OPTIONS EVALUATION REPORT (OER)

Increase capacity for generation in the Molong to Parkes area

OER- 000000002162 revision 3.0

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

Approvals

Author	Dragana Hele	Senior Planning Engineer
Reviewed	Mike Tamp	Senior Engineer (Contract), Network Planning & Operations
Endorsed	Kevin Hinkley	Customer Planning Manager
	Debashis Dutta	Asset Analytics and Insight Manager
Approved	John Howland	Acting Head of Network Planning
Date submitted for approval	23 December 2021	

Change history

Revision	Date	Amendment
0.0	28 July 2021	Initial issue
1.0	27 September 2021	Revision 1
3.0	23 December 2021	Cutler Merz comments addressed.

Executive summary

A number of new renewable generators have connected or are planning to connect to the network west of TransGrid's Molong 132/66 kV Substation.

Solar generation farms in the area with the combined output of 340MW are already in service with a further 320MW of generation committed to connect in 2022.TransGrid's 132kV line 94T (Molong – Orange North) has a thermal rating of 112MVA (summer daytime). The existing rating of line 94T is insufficient to cater for forecast growth of local renewable generation. This project will address immediate capacity limitations of line 94T. A substantial quantity of low-cost renewable energy from these generators will be curtailed throughout the course of a year, if the rating of transmission line 94T is not addressed.

There is an economic benefits need to increase the capacity of line 94T, in order to match the increase in renewable generators west of Molong 132/66 kV Substation.

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	Increase transmission line design temperature to 100 deg C	1.22	0.13	1.35	26.3	2
Option B	Restring with a higher rated conductor on existing structures	6.36	0.66	7.02	48.7	1

The preferred option is Option B, as it meets the requirements of the need, is technically and economically feasible, and has the highest NPV. Option B involves the reconductoring of line 94T with higher capacity conductors, to achieve a summer day rating of at least 150MVA. An Option Feasibility Study confirmed that the existing conductor can be replaced with a conductor of a higher thermal rating (Flicker ACSS/Linnet ACSS) on the existing structures.[2]

1. Need/opportunity

The need for this project is to address the capacity limitation of Line 94T, to meet forecast generation requirements in the area.

Line 94T is one of four 132 kV transmission lines which supply Orange North switching station, which in turn supplies Orange City, Cadia Mine and surrounding areas.

[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.

[2] Minor structure modification will still be required.

The existing 132kV Line 94T consists of sections that have Oxygen, Wolf and Neon conductors. Wolf conductor, which is installed for the majority of the length of 94T, has the lowest rating of 112MVA.

Several new renewable generation projects have connected or are committed to connect to the network west of TransGrid's Molong 132/66 kV Substation.

Solar generation in the area already in service, with the combined output of 340MW, are:

- Beryl SF – 89MW
- Parkes SF – 51MW
- Manildra SF – 50MW
- Goonumbla SF – 70MW
- Jemalong SF – 50MW
- Molong SF – 30MW

Committed generators, now in commissioning stage and to be operational in 2022 are:

- Suntop SF – 150MW
- Wellington SF – 170MW

Further, as per the latest assessments, the total forecast summer peak demand for Orange in 2021 is 222 MW with this expected to increase up to 243 MW by 2029/2030. The Orange area load mainly includes the load at Orange city, surrounding areas and the Cadia mine.

Network modelling has shown that, with the current level of in-service and committed generation dispatched to their maximum capacities, thermal overloading of Line 94T is expected under system normal network conditions. If the thermal capacity of Line 94T remains unchanged, regular limitations on the output of generators will be required. Consequently, a substantial quantity of low-cost renewable energy from these generators will be curtailed/constrained throughout the course of a year.

Forecast amount of constrained output of renewable generators per year is shown on Figure 1 below:

