OPTIONS EVALUATION REPORT (OER)

Supply to Vineyard BSP – Voltage Control

OER- N2360 revision 5.0

TransGrid

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Approvals

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Change history

Revision	Date	**Amendment**
0	25/06/2021	Initial Issue
1-2	20/07/2021	Revision to address HK comments and NPV results updated based on new NPV model (error in approval process created duplicate approvals)
3-4	1/11/2021	Revision to address Cutler Merz comments (error in approval process created duplicate approvals)
5	24/12/2021	Update to wording and context

Executive summary

The Vineyard Precinct is part of the North West Priority Growth Area, an area identified by the NSW Government for new development. Stage 1 of the Vineyard area has been rezoned and enabling infrastructure has been delivered to accommodate an anticipated 2,300 new dwellings and 7,000 people.

This is leading to rapid load growth in the area supplied by Vineyard Bulk Supply Point (BSP). As a result, the reactive margin is expected to drop to below one percent of the maximum fault level at the Vineyard 330 kV and 132 kV busbars from summer 2024/25 under a single credible contingency of the 330 kV Line 29 that supplies the Vineyard BSP from Sydney West.

The voltage stability requirement as defined in National Electricity Rules (NER) S5.1.8 is that the reactive margin (expressed as a capacitive reactive power (in MVAr)) must not be less than one percent of the maximum fault level (in MVA) at the connection point. The present network is unable to achieve this reactive margin for higher expected demands. Shedding of load will be required to maintain this reactive margin at times of higher loads.

To remain compliant with NER requirements and support the growth objectives for the Vineyard Precinct without unacceptable loss of supply to customers, it will be necessary to augment Transgrid's transmission network in the Vineyard area.

Assessment of the options considered to address the need is presented 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	Loop-in line 26 to Vineyard 330 kV Substation	38	2.7	40.7	12,695	1
Option B	Staged installation of new shunt capacitors at the Vineyard 330 and 132 kV busbar	38.3	3.6	41.9	12,355	2

The preferred option based on the options evaluated in this report is expected to be Option A, as this meets the requirements of the need, is economically and technically feasible, and has the highest NPV.

However, the final preferred option will be determined through the RIT-T process based on detailed network analysis, cost/benefit analysis, and the consideration of technical and economic feasibility.

[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. The capital cost is estimated based on P50 non-escalated 2020-21 $ value.

1. Need/opportunity

The Vineyard Precinct is part of the North West Priority Growth Area, an area identified by the NSW Government for new development. Stage 1 of the Vineyard area was rezoned in December 2017 and essential infrastructure such as roads, sewage and distribution infrastructure (provided by Endeavour Energy) has been delivered. Vineyard is now growing rapidly in line with the Stage 1 growth targets of 2,300 new homes and 7,000 residents.

This is causing rapid load growth in the area supplied by Vineyard Bulk Supply Point (BSP). As a result, the reactive margin is expected to drop to below one percent of the maximum fault level at the Vineyard 330 kV and 132 kV busbars from summer 2024/25 under a single credible contingency of the 330 kV Line 29 that supplies the Vineyard BSP from Sydney West, as shown in the figures below.

Figure 1 – Vineyard BSP demand forecast vs load limit due to reactive margin requirement

