OPTIONS EVALUATION REPORT (OER)

50V and 110V NiCad Battery Condition

OER 000000001360 revision 3.0

Ellipse project no.: P0007988
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Project reason: Capability - Asset Replacement for end of life condition
Project category: Prescribed - Replacement

Approvals

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Date submitted for approval	14 December 2016	

Change history

Revision	Date	Amendment
0	23 June 2016	Initial issue
1	31 October 2016	Update to 2016/17 dollars and SFAIRP/ALARP data
2	13 December 2016	Update to format
3	14 December 2016	Minor amendment

1. Need/opportunity

Nickel Cadmium batteries are used throughout the NSW network to provide a continuous supply of power to site equipment during a loss of primary supply across all voltage levels. The availability of an uninterruptible power supply is crucial particularly during a black event. The assets investigated under this Need are aged battery banks that have reached the end of their technical life resulting in reduced capabilities to meet backup supply performance requirements.

The use of battery banks to provide backup power supplies during an outage event are a continuing requirement of the Australian Energy Regulator (AER) as outlined in the National Electricity Rules (NER). Backup power supply systems are required into the foreseeable future.

2. Related Needs/opportunities

The following Need would benefit from coordination with these works:

- Need ID 1362 – 50V and 110V Battery Charger Condition

3. Options

All dollar values in this document are expressed in un-escalated 2016/17 dollars.

Base Case

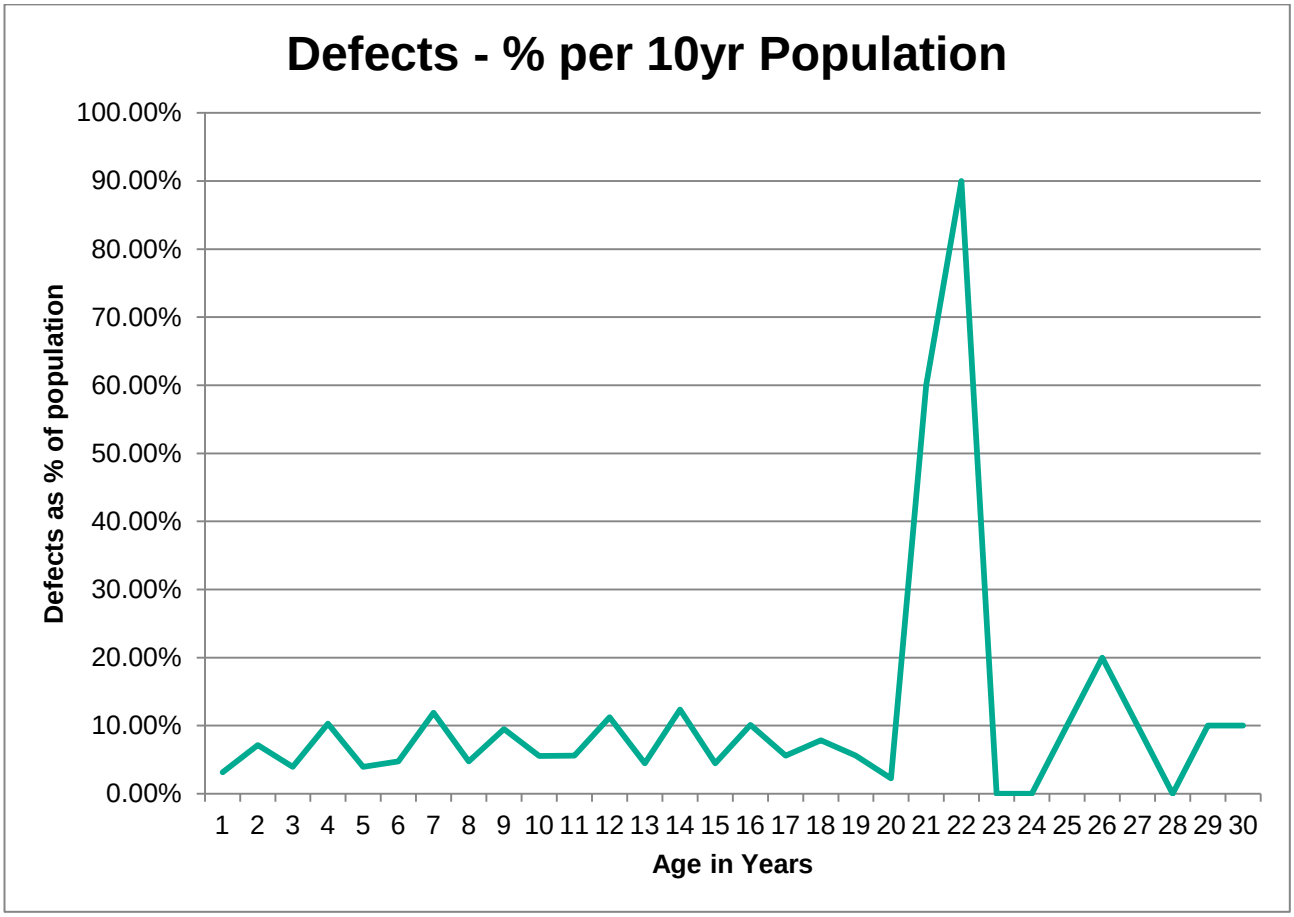
The Base Case for this Need is to run these assets to failure. This approach does not address the increasing failure rates or the risk cost associated with the Need. At $27.10m per annum, the risks are significant and foreseen to increase as the probability of failure of the assets will also likely increase. Key drivers for this risk cost are:

