

OPTIONS EVALUATION REPORT (OER)



Beryl Area Constraint

OER- 000000001316 revision 0.0

Ellipse project no(s): P0007638

TRIM file: [TRIM No]

Project reason: Reliability - To meet overall network reliability requirements

Project category: Prescribed - Augmentation

Approvals

Author	Ronny Schnapp	Professional Engineer
Reviewed	Lulu Shao	Network and Connection Analysis Senior Engineer
Endorsed	Jahan Peiris	Network Modelling & Performance Manager
	Azil Khan	Investment Analysis Manager
	Garrie Chubb	Investment Support Manager
Approved	Nalin Pahalawaththa	Manager Power System Analysis
Date submitted for approval	11 November 2016	

Change history

Revision	Date	Amendment
0	28/10/2016	Initial Issue

1. Need/opportunity

In a study commissioned by TransGrid¹, Ernst & Young (EY) has identified a number of projects which may impact the TransGrid network development plan. The EY study identifies, as a minimum, a total of 354 MW not considered by TransGrid in demand forecasts over the upcoming planning horizon. Of these additional loads, there are loads in the Beryl area which, if established, would have an adverse impact on the network.

TransGrid has analysed the impact of the additional loads and identified a voltage constraint at Beryl Substation, following a contingency on 132 kV line 94B Wellington to Beryl.

- > Under the existing Beryl demand forecast, the reactive margin following an outage of 132 kV 94B Wellington to Beryl would be 11 MVar. The reactive margin will be approximately 7 MVar if the additional loads are included. These future projected reactive margins do not comply with TransGrid's planning criteria for reactive support and voltage stability (Details refer to [NOS-1316](#)).
- > Following outages of 18 MVar Beryl capacitor bank and 94B line during peak load, the reactive margin at Beryl is below the minimum required reactive margin level (Details refer to [NOS-1316](#)).

During peak load in Summer 2021/22 with the additional area spot loads, it is expected that approximately 45 MW load would be at risk immediately following outage of 94B; after 1 hour subsequent power restoration, a continuous 14MW load would be at risk until Line 94B is restored. It is likely that voltage stability issues would also occur during large load swings from the Essential Energy load.

TransGrid's analysis hence determines that voltage stability issues at Beryl substation necessitates additional voltage support if the Beryl spot load projects were to occur within the next planning horizon.

TransGrid has estimated a 51% weighted likelihood of the Need eventuating within the 2018-23 regulatory period.

2. Related needs/opportunities

- > Need ID DCN190 - Supply to Beryl area
This project was for the installation of an 18 MVar 66 kV capacitor bank at Beryl Substation to help with existing voltage constraints, with completion expected at the end of 2016. Other options included a new Beryl 330 kV Substation.
- > Need ID 0705 - Beryl 330kV Substation Site - Strategic Property Acquisition
Strategic acquisition of land for a future Beryl 330/132 kV Substation.

3. Options

Base case – 'Do Nothing'

The Base Case involves continuing to operate the network 'as is'.

The primary risk of not addressing this Need is voltage instability resulting in a loss of load that is unserved energy (USE), in the Beryl area following a single critical contingency of TransGrid line 94B between Wellington and Beryl.

The risk cost of not addressing this Need is therefore composed of the following components:

- > exposing customer load of 45 MW (peak) to risk of being lost upon for an hour immediately after an outage event on line 94B

¹ EY 2016, Expansion of demand scenarios, Ernst and Young, 10 October 2016.

- > exposing customer load of 14 MW (peak) to risk of being lost for the outage duration until line 94B is restored
- > damage to TransGrid's reputation (negative media coverage).
- > litigation by customers/consumer groups.

A risk-cost summary extract from the Investment Risk Tool appears in Attachment 1.

The expected total risk cost will be \$3.65 million per annum.

Option A — Establish Beryl 330/132 kV Substation [OSA 1316, OFS 1316A]

This option is for a new 330/132 kV single-transformer substation near Beryl 132/66 kV Substation, with a cut-in to the 330 kV Wellington to Wollar transmission line, approximately 56km down the line from Wellington, and 61km down the line from Wollar.