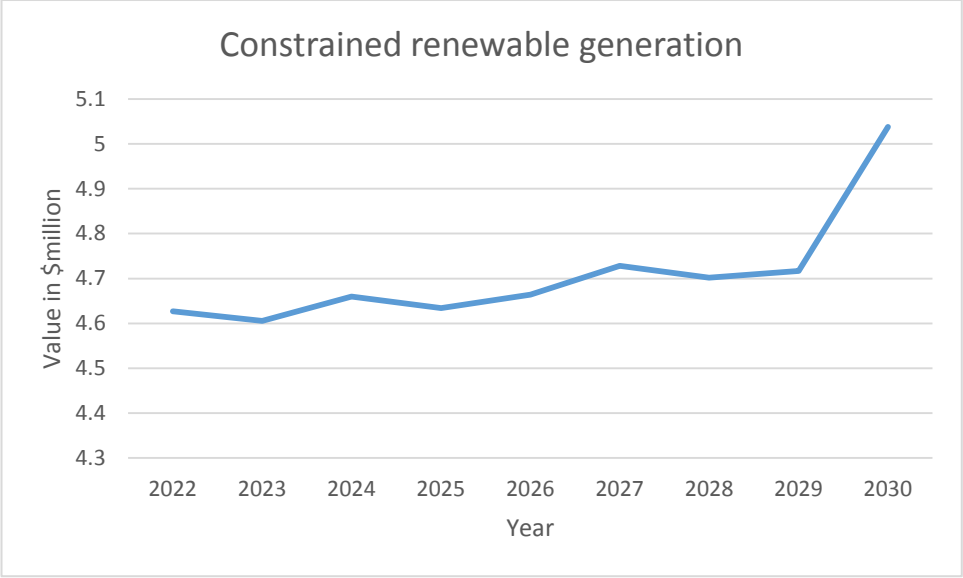

Figure 1 – Value of constraint renewable generation per year for base case scenario

2. Related needs/opportunities

> N2470 – Increase Capacity for Generation in the Central West Area

This Need, which is proposed as part of the Network Capability Incentive Parameter Action Plan (NCIPAP) for the 2018/19 to 2022/23 regulatory period, investigates the opportunity to improve the utilisation of the 132 kV transmission line 94T from Molong to Orange North using dynamic line ratings.

> N2384 - Supply to Central West

This Need investigates the suitable network and non-network options to supply the increased industrial demand in Orange/Parkes area.

3. Options

Options from A to I were considered and assessed in the NOSA. Options A and B were evaluated for commercial benefits. The other options were found either commercially non feasible or technically non feasible. Options considered and not progressed are detailed in section 3.3.

3.1 Base case

Under the base case, i.e. not facilitating network developments to address the issue, a substantial quantity of low-cost renewable energy will need to be curtailed, to avoid thermal overloading of Line 94T. The estimated loss of market benefits if no action is taken is shown in Figure 1, rising from $4.6m per annum from 2022.

3.2 Options evaluated

Line 94T currently consists of sections with Oxygen, Wolf and Neon conductor. Oxygen and Neon are installed on approximately 2km of the line, with the lower rated Wolf conductor installed for approximately 27km of the line length.

Option A — Increase transmission line design temperature to 125 MVA normal operation

This option requires the increase of the maximum operating temperature of the existing Wolf conductor to 100°C and the existing Neon conductor to 92°C. Under these conditions, a summer day line rating of 125 MVA can be achieved. While rating of Line 94T would increase from 112 MVA to 125 MVA, it is insufficient to address forecast loss of market benefits[4].

The following scope of works are associated with bringing the summer day rating up to at least 125 MVA.

Further detail can be found in (OFS) 2162 Option A Rev 0.

> One structure replacement.

> 18 structure conversions from I string to D string arrangement.

It is estimated that this option would cost $1.35M ± 25% in $2020-21.

The nominal estimated cost in each year is as follows:

[4] Loss of market benefits is generators output which will have to be curtailed due to low rating of line 94T. All connected and committed generators were considered in analysis.

Table 2 – Option A expected expenditure

	Total Project Base Cost	FY2022/23	FY2023/24
Estimated Cost- non escalated ($m 2020-21)	$1.35	$0.03	$1.32

It is expected that an amount up to $150,000 (already included in the cost estimate) is required to progress the project from Decision Gate 1 (DG1) to DG2. This is to cover activities such as site visits, development of the concept design, commencement of project approvals, and early procurement of long lead-time items if required.

This option is expected to be completed in an estimated 21 months, following the approval of DG1.

Option B — Restring 94T with a higher rated conductor on existing structures

This option involves re-conductoring of line 94T with a higher capacity conductor, to achieve a summer day rating of at least 150 MVA. This increase in rating is expected to address approximately 92% of forecast loss of market benefits.

The Option Feasibility Study (OFS) assessment has confirmed the existing support structures are adequate, with minor modifications.

The following scope of works are associated with bringing the summer day rating up to at least 150 MVA.

> Replacing existing conductor between structures 1 and 95 with Flicker ACSS conductor.

> Replacing existing conductor between structure 96 and Molong Gantry.

> Two structure replacements.

