OPTIONS EVALUATION REPORT (OER)

Armidale and Dumaresq QNI Transpositions

OER 000000001460 revision 3.0

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1. Need/opportunity

Schedule S5.1a.7 of the National Electricity Rules (NER) defines a maximum average negative-sequence voltage of 0.5% of nominal voltage over a 30-minute averaging period, for systems with no contingencies and nominal voltages greater than 100 kV.

Negative sequence voltages can arise as a result of the configuration of the phases of a transmission line. The power flow through the transmission line can influence the overall level of negative sequence seen within an interconnected system.

The presence of excessive negative sequence voltages may cause overheating of synchronous and induction machines. TransGrid studies of voltage unbalance levels at northern NSW 330 kV connection points (Armidale, Coffs Harbour and Lismore) revealed possible negative-sequence voltage magnitudes of greater than 0.5% of nominal[1].

The analysis showed that of the three monitored locations, for most levels of QNI power transfer, the highest negative-sequence voltage magnitudes were found at Coffs Harbour 330 kV during periods of maximum demand.

If exceedance of the 0.5% NER negative-sequence voltage limit were used to define the constraint on QNI power transfer (under system normal 'n' operation) at times of maximum loads then the following applies:

- No southerly flow on QNI from Queensland to NSW would be permitted; and
- Northerly flow on QNI from NSW to Queensland would need to be constrained to between 200 and 600 MW.

Refer to NS-1460 for details.

2. Related needs/opportunities

Nil.

3. Options

Base case

The base case for this Need is to continue operating the network "as is". This will require application of constraints on QNI in order to meet the NER specified negative sequence voltage magnitude limits.

The base case total risk cost is estimated to be $0.21 million (Refer to Attachment 1 in NS-1460 for Risk Cost summary), which is primarily made up of the value of unserved energy.

The risk cost is calculated as below:

Historical average southerly flows on QNI have been around 425 MW for around 74% of the year.

Historical average northerly flows on QNI have been greater than 200 MW (i.e. the maximum allowable flow) for around 9% of the year at an average level of 263 MW.

It has been assumed that the voltage limit violations occur for 1 hour at a time.

Based on historical loading pattern at Coffs Harbour substation, the maximum loading condition occurs about 1.7% of the time[2].

[1] Voltage Unbalances at the Renewable Hub 330 kV Connection Point -2016.

[2] Refer to the file "Coffs Harbour Loads.xls" filed in PDGS supporting documents

$$Risk\ cost = \{P_{import\ unavailable} + P_{export\ constrained}\} * VCR$$

$\therefore$

$$Risk\ cost = \{[southerly\ average\ flow * percent\ of\ the\ year\ southerly\ flows\ occur] + [(northerly\ average\ flow > northerly\ lowest\ allowable\ flow - northerly\ lowest\ allowable\ flow) * percent\ of\ the\ year\ northerly\ flows\ occur]\} * violation\ duration * VCR$$

$$\therefore\ Risk\ cost = \{[425\ MW * 0.74] + [(263 - 200)\ MW * 0.09]\} * 1\ hr * VCR$$

$$\therefore\ Risk\ cost = 320.2\ MW * \$38.35/kWh$$

$$\therefore\ \boldsymbol{Risk\ cost = \$12.28\ million\ per\ year}$$

In order for the network to be resilient, it would be opportune for AEMO to appropriately amend the constraint equations and for TransGrid to pre-emptively enable this by doing any necessary works in coordination with AEMO.

Option A — Transposition on 87, 8C and 8E

The scope of works associated with this option involves:

- Two transpositions on the 330 kV single-circuit Line 87 which will divide the line into three equal sections. Phasing of the three sections of the line are such that a full rotation of the phases are achieved.
- Two new transpositions on the double-circuit Line 8C/8E which will complete the first and sixth locations.