This option will require the following works to be carried out by TransGrid:

- > Establishment of a 330/132 kV Substation near Beryl on the existing site acquired by TransGrid.
- > Installation of one 330 kV double circuit steel lattice tension tower to cut-in the 79 line into Beryl 330 and associated conductor stringing works.
- > Acquisition of easements required for a 132 kV line between the new Beryl 330 and existing Beryl 132.
- > Construction of a 132 kV concrete pole double circuit transmission line, strung on one side only with Mango ACSR conductor, including the installation of OPGW between the new Beryl 330 and existing Beryl 132.
- > Augmentation works at the existing Beryl 132 kV substation.
- > Installation of a new 132 kV line termination structure on the 94M line and re-termination of the 94M line into the new 132 kV switchbay.
- > Installation of a new 132 kV line termination structure on the 94B Line and re-termination of the 94B line into the old 94M Line switchbay.
- > Modification of existing 79 Line protection systems at Wollar 500 kV Substation and Wellington 330kV Substation for cut-in of the new Beryl 330 kV Substation.
- > Installation of unduplicated VF intertripping and unduplicated PLC intertripping on the 94B Line at Beryl 132 and Wellington.
- > Installation of duplicated VF intertripping and unduplicated PLC intertripping on the 94M Line at Beryl 132 and Mount Piper 132.
- > Installation of an automatic changeover scheme for the 94M Line at Beryl 132 and Mount Piper 132.

This option has been assessed for feasibility in [OFS-1316A](#). The estimated un-escalated capital cost of the option is \$35.3 million ± 25% in 2016-17 AUD.

Option B — Install dynamic reactive support at Beryl [OSA 1316, OFS 1316B]

This option is for a new 132 kV SVC or STATCOM with -10 to +50 MVar capability at Beryl Substation including the necessary transformer, switchgear and secondary systems. This option will manage any voltage constraints arising due to mine developments and the background load growth in the Beryl area.

This option will require the following works to be carried out by TransGrid:

- > Installation of 1 x 132kV -10 MVar to +50MVar SVC.
- > Installation of 1 x 132kV switchbay.
- > Installation of 132kV busbar extension.
- > Installation of control, protection and cabling associated with the capacitors and switchbays.

- > Extension of switchyard substation bench.
- > Installation of substation security fence.

This option has been assessed for feasibility in [OFS-1316B](#). The estimated un-escalated capital cost of the option is \$18.4 million ± 25% in 2016-17 AUD.

Option C – Duplication of 94B Wellington to Beryl 132 kV Line

This option includes duplication of existing 132 kV lines 94B between Wellington and Beryl, options may include rebuilding the existing single circuit line as a double circuit line or building a second adjacent single circuit line.

As a major network augmentation, this option involves much greater environmental and community impact, and significantly higher property and line easement acquisition risks compared to Option A.

Hence this option is not further considered.

Option D – Duplication of 94M Mt Piper to Beryl 132 kV Line

This option includes duplication of existing 132 kV lines 94M between Mt Piper and Beryl, options may include rebuilding the existing single circuit line as a double circuit line or building a second adjacent single circuit line.

As a major network augmentation, this option involves much greater environmental and community impact, and significantly higher property and line easement acquisition risks compared to Option A.

Hence this option is not further considered.

Option E – Provision of Additional Reactive Support in Essential Energy's Underlying 66 kV Network

TransGrid has requested via Joint Planning that Essential Energy investigate this option. This option includes improvement of the reactive power consumption of the Essential Energy distribution load.

This option is not further considered.

Option F – Provision of a 66 kV 12 MVar Capacitor Bank at Beryl 132/66 kV Substation

This option includes the installation of additional capacitor banks. It has been assessed by TransGrid and evaluated as not an acceptable technical solution. Installation of additional capacitor banks would result in an oversaturation of capacitive plant and the subsequent voltage change with switching and tap changer operation of the Beryl 132/66 kV transformers would be outside of planning guidelines.

