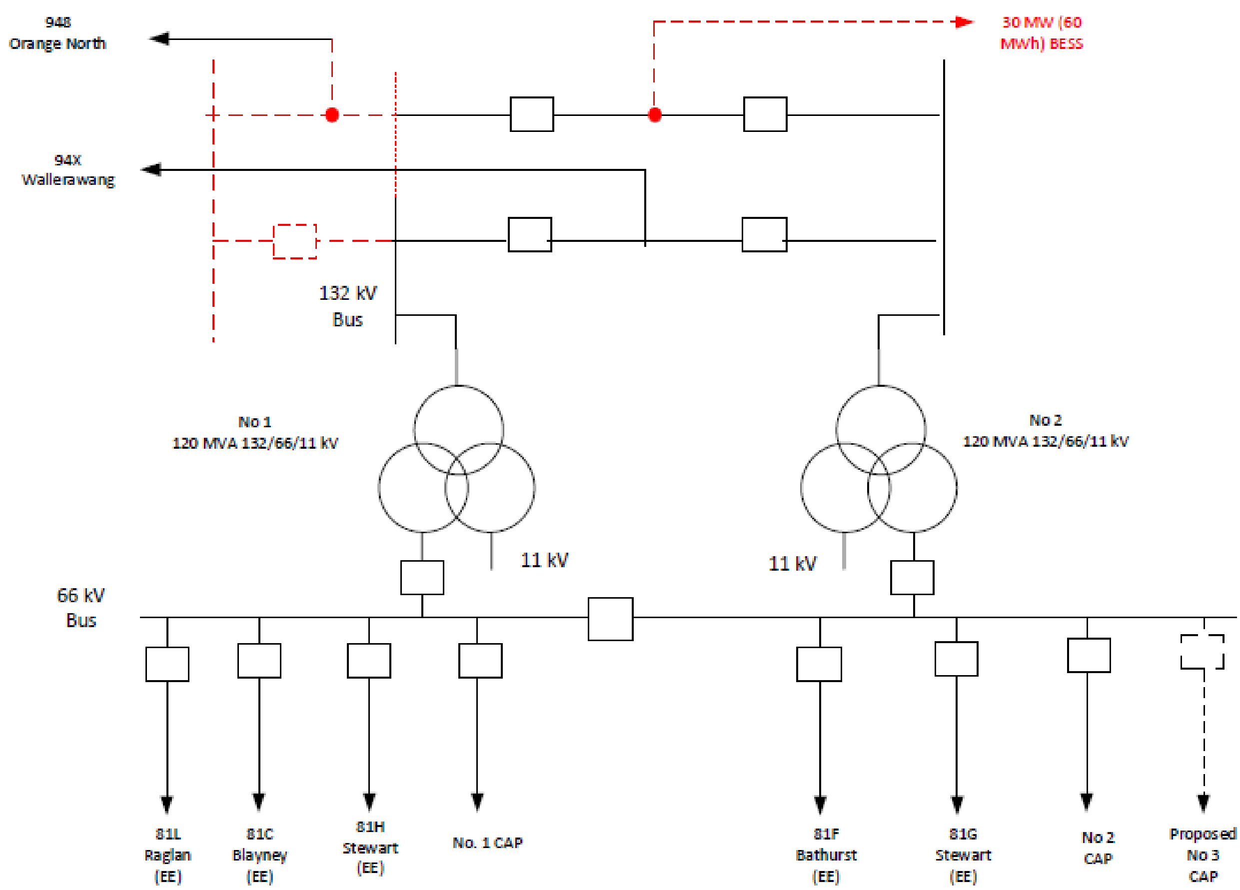
An indicative ultimate layout for the Parkes 132/66 kV substation under Option 4 is shown in Figure 3-7.

Figure 3-7: Indicative Parkes 132/66 kV substation layout under Option 4



The indicative layout for the Panorama 132/66 kV substation is shown in Figure 3-8.

Figure 3-8: Panorama 132/66 kV substation layout



A key difference between Option 4 and Option 3 is that Option 4 has single batteries at Parkes and Panorama in-place of one STATCOM/SVC/synchronous condenser.

TransGrid invites parties interested in supplying batteries as network assets to respond to this PSCR (via written submissions or otherwise) and the EOI that has been published with this report.

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);

> configuration of renewable generators to provide fast-acting reactive support;

> bulk or aggregated energy storage systems, e.g.:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage;
  - pumped hydro; and

> 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 3-6.