> Three conversions of suspension structure to tension structure.

It is estimated that this option would cost $7.02M ± 25% in $2020-21.

The nominal estimated cost in each year is as follows:

Table 3 – Option B expected expenditure

	Total Project Base Cost	FY2022/23	FY2023/24	FY2024/25
Estimated Cost- non escalated ($m 2020-21)	$7.02	$0.10	$2.51	$4.41

An amount of $500,000 (already included in the cost estimate) is required to progress the project from DG1 to DG2. This is to cover activities such as site visits, development of concept design, commencement of project approvals, and early procurement of long lead-time items if required.

This option is expected to be completed in an estimated 28 months, following the approval of DG1.

3.3 Options considered and not progressed

The options considered but not progressed are listed in the Table 4, together with the explanation of reasons for them not progressing.

Table 4 – Options not progressed

Option	Reason for not progressing
A3 – Increase conductor rating to 138MVA for contingency only	Option A3 provides for increasing the maximum operating temperature of the Wolf conductor sections to 120°C and the Neon conductor sections to 100°C, for contingency ratings only. Continuous rating of Line 94T has not increased. A contingency rating for the whole line of 138MVA can be achieved under this option. Power System analysis indicates that expected overload of Line 94T is under system normal peak load and generation conditions. Achieving higher rating for contingency situations only (overload can last for about 30 minutes) is not an acceptable solution for this issue. Technically non feasible.
C – Rebuild as a single circuit	This option involves removing the existing structures and conductor on line 94T and replacing with new single circuit towers and conductors with higher ratings. It is considered much higher in cost than Option B for the same benefit. Commercially non feasible.
D – Rebuild as a double circuit	This option involves removing the existing structures and conductor on line 94T and replacing with new dual circuit towers and dual conductors with higher ratings. Additional switch bays will be required at each substation. Economic benefit calculations indicate, preferred Option B addresses about 92% of forecast loss of market benefits[7] per year in the 25 year analysis period. Option D would address all of loss of market benefits. However approximate cost comparison between Option B and Option D indicates cost of Option D is at least five times higher than cost of Option B. Commercially non feasible.
E – New dedicated circuit parallel to existing line	This option involves building a new single circuit parallel to the existing line 94T. In effect, this will result in a similar outcome to Option D. However, a widening of the existing Line 94T easement may be required. It is deemed much higher in cost than other options but does not provide commensurate benefits, so does not justify further consideration. Commercially non feasible.
F- Demand management in Orange area	This option is to procure demand management in the Orange area to reduce load during periods of peak solar generation west of Molong, thereby reducing the loading of Line 94T. In order to achieve a minimum level of curtailment of solar farms, the expected level of demand management could equate to 70-80% of large industrial loads or 180-220% of Orange city load. Commercially non feasible.

[7] Analysis were done based on in service and committed renewable generation in Orange area, as currently known.

G – Battery storage at Molong Substation	The BESS (battery energy storage system) will be able to reduce the loading on line 94T by charging during peak solar generation periods. Battery size of about 50MW is required to address the issue. Cost of such battery is estimated to be greater than $63 million. Commercially non feasible.
H – Open circuit line 94T during daytime hours	This option involves switching out Line 94T during daytime hours. Switching out Line 94T would avoid overloading the circuit, however this approach would introduce several other issues including, but not limited to: • Reduced reliability of the network in the Central West • Voltage instability in the Orange Area for the next credible contingency • Activation of the Cadia Mine UVLS for the next credible contingency • Reduce the system strength for in service and committed asynchronous generators • Create thermal loading issues at alternate locations • Cyclic mechanical stress on switchgear Technically non feasible.
I – Smart Wires Line impedance control	This device can in close to real time increase/decrease the reactance of a transmission line and divert power away from the line with lower rating, by diverting power towards lines with higher rating. It can reduce load on the line 94T. This option is estimated to cost in excess of $21 million. Commercially non feasible.

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 the Table 5 below.

Table 5 – Assumptions used in commercial evaluation

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)

Fuel Cost ($/MWh)	35.48	44.35	26.61
Capital cost	100%	125%	75%
Operating expenditure	100%	125%	75%
VCR	AER Latest VCR [8] (escalated) 100%	70%	130%
Scenario weighting	**50%**	**25%**	**25%**

Weighting of each scenario reflects their likelihood of occurrence. The central scenario is most likely to occur and has therefore been given a higher weighting of 50 per cent based on available information at this time. The lower and higher bound scenario is expected to be equally likely to occur and has been weighted accordingly at 25 per cent. These two scenarios reflect extreme combinations of assumptions, designed to stress test the results.

