OPTIONS EVALUATION REPORT (OER)

Voltage Control - Light Load Conditions

OER N2649 revision 3.0

Ellipse project no(s):
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Project category: Prescribed - Augmentation-Sub Sys

Approvals

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Date submitted for approval	21/12/2021	

Change history

Revision	Date	Amendment
0	9/06/2021	Initial Issue
1	6/10/2021	Houston Kemp comments addressed
2	11/10/2021	Minor formatting changes
3	24/12/2021	CutlerMerz comments addressed

Executive summary

Transgrid is required to maintain voltage levels of the 132 kV subsystem in the North West of NSW to within permissible limits during light demand conditions. This is particularly important under circumstances where reactive power support from White Rock Wind and Solar Farm is unavailable.

The latest demand forecasts for New South Wales show a widespread trend of reduced active power consumption and increased reactive power injection over the planning horizon at most network locations, including the North Western subsystem. Consequently, high voltage levels are expected to occur at various supply locations in this subsystem during system normal light load conditions. Further, high voltage conditions have already arisen at Inverell and White Rock Wind and Solar Farm for a contingent trip of the 132 kV Line 96N Armidale to Inverell during an outage of the 132 kV Line 96T Armidale to Glen Innes.

It follows that the specified need of this project is compliance as Transgrid is required to maintain system voltage levels to standards under the NER Clause S5.1.a.4. Transgrid studies have presently identified locations in the North Western 132 kV Subsystem that are expected to require remediation to meet the voltage level requirements of the NER. Operational measures to mitigate high voltages are not acceptable since the use of these measures will result in non-compliance of reliability standards.

The assessment of the options considered to address the need/opportunity appears in Table 1.

Table 1 - Evaluated options

Option	Description	Direct capital cost ($m)	Network and corporate overheads ($m)	Total capital cost[1] ($m)	Weighted NPV (PV, $m)	Rank
Option A	Install a 66 kV 10 MVAr reactor at Moree and a 66 kV 15 MVAr reactor at Inverell	7.29	0.35	7.64	- 6.87	2
Option B	Install a 132 kV 25 MVAr reactor at Inverell	4.90	0.51	5.41	- 4.57	1

The preferred option is Option B because this is the option that meets the identified need, is technically feasible, and has the lowest net present cost.

This compliance driven project was observed to have a negative NPV due to high capital cost of the project.

[1] Total capital cost is the sum of the direct capital cost and network and corporate overheads. Total capital cost is used in this OER for all analysis.

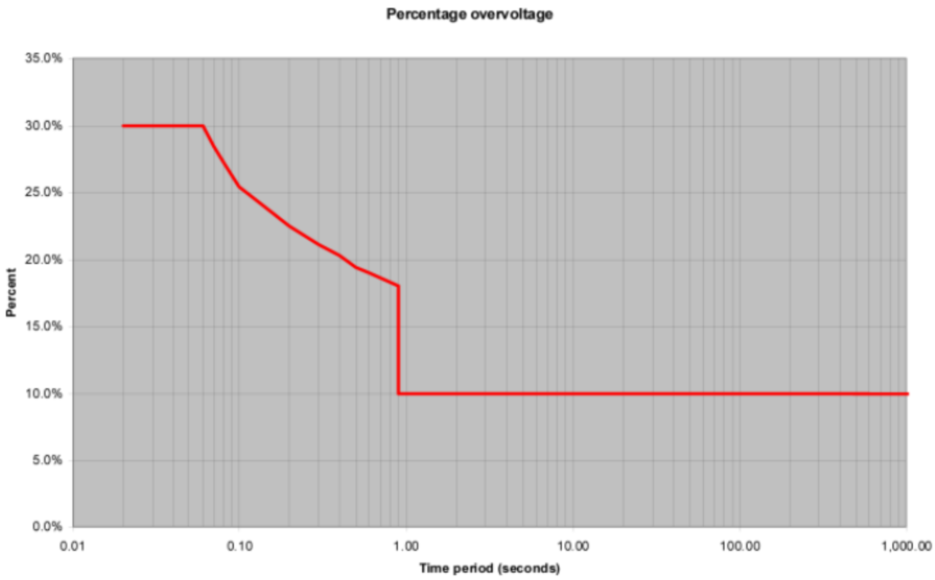
1. Need/opportunity

A compliance need has been identified to maintain the voltage levels of the 132 kV subsystem in the North West of NSW to within permissible limits during light demand conditions, especially when reactive power support from White Rock Wind and Solar Farm is unavailable.

