Options Evaluation Report (OER)

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Approvals

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Change history

Revision	Date	Amendment
0	25/01/2021	Initial Issue
1	28/09/2021	Updated as per the revised OFS and OER template
2	12 October 2022	Updated for the revised costs for 2021/22 and latest OER template; Wording updated on calculation of market benefits.

Executive summary

An opportunity has been identified to implement a dynamic rating system for the Yass No. 1 and No.2 330/132 kV transformers to reduce the constraints on low-cost renewable generation in the Southern and Central-West area by increasing the transfer capability of these units under contingency conditions.

A real-time transformer rating model enables more accurate projections of transformer loading limits under different operating scenarios using actual temperature monitoring of the transformer. This facilitates more accurate assessment of the impact of the loading levels of the transformer, potentially allowing higher loading of the transformer above deterministic static ratings, and therefore better utilisation of the unit.

With the recent development of renewable generation in the Wagga area and in the 132kV link between Yass and Parkes, significant power will flow towards Yass through the 132kV parallel lines between Yass and Wagga and via the 132kV link between Parkes and Yass. The total committed renewable generation in the Wagga area is approximately 460MW. Another 320MW of generation is committed along the Yass-Parkes 132kV link.

The two 330/132 kV transformers at Yass 330/132 kV substation have nameplate ratings of 200 MVA each, less than Transgrid's standard 375 MVA units. When renewable generation in the Wagga area and between Yass-Parkes are dispatched to their maximum capacity, a large amount of reverse power is expected to flow through the Yass 330/132 kV transformers into the main grid. The risk and severity of curtailment to avoid overloading the transformers and associated equipment will increase significantly as advanced generators become committed. Therefore, in order to ensure each transformer is not overloaded during a contingent trip of a single unit, generation will need to be curtailed pre-contingent via a constraint equation(s). As such notwithstanding the failure rate of the transformers and/or probability of the planned/forced outages, curtailment of the renewable generation is required to operate the system within the safe operating conditions.

Implementation of this project would reduce the constraints on low-cost renewable generation in the Southern and Central-West area by increasing the transfer capability of these units under contingency conditions.

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.

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	Implement dynamic rating facilities on the Yass No.1 and No.2 330/132kV transformers	1.5	0.1	1.7	24.1	1

[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.

Option A, which is the only technically feasible option considered in the assessment delivers positive Net Present Values (NPV) compared to the Base Case. Hence option A has been selected as the preferred option for the identified opportunity.

Implementation of Option A allows the optimisation of loading levels of the Yass No. 1 and No.2 transformers and delivers economic (market) benefits from the provision of up to an additional 50MW of capacity from each transformer under N-1 conditions. This in turn will facilitate the export of renewable generation into the main grid.

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

Yass 330kV Substation has two 330/132 kV transformers that have nameplate ratings of 200 MVA each and a maximum short-term rating of each unit of 300MVA. The ratings of these transformers are presently based on deterministic static ratings calculated in the form of step-jump overload capability, and documented in tables in operating manuals.

These transformers were historically used to supply the loads in Southern subsystem and rarely exceeded their nameplate ratings. However, with the recent development of renewable generation in the Wagga area and in the 132 kV link between Yass and Parkes, a significant amount of reverse power is expected to flow through the Yass 330/132 kV transformers back into the main grid during peak demand times, especially at times when renewable generation in the Wagga area and between Yass-Parkes is dispatched to maximum capacities.

This additional generation flow will increase the loading on the Yass 330/132 kV transformers to such an extent that there are times where these transformers are loaded close to the normal rating of 200MVA under system normal conditions. Hence, the power flow through a single transformer under 'N-1' outage conditions would be approximately 200 MVA above the rating of a single unit. If the static ratings continue to be used, a significant amount of low-cost renewable generation would be constrained on a regular basis to prevent the transformers becoming overloaded under system normal and contingency conditions.

An opportunity has been identified to use a dynamic rating system for the Yass 330/132 kV transformers to potentially reduce the constraints on low-cost renewable generation in the Southern area by increasing the transfer capability of these units under certain conditions. Implementation of a real-time transformer rating model, where actual temperature monitoring of the transformer is assessed, would enable more accurate projections of transformer loading limits under different operating scenarios. This facilitates more accurate assessment of the impact of the loading levels of the transformer, potentially allowing higher power flows and better utilisation of the units.

