

Options Evaluation Report (OER)

Maintain voltage in Alpine area
OER- N2645 revision 3.0

Ellipse project no(s):

TRIM file: [TRIM No]

Project reason: Reliability - To meet connection point reliability requirements

Project category: Prescribed - Augmentation-Sub Sys

Approvals

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Date submitted for approval	14 October 2022	

Change history

Revision	Date	Amendment
0	20/09/2021	Initial Issue
1	12/11/20221	Updated for minor errors
2	24/12/2021	Updated as per CutlerMerz's comments; Revised for minor editorial changes
3	14/10/2022	Revised the Need description, updated the unserved energy and NPV calculations using the latest demand forecast; Revised the required commissioning year; Updated the document for the latest OER template.

Executive summary

There is a need to manage existing peak demand in Alpine area of New South Wales and to meet expected future demand growth distribution network supplied from Queanbeyan and Williamsdale due to the spot loads in the distribution network. The identified need for this project is the requirement to ensure that the loads supplied from these supply points are reliably supplied whilst maintaining satisfactory voltage levels in the area as the loads grow.

The latest demand forecasts indicate that there will be spot loads in the Essential Energy network due to the new residential and commercial development in the South Jerrabomberra area. The total demand increase due this spot load would be approx. 93 MW over the next 10 years. In order to optimise the overall network capability, this load needs to be supplied via both Queanbeyan and Williamsdale BSPs.

It has been identified there will be potential future network constraints that are required to be remediated to ensure that this load can be connected to the network at its full capacity. Under N-1 outage conditions there will be voltage limitations reached and/or breached at Cooma and Mungah. If the spot load becomes operational as planned, there will be times when the voltages at Mungah and Cooma will be outside the acceptable levels for secure operation of the power system.¹ Under-voltage conditions (< 0.9pu) are expected to occur at Mungah 132 kV and 33 kV busbars, Cooma 132 kV and 66 kV busbars and Williamsdale 132 kV busbar under N-1 outage conditions. In addition, the step voltage changes following the critical contingency will exceed 10%. This non-compliance is expected to occur during peak demand times from in 2025/26 onwards.

As the transmission network services provider in New South Wales, Transgrid is obliged to comply with the relevant Clauses of the National Electricity Rules to facilitate connection of loads while operating the network in a secure and satisfactory state. Addressing the need will also assist in meeting connection point supply reliability requirements as required under Transgrid's NSW licence conditions.

The assessment of the options evaluated 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 ² (\$m)	Weighted NPV (PV, \$m)	Rank
Option A	Install a Static VAr Compensator (+75/-40 MVar) at Williamsdale	23.9	0.9	24.8	7.2	1
Option D	Install a 40 MW/80 MWh BESS system at Cooma	132.7	0.7	133.4	-84.4	2

In addition to the options listed in Table 1, operations measures have been reviewed and found that they are non-viable due to potential low supply standards to the existing customers.

Option A delivers the highest positive Net Present Value and requires lowest capital expenditure compared to the other technically feasible options considered. Based on the above reasons and meeting the requirement of the identified Need, Option A has been identified as the preferred Option.

It is therefore recommended that the project be approved to proceed to a RIT-T assessment, with a view to the preferred option being implemented and commissioned in 2027/28.

¹ The critical N-1 condition: Trip of Line 3F (Stockdill to Williamsdale)