Table 3-6: Options considered but not progressed

Option	Reason(s) for not progressing
Capacitor banks/ switched capacitors	Not technically feasible. Due to the expected extensive load growth in the Bathurst, Orange and Parkes areas, adding a number of additional capacitor banks or switched capacitors in the area is considered as a non-credible solution since it will not meet the forecast load growth. It should be noted that there are capacitor banks already in-service at Parkes, Orange and Panorama substations and further capacitor banks to be commissioned to address load growth in the short-term.
Inverter-based dynamic reactive power devices at Parkes substation	Not technically feasible. There are a number inverter based renewable generators in the vicinity of Parkes substation and the system strength around Parkes is already low. The likely interactions between dynamic reactive power support devices and inverter based generation at low system strength is likely to lead to system instability such as voltage oscillations. Inverter-based dynamic reactive power support devices, such as SVCs and STATCOMs, around Parkes are therefore considered non-credible.

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.[23] 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:[24]

- 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 Central 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.

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23 As per clause 5.16.4(b)(6)(ii) of the NER.

24 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:[25]

> 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 in the case the identified voltage and thermal constraints, since the exact characteristics are dependent on a range of factors unrelated to one another,[26] 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);

> 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 Bathurst, Orange and Parkes area, a combined non-network solution of up to 35 MW or 50 MVAr at Panorama and up to 55 MW or 100 MVAr at Parkes will be considered on a cost-benefit basis to address the voltage constraint.

As the wider area Bathurst/Orange/Parkes load grows further, up to 100 MW will be considered on a cost-benefit basis to address the thermal constraint.

Possible solutions include (but are not limited to):

> generation (both embedded and grid-connected);

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25 NER clause 5.16.4(b)(3).

26 Specifically, in the case of voltage control in the Central West 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 central west NSW; and (3) renewable generation in the region (and, in particular, wind generation).

- configuration of renewable generators to provide fast-acting reactive support;
- bulk or aggregated energy storage systems, e.g.:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage;
  - pumped hydro; and
- 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 TransGrid. Where TransGrid owns the solution, TransGrid 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 Parkes is expected to cause limitations in the local area for more than 50 per cent of the year by 2023-24 under system normal. Similarly, TransGrid expects the voltage constraint at Orange/Panorama to bind for approximately 10 per cent of the year by 2025-26. The thermal constraint, which occurs later in 2025, is expected to bind 7 per cent of that year following a transformer contingency.

4.2 Assisting with the voltage constraint

TransGrid notes that the voltage constraint can be addressed by providing either dynamic voltage support or reducing the load below the voltage stability limit, or a combination of both.

4.2.1 Providing dynamic voltage support (reactive power, MVAr)

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 Parkes 132 kV substation and the Orange or Panorama 66 kV substation.

Table 4-1: Expected Parkes 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)
2023	Up to 35 MVAr	4151	556 events	8 hours
2024	Up to 65 MVAr	4895	506 events	10 hours
2026	Up to 100 MVAr	5103	528 events	10 hours

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

Table 4-2: Expected Orange or Panorama 66 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)
2023	Up to 15 MVAr	581	271 events	2.5 hours
2024	Up to 25 MVAr	827	311 events	3 hours
2026	Up to 50 MVAr	870	332 events	3 hours

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.

4.2.2 Reduce load below voltage stability limit (active power, MW)

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.

To improve the efficacy of these solutions, the non-network solution will need to be located at these substations or be supplied by the respective zone substations.

The two tables below set out the expected requirements at both the Parkes 132 kV substation and the Orange or Panorama 66 kV substation.

Table 4-3: Expected Parkes 132 kV substation capacity for load reduction requirements

Year	Magnitude of load reductions required (MW)	Expected cumulative duration per annum (hours)	Frequency per annum	Expected duration per event (hours)
2023	25 MW	4151	556 events	8 hours
2024	41 MW	4895	506 events	10 hours
2026	55 MW	5103	528 events	10 hours

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

Table 4-4: Expected Orange or Panorama 66 kV substation capacity for load reduction requirements

Year	Magnitude of load reductions required (MW)	Expected cumulative duration per annum (hours)	Frequency per annum	Expected duration per event (hours)
2023	30 MW	581	271 events	2.5 hours
2024	35 MW	827	311 events	3 hours
2026	35 MW	870	332 events	3 hours

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 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.

The table below summarises the downstream Essential Energy zone substations to indicate where load reductions may occur.

