31st Jan 2017

MurrayLink Transmission Company Pty Ltd

Revenue Proposal

CAPITAL EXPENDITURE BUSINESS CASES - Public

Prepared by APA Group on behalf of Energy Infrastructure Investments

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Contents

1 Executive Summary

This document presents the background and justifications for proposed capital expenditure during the Regulated Revenue Period effective July 2018 to June 2023 applicable to the MurrayLink High Voltage Direct Current Transmission System.

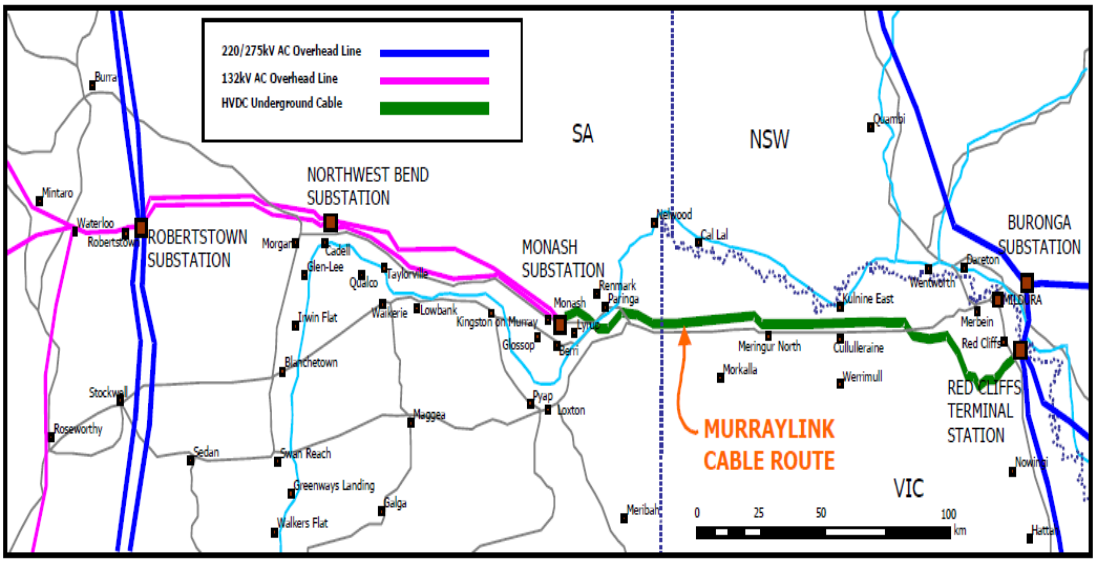
The information contained in this document is consistent with the Asset Management Plan that was approved by the Board of Energy Infrastructure Investments. These projects are consistent with all EII corporate governance, strategy and asset management policies. It is also consistent with the requirements of relevant state and national legislation.

2 Background

Murraylink is a 176 kilometre bipolar High Voltage Direct Current (HVDC) cable and converter stations located between Redcliffs (Victoria) and Berry (South Australia).

There is one circuit of 2 cables operating at ±150kV DC capable of transmitting up to 220MW. The system was commissioned in 2002 and became a regulated asset on 1 October 2003

The facility consists of the converter stations at Red Cliffs and Berri, the DC cables connecting them and the AC cables, switchgear and converter transformers connecting each converter station to the nearby AC substation (220kV Red Cliffs Terminal Station in Victoria and 132kV Monash Substation in South Australia).



3 Capital Summary

MurrayLink proposed Capital by project by year can be seen in the below table:

Table 2.1 – Detailed Capital Listing

Table 3.1: Capital Summary	2019 $'000	2020 $'000	2021 $'000	2022 $'000	2023 $'000
Cable relocation	77	77	77	77	77
Replacement of Control System	7,890	15,781	2,630	0	0
Spare IGBT's	523	262	274	274	274
Other minor capital works	75	154	44	13	615
VSD Refurbishment	0	0	562	0	0
Coms Site Huts x 2	153	0	0	0	0
Maintenance surveillance cameras	0	572	0	0	0
battery chargers	0	0	138	0	0
cable fault location relays	0	0	0	136	0
Spare Capacitors	1,050	204	204	204	204
Total	9,769	17,050	3,930	704	1,171

4 Business Cases

4.1 CABLE RELOCATION

4.1.1 Project Description

Two currently proposed relocations of the DC cable route have been planned for the regulatory period 2019-2023

4.1.2 Background/Problem

The Murraylink cable was impacted by the weigh bridge and fruit fly inspection station construction on the South Australian – Victorian border in 2011, with the Murraylink cable left in situ between the building and the weigh bridge. A recent review, of the engineering assessment criteria for construction around the cables, has identified the need to relocate that section of cable so as to be clear of the adjacent structures. This work will ensure the long term service reliability of the cable.

The Murraylink cable will be impacted in the next revenue period by a realignment of the Sturt Highway between Berri and Monash in South Australia. The installation of the cables will need to be modified to protect it from any impact associated with the highway above.

4.1.3 *Impacts to Operations, Maintenance or Safety*

No material impact is expected on normal daily operational maintenance of the sites / corridor, however the initiation of this project will have a significant impact on resources, cost and outage time.

4.1.4 *Justification under the NER*

These projects are required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The expenditure for this equipment is justified under clauses (3) and (4), being required protect the long term position of the cable / route

4.1.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	Do Nothing.	This is not prudent because of the potential impacts	N/A

4.1.6 *Funding and Estimating*

Forecast Cost:

The following table represents the estimated project execution costs:

Forecast Cost		
No	**Description**	
1	Specification / Administration **(Inspection Station)**	$15,400
1.2	Relocation Project (350m)	$124,500
1.3	APA Supervision (Contractor)	$40,100
1.4	APA Management	$18,000
	Sub Total	$198,000
1	Specification / Administration **(Roundabout)**	$15,400
1.2	Relocation Project (250m)	$115,500
1.3	APA Supervision (Contractor)	$40,100
1.4	APA Management	$17,100
	Sub Total	$188,100
	Forecast Annual Expenditure	$386,100

Basis of Estimate:

This is a provisional quote based on construction industry rates and estimates of duration, length and complexity.

Assumptions and Calculations Used in Financial Analysis:

Note that the above estimate is in $2016 and has not been inflated to $2018.

4.1.7 *Prudency and Efficiency of Expenditure*

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) is that the expenditure must be such as would be incurred by a prudent service provider acting efficiently, and represent a realistic expectation of the costs to achieve the requirement.

These projects will be tendered to the market to achieve the most competitive solution.

4.1.8 *Recommendations*

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and
- represent a realistic expectation of the costs to achieve the requirement.