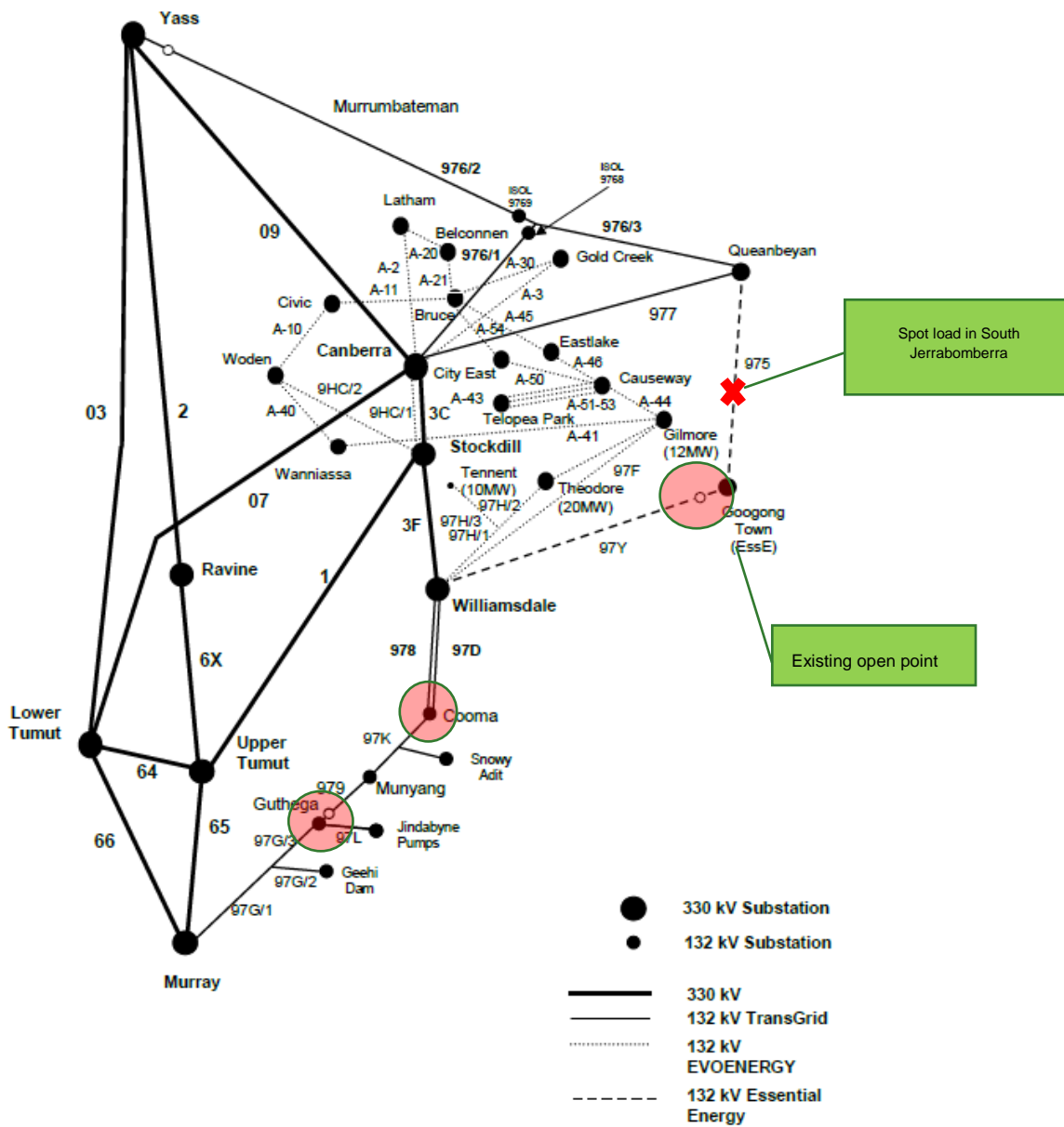
² Total capital cost is the sum of the direct capital cost and network and corporate overheads. Total capital cost is used in this OER for all analysis.

1. Need/opportunity

The existing peak demand in the Alpine area of New South Wales, supplied from Transgrid's Muryang and Cooma substations, is currently resulting in limitations in the network that supplies it. Further, demand increase has been identified due to the spot loads in Essential Energy network in Southern NSW. As such, the total demand supplied from Transgrid's Williamsdale bulk supply point is forecast to be increased substantially over the next 10 years, which will increase occurrence and extent of network supply limitations.

A need has been identified to address these current and expected future network supply limitations to reliably supply the existing load and to meet expected future demand growth in the subsystem supplied from Williamsdale. Addressing the identified need for this project will assist in meeting connection point supply reliability requirements as required under Transgrid's NSW licence conditions.

Figure 1: Transmission network in far Southern NSW



Transgrid's 330 kV network from the Yass - Canberra area to the Victorian border has a 132 kV parallel from Cooma, across the alpine region via Munyang 132/33 kV Substation and Snowy Hydro's Guthega Power Station to Murray 330/132/11 kV Substation (refer Figure 1). Munyang substation supplies the alpine villages of Thredbo and Perisher, with the majority of the Snowy Mountains winter ski resorts being supplied from this location. Munyang is a Winter demand peaking bulk supply point where the peak demand is typically around 30 MW.

Figure 1 also shows the 132 kV transmission network between Queanbeyan and Williamsdale. The latest demand forecast and as per Essential Energy's advice there will be spot load developments in this 132 kV link leading up to 95 MVA (approx. 93 MW) in next planning horizon. Figure 2 shows the demand forecast for the next 10 years for the new spot load (South Jerrabomberra) and the existing 132 kV demand at Googong Town which is currently supplied from Queanbeyan BSP. In order to optimise the supply capability and improved the reliability it has been proposed to close the normally operating point in this 132 kV link hence supply this new load from both Queanbeyan and Williamsdale. Figure 3 illustrates the total demand forecast in Essential Energy network to be supplied from Transgrid's Williamsdale and Queanbeyan BSPs.