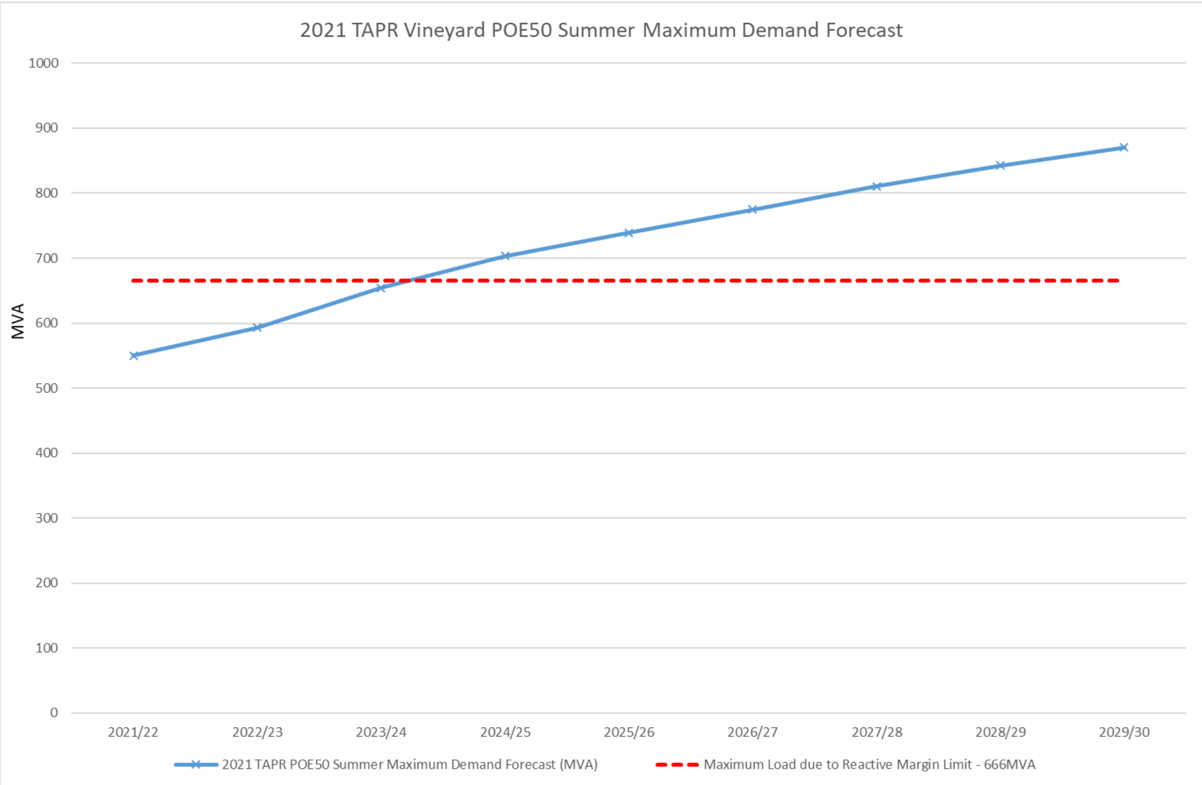
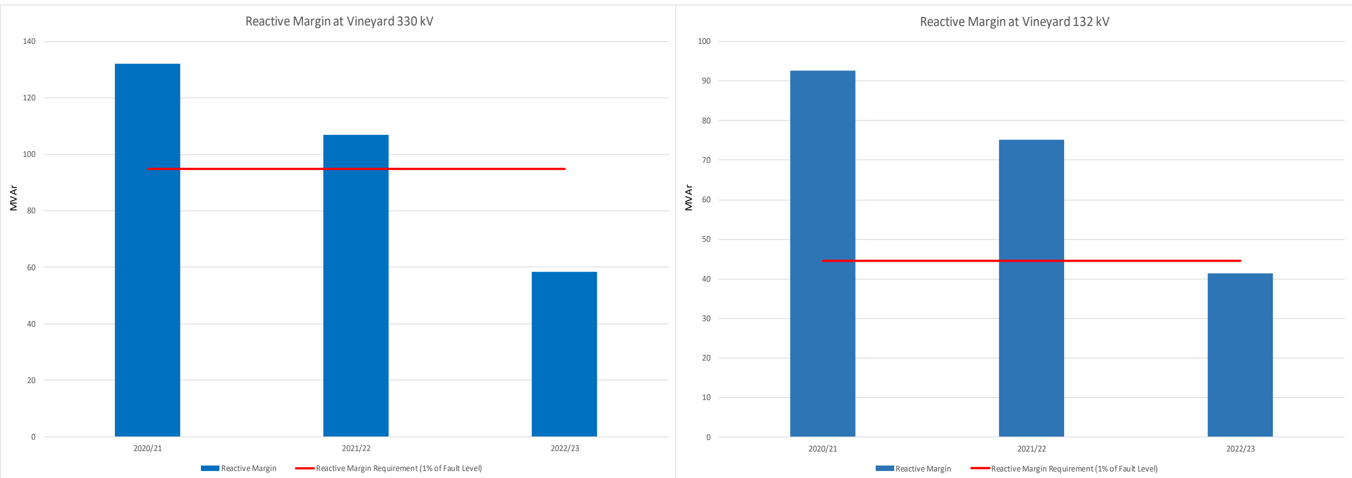


