OPTIONS EVALUATION REPORT (OER)

Relieve X5 Voltage Stability Constraints

OER- N2575 revision 2.0

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Project reason: Economic Efficiency - To provide market benefits
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Change history

Revision	Date	**Amendment**
1.0	10 November 2021	Initial issue
1.1	10 November 2021	SRMC and relevant benefit calculation updated.

Executive summary

A number of renewable generators have been recently commissioned in south-western NSW and north-western Victoria. The increased generation from the area (there is total of about 450 MW at Balranald and 250 MW at Broken Hill) has resulted in increased power flows on the 220 kV transmission network from Buronga / Balranald to Darlington Point, in particular under certain system conditions such as a 220 kV line trip in northwest Victoria. Limondale 1 (220 MW) and Sunraysia (200 MW) Solar Farms at Balranald are currently being commissioned and these power flows are expected to further increase.

At times of high generation in the area, a contingent trip of a transmission line in north-western Victoria would result in very high power flows through the 220 kV network from Buronga to Balranald to Darlington Point. This high power flow can lead to severe undervoltage conditions / voltage collapse at Balranald.

Currently, there is a constraint in AEMO's National Electricity Market Dispatch Engine (NEMDE) to limit power flow on Balranald to Darlington Point line X5 to ensure voltage stability at Balranald substation should a contingency event happen in north-west Victoria. This voltage stability constraint significantly limits renewable generation at Balranald, Broken Hill and north-west Victoria.

Voltage stability assessments in the area indicate that, in order to maintain the voltage at Balranald above the required level of 0.9 pu while considering the possible credible contingency events, power flow on line X5 needs to be limited to about 150 to 200 MW depending on system conditions.

Relieving this voltage stability limit on line X5 is expected to provide market benefits by allowing additional renewable generation into the market and avoid the need for higher cost generation to be dispatched.

The assessments indicate that reactive power injection, such as capacitors at Balranald substation, can relieve the limit on line X5 between 5 to 10 MW, depending on generation dispatch at Balranald, Broken Hill and power import from Victoria.

This project is expected to meet the requirement for a NCIPAP project in terms of the level of investment required and the potential market benefits through network capacity increases.

One option was evaluated to address the need/opportunity. The evaluation results for this option appears in Table 1 below.

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	New 20 MVAr Capacitor at Balranald Substation	4.96	0.48	5.44	4.27	1

Preferred Option

Option A is the preferred option being the only technically and commercially feasible option that meets the identified need for economic benefits.

[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.

This option involves installation of a new 20 MVAr capacitor bank, switchbay including a Point on Wave (POW) circuit breaker and all secondary systems associated with the control and protection of the capacitor bank at Balranald Substation.

Other potential options, including augmenting transmission lines were considered but not progressed due to their significantly higher cost and lack of commensurate benefits for the additional cost.

Given the market benefits derived from the additional capacity provided, and the estimated expenditure for the upgrade being below the RIT-T investment threshold, it is proposed that these works be funded as a NCIPAP project, for implementation by no later than 2024/25.

1. Need/opportunity

Voltage stability assessments in south-western NSW and north-western Victoria, where a number of renewable generators are being commissioned, indicate that, in order to maintain the voltage at Balranald above the required level of 0.9 pu while considering the possible credible contingency events, power flow on line X5 needs to be limited.

Currently, there is a constraint in AEMO's National Electricity Market Dispatch Engine (NEMDE) to limit power flow on Balranald to Darlington Point line X5 to ensure voltage stability at Balranald substation should a contingency event happen in north-west Victoria. This constraint reduces the amount of renewable generation that can be dispatched, requiring higher cost generation from other locations to be used. Relieving the voltage stability limit on line X5 will provide additional renewable generation to the market and result in market benefits.

This project is expected to meet the requirement for a NCIPAP project in terms of the level of investment required and the potential market benefits through network capacity increases.

2. Related needs/opportunities

> N2407 – FY24-28 BRD Secondary Systems Renewal
  Need N2407 addresses the need for the complete in-situ renewal and upgrade of secondary system assets at Balranald 220kV Substation

3. Options

3.1 Base case

The base case under this need is to not facilitate network developments to address the need. The primary risk of TransGrid not addressing the need is that curtailment of lower cost renewable generation which will increase with the commissioning of Balranald generation (Limondale 1 Solar Farm 220 MW and Sunraysia Solar Farm 200 MW) over the coming months due to the voltage limitations at Balranald. It is expected that total Balranald generation can be constrained to a range 150 to 200 MW due to this constraint depending on system conditions.

3.2 Options evaluated

Option A — New 20 MVAr capacitor at Balranald Substation

This option involves installing a new 20 MVAr capacitor at the Balranald Substation. This is expected to relieve the Line X5 voltage stability limit up to 10 MW depending on generation dispatch at Balranald, Broken Hill and MW import from Victoria.

The following scope of works are associated with this option:

> Installation of a 220kV 20 MVAr capacitor bank
> Installation of a 220kV switchbay including a Point on Wave (POW) circuit breaker
> Installation of all secondary systems associated with the control and protection of the capacitor bank.

The expected commissioning date for this option is in 2024/25.