The proposed relocations are likely to occur during FY 2019-23 regulatory control period, based on the best market intelligence available.

4.2 CONTROL SYSTEM UPGRADE

4.2.1 *Project Description*

Upgrade of ABB MACH 2 Control System and associated hardware including windows operating systems, local and remote workstations, communications systems, input and output control cards. The upgrade will replicate existing operating characteristics.

Details of the Scope Items can be seen in the Funding Basis section below and in the Appendix report.

4.2.2 *Background/Problem*

The MurrayLink control system has not been materially modified since its commissioning.

Central to the current control system is an industrial computer based on embedded Microsoft Windows NT 4.0 operating system and an ABB Mach 2 control philosophy and hardware original to the 2002 installation.

Work has been undertaken to secure replacement hardware, however this has had limited success as the operating system has not been supported by Microsoft since December 2004 and the hardware vendors have similarly ended their support.

ABB, the original equipment manufacturer, have recommended the system be upgraded to resolve the problem of technical obsolescence. ABB have advised the end of life, for their support of the control system components, by 2021.

(confidential)

Given the removal of support and the age of the system there is an increased risk to the operation and reliability of the link should this equipment fail and spares are no longer available.

4.2.3 *Impacts to Operations, Maintenance or Safety*

It is proposed to establish a support agreement with the control system EOM to ensure the continued reliable operation of the current control system in the lead up to the upgrade project. The support agreement will continue after the upgrade and become focused on minimising the total cost of ownership of future control systems.

This OPEX increase has been included in the adjacent submissions and is estimated as:

OPEX Estimate		
No	**Description**	**$pa ($2016)**
1	OEM Support Agreement pre-upgrade.	$156,577
2	OEM Support Agreement post upgrade.	$500,000

4.2.4 Justification under the NER

For this item of forecast capital expenditure to be accepted by the AER, it must meet the capital expenditure objectives set out in the Rules as Cl. 6A.6.7(a).

The replacement of elements of the control system of MurrayLink is required to meet the following capital expenditure objectives set out in clause 6A.6.7(a) of the Rules:

(3) (iii) maintain the quality, reliability and security of supply of prescribed transmission services;

(iv) maintain the reliability and security of the transmission system through the supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The project is justified under clauses 6A.6.7(a)(3) and (4), being required to ensure the continued reliable operation of MurrayLink. The project will ensure that operation of the control systems remain reliable to minimise the risk of short and long term outages, should component failure occur and serviceable options no longer exist.

4.2.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	(confidential)	Chosen:	$26.3m
2	(confidential)	Not Chosen: Technical risk (explained below)	N/A
3	Do Nothing	Not Chosen: lack of spares and support for existing system make this option insufficient to ensure the ongoing supply and reliability of MurrayLink.	N/A

(confidential)

4.2.6 *Funding and Estimating (confidential)*

The following table represents the estimated project execution costs:

Forecast Cost (Nominal)						
No	**Description**	**Yr1**	**Yr2**	**Yr3**	**Yr4**	**Yr5**
1	Control System Capex	$6,300,000	$ 12,600,000	$ 2,100,000	-	-
2	Management	$ 213,125	$ 426,251	$ 71,042	-	-
3	Owners Engineer	$ 660,000	$ 1,320,000	$ 220,000	-	-
	APA Management	$ 717,313	$ 1,434,625	$ 239,104	-	-
	Forecast Annual Expenditure	$7,890,438	$ 15,780,876	$ 2,630,146	-	-

Basis of Estimate:

Pricing includes all engineering, design, supply, installation and commissioning and is based on the following scope:

1. Remove all superseded or obsolete computers, control cards (processor, communications, IO and power supply cards).

2. Replace all stations control and monitoring hardware and systems and all communications hardware.
3. Migrate functionality from the existing cooling system controls into the main converter control system.
4. Remove all superseded or obsolete scada systems and hardware.

4.2.7 *Prudency and Efficiency of Expenditure*

The replacement of elements of the control system of MurrayLink is required to meet the following capital expenditure objectives set out in clause 6A.6.7(a) of the Rules:

(3) (iii) maintain the quality, reliability and security of supply of prescribed transmission services;

(iv) maintain the reliability and security of the transmission system through the supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The project is justified under clauses 6A.6.7(a)(3) and (4), being required to ensure the continued reliable operation of MurrayLink. The project will ensure that operation of the control systems remain reliable to minimise the risk of short and long term outages, should component failure occur and serviceable options no longer exist.

The option of replacing obsolete components of the control systems rather than continuing with the existing system is considered prudent on the basis that these devices have been in service for approximately 15 years, are displaying increasing failure rates near the end of their serviceable life and will in the near future not be supported by the manufacturer. To continue with the existing systems, even if additional spares are acquired, would lead to degraded Murraylink reliability.

The estimate of costs is considered efficient and realistic. The cost to upgrade the obsolete control system is that quoted by the original equipment manufacturer ABB for new systems of this nature. The complex task of installation has been estimated as described in Section 4.2.6.

The higher cost option of complete control system replacement has not been proposed.

4.2.8 *Recommendations*

It is recommended that the Control System Upgrade Project is implemented, to:

- Ensure the continued reliable operation of MurrayLink as the control system approaches end of life.
- Bring the system into line with good industry practice by maintaining a fully supported control system for the operation of the link.

The estimated costs have been included in the operating and capital expenditure forecasts for the MurrayLink Regulatory Proposal.

4.3 SPARE IGBTs

4.3.1 *Project Description*

Purchase of 108 Replacements and Spares for failed IGBT units

4.3.2 *Background/Problem*

The Insulated Gate Bipolar Transistors (IGBT) are a fundamental component in the AC to DC conversion and reconversion process.

The need to secure adequate stores of IGBTs arises from a mixture of:

- Good procurement practices which drives purchasing along commercially economic quantities to minimise costs;
- Balancing the need of having prudent store of critical inventory to meet operational requirements and minimise down-time of the asset; and,
- Management of supply risk by regularly securing critical stock (past endeavours has shown marked variability in delivery time for these long lead-time items into Australia, leaving the business potentially under equipped for maintenance activities).

Historic IGBT failure records indicate an average IGBT failure/purchasing rate of 20 IGBTs per annum, out of a total of 5832 IGBTs in service, or 0.34% p.a. The convertor stations can each continue in service with a maximum of 5 failed IGBTs per valve, although operation with this level of failed IGBTs increases the voltage stress on the remaining operable IGBTs and increases their failure rate. There are currently 30 failed IGBTs awaiting replacement and 42 spare IGBTs in stock. The stock of spare IGBTs will be depleted replacing the current and expected failed IGBTs in the lead up to the end of the current revenue period. This is expected to result in an operational deficit of 21 IGBTs between the number of failed units and the number or units repaired.