- Probability of asset failure
- Consequence assumes loss of load for a site with “N-1” redundancy. The restoration time has been set as 8 hours with an assumed 150MW of load interrupted to mixed customers (residential, commercial, and agricultural) to model a number of potential network scenarios based on this consequence.
- The total population of this asset group at 226 banks across all voltage levels and sites within the network.

Increasing the maintenance for the assets cannot reduce the probability of failure in order to reduce the risk cost.

A summary of defect rates based on age at defect has been provided in Figure 1. The percentages are calculated as defects per population per age bracket. This has taken the assumption that the age spread of assets has remained similar historically:

Figure 1 – Defect rates based on age



Option A — Replace Batteries at Various Locations [OFR 1360A, OFS 1360A]

This option covers the replacement of 40 assets in a “like for like” manner for 110V battery banks and replacement with Rack Power Supply (RPS) systems for 50V battery banks. This involves removing the existing battery bank and installing new cells in the same position for 110V and involves removing the existing battery bank and installing an RPS system for 50V.

Operating costs have been estimated at $67.80k per annum for this option based on current maintenance plan settings.

Due to the “like for like” nature of this option, no benefit has been calculated in accordance with TransGrid’s Renewal and Maintenance Strategy for Secondary Systems Site Installations1. It is noted however that maintenance costs would be reduced for RPS systems due to the lack of a need for routine maintenance.

The expected total capital cost to replace every asset identified under this Need is $2.42m. This costing is estimated using TransGrid’s “Success” estimating system. There is a reinvestment of $0.95m in 10 years due to the shorter life of modern RPS systems.

The residual risk associated with this option upon completion of the project amounts to $17.50m per annum (base case risk cost = $27.10m). The risk reduction is realised through the reduction in the probability of failure for all assets.

Option A has been identified as the only technically viable option as refurbishment of the batteries is not possible.

The assets under investigation have been categorised into four age brackets for the purpose of risk assessment:

[1] Refer SSA Strategy - Renewal and Maintenance - Secondary Systems Site Installations

Assets with an age <10

There are 128 assets within this grouping and all have been determined as meeting their requirements and have not been assessed further.

Assets with an age >10 and <=20 years

This configuration covers only replacing 29 out of 89 assets with a current age between 11 and 20 years.

The expected capital cost to replace this category of assets is $1.75m. This costing was estimated using the unit costs provided under Option Feasibility Study (OFS) OFS 1360A and applying them to those assets that would be replaced. These costs are broken down in Table 1.