Figure 2: Demand forecast in 132 kV link to be supplied both Williamsdale and Queanbeyan BSPs

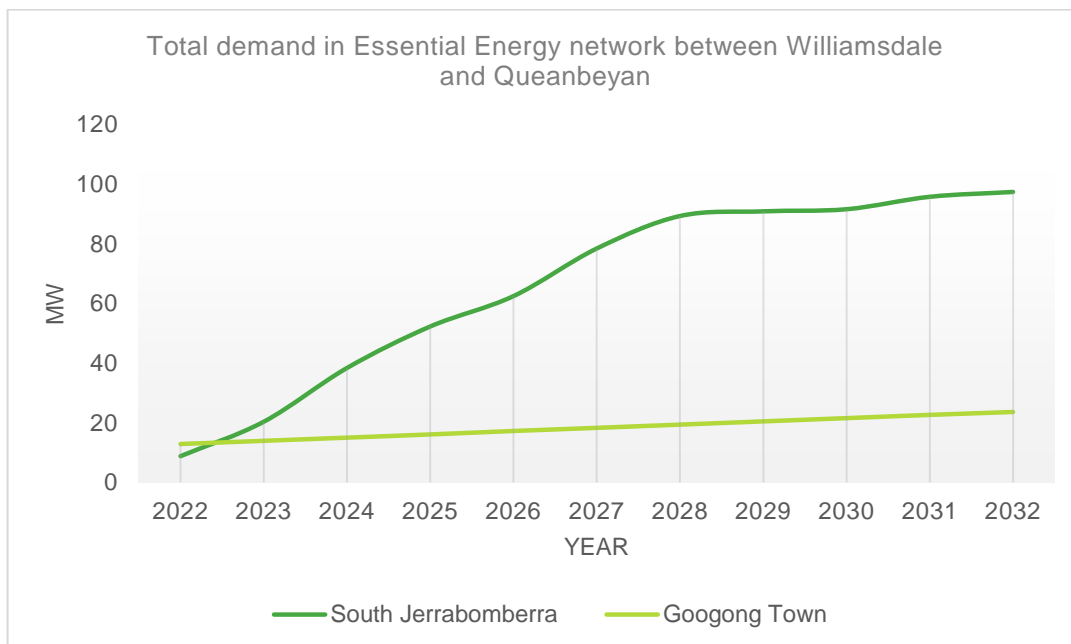
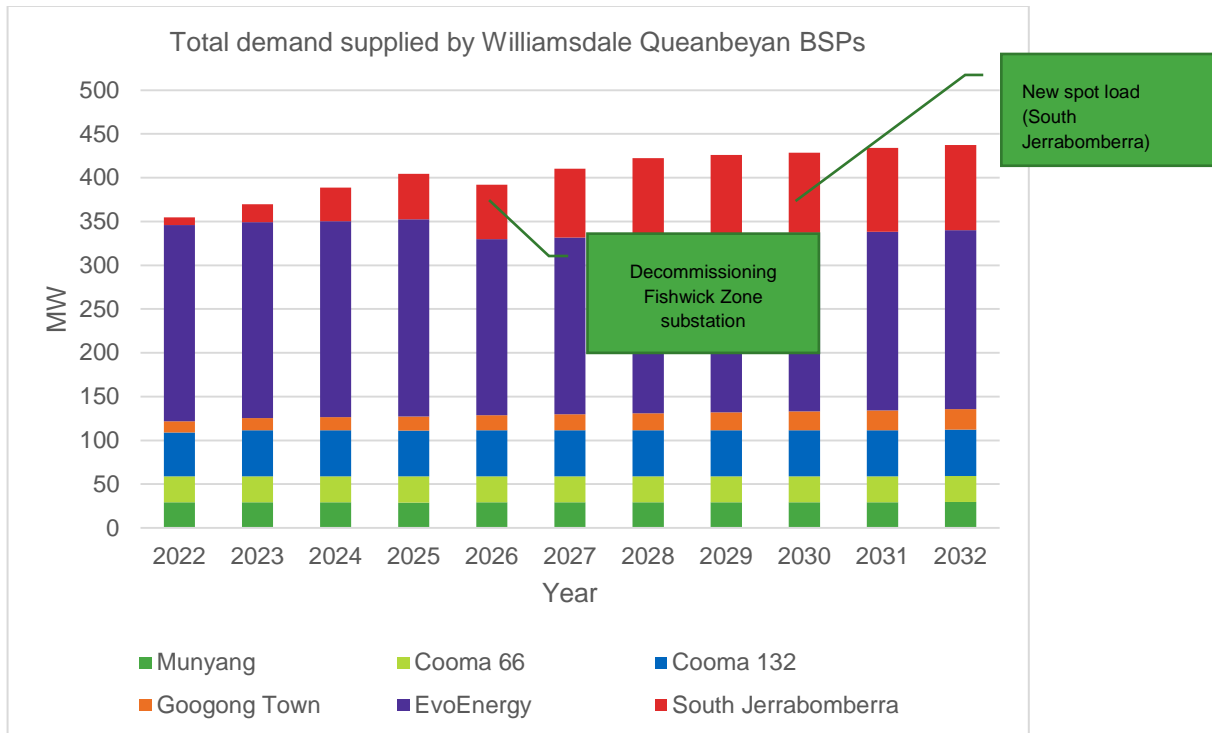