Parameters used in this commercial evaluation are shown in Table 6:

Table 6 – Parameters used in commercial evaluation

Parameter	Parameter Description	Value used for this evaluation
Discount year	Year that dollar values are discounted to	FY21
Base year	The year that dollar value outputs are expressed in real terms	FY21 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 (economic) evaluation of the technically feasible options, which are also deemed commercially feasible (based on initial estimate) 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	1.22	0.13	23.6	11.6	46.2	26.3	2
Option B	6.36	0.66	43.6	17.2	90.3	48.7	1

4.3 Preferred option

[8] VCR value used for this project is $43,032/MWh

The NPV assessment shows that both credible options can be expected to deliver significant net market benefits to the NEM, when compared to the do nothing base case option. This is since both options have been designed to increase the capacity of Line 94T, to meet the increase in renewable generation north of the Molong Substation.

Of the options assessed, Option B has the highest NPV. Therefore, Option B is the preferred option. Under this option, the following investments will be undertaken:

> Restring line 94T with a higher rated conductor on existing structures.

Capital and Operating Expenditure

The preferred option requires total capital expenditure of $7M. This figure includes direct capital cost and network and corporate overheads cost, listed in Table 1. No additional operating expenditure is required, as changing the conductor does not increase operating costs.

Regulatory Investment Test

As the estimated cost of the project 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 net benefits[9] (including avoided costs and safety disproportionality tests) of the preferred option exceed the cost 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 identify that there are positive market benefits from immediately implementing the preferred option. With a construction duration of three years, optimal timing analysis shows:

> Optimal commissioning year: 2024/25
> Commissioning year annual benefit: $4 million
> Annualised cost: $397,970

Based on the optimal timing, the project is expected to commence in the current Regulatory Period.

6. Recommendation

Based on the options evaluations in this report, the preferred option is Option B – restring Line 94T with a higher rated conductor on existing structures. In the do-nothing scenario, a substantial quantity of low-cost renewable energy from increased renewable generation north of the Molong Substation will be curtailed throughout the course of a year. Option B increases the capacity of Line 94T, addressing Transgrid's economic benefits need to cater for the additional renewable generation. 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 as soon as practicable from 2024/25.

Based on the options listed in Section 3.1, it is expected that this project would incur a capital cost of approximately $7.02 million in P50 non-escalated 2020/21 dollars.

The recommendation is to progress with Option B. This option requires $500,000 of capex, included in total capital cost, to progress the project to Decision Gate 2 (DG2).

[9] Net benefits are sum of benefits from first year of benefits to year where the total benefits exceed total cost of the project.

Appendix A – Option Summaries

Project Description	**Increase capacity for generation in the Molong to Parkes area**		
Option Description	Option B – Restring with a higher rated conductor on existing structures		
Project Summary			
Option Rank	1	Investment Assessment Period	25 years
Asset Life	40	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	43.65	Annualised CAPEX ($m)	0.398
NPV @ Lower Bound Scenario (PV, $m)	17.19	Network Safety Risk Reduction ($m)	*N/A*
NPV @ Higher Bound Scenario (PV, $m)	90.34	ALARP	*N/A*
NPV Weighted (PV, $m)	48.7	Optimal Timing	2024/25
Cost			
Direct Capex ($m)	6.36	Network and Corporate Overheads ($m)	0.66
Total Capex ($m)	3.16	Cost Capex (PV,$m)	5.48
Terminal Value ($m)	3.16	Terminal Value (PV,$m)	1.03

Project Description	Increase capacity for generation in the Molong to Parkes area		
Option Description	Option A – Increase transmission line design temperature to 100 deg C		
Project Summary			
Option Rank	1	Investment Assessment Period	25 years
Asset Life	40	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	23.62	Annualised CAPEX ($m)	0.08
NPV @ Lower Bound Scenario (PV, $m)	11.64	Network Safety Risk Reduction ($m)	N/A
NPV @ Higher Bound Scenario (PV, $m)	46.17	ALARP	N/A
NPV Weighted (PV, $m)	26.26	Optimal Timing	2024/25
Cost			
Direct Capex ($m)	1.22	Network and Corporate Overheads ($m)	0.1366
Total Capex ($m)	1.35	Cost Capex (PV,$m)	1.1
Terminal Value ($m)	0.57	Terminal Value (PV,$m)	0.19