The latest demand forecasts[2] for New South Wales show a widespread trend of reduced active power consumption and increased reactive power injection over the planning horizon at most network locations, including the North Western subsystem, as observed in Figures 2 and 3. Consequently, high voltage levels are likely to occur at various supply locations in this subsystem during system normal light load conditions. Further, high voltage conditions have already been experienced at Inverell and at White Rock Wind and Solar Farm for a contingent trip of the 132 kV Line 96N Armidale to Inverell during an outage of the 132 kV Line 96T Armidale to Glen Innes which required operator intervention.

Transgrid, as the transmission network service provider for NSW, is required by National Electricity Rules (NER) clause S5.1.4 to plan and design its network in order to maintain system voltages within limits stipulated in NER Clause S5.1a.4 of the system standards. The system standard requires the voltage of supply at connection points remain below its normal voltage by more than a given percentage of normal voltage for longer than the corresponding period as shown in Figure 1. Unless remedial action is taken, the expected high voltages identified through studies would result in Transgrid being non-compliant with the system standard.

Figure 1: NER system voltage requirement (Clause S5.1a.4)



Transgrid studies have identified locations in the North Western 132 kV Subsystem that are expected to require remediation to meet the voltage level requirements of the NER. Some of these sites are expected to breach overvoltage standards as soon as FY 2023/2024.

2 Minimum and maximum demand forecast sourced from DNSPs in early 2021

Figure 2: Minimum Active Power Forecast (POE50)