Figure 3: Total demand supplied by Williamsdale and Queanbeyan



As the transmission network services provider in New South Wales, Transgrid is obliged to comply with the relevant Clauses of the National Electricity Rules to facilitate connection of loads while operating the network in a secure and satisfactory state. As per NER Clause 4.2.2 Transgrid must operate the network in a *satisfactory operating state* where:

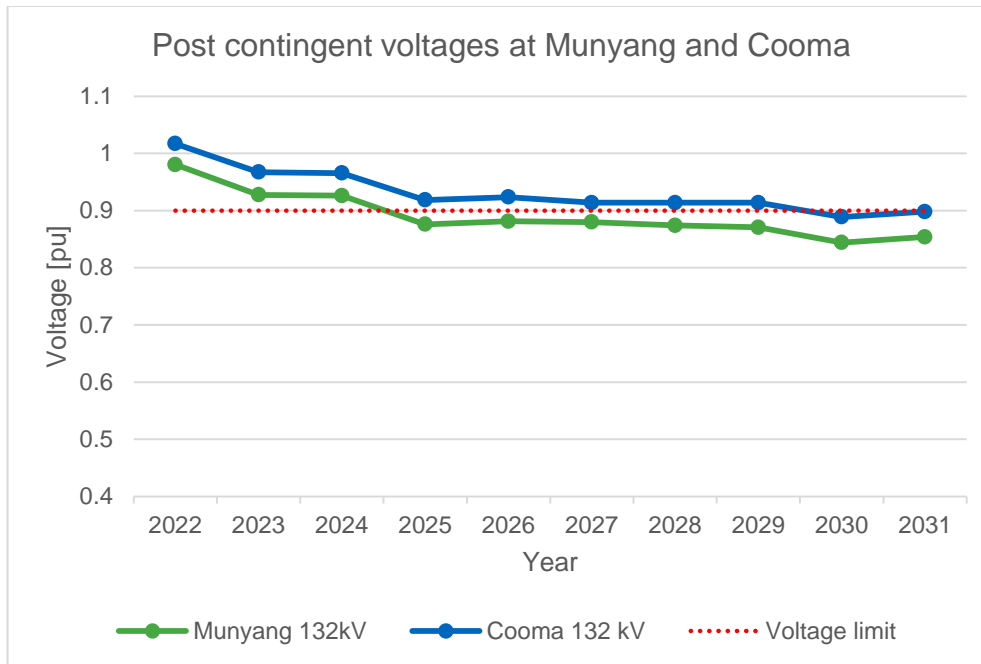
“The power system is defined as being in a satisfactory operating state when:

(b) the voltage magnitudes at all energised busbars at any switchyard or substation of the power system are within the relevant limits set by the relevant Network Service Providers in accordance with clause S5.1.4 of schedule 5.1;

(c) the current flows on all transmission lines of the power system are within the ratings (accounting for time dependency in the case of emergency ratings) as defined by the relevant Network Service Providers in accordance with schedule 5.1;”

Furthermore, in order to maintain system security, Transgrid's Operating Standards requires that the system must be operated such that, in the event of a single credible contingency, the voltage level will not exceed the maximum voltage rating for equipment, nor fall below 90% of nominal voltage.