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

- 1392 - Making the Grid More Resilient - Short-term Rating of Tie Transformers

  This Need has been raised to implement dynamic ratings on Darlington Point 330/220kV tie transformers to increase their ratings hence increase the transfer capability of the interconnector flows through periods of outage of one of the parallel transformers.

- Need N2211 – FY24-28 YSN Secondary Systems Renewal

  This Need has been raised for a complete in-situ renewal and upgrade of secondary systems asset at Yass 330kV Substation as part of revenue reset RP3. The project is currently in the need identification stage.

3. Options

3.1. Base case

The Base Case is the “Do Nothing” case. This is expected to result in the need to curtail Southern and Central- Western renewable energy generation to obviate the risk of excessive step-overloading of a transformer at Yass 330/132 kV substation in the event of a forced outage of one of the units. Further, as more renewable energy generation comes on-line, it may be necessary to curtail the generation output under system normal condition.

The above operational requirements will lead to curtailment of the solar/wind farms that could otherwise be dispatched, and in doing so prevent the realisation of market benefits.

Therefore, in the Base case in order to ensure each transformer is not overloaded during a contingent trip of a single unit, generation will need to be curtailed pre-contingent via a constraint equation(s). As such notwithstanding the failure rate of the transformers and/or probability of the planned/forced outages, curtailment of the renewable generation is required to operate the system within the safe operating conditions. Hence, the calculation of the expected market benefits from this project is carried out based on pre-contingent curtailment of generation as opposed to a probabilistic estimation of forced and planned outages.

Benefit Calculation

The expected market benefit of implementing dynamic rating on Yass 330/132 kV transformers under N-1 conditions can be calculated as follows:

- a life of the investment of 22 years which is assumed to be the remaining life of the older unit (No. 1 transformer) from the completion of installation of the proposed dynamic rating facilities and a corresponding residual/terminal value
- Both Transformers will be sharing the load pre-contingent, hence the loading on the Transformers is expected to be around 50% when the constraint equation will apply allowing the higher dynamic rating.
- Economic (market) benefit from the provision of additional 50MW (at unity power factor) capacity from each transformer under N-1 pre-contingent conditions to facilitate the export of renewable generation into the main grid, thereby displacing higher-cost thermal generation. The assessment is based on the following assumptions:
  - Expected use of pre-contingent extra capacity[2]: 7 hrs a day 50% of the year
  - Generation cost advantage of renewable generation compared to thermal generation[3]: $32.04/MWh
  - Additional renewable generation to be dispatched in a year = 50(MW) x 7(hrs/day) x 0.5 x 365
    = 63,875MWh
  - Expected annual market benefit = 63,875(MWh) x 32.04($/MWh)
    = $ 2.05 million per year

[2] Based on the expected generation considering solar and/or wind generation throughout the year.

[3] Fuel Cost used for the market benefit calculation is based on the average Short Run Marginal Cost (SRMC) of the NSW Coal-fired Generators excluding Liddell Reference: AEMO’s Electricity Statement of Opportunities ESOO 2020.

3.2. Options evaluated

Option A — Implement dynamic rating facility on the Yass No.1 and No.2 330/132 kV transformers.

This involves installation of necessary monitoring equipment, communication and other upgrades to secondary system equipment required to implement online monitoring and a dynamic rating system for the Yass 330/132 kV No.1 and No.2 transformers.

The scope of works associated with this option covers installation of dynamic rating facilities to the existing No.1 and No.2 330/132kV Transformers at Yass 330kV Substation. The scope of this option includes the following:

- OEM Design, Supply, Installation and Commissioning

An external equipment manufacturer to design and supply a dynamic rating system for the existing No.1 and No.2 Transformers, and the supply and installation of all necessary sensors for acquiring data from the existing transformer; and

- Design for Interfacing Dynamic Rating System to the existing secondary System

The in-house design of an interface of the dynamic rating system into Transgrid's existing secondary systems and Substation Automation system.

The expected expenditure profile for the total cost of the works for this option has been determined using the Transgrid's Standard Estimating System and summarised in Table 2. The estimates given below have an uncertainty of ± 25%.

