OPTIONS EVALUATION REPORT (OER)

Darlington Point 220 kV Transfer Tripping Scheme

OER- N2631 revision 1.0

Ellipse project no(s):
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Project reason: Economic Efficiency - Network developments to achieve market benefits
Project category: Prescribed - NCIPAP

Approvals

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Date submitted for approval	9 November 2021	

Change history

Revision	Date	Amendment
1.0	27 September 2021	Initial Issue
2.0	9th November 2021	Market benefit calculation added

Executive summary

There is an opportunity to increase the renewable energy generation output in the south and far west of the state, which is currently constrained under system normal conditions by the rating of the transformers at Darlington Point 330/220/33 kV Substation.

The 220 kV network supplying Far West NSW is supplied from Darlington Point 330/220/33 kV Substation through Line X5 from Darlington Point to Balranald Substation. Darlington Point Substation is equipped with 2 x 200 MVA 330/220/33 kV tie transformers. In order to prevent overloading of an in-service 330/220/33 kV transformer at Darlington Point Substation following an outage of the other, the pre-contingent loading is capped at 125 MVA per transformer for ambient temperatures of 45 degrees Celsius.

A tripping scheme can be implemented so that when one transformer trips off and the total flow is above the current 125 MVA limit per transformer, then the other transformer or Line X5 can be tripped off to prevent overload of the remaining transformer.

This arrangement will increase the power flow on the transformers under normal conditions to the capacity allowed on Line X5. Increasing the transformer limit under system normal is expected to provide market benefits by allowing additional low cost renewable generation into the market.

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 tripping scheme to trip remaining 330/220/33 kV transformer at Darlington Point Substation for a loss of one transformer	0.305	0.062	0.367	0.476	1
Option B	Install a tripping scheme to trip Line X5 for a loss of one 330/220/33 kV transformer at Darlington Point Substation	0.419	0.086	0.505	0.351	2

Preferred Option

The preferred option is Option A.

[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 tripping scheme to trip remaining 330/220/33 kV transformer at Darlington Point Substation for a loss of one transformer, by opening the 220 kV circuit breaker of the remaining transformer.

This option was selected because it meets the identified need, is technically feasible and has a higher Net Present Value than the other option.

1. Need/opportunity

There is an opportunity to increase the renewable energy generation output in the south and far west of the state, which is currently constrained under system normal conditions by the rating of the transformers at Darlington Point 330/220/33 kV Substation.

The 220 kV network supplying Far West NSW is supplied from Darlington Point 330/220/33 kV Substation through Line X5 from Darlington Point to Balranald Substation. Darlington Point Substation is equipped with 2 x 200 MVA 330/220/33 kV tie transformers. In order to prevent overloading of an in-service 330/220/33 kV transformer at Darlington Point Substation following an outage of the other, the pre-contingent loading is capped at 125 MVA per transformer for ambient temperatures of 45 degrees Celsius.

Since the two transformers provide supply to Line X5, it is not necessarily required to have N-1 capability at the substation, as following an outage of Line X5 renewable generation in the area is heavily curtailed. Therefore, the transformers can be treated as one, such that when one trips off and the total flow is above the current 125 MVA limit per transformer, then the other transformer can also be tripped off, by opening the 220 kV circuit breaker of the remaining in-service transformer to prevent its overload.

This arrangement will facilitate an increase in the power flow on the transformers to be permitted under normal conditions, up to the capacity allowed on Line X5, and prevent overload on the remaining in-service transformer under loss of one of the transformers.

Increasing the transformer power-flow limit under system normal conditions is expected to provide market benefits by allowing additional low cost renewable generation into the market.

2. Related needs/opportunities

> Need N2575 – Relieve Line X5 Voltage Stability Constraints:
  - Relieving the constraints on Line X5 will allow more power flow on the line, but it does not resolve the constraints on the 330/220/33 kV transformers at Darlington Point Substation.

3. Options

3.1 Base Case

Under the base case, no tripping schemes are installed. The maximum limit of 125 MVA on the Darlington Point 330/220/33 kV Substation transformers under system normal conditions must therefore be maintained to prevent overloading of the remaining transformer for a loss of the other unit.

This pre-contingent load capping will continue to limit the low cost renewable generation that otherwise could be allowed.

3.2 Options evaluated

Option A — Install a tripping scheme to trip the remaining 330/220/33 kV transformer at Darlington Point for a loss of one transformer

The scope of work of work for this option comprises:

- Install a tripping scheme to trip the 220 kV circuit breaker of the remaining in-service transformer upon loss of one of the 330/220/33 kV transformers if the pre-contingent power flow on the transformers is above 125 MVA.

- Increase the limit on the 330/220/33 kV transformers at Darlington Point Substation from the current limit of 125 MVA to 200 MVA per transformer (which is equivalent to the thermal limit of Line X5 under normal operating conditions).

This tripping arrangement ensures that the reactors connected to the 33 kV of the transformer remains in service in order to control voltage levels in the area.

The scheme will be armed when loading of the transformers reaches 125 MVA per transformer, otherwise the current scheme should still apply if the pre-contingent individual power flow on each of the transformers is less than 125 MVA. This is to prevent tripping of the remaining transformer even if the transformer loading is below or equal to the capacity of the transformer.