As the service life of the existing IGBTs increases, the failure rates of the active components are expected to increase. This trend has started to appear within the Murraylink statistics and the future failure rate of IGBTs is expected to increase to 22 per annum during the term of the next revenue period. The current lead time for replacement IGBT units is approximately 10 months. In an emergency, it is expected that the lead time could be reduced, however the expected outage duration of Murraylink is at least two months should adequate spares holding not be maintained. The minimum level of spare IGBTs required for secure operations is 10, being 5 per converter station site.

(confidential)

4.3.3 *Justification under the NER*

This strategic sourcing project for IGBTs is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The expenditure for the sourcing program is justified under clauses (1), (3) and (4), being required to maintain the efficient operability (minimise turnaround times on outages) and the security of supply in the provision of prescribed transmission services

4.3.4 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	(Confidential)	(Confidential)	$1.6m
2	(confidential)	(Confidential)	N/A
3	Do Nothing	Not Chosen: Increasing rates of failure and reduction in spares holding would eventually result in outages of circa 10 months in order to source new units	N/A

4.3.5 *Funding and Estimating*

The following table represents the estimated project execution costs:

Forecast Cost						
No	**Description**	**Yr1 (2019)**	**Yr2 (2020)**	**Yr3 (2021)**	**Yr4 (2022)**	**Yr5 (2023)**

1	IGBT Purchases	$475,877	$237,938	$249,269	$249,269	$249,269
	APA Management	$47,588	$23,794	$24,927	$24,927	$24,927
	Forecast Annual Expenditure	$523,464	$261,732	$274,196	$274,196	$274,196

Basis of Estimate:

Historic failure rates and operational experience has demonstrated that adequate stores of IGBTs need to be maintained to minimise the down time of the system.

Assumptions and Calculations Used in Financial Analysis:

The pricing includes a delivery component in the purchase price.

Note the estimate is in $2016 and has not been inflated for $2018.

4.3.6 *Prudency and Efficiency of Expenditure*

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and
- represent a realistic expectation of the costs to achieve the requirement.

The proposed IGB replacement plan is prudent and essential to maintain the capacity and availability of Murraylink.

(confidential)

The costs therefore are efficient and represent a reasonable expectation of those required to maintain the link in service.

The proposed period for undertaking this strategic sourcing program will be implemented in a staged sequence of procurement initiatives to efficiently manage the inventory levels for the business over the FY 2019-2023 regulatory period.

4.3.7 *Recommendations*

It is recommended to implement this strategic procurement initiative to source critical inventory of IGBTs to:

- Ensure effective procurement of commercially economic quantities that minimise overall costs;
- Maintain critical inventory for the efficient maintenance of the system; and,

- Minimise supply risk (delivery times) by establishing a staged regular supply-chain so critical inventory can be effectively maintained.

The estimated costs have been included in the operating and capital expenditure forecasts for the Murraylink Regulatory submissions.

4.4 OTHER MINOR CAPITAL WORKS

4.4.1 *Project Description*

The Works comprise an on-going program of:

- Sub-system equipment refurbishment; and
- Maintenance support systems and tools.

4.4.2 *Background/Problem*

The reliable operation of the converter stations is dependent on the proper operation of a number of sub-systems. These sub-systems perform essential operation functions such as cooling primary HV equipment, cooling computerised control system equipment, LV power distribution, room and building ventilation fans, pressure vessels and air-conditioning. The expenditure on these items is unevenly spread throughout the regulatory control period as the timing of the forecast is based on when essential maintenance on each is forecast to become necessary.

In addition, the site maintenance personnel require systems and tools to effectively and efficiently test, diagnose, repair and manage the operation of converter equipment. These systems and equipment include industrial computer systems, diagnostic test equipment, and facilities for maintenance access.

4.4.3 *Impacts to Operations, Maintenance or Safety*

Completion of this project will not materially change the maintenance or safety aspects of this system but is expected to maintain the existing high level of system availability and reliability.

4.4.4 *Justification under the NER*

For this item of forecast capital expenditure to be accepted by the AER, it must meet the capital expenditure objectives set out in the Rules as Cl. 6A.6.7(a).

The minor capital works program for Murraylink is required to meet the following capital expenditure objectives set out in clause 6A.6.7(a) of the Rules:

(3) (iii) maintain the quality, reliability and security of supply of prescribed transmission services;

(iv) maintain the reliability and security of the *transmission system* through the supply of *prescribed transmission services*; and and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The project is justified under clauses 6A.6.7(a)(3) and (4), being required to ensure the continued reliable operation of Murraylink. The project will ensure that operation of the converter station remains reliable to minimise the risk of long-term outages.

4.4.5 *Evaluation of Alternatives*

All available alternatives will be evaluated, at the time of each item of work, to ensure the probity and efficiency of the procurement process.

4.4.6 *Funding and Estimating*

The following table represents the estimated minor capital works execution costs:

Forecast Cost						
No	**Description**	**Yr1 (2019)**	**Yr2 (2020)**	**Yr3 (2021)**	**Yr4 (2022)**	**Yr5 (2023)**
	Materials / Resources	$68,426	$139,666	$40,426	$11,626	$559,186
	APA Management	$6,843	$13,967	$4,043	$1,163	$55,919
	Forecast Annual Expenditure	$75,269	$153,633	$44,469	$12,789	$615,105

4.4.7 *Prudency and Efficiency of Expenditure*

The requirement for AER acceptance of capital expenditure is that the expenditure must meet the capital expenditure criteria set out in Cl. 6A.6.7(c) of the Rules. That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and
- represent a realistic expectation of the costs to achieve the requirement.

The minor capital works program is considered prudent on the basis that the operational sub-systems and maintenance support systems are renewed prior to impacting the reliability of Murraylink.

The costs to complete the minor capital works program will be managed in compliance with the APA procurements policies and procedures to ensure the probity and efficiency of the procurement process.

These costs are based on previous expenditure incurred in these categories.

4.4.8 *Recommendations*

It is recommended that the minor capital works program be undertaken to ensure the on-going reliable operation of Murraylink.

4.5 VARIABLE SPEED DRIVE REPLACEMENT

4.5.1 *Project Description*

Purchase and installation of 6 replacement IGBT Valve cooling water circulation pump variable speed drives (VSD).

4.5.2 *Background/Problem*

The valve cooling water circulation pumping systems are required to ensure the secure operation of the Murraylink HVDC by maintaining adequate cooling of the IGBT components of the switching valves. Without these cooling systems, the link cannot operate.