Table 2: Option A expected expenditure (non-escalated)

	Total Project Base Cost [$M]	2023/24	2024/25
Estimated Cost – non-escalated ($m 2021-22)	1.7	1.2	0.5

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

It is estimated that an amount up to $500k is required to progress the project from DG1 to DG2 and this cost has been included in the expenditure listed in Table 2. This is to cover activities such as site assessments, the development of concept designs, the commencement of project approvals and the early procurement of long lead-time items if necessary.

This project is expected to be completed in an estimated 20 months following the approval of DG1.

3.3. Options considered and not progressed

No other options were considered.

4. Evaluation

4.1. Commercial evaluation methodology

The economic assessment undertaken for this project includes three scenarios that reflect a central set 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 1 below.

Table 3: Assumptions used in commercial evaluation

Parameter	Central scenario	Lower bound scenario	Higher bound scenario
Discount rate	5.5%	7.5%	2.3%
Fuel Cost[4]	100%	70%	130%
Capital cost	100%	125%	75%
Operating expenditure	100%	125%	75%
VCR	AER Latest VCR (escalated) 100%	AER Latest VCR (escalated) 70%	AER Latest VCR (escalated) 130%
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.

Table 4: Parameters used in the 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] Fuel Cost used for the market benefit calculation is based on the average Short Run Marginal Cost (SRMC) of the NSW Coal-fired Generators excluding Liddell Reference: AEMO's Electricity Statement of Opportunities ESOO 2020.

4.2. Commercial evaluation results

This project is being proposed on the basis of market benefit impacts only, expected to be funded as a NCIPAP project. As such, only an economic evaluation of the technically feasible option has been carried out, summarised below.

The commercial evaluation for the investment period of the technically feasible options is set out in Table 5. Details appear in Appendix A.

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	1.5	0.4	20.4	10.4	40.7	23.0	1

4.3. Preferred option

Option A has been selected as the preferred option based on the following reasons:

- The base case do nothing option is the reference case, against which the benefits and costs of Option A have been assessed;
- Option A provides market benefits that are larger than the investment cost, resulting in a positive NPV for all three scenarios considered; and
- Option A is the only technically feasible option.

The following scope of works has been included under the preferred Option:

Installation of dynamic rating facilities to the existing No.1 and No.2 330/132kV Transformers at Yass 330kV Substation.

Capital and Operating Expenditure

The preferred option requires capital expenditure of $1.7m. For the NPV analysis an annual operating expenditure of 2% of the capital cost has been identified for this option.

Regulatory Investment Test

As the expected cost of the project as per Table 2 is less than the trigger threshold of $7 million, the Regulatory Investment Test – Transmission (RIT-T) is not required for this project.

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 following:

Required project disbursement to the meet the commissioning year based on the Option Feasibility Study.

Remaining asset life of the Yass No.1 and No 2. 330/132/11kV transformers.

The results of optimal timing analysis is:

- Optimal commissioning year: 2024/25
- Commissioning year annual benefit: $1.0m
- Annualised cost: $128k

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

6. Recommendation

It is recommended to implement the dynamic rating facilities on the Yass No.1 and No. 2 330/132 kV (Option A) by installing the monitoring equipment, communication and other upgrades to secondary system equipment required to facilitate an online monitoring and a dynamic rating system for the Yass 330/132 kV No.1 and No.2 transformers.

The capital expenditure of $500k is required to progress the project to Decision Gate 2 (DG2).

Given the market benefits derived from the additional capacity thus 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 – Summary of Preferred Option

Project Description	**Increase Capacity in Yass Transformers**		
Option Description	**Option A – Implement dynamic rating facility on the Yass No.1 and No.2 330/132 kV transformers**		
Project Summary			
Option Rank	1	Investment Assessment Period	25
Asset Life	25	NPV Year	2021/22
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	20.4	Annualised CAPEX ($m)	0.1
NPV @ Lower Bound Scenario (PV, $m)	10.4	Network Safety Risk Reduction ($m)	N/A
NPV @ Higher Bound Scenario (PV, $m)	40.7	ALARP	N/A
NPV Weighted (PV, $m)	23.0	Optimal Timing	2024/25
Cost			
Direct Capex ($m)	1.5	Network and Corporate Overheads ($m)	0.2
Total Capex ($m)	1.7	Cost Capex (PV,$m)	1.5
Terminal Value ($m)	0.2	Terminal Value (PV,$m)	0.1