Table 1 – Expected costs for replacing assets with an age >10 and <=20 years ($ thousand)

Battery Voltage	Unit Cost, Including Labour	Quantity	Total Cost
110V	63	16	1,000
50V	58	13	749
Total estimated cost			**1,750**

The residual risk associated with this portion of assets upon completion of the project amounts to $5.32m per annum (base case risk cost component = $6.82m). The risk reduction is realised through the reduction in the probability of failure for the affected assets.

Assets with an age >20 and <=30 years

This configuration covers replacing all assets with a current age between 21 and 30 years.

The expected capital cost to replace this category of assets is $0.62m. This costing was estimated using the unit costs provided under OFS 1360A and applying them to those assets that would be replaced. These costs are broken down in Table 2.

Table 2 – Expected costs for replacing assets with an age >20 and <=30 years ($ thousand)

Battery Voltage	Unit Cost, Including Labour	Quantity	Total Cost
110V	63	7	444
50V	58	3	173
Total estimated cost			**617**

The residual risk associated with this portion of assets upon completion of the project amounts to $0.255m per annum (base case risk cost component = $4.93m). The risk reduction is realised through the reduction in the probability of failure for the affected assets.

Assets with an age >30 years

This configuration covers replacing all assets with a current age greater than 30 years.

The expected capital cost to replace this category of assets is $0.06m. This costing was estimated using the unit costs provided under OFS 1360A and applying them to those assets that would be replaced. These costs are broken down in Table 3.

Table 3 – Expected costs for replacing assets with an age >30 years ($ thousand)

Battery Voltage	Unit Cost, Including Labour	Quantity	Total Cost
110V	63	0	0
50V	58	1	58
Total estimated cost			**58**

The residual risk associated with this portion of assets upon completion of the project amounts to $0.03m per annum (base case risk cost component = $3.46m). The risk reduction is realised through the reduction in the probability of failure for the affected assets.

4. Evaluation

Evaluation of the proposed options has been completed using the ALARP (As Low as Reasonably Practicable) regulatory requirements and economic considerations. The results of this evaluation are outlined below.

4.1 Commercial evaluation

The result of commercial evaluation for each of the technically feasible options is summarised in Table 4.

Table 4 – Commercial evaluation ($ million)

Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Financial NPV @10%	Rank
Base Case	Run-to-fail	N/A	0.07	27.10	N/A	N/A	2
A	Replace Batteries at Various Locations	2.42	0.07	17.50	48.20	2.55	1
i)	Age 0-10 years	N/A	0.03	11.90	N/A	N/A	-
ii)	Age 11-20 years	1.75	0.03	5.32	6.22	(0.83)	-
iii)	Age 21-30 years	0.62	0	0.26	24.20	1.93	-
iv)	Age 31-40 years	0.06	0	0.03	17.90	1.71	-

The commercial evaluation is based on:

- Economic life of the NiCd assets is assumed as 20 years, hence this assessment period has been applied
- RPS systems have an estimated life of up to 10 years and as such a reinvestment has been applied at this point
- Write-offs have not been estimated
- Capital cost is not escalated and it does not include capitalised interest

Sensitivities on economic Net Present Value (NPV) for the options with changing discount rates are shown in Table 5.

Table 5 – Discount rate sensitivities ($ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Replace Batteries at Various Locations	34.40	71.80
ii)	Age 11-20 years	4.21	9.68
iii)	Age 21-30 years	17.40	35.80
iv)	Age 31-40 years	15.30	21.30

4.2 SFAIRP/ALARP evaluation

Options to reduce the network safety risk as per the risk treatment hierarchy have been considered in other lifecycle stages of the asset, and it has been determined that no reasonably practicable options exist to reduce the risk further than those capital investment options listed below.

Evaluation of the proposed options has been completed against the SFAIRP (So Far As Is Reasonably Practicable)/ALARP (As Low As Reasonably Practical) obligation, as required by the Electricity Supply (Safety and Network Management) Regulation 2014 and the Work Health and Safety Act 2011. The Key Hazardous Events and the disproportionality multipliers considered in the evaluation are as follows:

> Conductor drop/structure failure - 6 times the bushfire risk, 6 times the safety risk and 10% of the reliability risk (applicable to safety)

The results of this evaluation are summarised in the tables below.