Figure 4: Post contingent voltages at Munyang and Cooma (for trip of Line 3F)



Transgrid assessed the latest peak demand forecast in far South NSW and the impact of the additional spot loads planned to be supplied from Williamsdale as described above. This assessment identified existing and potential future network constraints as described below, and these are required to be remediated to ensure that these loads can be fully supplied from the network.

1. The present-day loads, and the forecast demand growth can be satisfactorily supplied under normal conditions without further network remediation, with the network voltage profile able to be maintained to within acceptable limits.
2. However, under N-1 outage conditions, there will be voltage limitations reached and/or breached at Cooma and Munyang. The critical contingency for the area under study is a trip of the 330 kV Line 3F (Stockdill to Williamsdale).
3. For 2021 winter peak demand times, voltages levels at Munyang and Cooma under N-1 outage conditions are expected to drop close to 0.9pu. The voltage step change at these locations for a contingent trip of 3F would exceed the acceptable limit of 10%. This observation has been noted by Transgrid System Operations via EMS on a high demand day. In order to manage the potential under voltages hence ensure the system security under N-1 conditions, all capacitors in the area need to be switched in pre-contingent. Other operational measures include increasing transformer AVR set points at Williamsdale and/or Canberra.
4. As the spot loads illustrated in Figure 2 become operational, there will be times during contingencies where the voltages at Munyang and Cooma will be outside the acceptable levels for secure operation of the power system³. This is demonstrated in Figure 4. Under-voltage conditions (< 0.9pu) are expected to occur at Munyang 132 kV and 33 kV busbars, Cooma 132 kV and 66 kV busbars and Williamsdale 132 kV busbar under N-1 outage conditions. The step voltage changes following the critical contingency will exceed 10%.

³ The critical N-1 condition: Trip of Line 3F (Stockdill to Williamsdale)

2. Related needs/opportunities

- N2577 Supply to ACT Maintain Reliability of Supply to ACT
 - This project investigates the network augmentation required to improve the supply reliability and supply resilience to the ACT network to avoid unplanned loss of load during planned or forced outage conditions.
- N2740 – Secondary Systems works for South Jerrabomberra
 - This is project raised to carry out the required secondary systems setting changes updated (in accordance with the agreed conceptual agreements) in relevant design systems for implementation Supply to South Jerrabomberra

3. Options

3.1. Base case

The Base Case for this Need is based on the “Do Nothing” option, with the present-day network operating as it currently is and allow the connection of the new spot load in South Jerrabomberra. In order to optimise the network capability hence to facilitate this load increase, the 132 kV link between Queanbeyan and Williamsdale will need to be operated normally closed. However, with the existing demand levels and with the proposed spot load increase, supply to this new spot load may need to be limited to obviate the risk of voltage limits being reached at Mungah and Cooma.

Transgrid will not be compliant with NER requirements if there is insufficient network supply capacity to meet the expected demand level in the new spot load. Figure 5 and 7 illustrates the expected unserved energy associated with the proposed spot load the estimated total risk cost for the proposed and Cooma for the next 25 years. In order to manage the potential under voltages hence ensure the system security under N-1 condition, all capacitors in the area need to be switched in pre-contingent during high demand times. In addition, voltage support to the area can be further improved by the changing the transformer AVR settings at Williamsdale and/or Canberra until a viable network or non-network solution is implemented.