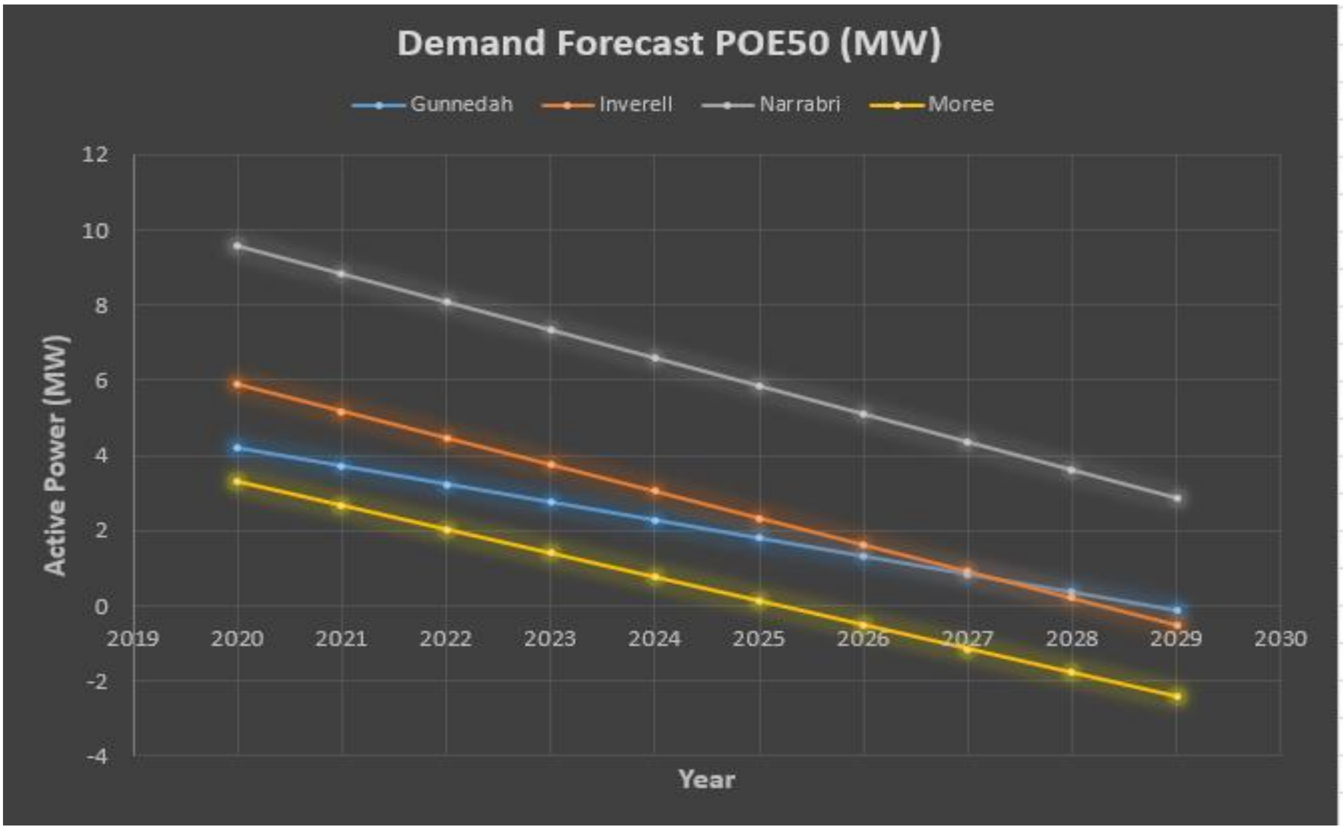
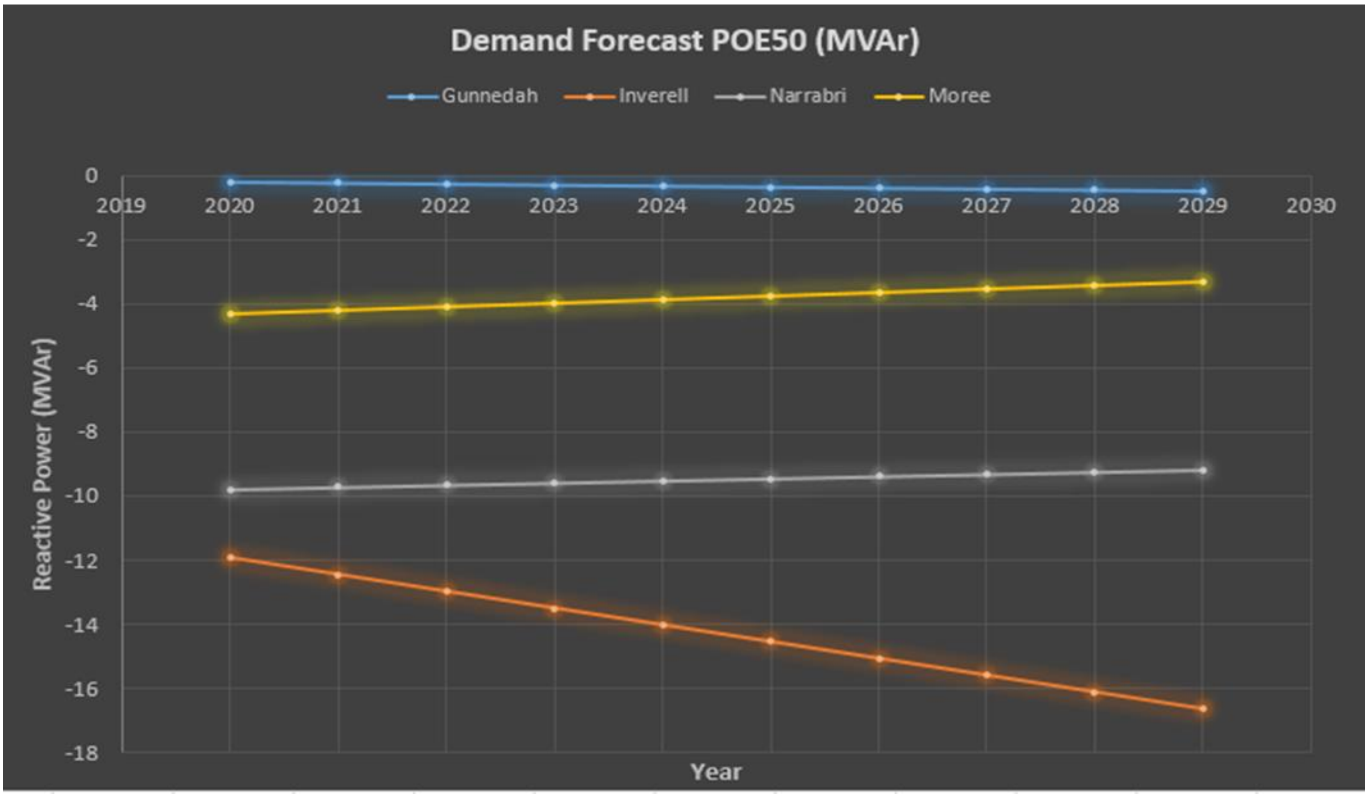