Figure 2 – Reactive margin at Vineyard 330 and 132 kV busbars



Transgrid is required under the National Electricity Rules (NER)[2] to maintain the required reactive margin above the one percent threshold. The present network is unable to achieve this reactive margin for higher expected demands. Without action, load curtailment would be required to maintain the reactive margin during high demand from Summer 2024/25, based on the POE50 demand forecast.

To remain compliant with NER requirements, while supporting the growth objectives for the Vineyard Precinct without unacceptable loss of supply to customers, augmentation of Transgrid's transmission network in the Vineyard area will be required.

2. Related needs/opportunities

- N2373 – Supply to Vineyard area – BSP supply capability enhancement
  - Address a thermal constraint from 2032/32 at the Vineyard Substation due to continued load growth in the area.
- N2371 – Supply to Sydney West BSP
  - Project to increase supply capacity in the Sydney West area due to imminent load growth.

3. Options

3.1 Base case

Under the base case, where there is no network development to address the need, and load curtailment is expected to be required from Summer 2024/25 if the contingency occurs at or near times of high demand. This will result in Expected Unserved Energy (EUE), the quantum of which is shown in the table below. This would have an unacceptable material economic impact on the commercial and residential developments expected in the area.

Table 1 – EUE at Vineyard BSP (2024/25-2033/34)

	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34
POE50 EUE (MWh)	148	638	1548	2957	4703	6637	8056	9706	11650	13943

3.2 Options evaluated

Option A — Loop-in line 26 to Vineyard 330 kV Substation

Option A can release the voltage stability (reactive margin) driven supply limit at Vineyard BSP for the assessment period (25 years). There is no voltage stability related EUE at Vineyard after Option A is implemented. It will also increase the supply reliability of Vineyard BSP significantly by increasing the 330 kV feeders supplying Vineyard from two feeders to four feeders.

The following scope of works is associated with the installation of a new 330 kV diameter at the existing Vineyard 330 kV substation.

- Three (3) 330 kV busbar extensions (Busbar A, B and D) and associated secondary system works;
- Four (4) 330 kV bus section breaker switchbays and associated new secondary system works;
- Two (2) 330 kV transmission line switchbays and associated new secondary system works;
- Relocation of existing No.2 330/132 kV transformer connection point to new 330 kV diameter.

[2] Reactive margin (in MVAr) must not be less than one percent of the maximum fault level (in MVA) at the connection point. – NER S5.1.8.

The following figures show the existing layout at Vineyard substation versus the new layout at the completion of Option A.