To efficiently control the flow of water in the cooling system, the pumps are powered by 2 off ABB ACS607-0210-5 Variable speed drives (VSD). The VSDs are arranged in a redundant configuration (N+1), to control the output of 2 off 160kW motor/pump units located at both the Berri and Redcliffs Converter stations.

Each motor, VSD and Pump set is an exact match. In the event of failure of one set, the other provides a backup. Each set is capable of the full operation of the plant.

In addition, each site has 1 off ABB ACS601-0009-3 DC battery fed VSD controlling the output of 1 off 4kW back-up emergency pump. The purpose of this pump is not to provide cooling in normal operation but to ensure the controlled cool down of the IGBT valves in event of a system trip event when auxiliary AC supply is lost.

The configuration of the VSDs and pumps at each site is shown below.

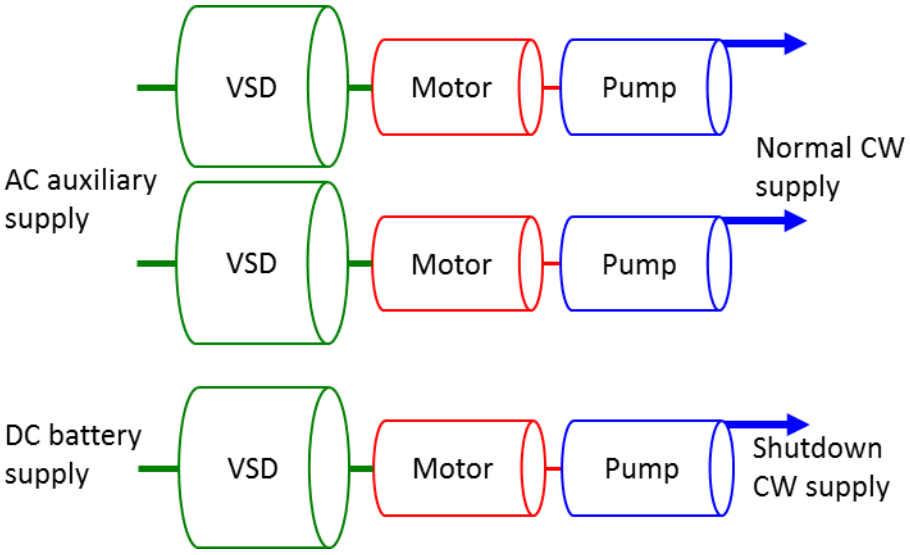


ABB have advised by notice that this model of drive will become obsolete (see Attachment: Product LC Status Statement_ACS600 Single Drives SDHW.pdf). This

transition takes these units into the "Limited" service and support range at the end of 2018. Spares will no longer be available after that date and good industry practice requires Murraylink to transition to a supported VSD model as a managed change rather than waiting for a breakdown event to force a change.

These drives are part of the original 2002 installation and while VSD life is a function of duty and conditions. These units will be circa 18 years at their estimated replacement date and are considered to present a risk to the reliability of the system.

Murraylink relies on the installed redundancy rather than holding spares for this equipment

4.5.3 *Impacts to Operations, Maintenance or Safety*

Completion of this project will not materially change the maintenance or safety aspects of this system but is expected to maintain the existing high level of system availability and reliability.

This replacement is to protect system availability against future failure during the upcoming period where required parts are no longer available or supported.

4.5.4 *Justification under the NER*

For this item of forecast capital expenditure to be accepted by the AER, it must meet the capital expenditure objectives set out in the Rules as Cl. 6A.6.7(a).

The replacement of the Cooling Water Pump VSDs for Murraylink is required to meet the following capital expenditure objectives set out in clause 6A.6.7(a) of the Rules:

(3) (iii) maintain the quality, reliability and security of supply of prescribed transmission services;

(iv) maintain the reliability and security of the *transmission system* through the supply of *prescribed transmission services*; and and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The project is justified under clauses 6A.6.7(a)(3) and (4), being required to ensure the continued reliable operation of Murraylink. The project will ensure that operation of the cooling water system remains reliable to minimise the risk of long-term outages, should unit failure occur and serviceable options no longer exist

4.5.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	Replacement Drives (no Full Spare)	Chosen: new VSD units will be in serviceable range and n+1 arrangement provides adequate levels of reliability.	$562,210
2	Replacement Drives (Full Spare unit)	Not Chosen: additional cost not justified for n+1 installation level	N/A
3	Buy Spare Units Only (existing types)	Not Chosen: End of support life planning for these units represents a risk to the reliability of the system and may only slightly defer cost while leaving residual failure risk in current period	N/A
4	Do Nothing	Not Chosen: With no current spares and OEM service life publically limited and decreasing this is not considered a viable option	N/A

4.5.6 Funding and Estimating

The following table represents the estimated project execution costs:

Forecast Cost						
No	**Description**	**Yr1 (2019)**	**Yr2 (2020)**	**Yr3 (2021)**	**Yr4 (2022)**	**Yr5 (2023)**
1	Specification / Administration		$8,401			
2	Materials / Resources		$431,000			
3	Supervision		$71,700			
	APA Management		$51,110			

	Forecast Annual Expenditure		**$562,211**			

Basis of Estimate:

1. Budget Quote received from ABB only as OEM for HVDC Light for Equipment.
2. Installation contractor rates and times based on estimate of recent electrical works on site.

Assumptions and Calculations Used in Financial Analysis:

1. All OEM pricing in AUD with no FX exposure cited in the received quote.

4.5.7 Prudency and Efficiency of Expenditure

The requirement for AER acceptance of capital expenditure is that the expenditure must meet the capital expenditure criteria set out in Cl. 6A.6.7(c) of the Rules. That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and
- represent a realistic expectation of the costs to achieve the requirement.

The option of replacing the VSDs rather than continuing with the existing units is considered prudent on the basis that these switching power electronic devices have been in service for 18 years, are nearing the end of their serviceable life and will by 2018 not be supported by the manufacturer.

The purchase costs to secure the replacement of the VSD equipment are those quoted by the original equipment manufacturer ABB and are consistent with their intended design specification for this system. Installation pricing is estimated from recent works carried out under contract by the current service provider.