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

The expected expenditure profile for this option is obtained using TransGrid's Estimating Database. The estimates in the table below have an uncertainty of ± 25% and exclude capitalised interest.

Table 2 – Option A expected expenditure

	Total Project Cost ($M)	FY2023/24 ($M)	FY2024/25 ($M)
Estimated Cost – non-escalated ($M 2020-21)	0.367	0.160	0.207

It is estimated that an amount up to $100k is required to progress the project from DG1 to DG2. 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 required.

This project is expected to be completed in an estimated 24 months following the approval of DG1.

Option B — Install a tripping scheme to trip Line X5 for a loss of one 330/220/33 kV transformer at Darlington Point Substation

The scope of work for this option comprises:

- Install a tripping scheme to trip Line X5 for a loss of one of 330/220/33 kV transformers at Darlington Point Substation, designed to trip the line only if the pre-contingent power flow on the transformers is above 125 MVA;
- Increase the limit on the 330/220/33 kV transformers at Darlington Point Substation from the present limit of 125 MVA to 200 MVA per transformer, which is equivalent to the thermal rating limit of Line X5 under normal operating conditions.

The scheme will be armed when loading of the transformers reaches 125 MVA per transformer, otherwise the current scheme should still apply if the pre-contingent individual power flow on each of the transformers is less than 125 MVA. This is to prevent tripping of the line even if the transformer loading is below or equal to the capacity of the transformer.

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

The expected expenditure profile for this option is obtained using TransGrid's Estimating Database. The estimates in the table below have an uncertainty of ± 25% and exclude capitalised interest.

Table 3 – Option B expected expenditure

	Total Project Cost ($M)	FY2023/24 ($M)	FY2024/25 ($M)
Estimated Cost – non-escalated ($M 2020-21)	0.505	0.203	0.302

It is estimated that an amount up to $150k is required to progress the project from DG1 to DG2. 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 required.

This project is expected to be completed in an estimated 25 months following the approval of DG1.

3.3 Options considered and not progressed

No other options were considered to address the need.

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 (%)	4.8%	2.23%	7.37%
Fuel saving ($/MWh)	32.04	22.43	41.66
Capital cost (%)	100%	75%	125%
Operating expenditure (%)	100%	75%	125%
VCR ($/MWh)	43,031	30,122	55,941
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 have been weighted at 25% each.

The parameters used in this commercial evaluation are as follows:

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 substations

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 4. Details appear in Appendix A.

The present transformer capacity at Darlington Point 330/220/33 kV Substation is 250 MVA for normal operating conditions. Generation flowing through those transformers is therefore curtailed to match this 250 MVA capacity. The amount of renewable generation thereby required to be curtailed (in MWh) is calculated as the Base Case scenario.

Option A and Option B increases the normal transformer capacity to a total of 400 MVA. This reduces the curtailed renewable generation by approximately 60% after implementing the options. The reduction in curtailed MWh provides the market benefit due to fuel savings from off-setting higher-cost thermal generation elsewhere in the market[2]. Figure 1 illustrates the reduction in the constrained energy as expected by implementing option A or B.

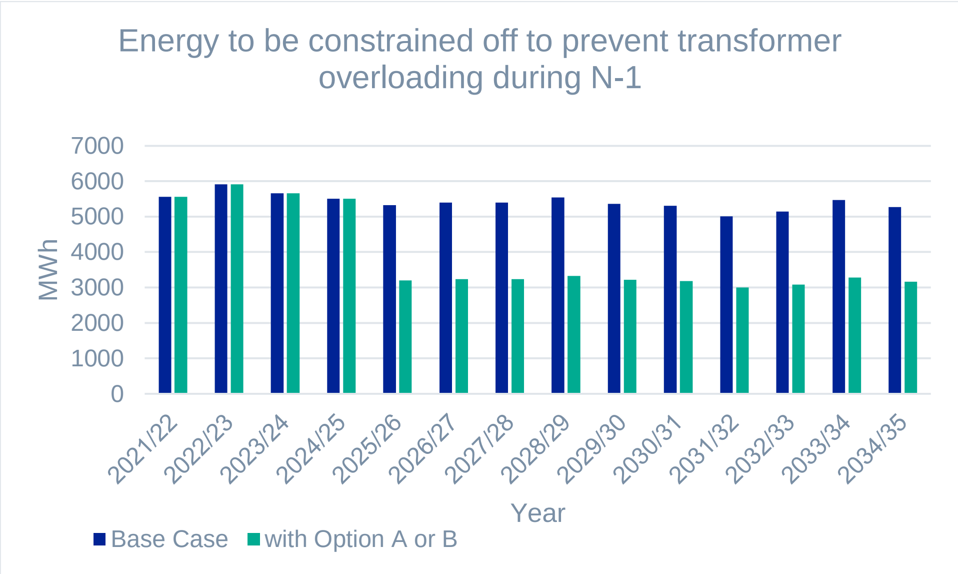

Figure 1: Total renewable energy to be constrained to prevent overloading in Darlington Point 330/220 kV transformers during N-1

The expected additional renewable energy to be transferred through the NEM via the uprated transformers per year is equal to the reduction in the total renewable generation to be constrained to prevent overloading of the transformer during N-1 in a year after implementing either option A or B.