Figure 3 – Existing Vineyard Substation Layout

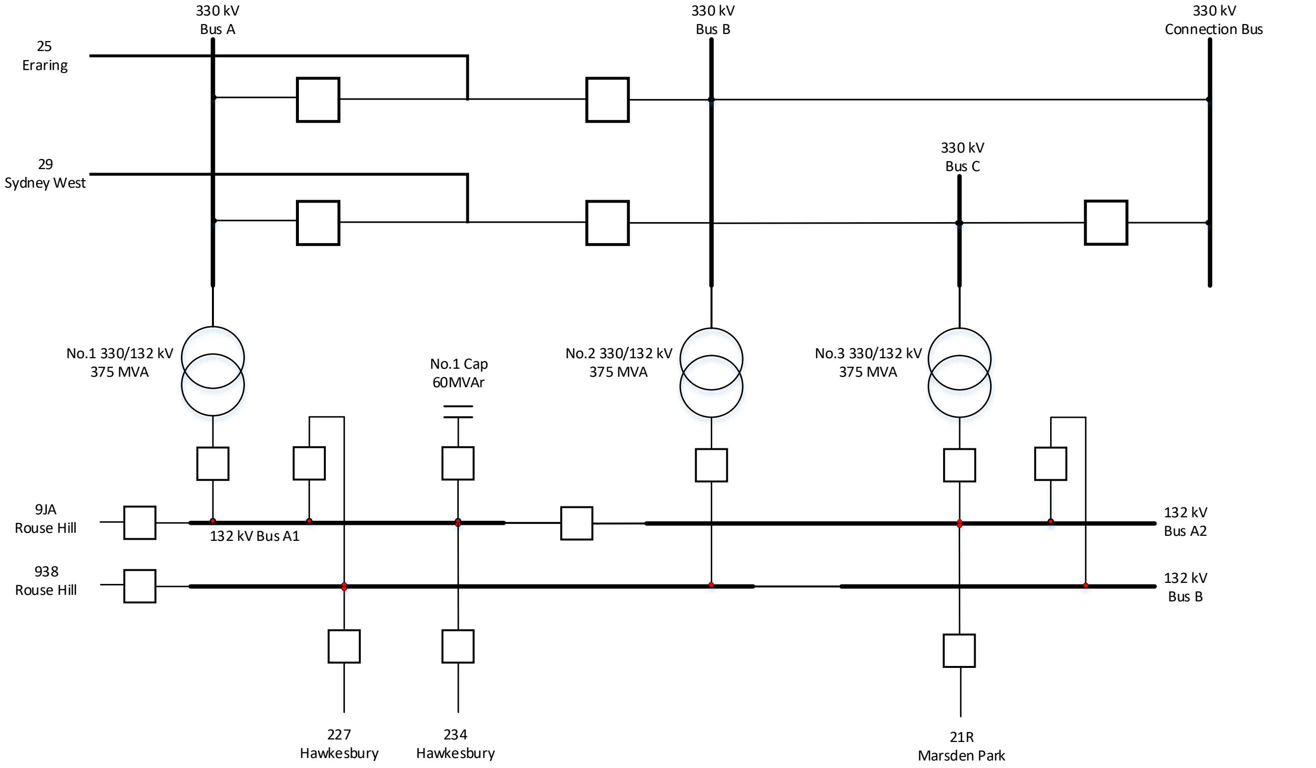
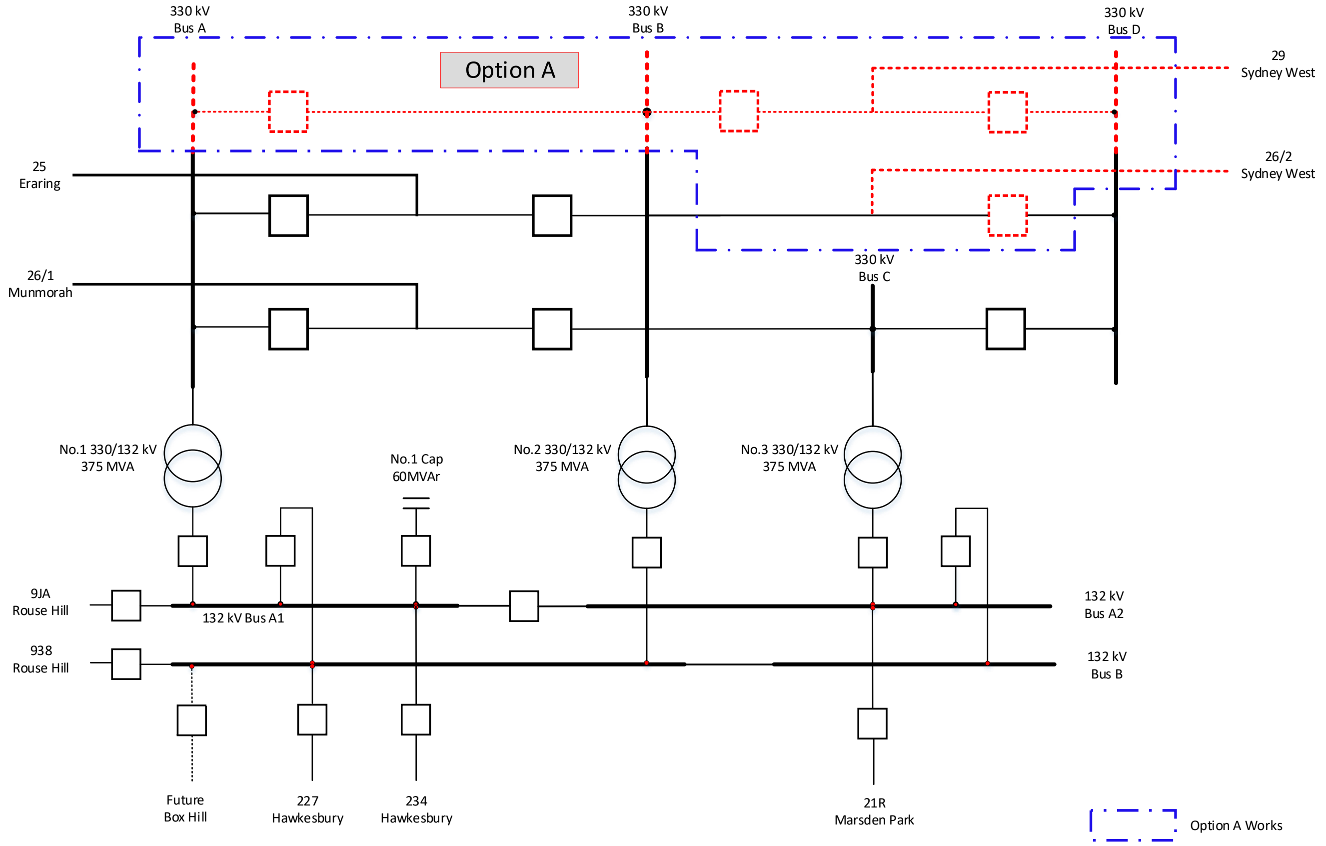