Table 6 – Feasible options ($ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A
A	Replace Batteries at Various Locations	2,420	15 years	120

Table 7 – Annual risk calculations ($ thousand)

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	107	24,241	3	N/A	N/A	N/A
A	70	15,783	2	37	8,638	1

Table 8 – Reasonably practicable test ($ thousand)

Option	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?

[2] The Network Safety Risk Reduction is calculated as 6 x Bushfire Risk Reduction + 3 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction

[3] Reasonably practicable is defined as whether the annualised CAPEX is less than the Network Safety Risk Reduction

Option	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?
A	981	120	Yes

Option A is reasonably practicable

4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that Option A is the preferred option as it is reasonably practicable and provides the greatest network safety risk reduction, and is therefore required to satisfy the organisation's SFAIRP/ALARP obligations.

The option to address the condition of the identified assets, Option A – Replacement of Selected Assets is the preferred option for each of the three categories of assets identified.

This option has been selected due to its technical viability, positive economic NPV and reduction in reliability risk.

Refer to Attachment 1 for details of the assets to be replaced under this Need.

Capital and operating expenditure

There is negligible difference in predicted ongoing operational expenditure between the option and Base Case. Implementing Option A will reduce callouts to address defects and this benefit has been captured in the risk assessment. These have been captured as benefits for delivering the project.

Regulatory Investment Test

A Regulatory Investment Test for Transmission (RIT-T) is not required as this is an asset replacement project with no augmentation component.

5. Recommendation

It is recommended to proceed with the replacement of all 40 identified assets with NiCd battery banks for the 110V voltage level and 50V RPS systems for the 50V voltage level.

Attachment 1 – Assets for replacement

A.1 110V

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000053163	SS	SWSANMBAT12	ANM NO2 110V BATTERY AND CHARGER	ANM
000000059887	SS	NNSBAYBAT1A	NO1 110V STATION BATTERY AND CHARGER	BAY
000000059889	SS	NNSBAYBAT1B	NO2 110V STATION BATTERY AND CHARGER	BAY
000000057996	SS	SYSBUKBAT12	BURRINJUCK NO2 110V BATTERY & CHARGER	BUK
000000075552	SS	NTSDMQBAT1A	NO1 120V BATTERY AND CHARGER	DMQ
000000075553	SS	NTSDMQBAT1B	NO2 120V BATTERY AND CHARGER	DMQ
000000071455	SS	SWSGRFBAT12	GRIFFITH NO2 110V BATTERY AND CHARGER	GRF
000000053427	SS	SWSGRFBAT11	GRIFFITH NO1 110V BATTERY AND CHARGER	GRF
000000048637	SS	NTSINVBAT1A	NO1 120V BATTERY AND CHARGER	INV
000000052969	SS	CMSKVSBAT11	KANGAROO VALLEY #1 110V STATION BATTERY	KVS
000000052970	SS	CMSKVSBAT12	KANGAROO VALLEY #2 110V STATION BATTERY	KVS
000000048033	SS	NTSKLKBAT1A	NO1 120V BATTERY AND CHARGER	KLK
000000049832	SS	NTSLSMBAT1B	NO2 120V BATTERY AND CHARGER	LSM
000000071314	SS	COSMPPBAT01	MT PIPER 132KV #1 110V BATT & CHARGERS	MPP
000000060637	SS	NNSNECBAT1B	NO2 110V STATION BATTERY AND CHARGER	NEC
000000060636	SS	NNSNECBAT1A	NO1 110V STATION BATTERY AND CHARGER	NEC
000000060651	SS	NNSPMQBAT1B	NO2 110V STATION BATTERY AND CHARGER	PMQ
000000060658	SS	NNSTOMBATA11	TOMAGO 330 MAIN NO1 110V BATTERY & CHAR	TOM
000000060666	SS	NNSVP1BAT1A	N01 110V STATION BATTERY AND CHARGER	VP1
000000070959	SS	CMSVYDBAT12	VINEYARD #2 110V STATION BATTERY	VYD
000000070958	SS	CMSVYDBAT11	VINEYARD #1 110V STATION BATTERY	VYD