The expected capital cost for this option is $1.15 million ± 25% (in un-escalated 2016/17 dollars). The scope of works included in this option is outlined in OFS-1460A. The post-project risk cost of Option A has been assessed to be $0, as the risk of excessive negative-sequence voltages on lines 87, 8C and 8E will have been eliminated by the transpositions.

Option B – Installation of a Balancing STATCOM at Coffs Harbour

The scope of work associated with this option involves the installation of a balancing STATCOM at Coffs Harbour.

In order to facilitate the connection of the STATCOM, the existing switchyard bench will need to be expanded and significant HV augmentation would be required. Previous investigations for STATCOM solutions for reactive power support indicate that this solution would be significantly greater in cost than Option A.

The injection of current into the network from a STATCOM, although solving the unbalance at the location of the STACOM, can cause voltage unbalance issues elsewhere in the transmission network.

This option has not been investigated further due to the identified shortcomings.

Non-network Solutions

No feasible non-network solutions have been identified to address this opportunity.

4. Evaluation

The base case of “Do Nothing” is not considered feasible as it will constrain QNI significantly as described in Section 3.

Option A is technically feasible and has been assessed commercially, and will remove limitations on QNI due to excessive negative-sequence voltages.

Option B is not technically feasible as it removes negative voltages from one location in the network to potentially other locations in the network. It is also expected to be significantly more expensive than Option A.

The financial and economic evaluation of the technically feasible options is set out in Appendix A.

Table 1: Commercial Evaluation

Option	Description	Capex ($m)	Yearly Opex ($m)	Yearly Post project risk cost ($m)	Economic NPV @10% ($m)	Financial NPV @10% ($m)	Rank
Base case	Do Nothing	-	-	12.28	-	-	2
A	Transpositions on 87, 8C and 8E lines	1.15	No additional opex	0	93.52	(0.93)	1

The commercial evaluation is based on:

> a 10% discount 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 give the following economic NPVs applied to the preferred Option A:

Discount Rate (%)	Economic NPV ($m)
6.75	133.07
13.00	70.66

Preferred Option

The preferred option to address the negative-sequence voltages experienced in northern NSW is Option A – Transposition on Lines 87, 8C and 8E, as it reduces TransGrid’s risk of negative-sequence voltages and reduces TransGrid’s risk exposure from $0.21 million per year to zero.

Capital and operating expenditure

The transposition of these transmission lines is not expected to materially change the existing ongoing operations and maintenance costs of these transmission lines.

Regulatory Investment Test

The RIT-T is not required as this is a minor network augmentation project with the cost of the preferred option under $6 million.

5. Recommendation

Based on the economic evaluation above, Option A is the preferred option to address the need as it enables TransGrid to meet the NER system standards and reduces the total risk from $12.28 million to zero.

It is therefore recommended that a Request for Project Scoping (RPS) be prepared for Option A – Transposition on Lines 87, 8C and 8E.

Appendix A – Financial and Economic Evaluation Reports

Project_Option Name	Transpositions on 8C, 8E and 87 lines

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	-$0.93m	*NPV / Capital (Ratio)*	*-0.81*
NPV @ upper bound rate	13.00%	-$0.90m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	-$0.94m	*IRR%*	*-2.88%*

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%	$93.52m	*NPV / Capital (Ratio)*	*81.32*
NPV @ upper bound rate	13.00%	$70.66m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	$133.07m	*IRR%*	*656.09%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$12.28m*
Systems (reliability)	*$12.28m*	*$0.00m*	*$12.28m*	*ENS Penalty*	*$0.00m*
Financial	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.00m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$12.28m
People (safety)	*$0.00m*	*$0.00m*	*$0.00m*		
Environment	*$0.00m*	*$0.00m*	*$0.00m*	Benefits in the financial NPV*	$0.00m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$12.28m	$0.00m	$12.28m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$12.28m
Total Benefits			$12.28m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$1.15m	Major Asset Life (Yrs)	50.00 Yrs
Residual Value - initial investment	$0.51m	Re-investment capital	$0.00m
Capitalisation period	2.00 Yrs	Start of the re-investment period	0.00 Yrs