Figure 5: Estimated expected unserved energy in the Base Case

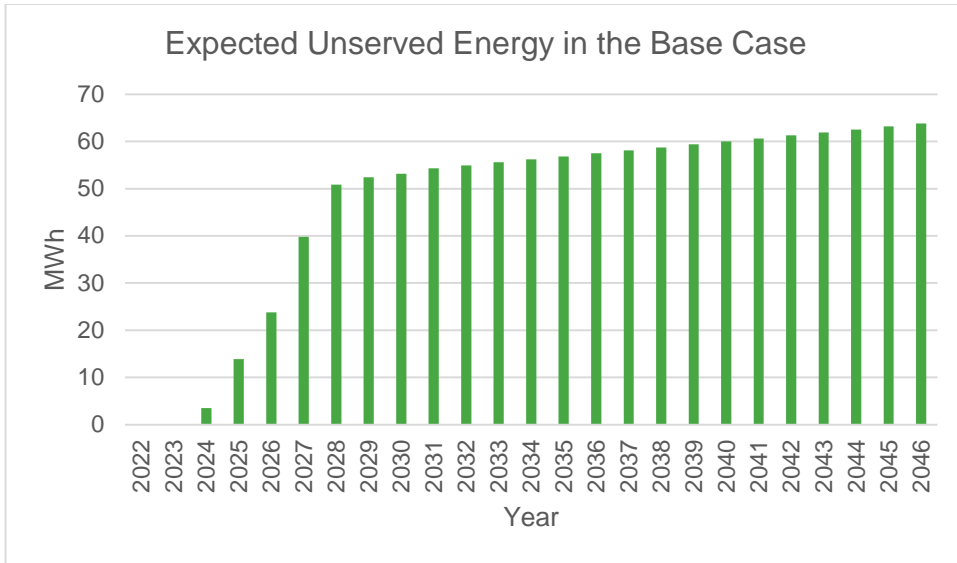


Figure 6: Estimated Risk Cost Total risk cost of the unserved energy



3.2. Options evaluated

Option A — Install a Static VAr Compensator (+75/-40 MVar) at Williamsdale

Under this option it is proposed to install an SVC connected to the 132 kV busbar at Transgrid’s Williamsdale 330/132 kV substation, with a reactive power range of 75 MVA capacitive and -40 MVar inductive. It is proposed to use the new SVC to control the 330 kV voltage at Williamsdale hence maintain a healthy supply voltage to the far south transmission network and Southern ACT during contingencies.

The benefits of this option include the rapid response of the SVC to the voltage variations in the 132 kV subsystem due to the disturbances in the main 330 kV grid and ability to maintain the standard operating levels of the pre-contingent voltages in the 132 kV network between Williamsdale and Munyang during times of peak demand, thereby managing and containing the post contingent voltage step size to within

acceptable limits. Implementation of this option will ensure the both the steady-state voltage levels and the transient step voltage changes on occurrence of the critical contingency are maintained to within acceptable limits at Cooma and Munyang.

The works associated with this Option includes:

- extending the existing switchyard within the existing property boundaries;
- installation of a new 100 MVA 132/33 kV transformer;
- installation of a new +75/-40 MVar SVC; and
- associated other primary equipment installation, civil works and secondary systems works.

The expected commissioning date for this option is 2027/28.

The expected expenditure profile for this option has been obtained from the Transgrid's Standard Cost Estimating System. The estimates in Table 2 below includes an uncertainty of $\pm 25\%$.

Table 2 - Projected expenditure profile for Option A

	Total Project Base Cost (\$M)	2024/25	2025/26	2026/27	2027/28
Estimated Cost – non-escalated (\$m 2021-22)	24.8	0.3	2.0	16.4	6.1

It is estimated that an amount up to \$2 million is required to progress the project from DG1 to DG2 and this cost has been included in the expenditure provided in the Table 2. This is to cover activities such as site assessments, development of concept design, the commencement of project approvals and the early procurement of long lead-time items if required.

This project is expected to be completed in an estimated 41 months following the approval of DG1.

Option D — Install a 40 MW/80 MWh BESS system at Cooma

Option D would utilise the ability of a battery storage system to charge and to store renewable generation, and discharge active or reactive power when required, thereby providing additional dynamic active or reactive power support as needed. Under this option a 40 MW/80 MWh Battery Energy Storage System (BESS) would be installed at Cooma.

The benefits of this option includes the ability to provide dynamic active or reactive power support as required during the disturbances, capability to storing the excess generation of nearby Boco Rock Wind Farm and potential future renewable generators in the Cooma area. During a contingency or planned outage of a main grid Line 3F, the BESS should be able to provide additional reactive power support required to maintain voltage profile in the 132 kV link between Williamsdale and Munyang above 0.9pu.

The scope of the works under this option include but not limited to:

- extension of the existing switchyard and 132 kV busbar;
- installation of a new 60 MVA 132/33 kV transformer; and
- other minor primary equipment installation and modifications the existing secondary systems.

The expected commissioning date for this option is 2027/2028.

The expected expenditure profile for this option is obtained from the Transgrid's Standard Cost Estimating System. The estimates in the table below have an uncertainty of $\pm 25\%$.

Table 3: Project Expenditure Profile - Option D

	Total Project Base Cost (\$M)	2024/25	2025/26	2026/27	2027/28
Estimated Cost – non-escalated (\$m 2020-21)	133.4	1.6	9.4	72.5	49.9

It is estimated that an amount up to \$5 million is required to progress the project from DG1 to DG2 and this cost has been included in the expenditure listed in Table 3. This is to cover activities such as site assessments, development of concept designs, the commencement of project approvals and the early procurement of long lead-time items if required.

This project is expected to be completed in an estimated 41 months following the approval of DG1.