Proposed project timing

Activity	2020	Working Days	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 47	Day 48	Day 49	Day 50	Day 51	Day 52	Day 53	Day 54	Day 55	Day 56	Day 57	Day 58	Day 59	Day 60	Day 61	Day 62	Day 63	Day 64	Day 65	Day 66	Day 67	Day 68	Day 69	Day 70	Day 71	Day 72
Administration (Assumes Board Approval Secured)		Effort																																								
Coordination / schedule outage with NEM		2																																								
Source / Engage Contractors																																										
ABB		5																																								
Other contractors		5																																								
Materials																																										
Assume 5 weeks		25																																								
Site Deliveries																																										
Deliver building to site onto blocks (Red Cliffs)		1																																								
Deliver building to site onto blocks (Berri)		1																																								
Murraylink Switching																																										
Localised Isolations (Red Cliffs & Berri)		1																																								
Site Works Red Cliffs																																										
Delivery / Acceptance		1																																								
Removal		1																																								
Installation		2																																								
Testing / Commissioning		1																																								
Site Works Berri																																										
Delivery / Acceptance		1																																								
Removal		1																																								
Installation		2																																								
Testing / Commissioning		1																																								
Murraylink Switching																																										
Switch in (Red Cliffs & Berri)		1																																								

4.5.8 Recommendations

It is recommended that replacement Cooling water pump VSDs are purchased and installed to ensure stable operation and remove the risk of extended outages of the cooling system and hence the DC Link.

4.6 COMMUNICATIONS HUT

4.6.1 *Project Description*

Establish new fire rated communications buildings at each convertor site (Berri and Red Cliffs) and transfer the existing communications equipment into these new facilities.

4.6.2 *Background/Problem*

Currently the communications equipment for the Murraylink converter stations are housed in prefabricated buildings which were not constructed with the communications equipment use in mind. These types of buildings (comprising of expanded polystyrene wall panels) have been flagged by APA's insurance advisor (FM Global) as susceptible to being rapidly consumed by fire and unsuitable for their current use.

The communications equipment used in these buildings is critical to the dispatch of Murraylink. Should one of the communication facilities be damaged or destroyed by fire, the ability to dispatch on a continuous basis will be affected for up one month. As part of the risk assessment reviews, upgrading to appropriate fire-rated structures, as is the industry norm, is warranted.

4.6.3 *Impacts to Operations, Maintenance or Safety*

No significant change to OPEX is anticipated

4.6.4 *Justification under the NER*

The transfer of the communications equipment into new facilities Murraylink is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The project is justified under clauses 6A.6.7 (a) (3) and (4), being required to ensure the continued reliable operation of Murraylink. The project will ensure that operation of the telecommunications equipment is protected through the establishment of appropriate fire proof facilities

4.6.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	Establish a fire rated building and transfer all equipment to this facility.	Remove the uncertain combustibility risk associated with the existing buildings, ensuring a fit for purpose building to protect the critical communications equipment.	$152,680
2	Establish Fire Protection Systems to protect facilities.	Not Chosen: given the combustible material of the buildings is sandwiched within the walls, there is no guarantee that the suppression system would stop fire within the walls or transferring across from other rooms in the prefabricated buildings.	$30-40,000 2 x $15-20,000 (Novec Gas Suppression System and sealing of building)
3	Do Nothing.	Not Chosen: fire in an expanded polystyrene wall panel building is a real risk and needs to be addressed because of the significant consequence of such an event.	N/A

4.6.6 *Funding and Estimating*

The following table represents the estimated project execution costs:

Forecast Cost						
2019	**2020**	**2021**	**2022**	**2023**	**2019**	**2020**
1	Specification / Administration (Contractor)	$7,000				
2	Materials	$56,000				
3	Installation and Commissioning	$40,000				

4	APA System Outage	$4,000				
5	APA Supervision (Contractor)	$31,800				
6	APA Management	$13,880				
	Forecast Annual Expenditure	**$152,680**				

Basis of Estimate:

1. Budget Quote received from E.I Group Portable Buildings.
2. Installation contractor rates and times based on estimate of works on site.
3. Outage and Project costs are based on current working costs occurring for like activities in APA.

Investigation of the proposed solution has confirmed that much of the work can be done off site i.e. 2 prefabricated buildings constructed to agreed design / specifications. Installation would then be minimal, with outages required solely for transferring and testing of the communications equipment.

Assumptions and Calculations Used in Financial Analysis:

Note these are 2016$ and have not been inflated for 2018$

4.6.7 Prudency and Efficiency of Expenditure

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the Electricity Rules is that the expenditure must be such as would be incurred by a prudent service provider acting efficiently, and represent a realistic expectation of the costs to achieve the requirement.

APA considers that the proposed expenditure is prudent, since it addresses a fire risk that has been raised by APA's insurer advisor. If this risk were to materialise, it would have very significant potential affect the availability of Murraylink.

The expenditure is also considered efficient, in that a quotation has been competitively sourced for the provision of prefabricated fireproof buildings. This equipment and its installation comprises the majority of the proposed expenditure and thus are a realistic expectation of the costs of the project.

Proposed project timing

The following schedule represents the key activities to undertake the recommended project.

Activity	2019	Working Days	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 61	Day 62	Day 63	Day 64	Day 65	Day 66	Day 67	Day 68	Day 69	Day 70	Day 71	Day 72	Day 73	Day 74	Day 75	Day 76	Day 77	Day 78	Day 79
Administration (Assumes Board Approval Secured)		Effort																																	
Coordination / schedule outage with NEM		2																																	
Organise additions / extension of site utilities		3																																	
Source / Engage Contractors																																			
Building provider		5																																	
Utilities connections on site		5																																	
Contractor to transfer communications equipment		5																																	
Construction																																			
Buildings (x2)		40																																	
Site Deliveries																																			
Deliver building to site onto blocks (Red Cliffs)		1																																	
Deliver building to site onto blocks (Berri)		1																																	
Murraylink Switching																																			
Switch out (Red Cliffs & Berri)		1																																	
Site Works Red Cliffs																																			
Extend utilities to and in building		2																																	
Transfer Equipment		2																																	
Testing / Commissioning		1																																	
Site Works Berri																																			
Extend utilities to and in building		2																																	
Transfer Equipment		2																																	
Testing / Commissioning		1																																	
Murraylink Switching																																			
Switch in (Red Cliffs & Berri)		1																																	

4.6.8 *Recommendations*

It is recommended that the "Transfer of communication facilities to a fire rated buildings" Project is implemented, to:

- Ensure the continued reliable operation of Murraylink.
- Bring the system into line with good industry practice by establishing a fit'-for-purpose communications facility for the operation of Murraylink.

The estimated costs have been included in the operating and capital expenditure forecasts for the Murraylink Regulatory Proposal.

4.7 MAINTENANCE SURVEILLANCE CAMERAS

4.7.1 *Project Description*

This project proposes to install surveillance and infra-red cameras, in the AC and DC filter yards of the converter building, to undertake routine inspections of the high voltage equipment in areas that cannot be accessed while the converter is in operation

4.7.2 *Background/Problem*

The AC and DC filter yards inside the converter buildings cannot be safely entered during operation. Consequently, maintenance inspections can currently only be completed while the converter is shutdown.