This has been calculated as follows in Table 4:

Table 4: Estimation of annual market benefit

Parameter	Quantity
Total renewable generation to be constrained in a year to prevent overloading in the transformers in Base Case[3]	5,186 MWh

[2] Refer to TransGrid HK RIT-T NPV Model – Jul 2021 – V4_N2631 spreadsheet on the Supporting documents

[3] Estimated based on the yearly generation curtailment calculated using projected solar traces and demand forecasts and load duration curves. Averaged over the investment period to estimate the yearly constrained generation.

Total renewable generation to be constrained in a year to prevent overloading in the transformers with options A or B	3,060 MWh
Reduction in the renewable generation to be constrained due to Option A or B	= 5,186 – 3,060 = 2,126
Fuel cost difference[4]	$32.04 /MWh
Expected annual market benefit to the NEM	= Total reduction in the renewable generation to be constrained x Fuel cots difference = 2,126 x 32.04 = $ 0.07 million

Table 5 - Commercial evaluation (PV, $ million)

Option	Capital Cost PV	OPEX Cost PV	Central scenario NPV	Ranking
Option A	-0.254	-0.083	0.415	1
Option B	-0.349	-0.115	0.289	2

4.3 Preferred option

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

- Install a tripping scheme to trip the 220 kV circuit breaker of the remaining transformer under loss of one of 330/220/33 kV transformers (trip the breaker if the pre-contingent power flow on the transformers is above 125 MVA).
- Increase the limit on the 330/220/33 kV transformers at Darlington Point Substation from the current limit of 125 MVA to 200 MVA per transformer (which is equivalent to the thermal limit of Line X5 under normal operating conditions).

Both options A and B meets the identified need, are technically feasible and have a positive Net Present Value that is achieved from the Market Benefits from increasing the amount of renewable energy generation that can be transferred through the Darlington Point transformers.

Both options A and B yield the same benefits. However, Option A has been selected as the total cost of this option is the lower of the two, and hence this option has the highest overall Net Present Value.

[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.

Capital and Operating Expenditure

The preferred option requires capital expenditure of $0.367 million. Additional operating expenditure of 2% of the capital costs will be incurred and the cost will be $0.01 million for this option.

The base case requires no capital or operating expenditure.

Regulatory Investment Test

A RIT-T is not required for this project as the capital expenditure of the selected option is below the RIT-T threshold of $6 million. The selected option is $0.367 million, which is less than the most expensive option which is $0.505 million.

5. Optimal Timing

The practical delivery date of the project is based on the delivery of major projects, which is FY2024/25. The annualised cost for the project is $0.021 million.

6. Recommendation

The recommendation is to progress with Option A as the total cost of this option is the lower of the two, and has the highest overall Net Present Value. This option requires $100k of capex to progress the project to Decision Gate 2 (DG2).

Appendix A – Option Summaries

Project Description	***Darlington Point 220 kV Transfer Tripping Scheme***		
Option Description	Option A - Install a tripping scheme to trip remaining 330/220/33 kV transformer at Darlington Point for a loss of one transformer		
Project Summary			
Option Rank	*1*	Investment Assessment Period	25
Asset Life	*40*	NPV Year	*2021*
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	*0.415*	Annualised CAPEX ($m)	*0.021*
NPV @ Lower Bound Scenario (PV, $m)	*0.002*	Network Safety Risk Reduction ($m)	-
NPV @ Higher Bound Scenario (PV, $m)	*1.071*	ALARP	*N/A*
NPV Weighted (PV, $m)	*0.476*	Optimal Timing	*FY2024/25*
Cost			
Direct Capex ($m)	0.305	Network and Corporate Overheads ($m)	*0.062*
Total Capex ($m)	0.367	Cost Capex (PV,$m)	*-0.254*
Terminal Value ($m)	0.174	Terminal Value (PV,$m)	*0.057*

Project Description	***Darlington Point 220 kV Transfer Tripping Scheme***		
Option Description	Option B - Install a tripping scheme to trip Line X5 for a loss of one 330/220/33 kV transformer at Darlington Point Substation		
Project Summary			
Option Rank	*2*	Investment Assessment Period	25
Asset Life	*40*	NPV Year	*2021*
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	*0.289*	Annualised CAPEX ($m)	*0.029*
NPV @ Lower Bound Scenario (PV, $m)	*-0.145*	Network Safety Risk Reduction ($m)	-
NPV @ Higher Bound Scenario (PV, $m)	*0.973*	ALARP	*N/A*
NPV Weighted (PV, $m)	*0.351*	Optimal Timing	*FY2024/25*
Cost			
Direct Capex ($m)	0.419	Network and Corporate Overheads ($m)	*0.086*
Total Capex ($m)	0.505	Cost Capex (PV,$m)	*-0.427*
Terminal Value ($m)	0.240	Terminal Value (PV,$m)	*0.077*