Figure 3: Reactive Power Forecast at Minimum Active Power (POE50)



2. Related needs/opportunities

- Need 1693 – Supply to North West Slopes Area

  This Need investigates the potential options to meet or manage demand growth in North West Slopes area of NSW. The expected voltage limits may be affected following implementation of a suggested option.

- N2404 – FY24-28 Transformer Refurb Program

  The No.1 and No.2 Transformers at Inverell Substation are proposed to be replaced in RP3. The proposed location of the new No.2 Transformer under OFS-N2404A clashes with the location of the new 132 kV 25 MVAr Reactor proposed in this OFS.

3. Options

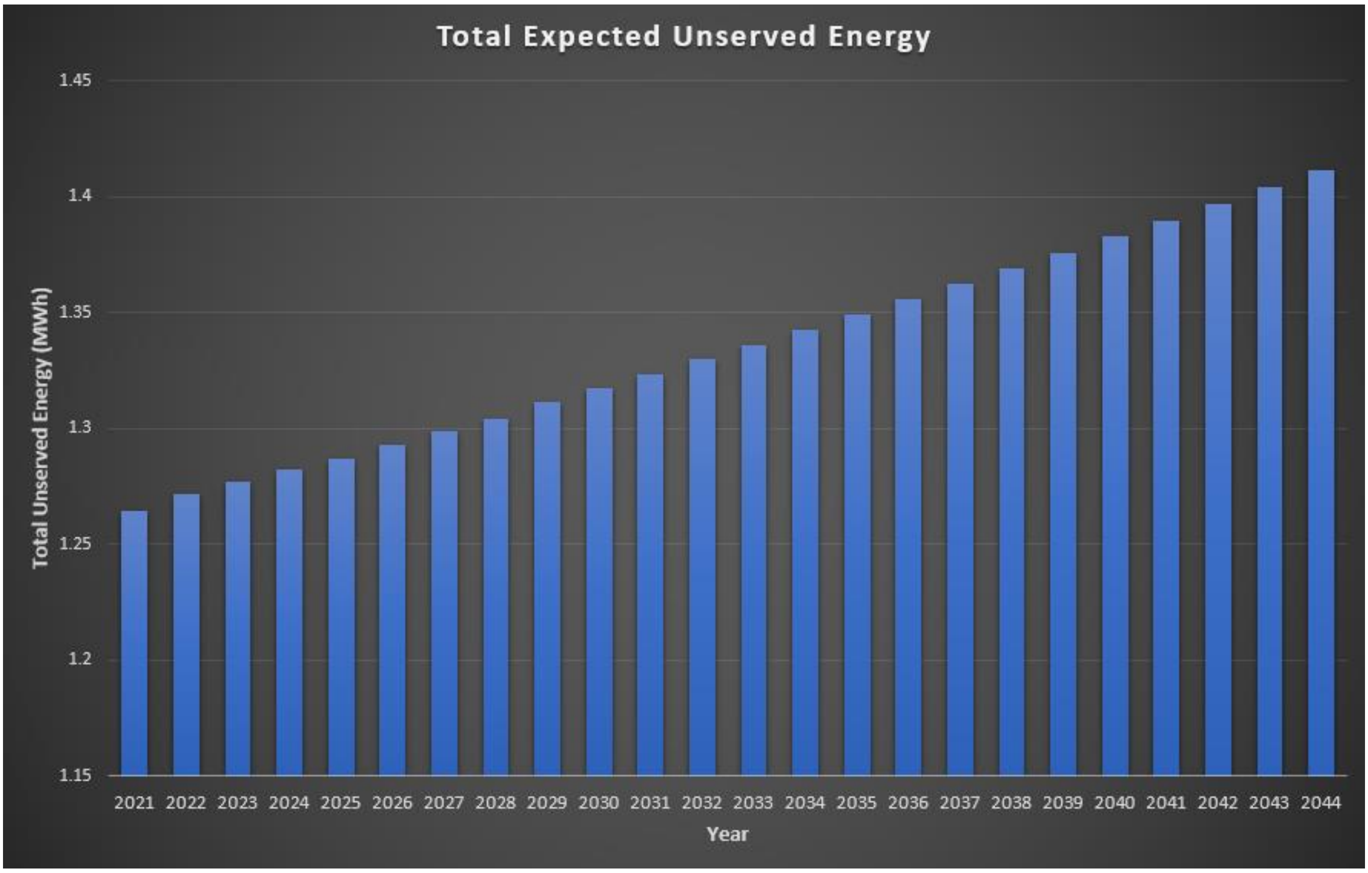
3.1 Base case

The base case under this need is to not modify the network to meet the voltage level requirements. The primary risk of Transgrid not addressing this need is that high voltage levels in excess of the NER standard can be expected in the Transgrid network. Further, these conditions would also occur downstream in the Essential Energy network especially during light load conditions. This increases the risk of potentially high-voltage levels being experienced by end-use customers with the potential impact of damage to consumers' equipment.

If the network is not modified, operational measures will need to be undertaken to remain compliant with the voltage standards. This is not acceptable as it will result in non-compliance of the NSW Electricity Reliability and Performance Standard 2017.[3] The operational measures involve switching off transmission links in the area resulting in radial supply of Moree and Inverell and thereby lowering the reliability of customers at both these locations. The risk cost associated with the radial supply was calculated using the Expected Unserved Energy (EUE) and the Value of Customer Reliability (VCR). Figure 4 shows the additional expected unserved energy over the next few years if the network is not modified.