The ability to unobtrusively and regularly monitor and evaluate the state of equipment and identify thermally stressed components will offset the expected increase in outage time resulting from the increasing service life duration age of the converter station equipment.

4.7.3 *Impacts to Operations, Maintenance or Safety*

The reduction in outages for inspection maintenance will deliver a net improvement in operational performance.

Annual camera maintenance cost is expected to be $4000 per annum. It is expected that these costs will be offset by some modest savings from the removal of secondary service costs for preforming thermal inspections and other visual inspection services

4.7.4 *Justification under the NER*

This Establishment of Surveillance Cameras within converter buildings is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The expenditure for this project is justified under clauses (1), (3) and (4), being required to maintain the efficient operability (minimise turnaround times on outages) and the security of supply in the provision of prescribed transmission services.

4.7.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	Establish a surveillance system to monitor visual and thermal operating of the equipment within the converter buildings	As stated above this will minimise outages, improve operational oversight and minimise maintenance activities	$572,220
2	Establish additional viewing portals and walk ways to provide an equivalent observation perspective	Not Chosen: The works required and the degree of modifications to the building to establish inspection portals and gangways coupled with risks of work at heights to be able to secure the appropriate vantage points – makes this a unrealistic, expensive and poorer solution	N/A
3	Do Nothing.	Not Chosen: the inability to inspect equipment during operation will continue the need to plan shutdowns. Securing market impact free outage time is increasingly difficult with the South Australian market conditions. This option provides no improvement on the Murraylink availability.	N/A

4.7.6 *Funding and Estimating*

The following table represents the estimated project execution costs:

Forecast Cost

No	Description	Yr1 (2019)	Yr2 (2020)	Yr3 (2021)	Yr4 (2022)	Yr5 (2023)
1	Specification / Administration		$11,200			
2	Materials / Installation		$453,000			
3	Outage Resource Costs		$4,000			
4	Project Supervision		$52,000			
	APA Management		$52,020			
	Forecast Annual Expenditure		**$572,220**			

Basis of Estimate:

Quotes have been developed based on learnings from other sites. Outage and Project costs are based on current working costs occurring for like activities in APA.

Establish surveillance cameras throughout the converter stations at Berri and Redcliffs to aid operational assessment / performance management of the facilities contained therein.

It is proposed to adopt two track mounted cameras (both surveillance and infra-red) per building to obtain live working information of the facility whilst in operation. Other static cameras will be located in areas that cannot be accessed by the track mounted units.

Assumptions and Calculations Used in Financial Analysis:

Note these are 2016$ and have not been inflated for 2018$

4.7.7 Prudency and Efficiency of Expenditure

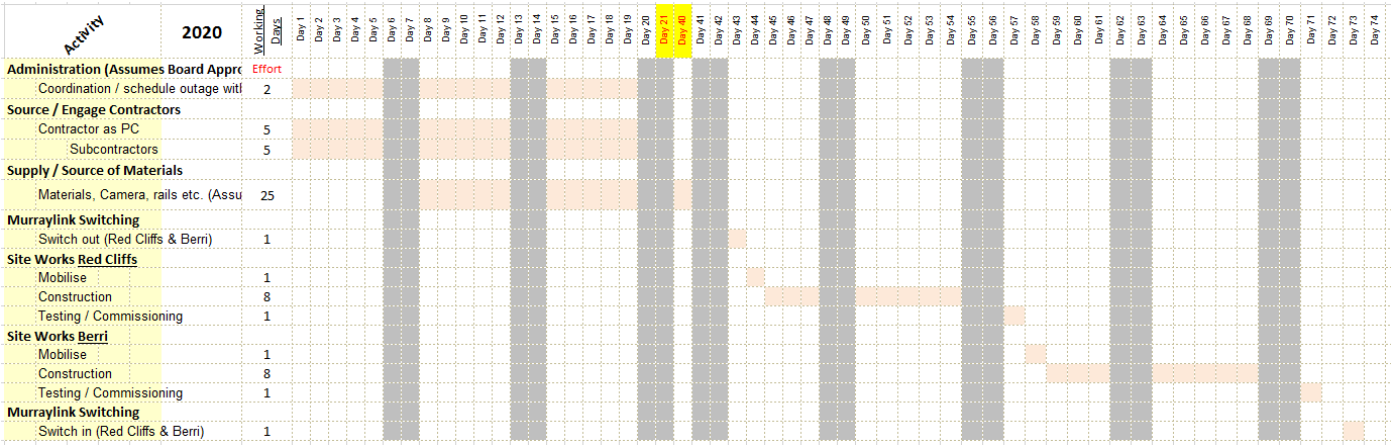
The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) is that the expenditure must be such as would be incurred by a prudent service provider acting efficiently, and represent a realistic expectation of the costs to achieve the requirement.

The proposed expenditure is considered prudent, in that it should reduce the number of shutdowns for maintenance inspection and improve the reliability and availability of Murraylink.

The estimate for costs is obtained from similar projects and is considered a realistic expectation of the efficient cost of establishing the surveillance equipment.

Proposed project timing

The following schedule represents the key activities to undertake the recommended project.



4.7.8 Recommendations

It is recommended that the "Establishment of Surveillance Cameras within converter buildings" Project is implemented, to:

- Ensure the continued reliable operation of Murraylink.
- Bring the system into line with good industry practice by establishing an un-evasive facility for the operation of Murraylink.
- Increase surveillance, monitoring and achieve more effective / less outages

The estimated costs have been included in the operating and capital expenditure forecasts for the Murraylink Regulatory Proposal.

4.8 REPLACEMENT UNINTERRUPTABLE POWER SUPPLIES AND INVERTERS

4.8.1 *Project Description*

Purchase and installation of replacement switching power electronic subsystems for the station Uninterruptable Power Supplies (UPS).

4.8.2 *Background/Problem*

The UPSs are necessary to ensure that critical control and protection systems at the convertor stations can operate during power system disturbances or supply disconnection. The critical switching power electronic subsystems in the UPS are the battery chargers and the inverters.

The UPSs are arranged in a redundant configuration (N+1) where each UPS is an exact match for the others. In the event of failure of one set, the other provides a backup. Each set is capable of the full operation of the plant.

The battery chargers and inverters have been in service for 14 years. At the proposed time of replacement, the systems will be 20 years old and, based on current service experience are expected to reach the end of their service life during the next revenue period. Good industry practice requires Murraylink to transition to a supported UPS model as a managed change rather than waiting for a breakdown event to force a change.

4.8.3 *Impacts to Operations, Maintenance or Safety*

Replacement prior to any failure would see no change in forecast OPEX. However, a failure of the systems would create a significant outage and outlays due to having to secure a source, delivery, installation and commissioning. Hence the timely replacement of the units is consistent with good industry practice.

