OPTIONS EVALUATION REPORT (OER)

Over Voltage Control after an Automatic Under Frequency Load Shedding (AUFLS) Event

OER-1520 Revision 0

Ellipse project no(s): P0008780
TRIM file: [TRIM No]

Project reason: Imposed Standards - Control Systems to meet NER requirements
Project category: Prescribed - NCIPAP

Approvals

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Date submitted for approval	4 November 2016	

1. NEED/OPPORTUNITY

The National Electricity Rules requires all market customers with peak demands at connection points in excess of 10 MW to have at least 60% of their load available for shedding by under-frequency relays. This is required to arrest the fall in frequency in case of non-credible contingencies which result in a sudden large deficiency of generation. At present up to 60% of the state demand is subjected to automatic under-frequency load shedding (AUFLS).

TransGrid studies indicated that overvoltage would occur following an automatic under-frequency load shedding event due to excessive line charging and lack of load in the system.

The NSW transmission system includes emergency switching settings for most reactive plant, which can provide fast acting voltage control following a multiple contingency event. However, these schemes do not appear to be fast enough to cater for widespread under-frequency load shedding.

For details, refer to the Need/Opportunity Statement (NOS-1520).

2. RELATED NEEDS/OPPORTUNITIES

Nil.

3. OPTIONS

Base case

The base case is to maintain the present AUFLS arrangement.

This will lead to an annual risk cost of $1.90 million. The risk cost is primarily made up of the value of unserved energy. The risk cost summary is included in Attachment 3.

Base Case Risk Cost

The risk cost for the base case is calculated to be $3.648 million per annum and is based on:

- Failure rate of: 1 in 100 years
- Failure duration of: 4 hours
- Load form factor of: 0.5
- System Load: 12,000 MW
- Load shed due to AUFLS: 60% of load
- VCR = $38/kWh

Risk Cost = failure rate * failure duration * load form factor * (System Load – Load shed due to AUFLS)[1] * VCR

= (1/100) * (4) * (0.5 * 12,000 * 0.2) * (38.35 * 1,000)

= $1.84 million

[1] Could lead to significant un-intentional load shedding or a blackout in the event of an overvoltage event following AUFLS. The additional load lost as a result of an unmanaged over voltage following an AUFLS event is assumed to be 20%.

Option A – Implement over-voltage control scheme

Implementation of an over-voltage control scheme to configure all the existing reactive plant, to utilise a reduced time settings when the system frequency is below a certain level, would reduce the risk of an overvoltage in the event of an under-frequency load shedding event.

The benefit is the risk cost savings achieved by avoiding the widespread over-voltage condition and the subsequent loss of the remaining loads in the HV transmission network following an under-frequency load shedding event.

This option has been assessed for feasibility in OFS-1520A. The estimated un-escalated capital cost of the option is $3.83 M ± 25% in 2016-17.

Option Risk Cost

This option eliminates the risk of additional load shedding, over and above the 60% of state demand that is subject to the current AUFLS scheme, due to overvoltage events following automatic under-frequency load shedding. Therefore the additional risk cost is zero.

4. EVALUATION

A single option was identified and is evaluated below against the base case.

The economic evaluation of the technically feasible options is set out in Table 1.

Table 1 – Options Comparison

Option	Description	Capex ($m)^#	Opex ($m)	Yearly post project risk cost ($m)	NPV ($m)	Rank
Base case	'Do nothing'	Nil	-	1.90	-	2
A	Implement over-voltage control scheme	3.83	0	0	8.66	1

^ In 2016-17 dollars
 # Expenditure in 2018-19 period

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 Attachment 1.

The applied sensitivities on the discount rate give the following economic NPVs:

Discount Rate (%)	Economic NPV (2018/19 $m)
6.75	11.98
13.00	6.47

Preferred Option

The preferred option is Option A, as it improves TransGrid's risk exposure, and yields the most benefit, as calculated using TransGrid's NPV Calculation Tool (refer to Attachment 1) and Risk Tool. Risk cost summaries are included in Attachment 3.

A summary of the preferred option can be found in Attachment 2.

ALARP Evaluation

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

> Unplanned outage of high voltage equipment – 3 times the safety risk reduction and taking 10% of the reliability risk reduction as applicable to safety.

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

Capital and operating expenditure

There is no capital and operating expenditure trade-offs associated with this option.

Regulatory Investment Test

No RIT-T is required for this project as the total cost is less than $6 million.

5. Recommendation

It is recommended that an over-voltage control scheme be implemented to configure the existing reactive plant to increase the reactive power reserve during an under-frequency load shedding event in the period 2018-23. This will reduce TransGrid's risk exposure and yield a yearly benefit of $1.90 million.