Figure 4 – Proposed new layout following Option A - loop-in line 26



It is estimated that this option would cost $40.7m ± 25% in $2020-21, excluding capitalised interest.

The expected expenditure profile for this project based on the standard spending distribution curve for 330 kV Substation – Augmentation is as follows:

Table 2 – Option A expected expenditure

	Total Project Cost ($M)	FY2021/22 ($M)	FY2022/23 ($M)	FY2023/24 ($M)	FY2024/25 ($M)
Estimated P50 Cost non-escalated ($m 2020-21)	40.7	1.6	6.1	32.1	0.9

It is estimated that an amount up to $1.6 million is required to progress the project from DG1 to DG2. This is to cover activities such as site visits, development of concept design, and commencement of project approvals and early procurement of long lead-time items.

This project is expected to be completed in an estimate 42 months following the approval of DG1. Commissioning of this option is planned for the 2024/25 year.

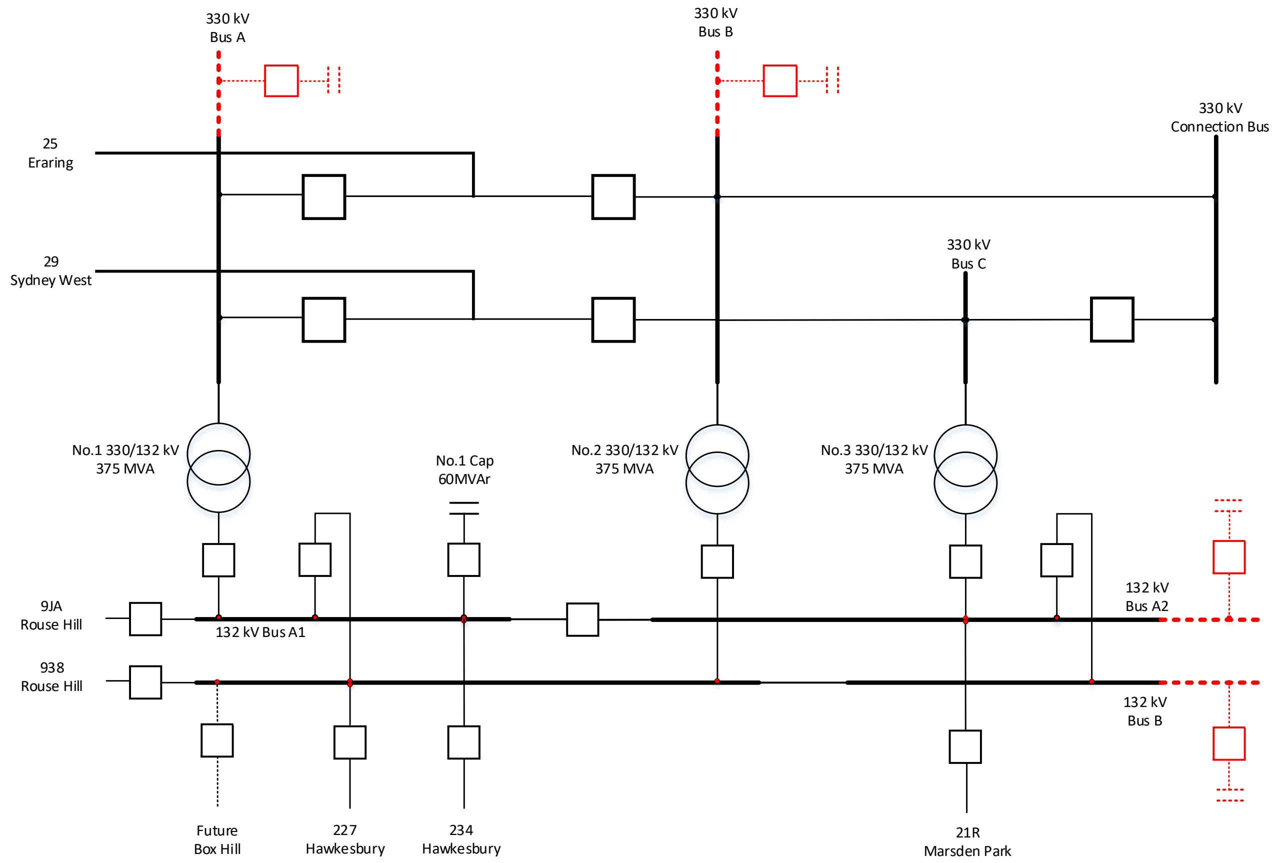
Option B — Staged installation of new shunt capacitors at the Vineyard 330 and 132 kV busbars

Option B can increase the BSP supply limitation due to voltage stability to 972 MW (1023 MVA) which is adequate for the BSP demand up to 2036 based on the latest Endeavour Energy demand forecast. It is expected that EUE will occur after 2036 as the demand growth will exceed the reactive margin (voltage stability) limitation. This option will require more switchbays to connect multiple shunt capacitors and needs the installation of more reactive support at Vineyard substation along with the load growth, which could potentially lead to voltage step change issues in the future.

This following scope of works is associated with the installation of a new shunt capacitors at the existing Vineyard 330 kV substation.