Option F — Non-network Options

Potential non-network options may include but are not limited to the following, or may include a combination of:

- procurement of reactive power support from a BESS to be installed at a nearby site (Williamsdale or Cooma);
- procurement of demand management services within the area supplied by Williamsdale (South Jerrabomberra new spot load or existing load at Munyang) during the times of peak demand and/or outage conditions to alleviate the network constraints; and
- Voluntary under voltage load shedding schemes associated with the commercial loads in the Perisher/Thredbo area and in Cooma area.

It is expected that investigation of potential non-network options will be undertaken during the RIT-T process.

3.3. Options considered and not progressed

The options that were not progressed as they were considered not technically or economically feasible are outlined in the table below.

Option	Reason for not progressing
Option B - Install 2 x 30 MVar 132 kV capacitors at Williamsdale and 1 x 8 MVar 132 kV capacitor at Munyang	Installation of a new 132 kV capacitor bank at Munyang and relocating the Line 94K feeder bay would require extension of the existing switchyard. As the switchyard at Munyang is located next to the Snowy River further extension is not feasible. Due to this physical constraint identified at Munyang, this option is not technically feasible and has not been considered for further development.

Option	Reason for not progressing
<p>Option C- Install 1 x 16 MVAR 132 kV capacitor at Cooma and 2 x 8 MVAR 132 kV capacitors at Munyang</p>	<p>Studies confirmed that despite the acceptable post-contingency voltage levels, by installation of the capacitors at Cooma and Munyang, the step voltage change can still be outside the acceptable limit of 10% as required under the NER. This is due to the relatively high pre-contingent voltages in the 132 kV that could lead to large step voltages after the critical contingency. This option is not technically feasible.</p>
<p>Option E - Operational arrangement to move the normally open point at Guthega.</p>	<p>Following operational arrangements were considered:</p> <p>(a) Supply the new spot load at South Jerrabomberra from only Queanbeyan hence maintain the open point in 132 kV link between Queanbeyan and Williamsdale as it is. This option would require large scale augmentation in transmission network around Queanbeyan including the upgrades to the multiple 132 kV feeders (976 and 977) to increase the thermal capacity and installation of reactive plants at Queanbeyan to alleviate the voltage non-compliance. Hence, this option has been excluded from the analysis to avoid extensive network augmentations.</p> <p>OR</p> <p>(b) Implementing a trip scheme for Guthega, and a changeover scheme to transfer the generation of Guthega to flow to Cooma when required under the appropriate operational and network conditions. A feasibility assessment has confirmed that this option would have the following limitations:</p> <p>Although a trip scheme on Guthega would resolve potential islanding during N-1 outage conditions, if the Jindabyne Pumps are to be supplied from Cooma side there will be voltage and thermal constraints whenever reactive power support is not available from Guthega, i.e. when Guthega is not generating. Therefore, Jindabyne pumps may have to be constrained off most of the time until Guthega is generating.</p> <p>As such this option is deemed to impose a lower Standard on Jindabyne Pumps hence identified as technically not feasible.</p>

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 the table below.

Parameter	Central scenario	Lower bound scenario	Higher bound scenario
Discount rate	5.5%	7.5%	2.3%
Demand Growth	Medium (POE50)	Low (POE90)	High (POE10)
Capital cost	100%	125%	75%
Operating expenditure	100%	125%	75%
VCR	AER Latest VCR ⁴ (escalated) 100%	70%	130%
Scenario weighting	50%	25%	25%

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

Parameters used in this commercial evaluation:

Parameter	Parameter Description	Value used for this evaluation
Discount year	Year that dollar values are discounted to	2021/22
Base year	The year that dollar value outputs are expressed in real terms	2021/22 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 2. Details appear in Appendix A.

Table 4 - Commercial evaluation (PV, \$ million)

Option	Capital Cost PV	OPEX Cost PV	Central scenario	Lower bound	Higher bound	Weighted NPV	Ranking
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⁴ AER 2019 December VCR value escalated by CPI to 2020/21 dollars.

			NPV	scenario NPV	scenario NPV		
Option A	19.9	4.8	1.8	-12.3	37.6	7.2	1
Option D	106.2	25.7	-90.4	-120.7	-36.3	-84.4	2

4.3. Preferred option

Amongst the 5 options considered, Options A and D have been assessed through the commercial evaluation with the Base Case as a reference. Option B, C and E have been excluded from the commercial evaluation due to the limitations in their respective technical feasibility.