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
SWSYA2BAT12	SS	SWSYA2BAT12	YANCO NO2 110V STATION BATTERY & CHARGER	YA2
000000057207	SS	SWSYA2BAT11	YANCO NO1 110V STATION BATTERY & CHARGER	YA2

A.2 50V

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000053164	SS	SWSANMBAT21	ANM NO1 50V BATTERY AND CHARGER	ANM
000000059893	SS	NNSBAYBAT2A	NO1 50V COMMS BATTERY AND CHARGER	BAY
000000059895	SS	NNSBAYBAT2B	NO2 50V COMMS BATTERY AND CHARGER	BAY
000000065778	SS	COSBERBAT03	BERYL #1 50V BATTERY AND CHARGER	BER
000000065781	SS	COSCW2BAT03	COWRA #1 50V BATTERY AND CHARGER	CW2
000000065790	SS	COSFB2BAT03	FORBES #1 50V BATTERY AND CHARGER	FB2
000000053428	SS	SWSGRFBAT21	GRIFFITH NO1 50V COMMS BATTERY & CHARGER	GRF
000000053518	SS	SWSJDABAT21	JINDERA NO1 50V BATTERY & CHARGER	JDA
000000053519	SS	SWSJDABAT22	JINDERA NO2 50V BATTERY & CHARGER	JDA
000000052971	SS	CMSKVSBAT21	KANGAROO VALLEY #1 50V COMM BATTERY	KVS
000000052972	SS	CMSKVSBAT22	KANGAROO VALLEY #2 50V COMM BATTERY	KVS
000000071316	SS	COSMPPBAT03	MT PIPER 132KV #1 50V BATT & CHARGERS	MPP
000000048247	SS	NTSNB2BAT2A	NO1 50V BATTERY AND CHARGER	NB2
000000060652	SS	NNSPMQBAT2A	NO1 50V COMMS BATTERY AND CHARGER	PMQ
000000053635	SS	SWSTU2BAT21	TUMUT NO1 50V COMMS BATTERY & CHARGER	TU2
000000070960	SS	CMSVYDBAT21	VINEYARD #1 50V COMMUNICATION BATTERY	VYD
000000070961	SS	CMSVYDBAT22	VINEYARD #2 50V COMMUNICATION BATTERY	VYD

Attachment 2 – Commercial evaluation report

Option A NPV calculation

Project_Option Name	Need ID 1360 - 50V and 100V NiCd Battery Condition - Option A

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	$2.55m	*NPV / Capital (Ratio)*	*1.05*
NPV @ upper bound rate	13.00%	$1.46m	*Pay Back Period (Yrs)*	*0.22 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$4.48m	*IRR%*	*21.92%*

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%	$48.23m	*NPV / Capital (Ratio)*	*19.90*
NPV @ upper bound rate	13.00%	$34.41m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	$71.81m	*IRR%*	*83.18%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$8.64m*
Systems (reliability)	*$24.42m*	*$15.78m*	*$8.64m*	*ENS Penalty*	*$0.00m*
Financial	*$2.60m*	*$1.69m*	*$0.91m*	*All other risk benefits*	*$0.95m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$9.59m
People (safety)	*$0.11m*	*$0.07m*	*$0.04m*		
Environment	*$0.00m*	*$0.00m*	*$0.00m*	Benefits in the financial NPV*	$0.95m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$27.13m	$17.54m	$9.59m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$9.59m
Total Benefits			$9.59m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	-$0.07m	Write-off cost	$0.00m
Capital - initial $m	-$2.42m	Major Asset Life (Yrs)	20.00 Yrs
Residual Value - initial investment	$0.07m	Re-investment capital	-$0.95m
Capitalisation period	5.00 Yrs	Start of the re-investment period	2028-29

Option A(ii) NPV calculation

Project_Option Name	Need ID 1360 - 50V and 100V NiCd Battery Condition - Option A