4.8.4 *Justification under the NER*

This project is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The project is justified under clauses 6A.6.7(a)(3) and (4), being required to ensure the continued reliable operation of Murraylink. The project will ensure that operation of the plant remains reliable to minimise the risk of long term outages.

4.8.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	switching power electronic subsystems for the station Uninterruptable Power Supplies	As stated above this will minimise unplanned outages, improve operational resilience	$137,780
2	Do Nothing.	Not Chosen: the increasing failure rate of these units is expected to impair convertor station availability and is not consistent with good engineering practice. The flow on affects to the electricity market would be potentially significant.	N/A

4.8.6 *Funding and Estimating*

The following table represents the estimated project execution costs:

Forecast Cost						
No	**Description**	**2019**	**2020**	**2021**	**2022**	**2023**
1	Project Initiation			$8,400		
2	Removal and Disposal of existing equipment			$8,000		
3	Equipment / Delivery / Installation			$80,960		

4	Outage Resource Costs			$2,000		
5	Project Supervision (Contractor)			$25,900		
	APA Management			$12,520		
	Forecast Annual Expenditure			**$137,780**		

Basis of Estimate:

The project will source either the same or equivalent equipment to meet the design parameters / constraints of the existing system. Contractors will be used to remove the existing system and dispose in an environmentally appropriate means. The new suppler will then install and commission the new equipment.

Sourced estimates are from the Local supplier. A price was obtained from the OEM, however two battery chargers failed in 2018 and replacements were sourced from a local supplier to cover the spares consumed in the reinstatement works.

Assumptions and Calculations Used in Financial Analysis:

Note these are 2016$ and have not been inflated for 2018$

4.8.7 Prudency and Efficiency of Expenditure

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the Rules is that the expenditure must be such as would be incurred by a prudent service provider acting efficiently, and represent a realistic expectation of the costs to achieve the requirement.

APA considers that the proposed expenditure is prudent and in line with good industry practice, since it replaces assets at the end of their serviceable life that otherwise have significant potential to impair the reliability and availability of Murraylink.

The expenditure is efficient, in that quotations have been competitively sourced for the provision of the replacement equipment. The equipment and its installation comprise the majority of the proposed expenditure and thus are a realistic expectation of the costs of the project.

Proposed project timing

The following schedule represents the key activities to undertake the recommended project.

Activity	2021	Working Days	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 68	Day 69	Day 70	Day 71	Day 72	Day 73	Day 74	Day 75	Day 76	Day 77	Day 78	Day 79	Day 80	Day 81	Day 82	Day 83	Day 84	Day 85	Day 86
Administration (Assumes Board Approval Secured)		Effort																																								
Coordination / schedule outage with NEM		2																																								
Source / Engage Contractors																																										
Contractor		5																																								
Supply / Source of Materials																																										
Materials		40																																								
Murraylink Switching																																										
Switch out (Red Cliffs & Berri)		1																																								
Site Works Red Cliffs																																										
Mobilise		1																																								
Remove Battery System		2																																								
Install New Battery Systems		2																																								
Testing / Commissioning		1																																								
Site Works Berri																																										
Mobilise		1																																								
Remove Battery System		2																																								
Install New Battery Systems		2																																								
Testing / Commissioning		1																																								
Murraylink Switching																																										
Switch in (Red Cliffs & Berri)		1																																								

4.8.8 Recommendations

It is recommended that the replacement of the switching power electronic subsystems for the station Uninterruptable Power Supplies is implemented, to:

- Ensure the continued reliable operation of Murraylink.
- Bring the system into line with good industry practice by proactively managing operational equipment life for the optimum availability of Murraylink.

The estimated costs have been included in the operating and capital expenditure forecasts for the Murraylink Regulatory Proposal.

4.9 CABLE FAULT LOCATION RELAYS

4.9.1 *Project Description*

Install an online cable fault location system to reduce the outage time in locating and repairing the DC cables.

4.9.2 *Background/Problem*

Previous Murraylink cable faults have required substantial time (2 weeks) to locate. The two DC cables are buried in the road reserve for the Sturt Highway and identifying the exact location of the fault is made more difficult by the noise and vibration generated from the regular highway traffic.

Cable faults are currently located by injecting a high voltage impulse onto the failed cable then timing the arrival of the impulse reflections from the fault. The equipment used is portable and needs to be manually set up after a fault. The equipment is set up at one end and relies on a calculated impulse travel speed which results in a margin of error, increasing the time and effort required to identify the exact fault location.

The proposed equipment is to be permanently installed at both ends of the cables. It operates immediately at the time of a cable fault, and provides a more accurate fault position by comparison of the fault location from each end of the cable.

There is a credible risk of disturbance along the cable route due to environmental factors, such as rabbit burrows and erosion, and due to urban development such as road maintenance, other services, farming and irrigation activities. The risk of disturbance and the critical nature of the Murraylink facility, are all driving a focus to minimise any outage duration.

4.9.3 *Impacts to Operations, Maintenance or Safety*

No material impact is expected on normal daily operational maintenance of the sites / corridor, however the potential response (resources, cost and outage time) to a cable fault will be significantly improved and more efficiently undertaken.

4.9.4 *Justification under the NER*

This the establishment of a cable fault location system is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;
(3) maintain the quality, reliability and security of supply of prescribed transmission services; and
(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The expenditure for this equipment is justified under clauses (3) and (4), being required to maintain the efficient operability (minimise turnaround times on outages) and the security of supply in the provision of prescribed transmission services.

4.9.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	Establishment of a cable fault location system	As stated above this will depend on the difficulty in locating a fault and the consequential outage time impact to market activities. The criticality of Murraylink is driving mitigation / management strategies to minimise down time.	$136,070
2	Do Nothing.	Not Chosen:	N/A

4.9.6 *Funding and Estimating*

The following table represents the estimated project execution costs:

Forecast Cost						
No	**Description**	**Yr1**	**Yr2**	**Yr3**	**Yr4**	**Yr5**
1	Specification / Administration	$8,400				
2	Phase 1 – Validation / Testing of Solution	$14,000				
3	Phase 2 – Materials & Installation of Solution	$83,200				
4	Project Supervision	$18,100				

	APA Management	$12,370				
	Forecast Annual Expenditure	**$136,070**				

Basis of Estimate:

Provisional quote supplied from supplier

The project will test the proposed solution first to ensure the appropriate outcomes can be achieved from the cable location system. Then the main installation will occur.

Assumptions and Calculations Used in Financial Analysis:

Note the estimate is in$2016 and has not been inflated for $2018.