Attachment 1 – Financial and Economic Evaluation Reports

Project_Option Name	Overvoltage Control after AUFLS Event

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$2.91m	*NPV / Capital (Ratio)*	*-0.76*
NPV @ upper bound rate	13.00%	-$2.84m	*Pay Back Period (Yrs)*	*-0.14 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$2.96m	*IRR%*	*-13.87%*

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%	$8.66m	*NPV / Capital (Ratio)*	*2.26*
NPV @ upper bound rate	13.00%	$6.47m	*Pay Back Period (Yrs)*	*2.02 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$11.98m	*IRR%*	*42.45%*

Benefits

Risk cost	As Is	To Be	Benefit
Systems (reliability)	*$1.84m*	*$0.00m*	*$1.84m*
Financial	*$0.00m*	*$0.00m*	*$0.00m*
Operational/compliance	*$0.06m*	*$0.00m*	*$0.06m*
People (safety)	*$0.00m*	*$0.00m*	*$0.00m*
Environment	*$0.00m*	*$0.00m*	*$0.00m*
Reputation	*$0.00m*	*$0.00m*	*$0.00m*
Total Risk benefits	$1.90m	$0.00m	$1.90m
Cost savings and other benefits			$0.00m
Total Benefits			$1.90m

VCR Benefit	*$1.84m*
ENS Penalty	*$0.00m*
All other risk benefits	*$0.06m*
Total Risk benefits	$1.90m
Benefits in the financial NPV*	$0.06m
**excludes VCR benefits*	
Benefits in the economic NPV**	$1.90m
***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$3.83m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	$0.00m	Re-investment capital	$0.00m
Capitalisation period	3.00 Yrs	Start of the re-investment period	2024-25

Attachment 2 – Summary of Preferred Option

Over Voltage Control After AUFLS Event	The National Electricity Rules requires all market customers with peak demands at connection points in excess of 10 MW to have at least 60% of their load available for shedding by under-frequency relays. The studies indicate that overvoltage would occur following an automatic under-frequency load shedding event due to an oversupply of capacitive reactive support. Implementation of an over-voltage control scheme to configure existing, salient reactive plant, to utilise a reduced time settings when the system frequency is below a certain level, would reduce the capacitive reactive power support in the network during an under-frequency load shedding event. This could avoid the loss of an additional 20% loads on the system post-contingent.
Transmission circuit / Injection point	On all main grid capacitor locations: Tomago, Newcastle, Vales Point, Beaconsfield, Sydney East, Sydney North, Sydney South, Sydney West, Kemps Creek, Regentville, Vineyard, Armidale, Dapto, Darlington Pt, Lismore, Muswellbrook, Tamworth330, Tuggerah, Wagga 330, Wellington, Yass
Scope of works	Implementation of over-voltage control schemes to automatically configure all the existing capacitive plants to utilise reduced time-settings when the system frequency is below a certain level.
Reasons to undertake the project	Mitigate against additional loss of loads following an AUFLS event by the implementation of a voltage control scheme that automatically configure all the existing capacitive plants to utilise reduced time-settings when the system frequency is below a certain level.
Current value of the limit	0 MW for 4 hours (the loss of an additional 20% loads on the system following under-frequency load shedding event)
Target limit	1200 MW average supply to customers for 4 hours following under-frequency load shedding event
Capital cost	The total capital cost is $3.83M (un-escalated)
Operating cost	Nil
Market benefits	Benefit = Pre-option Risk Cost – Post-option Risk Cost Benefit = failure rate * failure duration * load form factor * (load – load shed due to AUFLS) * VCR = (1/100) * (4) * (0.5 * 12,000 * 0.2) * (38.35 * 1,000) = $1.84 million
Pay-back period	2.02 years
Completion date	Within the regulatory period 2018-2023

Attachment 3 – Base case Risk Cost Summary

Current Option Assessment - Risk Summary

Project Name: Over voltage control after an AUFLS event

Option Name: 1520 - Base case

Option Assessment Name: 1520 - Option 1 - Assessment 1

Rev Reset Period: Next (2018-23)

Major Component	No.	Minor Component	Sel. Hazardous Event	LoC x CoF ($M)	Failure Mechanism	NoxLoC xCoF ($M)	PoF (Yr 1)	Total Risk ($M)	Risk ($M) (Rel)	Risk ($M) (Op)	Risk ($M) (Fin)	Risk ($M) (Peo)	Risk ($M) (Env)	Risk ($M) (Rep)
Structure	1	Steel Structure	Unplanned Outage - HV (Structure)	$190.38	Structural Failure	$190.38	1.00%	$1.90	$1.85		$0.00			$0.06
				$190.38		$190.38		$1.90	$1.85		$0.00			$0.06

Total VCR Risk: $1.84 **Total ENS Risk:** $0.00

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