[3] The reliability level of Moree will be breached. The NSW Electricity Reliability and Performance Standard 2017 allows an expectation of 5 minutes of unsupplied power at average load. There is an expectation of 2.2 minutes if the operational measures are not considered. The use of operational measures, adds an additional 3.15 minutes of expected unsupplied energy, so the total expected unsupplied energy would be 5.35 minutes which is unacceptable as it exceeds the permitted 5 minutes.

Figure 4: Total Expected Unserved Energy (Summation of Moree and Inverell)



3.2 Options evaluated

Option A — Install a 66 kV 10 MVAr reactor at Moree and a 66 kV 15 MVAr reactor at Inverell

Option A involves the installation of a 66 kV 10 MVAr reactor at Moree and a 66 kV 15 MVAr reactor at Inverell. The following works are required by Transgrid:

- Moree 132 kV substation:
  - Extension of the 66 kV Busbar with rigid busbar by 15m to the South
  - Installation of a new 66 kV Reactor switchbay and associated conduits including:
    - 1 x 66 kV Disconnector with associated Earth Switch
    - 1 x 66 kV Dead Tank Circuit Beaker with POW functionality
    - 3 x 66 kA Surge Arrestors (Single Phase)
  - Installation of a new Reactor foundation, bund and associated pipework to the existing oil dump tank
  - Installation of a 10 MVAr 66 kV Shunt Reactor and associated bushings and surge arrestors
  - Installation of a new reactor combined control/protection panels and associated cabling
  - Modifications to the existing Substation Automation System to include the new reactor and associated switchbay.
- Inverell 132 kV substation:
  - Extension of the 66 kV Busbar with rigid busbar by 15m to the South
  - Installation of a new 66 kV Reactor switchbay and associated conduits including:

- 1 x 66 kV Disconnector with associated Earth Switch
- 1 x 66 kV Dead Tank Circuit Beaker with POW functionality
- 3 x 66 kA Surge Arrestors (Single Phase)

> Installation of a new Reactor foundation, bund and associated pipework to the existing oil dump tank

> Installation of a 15 MVAr 66 kV Shunt Reactor and associated bushings and surge arrestors

> Installation of a new reactor combined control/protection panels and associated cabling

> Modifications to the existing Substation Automation System to include the new reactor and associated switchbay.

