OPTIONS EVALUATION REPORT (OER)

Capacitors to improve NSW-VIC limits

OER- 000000001699 revision 2.0

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

Project reason: Economic Efficiency - Network developments to achieve market benefits
Project category: Prescribed - NCIPAP

Approvals

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Date submitted for approval	29/11/2016	

Change history

Revision	Date	Amendment
0	November 2016	Initial issue

1. Need/opportunity

According to recent historical performance of the NSW - VIC interconnector, NSW export to Victoria is often limited due to the following constraint:

> N^^V_NIL_1: Avoid voltage collapse in southern NSW for loss of the largest VIC generating unit or Basslink

The above voltage stability limit can be improved by adding capacitor banks at Canberra, Williamsdale or Stockdill (future). The addition of a 100 MVAr capacitor at these locations will realise an increase of about 30 MW in the transfer limit[1].

2. Related needs/opportunities

Need ID 9031/DCN335 - Construction of Stockdill substation.

> If the location of the southern capacitor bank is to be constructed at Stockdill, then this will need to be incorporated in the Stockdill project.

3. Options

3.1 Base case

The cost to the market each year for the "do nothing" option is valued at $0.79 million per year. This will be realised as market benefit if either option A, B, or C is implemented.

Market impact calculation

The market benefit due to a new 100 MVAr capacitor is estimated using the following assumptions:

Market impact due to NSW export limit binding[2] = $15/MWh

Probability of NSW export to VIC limit binding = 20%[3]

Market impact = [{(Probability of NSW export limit binding) * (Market impact due to NSW export limit binding) * (MW increase in NSW export due to 100 MVAr capacitor)}] * (duration)

Market impact = $[{0.2*15* 30}]*24*365 = $0.79 million /year

Market impact = $0.79 million/year

[1] Estimated based on the limit provided in Operating Manual 520 – Operation of Main Grid Under Normal Conditions

[2] Based on the difference between VIC Brown Coal variable costs and typical Renewable Generation bid price of $0 (or less) – refer page 61 of Jacobs report "Retail electricity price history and projections.pdf" filed in PDGS supporting documents for VIC Brown Coal Price details. VIC price is expected to be at higher end following retirement of Hazelwood Coal Power Station. Hence, high -range Coal prices in VIC was used. Accordingly, Market impact = $15 - $0 = $15.

[3] Based on total duration of the constraint N^^V_NIL_1 binding historically , expected change in NSW export to Victoria due to retirement of Hazelwood power station in Victoria, and expected increase in NSW Renewable Generation. Average Hazelwood generation in 2015-16 was 1200 MW. It is assumed that about 50% of this generation would be supplied from NSW/QLD and Renewables in NSW.

3.2 Option A – 100 MVAr capacitor at Canberra substation (OSA 1699, OFS 1699A)

This option is to install 100 MVAr 330 kV capacitor at Canberra 330/132 kV Substation.

The following scope of work is associated with the installation of a 330 kV 100 MVAr capacitor bank at Canberra substation:

- Installation of a 330 kV 100 MVAr capacitor bank
- Installation of a 330 kV switchbay including a Point on Wave circuit breaker
- Installation of secondary systems associated with the control and protection of the capacitor bank.

This option is technically feasible and will achieve a 30 MW increase in NSW export to VIC and a 75 MW increase in NSW import from VIC.

The expected capital cost for this option is $3.61 million ± 25% (in un-escalated 2016/17 dollars). The project is expected to be completed in an estimated 21 months from the issue of a Request for Project Scoping (RPS).

However, this option is not preferred due to the ACT Government requirement of having transmission capacity to supply ACT system if the whole Canberra substation is not available as a result of a catastrophic failure/ natural disaster. Additionally, for the total catastrophic loss of Canberra substation, having the capacitors available at other locations ensures the ongoing stability of the interconnector for this event.

With the reduction in transformers at Canberra (to 2 transformers) following the construction of Stockdill substation, a planned outage of one transformer at Canberra combined with the unplanned outage of the second transformer will deplete the reactive power support for the 330 kV transmission (from all existing 132 kV capacitor banks). This scenario supports the case for placing the new capacitor bank elsewhere.

3.3 Option B – 100 MVAr capacitor at Williamsdale substation (OSA 1699, OFS 1699B)

This option is to install 100 MVAr 330 kV capacitor at Williamsdale 330/132 kV Substation.