As per Table 7, only Option A delivers positive Net Present Values (NPV) for central and high scenarios whereas Option D delivers negative NPV for all three scenarios. Option A has a higher weighted NPV than that of Option D. Furthermore, the capital expenditure of Option D is approximately five times higher than Option A.

As Option A provides the highest NPV with the lowest capital expenditure while meeting the requirement of the identified Need, it has been selected as the preferred option.

Under this option, the following investments are proposed to be undertaken:

- Extend the existing switchyard including earth grid, earthworks and drainage;
- Installation of a new +75/-40 MVar 132 kV Static VAr Compensator (SVC);
- Installation of a new 132/33 kV 100 MVA SVC Transformer including associated civil, and secondary systems;
- Installation of a new 132 kV and 33 kV SVC Transformer switchbay and associated secondary systems;
- Install a new firewall on the eastern side of the existing No.3 Transformer and new gantries to string overhead; conductor from 33 kV switchbay to the new SVC;
- Update the existing Substation Automation System (SAS) to include the new 132 kV switchbay and SVC; and
- Update the existing HMI to reflect the new 132 kV switchbay, SVC and Reactive Plant Control (RPC).

likelihood that it may become the preferred option following further work which reduces the variability in the estimate.

Capital and Operating Expenditure

The preferred option requires capital expenditure of \$24.8 million. For the commercial evaluation an operating expenditure of 2% (of the Capital expenditure) has been assumed.

Regulatory Investment Test

As the estimated cost of the project is above the Regulatory Investment Test (RIT-T) threshold of \$7 million, 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 net benefits (including avoided costs and safety disproportionality tests) of the preferred option exceeds the annualised costs of the option. The commencement year is determined based on the required project disbursement to meet the commissioning year based on the OFS.

The results of optimal timing analysis is:

- Optimal commissioning year: 2027/28
- Commissioning year annual benefit: \$1.7 million
- Annualised cost: \$ 1.5 million

Based on the optimal timing, the project is expected to commence and complete in the 2023-2028 Regulatory Period.

6. Recommendation

Given there may be non-network options that will be required to be assessed, the final preferred option will be determined through the RIT-T process. This will be based on detailed network analysis, market modelling, technical and economic feasibility. However, based on the option evaluations in this report, the preferred network option is:

- Option A – Install a Static VAr Compensator (+75/-40 MVar) at Williamsdale.

It is therefore recommended that the project be approved to proceed to a RIT-T assessment, with a view to the preferred option being implemented by 2027/28.

Based on the options listed in Section 3.1, it is expected that this Project would incur a capital cost of approximately \$24.8 million in non-escalated 2021/22 dollars. Further, the preferred option requires \$2 million of capital cost to progress the project to Decision Gate 2 (DG2).

Appendix A – Option Summaries

Project Description		Maintain Voltage at Alpine area	
Option Description		Option A: Install a Static VAr Compensator (+75/-40 MVar) at Williamsdale	
Project Summary			
Option Rank	1	Investment Assessment Period	25
Asset Life	40	NPV Year	2022
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, \$m)	1.8	Annualised CAPEX (\$m)	1.5
NPV @ Lower Bound Scenario (PV, \$m)	-12.3	Network Safety Risk Reduction (\$m)	N/A
NPV @ Higher Bound Scenario (PV, \$m)	37.6	ALARP	N/A
NPV Weighted (PV, \$m)	7.2	Optimal Timing	2027/28
Cost			
Direct Capex (\$m)	23.9	Network and Corporate Overheads (\$m)	0.9
Total Capex (\$m)	24.8	Cost Capex (PV,\$m)	19.9
Terminal Value (\$m)	12.4	Terminal Value (PV,\$m)	3.4

Project Description	Maintain Voltage at Alpine area		
Option Description	Option D — Install a 40 MW/80 MWh Battery Energy Storage System (BESS) at Cooma		
Project Summary			
Option Rank	2	Investment Assessment Period	25
Asset Life	40	NPV Year	2022
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, \$m)	-90.4	Annualised CAPEX (\$m)	8.3
NPV @ Lower Bound Scenario (PV, \$m)	-120.7	Network Safety Risk Reduction (\$m)	N/A
NPV @ Higher Bound Scenario (PV, \$m)	-36.3	ALARP	N/A
NPV Weighted (PV, \$m)	-84.4	Optimal Timing	2027/28
Cost			
Direct Capex (\$m)	132.7	Network and Corporate Overheads (\$m)	0.7
Total Capex (\$m)	133.4	Cost Capex (PV,\$m)	106.2
Terminal Value (\$m)	66.7	Terminal Value (PV,\$m)	18.5