The expected expenditure profile for this option was estimated using the MTWO Estimating System. 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	FY2023/24	FY2024/25
Estimated P50 Cost non-escalated ($m 2020-21)	5.44	0.89	4.55

It is expected that an amount up to $1 million (included in Table 2, above) is required to progress the project from DG1 to DG2. This will cover completion of concept designs, scoping activities, establishment of project agreement with SHL, obtaining environmental approval, and procurement of major plant equipment.

This project is expected to be completed in an estimate 22 months following the approval of DG1.

3.3 Options considered and not progressed

Other potential options, including augmenting transmission lines were considered but not progressed due to their significantly higher cost and lack of commensurate benefits for the additional cost.

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.

Table 3 – Scenario Based Sensitivities

Parameter	Central scenario	Lower bound scenario	Higher bound scenario
Discount rate	4.8%	7.37%	2.23%
Capital cost	100%	125%	75%
Operating expenditure	100%	125%	75%
Thermal generation cost	100%	70%	130%

MW increase on X5	100%	67%	133%
Scenario weighting	**50%**	**25%**	**25%**

Since the central scenario represents the most likely scenario to occur, we have weighted it 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.

The parameters used in this commercial evaluation are in Table 4 below:

Table 4 – 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
Thermal generation cost	Average generation cost of thermal generation compared to renewable generation	$32.05/MWh[2] for Central Scenario as 100%
MW increase on X5	MW increase due to the relieved binding constraint	Expected range of 5-10 MW 7.5 MW for Central Scenario as 100%

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 5. Details appear in Appendix A.

Market benefit calculation

The market benefit of installing a new 20 MVAr capacitor bank can be calculated as follows:

> Improvement in Line X5 transfer towards Darlington Point direction of 5-10 MW.
> Average hours of 10 hours in a day and average days of approx. 300 days in one year with good weather, causing the current Line X5 voltage constraint binding to curtail the renewable generation from Balranald end.
> Average generation cost of thermal generation compared to renewable generation = $32.05/MWh.

Estimated market benefit = (MW increase due to the new capacitor bank) * (Average hours X5 constraint being binding) * (Average days X5 constraint being binding in a year) * (Average generation cost of thermal generation compared to renewable generation)

[2] Based on the NSW Average Short Run Marginal Cost for coal-fired generators (excluding Liddell) of $32.05/MWh – refer to AEMO IASR 2021 workbook. Typical bid price for renewable (wind/solar) generation is either $0 or negative. Accordingly, Market impact = $32.05 - $0 = $32.05

= 7.5 MW * 300 days/year * 10 hours/day * $32.05/MWh = $721,125 per year[3]

Table 5 - 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	4.55	1.14	2.77	-3.01	14.56	4.27	1

4.3 Preferred option

The preferred option is Option A. Under this option, the following investments will be undertaken:

> Installation of a 220kV 20 MVAr Capacitor Bank

> Installation of a 220kV switchbay including a Point on Wave (POW) Circuit Breaker

> Installation of all secondary systems associated with the control and protection of the 20 MVAr capacitor bank.

The preferred option was selected because this is the only technical and commercially feasible option that meets the identified need that results in higher benefits in NPV terms compared to the base case.

Capital and Operating Expenditure

The preferred option requires capital expenditure of $5.44 million and additional operating expenditure of $108,000 per year.

The base case does not require capital or operating expenditure.

Regulatory Investment Test

As this project is under the threshold for RIT-T, a regulatory investment test will not be required.

Further, as this project is below the RIT-T investment threshold and yields significant market benefit through the provision of additional market capacity, it is proposed that this project be funded as a NCIPAP project.

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: 2024/25

> Commissioning year annual benefit: $0.72 million

> Annualised cost: $0.31 million

3 The values appear in the calculation presented as an example are included in the Central Scenario.

Based on the optimal timing assessment, the project is expected to be completed in the 2023-2028 Regulatory Period.

6. Recommendation

The recommendation is to progress with Option A.

Based on the details listed in Section 3, this option will incur a capital cost of approximately $5.44 million in P50 non-escalated 2020/21 dollars. It is estimated that an amount up to $1 million is required to progress the project from DG1 to DG2, which is included in the capex estimate. Optimal commissioning year of 2024/25 is recommended.

Given the market benefits derived from the additional capacity provided, and the estimated expenditure for the upgrade being below the RIT-T investment threshold, it is proposed that these works be funded as a NCIPAP project, for implementation by no later than 2024/25.

Appendix A – Option Summaries

Project Description	Relieve X5 Voltage Stability Constraints		
Option Description	Option A — New Capacitor Bank at Balranald Substation		
Project Summary			
Option Rank	1	Investment Assessment Period	25
Asset Life	40	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	2.77	Annualised CAPEX ($m)	0.31
NPV @ Lower Bound Scenario (PV, $m)	-3.01	Network Safety Risk Reduction (PV, $m)	n/a
NPV @ Higher Bound Scenario (PV, $m)	14.56	ALARP	n/a
NPV Weighted (PV, $m)	4.27	Optimal Timing	2024/25
Cost			
Direct Capex ($m)	4.96	Network and Corporate Overheads ($m)	0.48
Total Capex ($m)	5.44	Cost Capex (PV, $m)	4.55
Terminal Value ($m)	2.72	Terminal Value (PV, $m)	0.88