The following scope of work associated with the installation of a 330 kV 100 MVAr capacitor bank at Williamsdale Substation.

- Minimum Scope of Works:
  - Installation of a 330 kV 100 MVAr capacitor bank
  - Installation of one 330 kV switchbay including a Point on Wave circuit breaker
  - Installation of rigid busbar for connection of the new switchbay to the new capacitor
  - Installation of secondary systems associated with the control and protection of the capacitor bank
  - Modification of the No.3 Transformer control and protection systems for operation in the new arrangement.
- Additional Scope of Works:
  - Installation of one 330 kV switchbay including a Point on Wave circuit breaker
  - Installation of high voltage connections between the new switchbay and No.3 Transformer
  - Installation of rigid busbar for the connection to the new switchbay
  - Modification of the No.1 Transformer control and protection systems for operation in the new arrangement.

This option is technically feasible and will achieve a 30 MW increase on NSW export to VIC and a 75 MW increase in NSW import from VIC.

The minimum scope of works arrangement has the operational limitation that the capacitor cannot be in service whenever the No.1 Transformer is out of service. The additional scope of works includes the installation of an additional 330kV switchbay and high voltage connections to allow the 330kV equipment be operated as a mesh substation arrangement.

The expected capital cost for this option is $5.94 million ± 25% (in un-escalated 2016/17 dollars). However, the minimum scope of works would cost only $3.98 million ± 25% (in un-escalated 2016/17 dollars). The project is expected to be completed in an estimated 23 months from the issue of a Request for Project Scoping (RPS).

Item	Cost ($m)
Minimum Scope of Works	3.98
Additional Scope of Works	1.96
TOTAL PROJECT COST	**5.94**

3.4 Option C – 100 MVAr capacitor at Stockdill substation (OSA 1699, OFS 1699C)

This option is to install 100 MVAr 330 kV capacitor at Stockdill 330/132 kV substation.

The following scope of work associated with the installation of a 330 kV 100 MVAr capacitor bank at Stockdill substation.

- Extension of the switchyard bench
- Installation of a 330 kV 100 MVAr capacitor bank
- Installation of a 330 kV switchbay including a Point on Wave circuit breaker
- Installation of rigid busbar for connection of the new capacitor switchbay to the existing busbar
- Installation of secondary systems associated with the control and protection of the capacitor bank.

This option is technically feasible and will achieve a 30 MW increase on NSW export to VIC and a 75 MW increase in NSW import from VIC.

The expected capital cost for this option is $5.51 million ± 25% (in un-escalated 2016/17 dollars). The project is expected to be completed in an estimated 23 months from the issue of a Request for Project Scoping (RPS).

4. Evaluation

All the options (base case, options A, B and C) are technically feasible.

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

The full financial and economic evaluations are shown in Attachment 1.

Table 1 — Commercial evaluation ($ million)

Option	Description	Total capex ($m)	Annual opex ($m)	Annual post project risk cost /Benefit ($m)	Economic NPV @ 10%	Rank
Base case	Do nothing			0		-
A	100 MVAr capacitor at Canberra substation[4]	3.61	0.07	-0.79 (Benefit)	N/A	N/A
B	100 MVAr capacitor at Williamsdale substation	5.94	0.12	-0.79 (Benefit)	-0.16	2
C	100 MVAr capacitor at Stockdill substation	5.51	0.11	-0.79 (Benefit)	0.29	1

The commercial evaluation for Option C is based on:

Discount Rate (%)	Economic NPV ($m)
6.75	2.23
13.00	-0.75

Preferred option

The preferred option is Option C – 100 MVAr capacitor at Stockdill substation, as described in OSA 1699 and assessed in OFS 1699C, as it addresses the need and results in a positive NPV.

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

Payback period

Expected payback period for Option C is approximately about 8.26 years.

Capital and operating expenditure

There is no expected material increase in operating expenditure for the preferred option over and above the 2% expected operating expenditure related to installing additional plant in the network.

[4] This option is not preferred due to ACT Government requirements.

Regulatory Investment Test

The RIT-T is not required as the cost of the preferred option is under $6 million.