Option A is expected to benefit customers by reducing the expected unserved energy from FY2024/25 onwards which aligns with the expected commissioning date for this option.

The estimates in the table below have an uncertainty of ± 25% and exclude capitalised interest.

Table 2 – Option A expected expenditure

	Total Project Base Cost	FY2022/23	FY2023/24	FY2024/25
Estimated Cost – non-escalated ($m 2020-21) for Moree 132 kV substation	3.81	0.29	2.04	1.48
Estimated Cost – non-escalated ($m 2020-21) for Inverell 132 kV substation	3.83	0.29	2.05	1.49
Total	7.64	0.58	4.09	2.97

It is estimated that an amount up to $1 million is required to progress the project from DG1 to DG2[4]. This is to cover activities such as site visits, development of concept design, and commencement of project approvals and early procurement of long lead-time items.

This project is expected to be completed in an estimated 32 months following the approval of DG1.

Option B — Install a 132 kV 25 MVAr reactor at Inverell

Option B involves the installation of a 132 kV 25 MVAr reactor at Inverell. The following works are required by Transgrid under this option:

> Extension of substation bench by 24m x 30m in South Eastern direction. This also requires:

- Extension of palisade fencing
- Extension of substation earth grid
- Extension of existing cable trench by 30m

> Extension of 132 kV busbar with rigid busbar by 30m in South Eastern direction

> Construction of a new 132 kV reactor foundation in the South Eastern direction of No.2 66 kV capacitor bank and adjacent to transformer runway. This requires:

- Installation of new reactor bund

[4] DG stands for decision gate, which forms part of Transgrid's investment process.

    - Connection of bund to existing transformer spill oil tanks
- Installation of new 132 kV Reactor switchbay and associated conduits. The new switchbay includes:
    - 1 x 132 kV Disconnector with associated Earth Switch
    - 1 x 132 kV Dead Tank Circuit Breaker with POW functionality
    - 1 x 132 kV Surge Arrestors (for 3 phases)
    - 8m of 132 kV rigid bus over transformer runway
- Installation of 132 kV 25 MVAr Shunt Reactor and associated bushings and surge arrestors
- Installation of a new reactor combined control/protection panels and associated cabling
- Modifications to the existing Substation Automation System to include the new reactor and associated switchbay.

Option B is expected to benefit customers by reducing the expected unserved energy from FY2024/25 onwards which aligns with the expected commissioning date for this option.

The estimates in the table below have an uncertainty of ± 25% and exclude capitalised interest.

Table 3 – Option B expected expenditure

	Total Project Base Cost	FY2022/23	FY2023/24	FY2024/25
Estimated Cost – non-escalated ($m 2020-21)	5.41	0.40	2.90	2.11

It is estimated that an amount up to $500k is required to progress the project from DG1 to DG2. This is to cover activities such as site visits, development of concept design, and commencement of project approvals and early procurement of long lead-time items.

This project is expected to be completed in an estimated 34 months following the approval of DG1.

3.3 Options considered and not progressed

Table 4 shows the option that was considered but not progressed, together with the explanation for it not progressing.

Table 4: Options considered and not progressed

Option	Reason for not progressing
Installing a Static VAr Compensator (+25/-25 MVAr) at Inverell	This option is not commercially feasible since its expected cost is more than double the cost of other options and does not provide any extra benefit. Hence, this option has not been considered for further development.

4. Evaluation

4.1 Commercial evaluation methodology

The economic assessment undertaken for this project includes three scenarios that reflect a central set of assumptions based on current information that is most likely to eventuate (central scenario), a set of assumptions that give rise to a lower bound for net benefits (lower bound scenario), and a set of assumptions that give rise to an upper bound on benefits (higher bound scenario).

Assumptions for each scenario are set out in Table 5 below.

Table 5 – Scenario assumptions

Parameter	Central scenario	Lower bound scenario	Higher bound scenario
Discount rate	4.8%	7.37%	2.23%
Demand Growth	Medium (POE50)	Low (POE90)	High (POE10)
Capital cost	100%	125%	75%
Operating expenditure	100%	125%	75%
VCR	AER Latest VCR (escalated) 100%	70%	130%
Fuel Cost	100%	70%	130%
Scenario weighting	**50%**	**25%**	**25%**

Since the central scenario represents the most likely scenario to occur, this has been weighted at 50 per cent. The other two scenarios reflect extreme combinations of assumptions designed to stress test the results. Accordingly, these scenarios are weighted at 25 per cent each.