Table 4-5: Downstream Essential Energy zone substations supplied by TransGrid

Orange zone Substations	Panorama zone Substations	Parkes zone Substations
Cadia	Blayney	Parkes Town
Orange Industrial	Mandurama	North Parkes Mine
Orange North	Raglan	Peak Hill
Orange South	Russell Street	Tomingley Mine
Orange West	Stewart	Trundle

4.3 Assisting with the thermal constraint

TransGrid notes that the thermal constraint can be addressed by reducing the load below the thermal capacity limit.

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.

While only Parkes, Orange, and Panorama zones are able to address the voltage constraint, the Wellington substation supplies many areas in Essential Energy's network and non-network options in these locations are able to address this thermal constraint. However, non-network options that can address both constraints are expected to be more valuable.

The table below sets out the expected load reductions at the Wellington 330 kV substation.

Table 4-6: Wellington 330 kV substation: load reductions

Year	Magnitude of load reductions required (MW)	Expected cumulative exposure per annum (hours)	Frequency per annum	Expected duration per event (hours)
2025	18 MW	7	8 events	1
2026	21 MW	7	8 events	1
2030	46 MW	22	17 events	1.5

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

In practice, network support is typically required within 30 minutes of a contingent trip of a 330/132 kV transformer.

The table below summarises the downstream Essential Energy zone substations to indicate where load reductions may occur.

Table 4-7: Downstream Essential Energy zone substations supplied by TransGrid

Orange	Panorama	Parkes	Wellington	Forbes	Cowra	Molong	Dubbo	Nyngan
Cadia	Blayney	Parkes Town	Mumbil	Condobolin	Bendick Murrell	Cumnock	Coonamble	Bourke
Orange Industrial	Mandurama	North Parkes Mine	Wellington	Forbes Town	Canowindra	Manildra	Dubbo Phillip St	Byrock
Orange North	Raglan	Peak Hill	-	Lake Cargelligo	Cowra	Molong	Dubbo South	Cobar CSA
Orange South	Russell Street	Tomingley Mine	-	Paytens Bridge	Grenfell	-	Dubbo West	Cobar Elura
Orange West	Stewart	Trundle	-	West Jemalong	Monteagle	-	Eulomogo	Cobar Peak
-	-	-	-	-	-	-	Geurie	Cobar Town
-	-	-	-	-	-	-	Gilgandra	Girilambone
-	-	-	-	-	-	-	Gulargambone	Nyngan Town
-	-	-	-	-	-	-	Narromine	Nyngan
-	-	-	-	-	-	-	Nevertire	-
-	-	-	-	-	-	-	Yarrandale	-

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.[27]

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.[28]

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. This category of benefit is expected to be material both relative to the base case and between credible options.

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 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.

5.3 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 the credible network options set out in this PSCR will provide additional system strength around Parkes and/or relieve emerging line constraints around Bathurst and Orange, TransGrid does not consider there to be material wholesale market benefits associated with this. Specifically, while providing additional system strength around Parkes and/or relieving line constraints 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 mean that any new generation is not expected to displace the output of generation elsewhere and so there is not expected to be any material wider wholesale market impacts between the options and the base case.

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;

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

[28] NER clause 5.16.4(b)(6)(iii).

- 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.

5.4 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 us to consider the following classes of market benefits, listed in Table 5-1, arising from each credible option.

The same table sets out the reasons we consider these classes of market benefits to be immaterial.

Table 5-1: Reasons non-wholesale electricity market benefits categories are considered not material

Market benefits	Reason
Differences in the timing of expenditure	The credible options considered are all designed to meet all required 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	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 Bathurst, Orange and Parkes areas 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,[29] 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 were 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.

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[29] 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.[30]

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	Medium demand (as shown in section 2 of this PSCR)	Low demand (as shown in section 2 of this PSCR)	High demand (as shown in section 2 of this PSCR)
New renewable generation in the area	In-service, commissioning and committed generators from Table 2-1.	All in-service, commissioning, committed and advanced generators from Table 2-1.	In-service, commissioning 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[31]	30 per cent higher VCR in accordance with the AER's stated confidence level[32]
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 therefore assigned this scenario a weighting of 50 per cent, with the other two scenarios being weighted equally with 25 per cent each.

30 AER, *Values of Customer Reliability, Final report on VCR values*, December 2019.
31 AER, *Widespread and Long Duration Outages – Values of Customer Reliability Final Conclusions*, September 2020, p. 8.
32 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 156.

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