5. Recommendation

It is recommended that a NCIPAP project be initiated to implement Option C – 100 MVAr capacitor at Stockdill substation, in the period 2019-23. This option is technically feasible and yields a yearly benefit of $0.7m (includes market benefit $0.79m and ongoing opex $0.11m).

Attachment 1 – Financial and Economic Reports

Project_Option Name	Need 1699 - Option B - 100 MVAr capacitor at Williamsdale

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	-$0.16m	*NPV / Capital (Ratio)*	*-0.03*
NPV @ upper bound rate	13.00%	-$1.17m	*Pay Back Period (Yrs)*	*0.10 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$1.74m	*IRR%*	*9.65%*

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%	-$0.16m	*NPV / Capital (Ratio)*	*-0.03*
NPV @ upper bound rate	13.00%	-$1.17m	*Pay Back Period (Yrs)*	*9.05 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$1.74m	*IRR%*	*9.65%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$0.00m*
Systems (reliability)	*$0.00m*	*$0.00m*	*$0.00m*	*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	$0.00m
People (safety)	*$0.00m*	*$0.00m*	*$0.00m*		
Environment	*$0.00m*	*$0.00m*	*$0.00m*	Benefits in the financial NPV*	$0.79m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$0.00m	$0.00m	$0.00m		
Cost savings and other benefits			$0.79m	Benefits in the economic NPV**	$0.79m
Total Benefits			$0.79m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	-$0.12m	Write-off cost	$0.00m
Capital - initial $m	-$5.94m	Major Asset Life (Yrs)	40.00 Yrs
Residual Value - initial investment	$1.78m	Re-investment capital	$0.00m
Capitalisation period	2.00 Yrs	Start of the re-investment period	0.00 Yrs

Project_Option Name	Need 1699 - Option C - 100 MVAr capacitor at Stockdill

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	$0.29m	*NPV / Capital (Ratio)*	*0.05*
NPV @ upper bound rate	13.00%	-$0.75m	*Pay Back Period (Yrs)*	*0.11 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$2.23m	*IRR%*	*10.70%*

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%	$0.29m	*NPV / Capital (Ratio)*	*0.05*
NPV @ upper bound rate	13.00%	-$0.75m	*Pay Back Period (Yrs)*	*8.26 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$2.23m	*IRR%*	*10.70%*

Benefits

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

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.11m	Write-off cost	$0.00m
Capital - initial $m	-$5.51m	Major Asset Life (Yrs)	40.00 Yrs
Residual Value - initial investment	$1.65m	Re-investment capital	$0.00m
Capitalisation period	2.00 Yrs	Start of the re-investment period	0.00 Yrs

Attachment 2 – Summary of Preferred Option

NSW-VIC Interconnector Constraint	**According to recent historical performance of the NSW - VIC interconnector, NSW export to Victoria is often limited due to the following constraint:** **1. N^^V_NIL_1: Avoid voltage collapse in southern NSW for loss of the largest VIC generating unit or Basslink** **The above voltage stability limit can be improved by adding capacitor banks at Wagga (40 MW per 100 MVAr), Canberra (30 MW per 100 MVAr) and Yass (46 MW per 100 MVAr). The addition of a 100 MVAr capacitor at Stockdill (future substation) or Williamsdale will also realise an increase of about 30 MW in the transfer limit.**
Transmission Circuit / Injection Point	Stockdill 330/132 kV Substation
Scope of works	Installation of 330 kV 100 MVAr capacitor bank at Stockdill as per OSA-1699 and OFS-1699C
Reasons to undertake the project	Relieve voltage stability limits that cause constraints on NSW export to Victoria, increase interconnector capability
Current value of the limit	Market impact = [{(Probability of NSW export limit binding) * (Market impact due to NSW export limit binding) * (MW increase in NSW export due to 100 MVAr capacitor)}] * (duration) = $[{0.2*15* 30}]*24*365 Market impact = $0.79 million /year
Target limit	Remove voltage stability limits that constrain NSW export to VIC at certain times. Market benefit = $0.79 million/year (based on 100 MVAr capacitor).
Priority project improvement target	Increase transfer limits on NSW-VIC interconnector
Capital Cost	$5.51 million
Operating Cost	$110k per annum
Market benefits	Market Benefit = $0.79 million per annum
Pay-back period	Pay-back period = 8.26 years
Completion date	Over the 2018-23 period