- Two (2) new 200 MVAr shunt 330 kV capacitors and associated switchyard bench extensions, new 330 kV switchbays and secondary system works;
- Two (2) new 100 MVAr shunt 132 kV capacitors and associated switchyard bench extensions, new 132 kV busbar extension, switchbays and secondary system works.

Figure 5 – Proposed new layout following Option B – New capacitor banks



It is estimated that this option would cost $41.9m ± 25% in $2020-21, excluding capitalised interest.

The expected expenditure profile for this project based on the standard spending distribution curve for 330 kV Substation – Capacitive works is as follows (assuming project completion in November):

Table 3 – Option B expected expenditure

	Total Project Cost ($M)	FY2021/22 ($M)	FY2022/23 ($M)	FY2023/24 ($M)	FY2024/25 ($M)
Estimated P50 Cost non-escalated ($m 2020-21)	41.9	1.7	4.4	33.8	2.0

It is estimated that an amount up to $1.7 million is required to progress the project from DG1 to DG2. This is to cover activities such as site visits, development of concept design, and commencement of project approvals.

This project is expected to be completed in an estimate 37 months following the approval of DG1. Commissioning of this option is planned for the 2024/25 year.

Option C — Non-network solution

This option is to investigate the potential demand management within the area supplied by Vineyard BSP to reduce the load at Vineyard BSP to below the limit of 666 MVA. Demand management may be able to address both this need, which occurs in Summer 2024/2025, and the transformer capacity need (N2373) in Summer 2032/2033 at the substation. Transgrid currently does not have information on the potential costs of a demand management solution.

Demand management could also take the form of a grid-connected battery providing load reductions or voltage support. However, given the magnitude of reactive support required at the required voltages, it is not likely commercially viable to provide 600 MVA of inverters to deliver voltage support.

At this stage, it is not clear whether a demand management solution will be economically viable, and we have not evaluated it in the NPV analysis. However, the least cost network option exceeds $6m and will be subject to a RIT-T, where an Expression of interest (EOI) is expected to be released calling for non-network solutions. This will enable the viability of a non-network option to be fully assessed.

3.3 Options considered and not progressed

This section discusses additional options that Transgrid and Endeavour Energy have considered but do not consider technically and/or economically feasible, and therefore which are not being progressed as credible options.

Table 4 – Options considered but not progressed

Option	Reason for not progressing
Endeavour Energy Load Transfer from Vineyard to Sydney West BSP	This option will require a new feeder from Baulkham Hills to Bella Vista and potential feeder upgrades or new feeder from Blacktown to Baulkham Hills. As Sydney West BSP is already experiencing the high load growth and the supply capacity at Sydney West is reaching its limit, this option is not technically feasible. The cost of this option is also likely to be significantly higher than options A and B due to the cost of the new feeder.
New Shunt Capacitors in Endeavour Energy distribution network	This option include the installation of 10 x 5 MVAr shunt capacitors in Endeavour Energy's distribution network. Due to space limitations, only 10 x 5 MVAr shunt capacitor units can be installed in the existing Endeavour Energy zone substations. The 50 MVAr additional reactive support in the Endeavour Energy network can only provide the relief of load curtailment by one year. Additional reactive support will be needed in the Endeavour Energy network along with the load growth which will require expansion of multiple zone substations. Therefore, this option is technically viable but not economically feasible due to higher cost than options A and B.

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 5 below.

Table 5 – Scenario assumptions

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)
Capital cost	100%	125%	75%
Operating expenditure	100%	125%	75%
Value of Customer Reliability (VCR) [3]	100%	70%	130%
Scenario weighting	**50%**	**25%**	**25%**

The parameters used in this commercial evaluation are presented in Table 6 below.

Table 6 – Parameters used in commercial evaluation

Parameter	Parameter Description	Value used for this evaluation
Discount year	The year that dollar values are discounted to	2020/21
Base year	The year that dollar value outputs are expressed in real terms	2020/21 dollars
Period of analysis	The 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

Commercial evaluation of the technically and economically feasible options is set out in Table 7 below. Details are given 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	37.4	9.2	9,847	3,008	28,076	12,695	1
Option B	38.4	9.5	9,655	2,981	27,131	12,355	2

Transgrid currently does not have information on the potential costs of a demand management solution, however will be engaging with non-network proponents through an EOI as part of the RIT-T process to allow evaluation of non-network options.