Hence this option is not further considered.

Option G – Provision of a new 132 kV 20 MVar Capacitor Bank at Beryl 132/66 kV Substation

This option includes the installation of additional capacitor banks. It has been assessed by TransGrid and evaluated as not an acceptable technical solution. Installation of additional capacitor banks would result in an oversaturation of capacitive plant and the subsequent voltage change with switching and tap changer operation of the Beryl 132/66 kV transformers would be outside of planning guidelines.

Hence this option is not further considered.

Option H – Replace the existing No.2 10 MVar 66 kV Capacitor Bank with a 18 MVar Capacitor Bank at Beryl 132/66 kV Substation.

This option includes the installation of additional capacitor banks. It has been assessed by TransGrid and evaluated as not an acceptable technical solution. Installation of additional capacitor banks would result in an

oversaturation of capacitive plant and the subsequent voltage change with switching and tap changer operation of the Beryl 132/66 kV transformers would be outside of planning guidelines.

Hence this option is not further considered.

Option I – Provision of a 66 kV 18 MVar Capacitor Bank

This option includes the installation of additional capacitor banks. It has been assessed by TransGrid and evaluated as not an acceptable technical solution. Installation of additional capacitor banks would result in an oversaturation of capacitive plant and the subsequent voltage change with switching and tap changer operation of the Beryl 132/66 kV transformers would be outside of planning guidelines.

Hence this option is not further considered.

Option J – Provision of a 132 kV 25 MVar Capacitor Bank at Beryl 132/66 kV Substation

This option includes the installation of additional capacitor banks. It has been assessed by TransGrid and evaluated as not an acceptable technical solution. Installation of additional capacitor banks would result in an oversaturation of capacitive plant and the subsequent voltage change with switching and tap changer operation of the Beryl 132/66 kV transformers would be outside of planning guidelines.

Hence this option is not further considered.

Option K - Non-network options

No feasible non-network solutions have been identified which could manage the voltage constraint at Beryl – refer to OFS 6006H.

4. Evaluation

4.1 Technical evaluation

Options A – Option D are technically feasible. However Option C and Option D involve much greater environmental and community impacts, and significantly higher property and line easement acquisition risks compared to Option A and B, therefore they are not considered further.

Therefore only Options A and B are compared in Table 1 against the base case option.

4.2 Commercial evaluation

The commercial evaluations of the technically feasible options are set out in Table 1. The full financial and economic evaluations are shown in Appendix A.

Table 1 — Commercial evaluation (\$ million)

Option	Description			Total capex (\$m)	Annual opex (\$m)	Annual post project risk cost (\$m)	Economic NPV @ 10% (\$m)	Financial NPV @10% (\$m)	Rank
Base case	'Do nothing'			0	0	3.65	0	0	2
A	Establish Substation	Beryl	330/132 kV	35.3	0.71	0	(8.91)	(26.81)	3
B	Install dynamic reactive support at Beryl Substation			18.4	0.37	0	8.07	(11.78)	1

The commercial evaluation is based on:

- > a 10% discount rate, with sensitivities based on TransGrid's current AER-determined pre-tax real regulatory WACC of 6.75% for the lower bound and 13% for the upper bound provided in Appendix A.
- > The applied sensitivities on the discount rate given the following NPVs for the Options.

Table 2 — Discount rate sensitivities (\$ million)

Option	Description	Economic NPV @ 13%	Economic NPV @ 6.75%
B	Install dynamic reactive support at Beryl Substation	3.08	17.46

4.3 ALARP evaluation

An ALARP assessment is triggered by the following hazard and the disproportionate factor:

- > Unplanned outage of HV equipment → 3 times the safety risk reduction and taking 10% of the reliability risk reduction as being applicable to safety.

However, as this will only produce 30% of the benefit derived in the economic evaluation, a full ALARP evaluation will not produce an alternative preferred solution.

4.4 Preferred Option

The preferred Option B is to install dynamic reactive support at Beryl substation as it ranks 1 under both commercial and sensitivity analysis.