Parameters used in this commercial evaluation are set out in Table 6 below.

Table 6 – Parameters used in commercial evaluation

Parameter	Parameter Description	Value used for this evaluation
Discount year	Year that dollar values are discounted to	FY2020/21
Base year	The year that dollar value outputs are expressed in real terms	FY2020/21 dollars
Period of analysis	Number of years included in economic analysis with remaining capital value included as terminal value at the end of the analysis period.	25 years

The capex figures in this OER do not include any real cost escalation.

4.2 Commercial evaluation results

The commercial evaluation of the technically feasible options is set out in Table 7. Details appear in Appendix A.

Table 7 - Commercial evaluation (PV, $ million)

Option	Capital Cost PV	OPEX Cost PV	Central scenario NPV	Lower bound scenario NPV	Higher bound scenario NPV	Weighted NPV	Ranking
Option A	- 6.07	-1.87	-7.02	-9.26	-4.16	-6.87	2
Option B	-4.30	-1.32	-4.71	-6.42	-2.43	-4.57	1

Both options meet the need to maintain voltage level within compliance limit. However, Option B has lower capital cost and correspondingly lower operational cost due to requiring installation of only one shunt reactor in contrast to two in Option A.

4.3 Preferred option

The preferred option is Option B as it results in the lowest overall net present cost. Under this option, the installation of a 132 kV 25 MVAr reactor at Inverell will be undertaken.

This compliance driven project was observed to have a negative NPV. The preferred option was selected because this is the option that meets the identified need, and has a lower net present cost than the other option.

Capital and Operating Expenditure

The preferred option requires capital expenditure of $5.41 million. Additional operating expenditure of $108,000 per year has been identified for this option.

Regulatory Investment Test

The estimated cost of the preferred option (Option B) is below the Regulatory Investment Test (RIT-T) threshold of $6 million. However, as the estimated cost of Option A which is both technically and economically feasible is above the Regulatory Investment Test (RIT-T) threshold of $6M, a RIT-T will be required.

5. Optimal Timing

The test for optimal timing of the preferred option has been undertaken. The approach taken is to identify the optimal commissioning year for the preferred option where the net present cost is minimised whilst remaining compliant with all regulatory obligations.

The results of optimal timing analysis is:

> Optimal commissioning year: 2024/25
> Commissioning year annual benefit: $72.5
> Annualised cost: $307,000

The project is expected to commence in the 2023-2028 Regulatory Period.

6. Recommendation

Based on Transgrid's requirements to maintain voltage levels in the 132 kV subsystem in the North West of NSW, Option B has been identified as the preferred project as it best addresses the identified compliance need at the lowest net present cost. This option requires approximately $5.41 million of capital expenditure to progress the project to Decision Gate 2 (DG2) and is expected to be completed in 32 months following approval of DG1.

The recommendation is to progress with Option B.

Appendix A – Option Summaries

Project Description	North West 132 kV Subsystem Voltage Control - Light Load		
Option Description	Option B — Install a 132 kV 25 MVAr reactor at Inverell		
Project Summary			
Option Rank	1	Investment Assessment Period	25
Asset Life	*40*	NPV Year	*2021*
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	*-4.71*	Annualised CAPEX ($m)	*0.22*
NPV @ Lower Bound Scenario (PV, $m)	*-6.42*	Network Safety Risk Reduction ($m)	*N/A*
NPV @ Higher Bound Scenario (PV, $m)	*-2.43*	ALARP	*N/A*
NPV Weighted (PV, $m)	*-4.57*	Optimal Timing	*2024/25*
Cost			
Direct Capex ($m)	$4.90	*Network and Corporate Overheads ($m)*	*$0.51*
Total Capex ($m)	$5.41	*Cost Capex (PV, $m)*	*-$4.30*
Terminal Value ($m)	$2.43	Terminal Value (PV, $m)	*$0.79*