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$0.83m	*NPV / Capital (Ratio)*	*-0.48*
NPV @ upper bound rate	13.00%	-$0.87m	*Pay Back Period (Yrs)*	*0.01 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$0.71m	*IRR%*	*0.93%*

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%	$6.22m	*NPV / Capital (Ratio)*	*3.55*
NPV @ upper bound rate	13.00%	$4.21m	*Pay Back Period (Yrs)*	*1.19 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$9.68m	*IRR%*	*38.62%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$6.14m*	*$4.81m*	*$1.33m*	*VCR Benefit*	*$1.33m*
Financial	*$0.65m*	*$0.51m*	*$0.14m*	*ENS Penalty*	*$0.00m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.17m*
People (safety)	*$0.03m*	*$0.00m*	*$0.03m*	Total Risk benefits	$1.50m
Environment	*$0.00m*	*$0.00m*	*$0.00m*	Benefits in the financial NPV*	$0.17m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$6.82m	$5.32m	$1.50m		
Cost savings and other benefits			-$0.00m	Benefits in the economic NPV**	$1.50m
Total Benefits			$1.50m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.03m	Write-off cost	$0.00m
Capital - initial $m	-$1.75m	Major Asset Life (Yrs)	20.00 Yrs
Residual Value - initial investment	$0.05m	Re-investment capital	-$0.73m
Capitalisation period	5.00 Yrs	Start of the re-investment period	2028-29

Option A(iii) NPV calculation

Project_Option Name	Need ID 1360 - 50V and 100V NiCd Battery Condition - Option A

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	$1.93m	*NPV / Capital (Ratio)*	*3.13*
NPV @ upper bound rate	13.00%	$1.30m	*Pay Back Period (Yrs)*	*0.36 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$3.03m	*IRR%*	*36.28%*

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%	$24.19m	*NPV / Capital (Ratio)*	*39.20*
NPV @ upper bound rate	13.00%	$17.35m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	$35.84m	*IRR%*	*107.93%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$4.21m*
Systems (reliability)	*$4.44m*	*$0.23m*	*$4.21m*	*ENS Penalty*	*$0.00m*
Financial	*$0.47m*	*$0.03m*	*$0.45m*	*All other risk benefits*	*$0.47m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$4.68m
People (safety)	*$0.02m*	*$0.00m*	*$0.02m*		
Environment	*$0.00m*	*$0.00m*	*$0.00m*	Benefits in the financial NPV*	$0.47m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$4.93m	$0.26m	$4.68m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$4.68m
Total Benefits			$4.68m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	-$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$0.62m	Major Asset Life (Yrs)	20.00 Yrs
Residual Value - initial investment	$0.00m	Re-investment capital	-$0.17m
Capitalisation period	5.00 Yrs	Start of the re-investment period	2028-29

Option A(iv) NPV calculation

Project_Option Name	Need ID 1360 - 50V and 100V NiCd Battery Condition - Option A

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	$1.71m	*NPV / Capital (Ratio)*	*30.48*
NPV @ upper bound rate	13.00%	$1.46m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	$2.04m	*IRR%*	*562.50%*

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%	$17.85m	*NPV / Capital (Ratio)*	*318.75*
NPV @ upper bound rate	13.00%	$15.34m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	$21.28m	*IRR%*	*5723.21%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$3.12m*	*$0.23m*	*$2.89m*	*VCR Benefit*	*$2.89m*
Financial	*$0.33m*	*$0.03m*	*$0.31m*	*ENS Penalty*	*$0.00m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.32m*
People (safety)	*$0.01m*	*$0.00m*	*$0.01m*	Total Risk benefits	$3.21m
Environment	*$0.00m*	*$0.00m*	*$0.00m*	Benefits in the financial NPV*	$0.32m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$3.46m	$0.26m	$3.21m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$3.21m
Total Benefits			$3.21m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$0.06m	Major Asset Life (Yrs)	10.00 Yrs
Residual Value - initial investment	$0.00m	Re-investment capital	-$0.06m
Capitalisation period	1.00 Yrs	Start of the re-investment period	2028-29