[3] AER 2019 December VCR value escalated by CPI to 2020/21 dollars.

4.3 Preferred option

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 due to the fact that both options have been designed to manage the risk of substantial unserved energy to the loads supplied by Vineyard BSP.

Of the network options assessed, Option A has highest NPV, and it can enhance the system strength of Vineyard BSP. Moreover, Option A can completely address the voltage limitation while Option B can only address the limitation up to 2036. Therefore, Option A is expected to be the preferred option, which involves looping in 330 kV Line 26 into Vineyard to provide two more 330 kV supplies for Vineyard BSP.

Capital and Operating Expenditure

The preferred option requires capital expenditure of $40.7 million. Additional operating expenditure of $0.8 million per year has been identified for this option.

Regulatory Investment Test

As the estimated cost of the project is above the Regulatory Investment Test (RIT-T) threshold of $6 million, therefore a RIT-T will be required.

A Project Specification Consultation Report (PSCR) is expected to be published in Q1 2022.

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, avoided EUE, 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 the meet the commissioning year based on the OFS.

The results of optimal timing analysis is:

> Optimal commissioning year: 2024/25[4]
> Commissioning year annual benefit: $27 million
> Annualised cost: $2.3 million

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

6. Recommendation

The final preferred option will be determined through the RIT-T process 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 – Loop-in 300 kV Line 26 to Vineyard 330 kV Substation. It is therefore recommended that the project be approved to proceed to a RIT-T assessment, with a view to the preferred option being commissioned 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 $40.7 million in P50 non-escalated 2020/21 dollars.

The recommendation is to progress with Option A. This option requires $1.6 million of capex to progress the project to DG2.

[4] This is the earliest date that project can be completed based on OFS N2360A

Appendix A – Option Summaries – Option A

Project Description	**Supply to Vineyard BSP – Voltage Control**		
Option Description	Loop-in line 26 to Vineyard 330 kV Substation		
Project Summary			
Option Rank	*1*	Investment Assessment Period	25
Asset Life	40	NPV Year	*2021*
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	*9,847*	Annualised CAPEX ($m)	2.31
NPV @ Lower Bound Scenario (PV, $m)	3,008	Network Safety Risk Reduction ($m)	N/A
NPV @ Higher Bound Scenario (PV, $m)	*28,076*	ALARP	N/A
NPV Weighted (PV, $m)	*12,695*	Optimal Timing	*2024/25*
Cost			
Direct Capex ($m)	38	OPEX (PV $m)	9.2
Total Capex ($m)	40.7	Cost Capex (PV,$m)	37.4
Terminal Value ($m)	19.3	Terminal Value (PV,$m)	6.3

Appendix B – Option Summaries – Option B

Project Description	Supply to Vineyard BSP – Voltage Control		
Option Description	Staged installation of new shunt capacitors at the Vineyard 330 and 132 kV busbar		
Project Summary			
Option Rank	*2*	Investment Assessment Period	25
Asset Life	40	NPV Year	*2021*
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	*9,655*	Annualised CAPEX ($m)	2.38
NPV @ Lower Bound Scenario (PV, $m)	2,981	Network Safety Risk Reduction ($m)	N/A
NPV @ Higher Bound Scenario (PV, $m)	*27,131*	ALARP	N/A
NPV Weighted (PV, $m)	*12,355*	Optimal Timing	*2024/25*
Cost			
Direct Capex ($m)	38.3	OPEX (PV $m)	9.5
Total Capex ($m)	41.9	Cost Capex (PV,$m)	38.4
Terminal Value ($m)	19.9	Terminal Value (PV,$m)	6.5