Capital and operating expenditure

The yearly incremental operating expenditure of Option B is estimated to be 2% of the upfront capital cost of the option, which equates to \$0.37 million, escalated at a rate of 2.9% per annum.

Regulatory Investment Test

Option B will be subject to the RIT-T process as it has an estimated cost greater than the mandated \$6 million threshold.

5. Recommendation

Based on the options evaluated, Option B - Install dynamic reactive support at Beryl Substation, is the preferred option with the highest benefit, to address the need as it:

- > Enables TransGrid to meet its supply obligations under the National Electricity Rules.
- > Significantly reduces TransGrid's risk exposure and reduces the annual risk cost from \$3.65m to zero.

It is recommended that the preferred option be scoped in detail.

Appendix A – Financial and Economic Evaluation Reports

Project_Option Name

1316A - Establishment of Beryl 330/132 kV Substation

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-\$26.81m	NPV / Capital (Ratio)	-0.76
NPV @ upper bound rate	13.00%	-\$24.74m	Pay Back Period (Yrs)	Not measurable
NPV @ lower bound rate (WACC)	6.75%	-\$28.85m	IRR%	-3.86%

2. Economic Evaluation (includes VCR benefits but excludes tax benefits from non-cash transactions, ENS penalty and overall tax cost)

NPV @ standard discount rate	10.00%	-\$8.91m	NPV / Capital (Ratio)	-0.25
NPV @ upper bound rate	13.00%	-\$11.81m	Pay Back Period (Yrs)	13.68 Yrs
NPV @ lower bound rate (WACC)	6.75%	-\$2.19m	IRR%	6.07%

Benefits

Risk cost	As Is	To Be	Benefit	VCR Benefit	
Systems (reliability)	\$2.86m	\$0.00m	\$2.86m	ENS Penalty	\$0.00m
Financial	\$0.00m	\$0.00m	\$0.00m	All other risk benefits	\$0.43m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$3.29m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.43m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.43m	\$0.00m	\$0.43m	Benefits in the economic NPV**	\$3.29m
Total Risk benefits	\$3.29m	\$0.00m	\$3.29m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$3.29m		

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-\$0.71m	Write-off cost	\$0.00m
Capital - initial \$m	-\$35.30m	Major Asset Life (Yrs)	50.00 Yrs
Residual Value - initial investment	\$16.94m	Re-investment capital	\$0.00m
Capitalisation period	4.00 Yrs	Start of the re-investment period	2024-25

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-\$11.78m	NPV / Capital (Ratio)	-0.64
NPV @ upper bound rate	13.00%	-\$11.61m	Pay Back Period (Yrs)	Not measurable
NPV @ lower bound rate (WACC)	6.75%	-\$11.40m	IRR%	-0.98%

2. Economic Evaluation (includes VCR benefits but excludes tax benefits from non-cash transactions, ENS penalty and overall tax cost)

NPV @ standard discount rate	10.00%	\$8.07m	NPV / Capital (Ratio)	0.44
NPV @ upper bound rate	13.00%	\$3.08m	Pay Back Period (Yrs)	5.65 Yrs
NPV @ lower bound rate (WACC)	6.75%	\$17.46m	IRR%	16.01%

Benefits

Risk cost	As Is	To Be	Benefit	VCR Benefit	\$2.86m
Systems (reliability)	\$3.65m	\$0.00m	\$3.65m	ENS Penalty	\$0.00m
Financial	\$0.00m	\$0.00m	\$0.00m	All other risk benefits	\$0.79m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$3.65m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.79m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.00m	\$0.00m	\$0.00m	Benefits in the economic NPV**	\$3.65m
Total Risk benefits	\$3.65m	\$0.00m	\$3.65m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$3.65m		

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-\$0.37m	Write-off cost	\$0.00m
Capital - initial \$m	-\$18.40m	Major Asset Life (Yrs)	50.00 Yrs
Residual Value - initial investment	\$8.46m	Re-investment capital	\$0.00m
Capitalisation period	3.00 Yrs	Start of the re-investment period	2024-25