4.9.7 Prudency and Efficiency of Expenditure

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) is that the expenditure must be such as would be incurred by a prudent service provider acting efficiently, and represent a realistic expectation of the costs to achieve the requirement.

The following schedule represents the key activities to undertake the recommended project.

Activity	2019	Working Days	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 40	Day 41	Day 42	Day 43	Day 44	Day 45	Day 46	Day 47	Day 48	Day 49
Administration (Assumes Board Approval Secured)		Effort																															
Coordination / schedule outage with NEM		2																															
Source / Engage Contractors																																	
Primary Contractor		5																															
Supply / Source of Materials PHASE 1																																	
Materials (Assume 3 weeks)		15																															
Murraylink Switching																																	
Switch out (Red Cliffs & Berri)		1																															
Site Works Red Cliffs																																	
Install test equipment		1																															
Site Works Berri																																	
Install test equipment		1																															
Murraylink Switching																																	
Switch in (Red Cliffs & Berri)		1																															
												Different timeframe move to next outage																					
Assume report support main rollout PHASE 2																																	
Align to next Outage																																	
Engage Contractors for next phase																																	
Primary Contractor		5																															
Source of Materials PHASE 2																																	
Materials (Assume 3 weeks)		15																															
Murraylink Switching																																	
Switch out (Red Cliffs & Berri)		1																															
Site Works Red Cliffs																																	
Remove Test Equipment		0																															
Install test equipment		1																															
Site Works Berri																																	
Remove Test Equipment		0																															
Install test equipment		1																															
Murraylink Switching																																	
Switch in (Red Cliffs & Berri)		1																															

4.9.8 Recommendations

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and
- represent a realistic expectation of the costs to achieve the requirement.

The proposed installation of cable fault location equipment will see a reduction in the outage time to locate and repair a DC cable fault.

4.10 FIRE PROTECTION SYSTEMS

4.10.1 *Project Description*

This project plans to construct Fire Suppression Systems for each of the buildings at Berri and RedCliffs and arises from prudent management of the risks associated with operating such a facility.

4.10.2 *Background/Problem*

(confidential)

4.10.3 *Impacts to Operations, Maintenance or Safety*

No material impact is expected on normal daily operational maintenance of the sites

4.10.4 *Justification under the NER*

This Fire Suppression project for MurrayLink is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules), which states:

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of

prescribed transmission services.

The project is justified under clauses (3) and (4), being required to minimise the risk of fire damage causing the extended unavailability of the link.

The estimate of capital and operating costs is considered to be a realistic estimate of the efficient costs that would be incurred by a prudent operator in meeting the expenditure objectives

4.10.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered

Alternatives			
No	**Description**	**Outcome**	**$**
1	Installation of Fire Suppression System	Chosen: This submission	$12.2m

2	Do Nothing	Not Chosen (confidential)	N/A

The works associated with this project are in-line with and utilising the works and investigations completed as part of the DirectLink works. Scoping studies and required technical clarifications have been sought from expert consultancies and fire experts with close collaboration with APA's Insurer.

4.10.6 Funding and Estimating

The following table represents the estimated project execution costs:

Forecast Cost						
No	**Description**	**Yr1**	**Yr2**	**Yr3**	**Yr4**	**Yr5**
1	Project Management, Procurement and Contract Administration	$640,000				
2	Construction Supervision and Operations Permitting	$1,337,900				
3	Owners Engineer Cost	$360,700				
4	EPC Contract Amount	$8,725,400				
5	KWM Cost	$50,000				
6	Interfacing Works (Cabling and Programming	$110,000				
	Subtotal	*$11,224,000*				
	APA Management*	$1,122,400				
	Forecast Annual Expenditure	**$12,346,400**				

Basis of Estimate:

1. FEED Study completed in 2016
2. The estimated EPC Contract amount used above is preliminary only. The value used is based on an expected EPC price using the offers received on 16 November 2016.
3. Due to only 2 respondents (7 were requested), APA has retendered the works scope and will receive updated pricing in February of 2017. Post this, the amount will be adjusted after further evaluation, clarification of offer with contractors and final negotiation.

4. The estimated costs for project management, supervision, procurement, administration and permitting are based on a staffing organisation chart with a bar chart based on the overall schedule.
5. APA management pricing based on DirectLink works and experience in project delivery

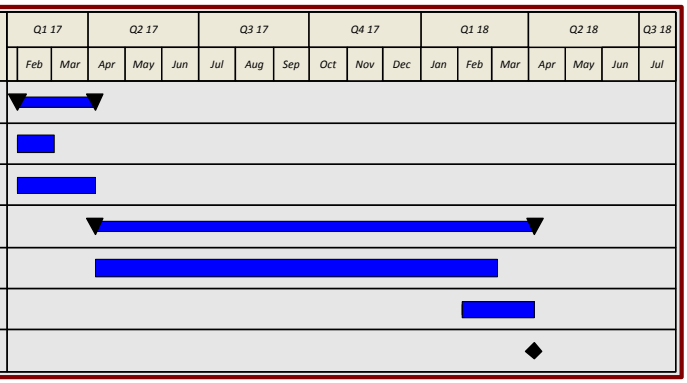
4.10.7 *Prudency and Efficiency of Expenditure*

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules). That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and
- represent a realistic expectation of the costs to achieve the requirement.

The following schedule represents the key activities in going to market to finalise design and secure construction of the Fire Suppression Project during the 2019-23 regulatory control period.

ID	Task Name	Start	Finish
1	**Planning Phase**	**1/02/2017**	**5/04/2017**
2	Engage EPC Conttractor	1/02/2017	3/03/2017
3	Offsite Engineering and Procurement (by EPC Contractor)	1/02/2017	5/04/2017
4	**Execution Phase**	**6/04/2017**	**5/04/2018**
5	Construction	6/04/2017	5/03/2018
6	Commisioning	5/02/2018	5/04/2018
7	Completion	5/04/2018	5/04/2018



This schedule is based on indicative dates and has been prepared to determine staff durations. Final schedule will be developed when project is presented for board approval.

4.10.8 *Recommendations*

It is recommended that this Fire Suppression Project is implemented to manage risks associated with the operation of the MurrayLink facility by:

- protecting and limiting the potential for extensive fire damage to MurrayLink assets;
- avoiding the risk of an extended shutdown to the link as a result of fire damage;
- limiting the potential for damage to adjacent properties;
- limiting the risk of injury to employees, emergency response personnel and the general public; and

- complying with the recommendations of both energy and insurance industry advisors.

The estimated costs have been included in the operating and capital expenditure forecasts of the MurrayLink Regulatory Proposal.

4.11 SPARE CAPACITORS

4.11.1 Project Description

The strategic purchase of spare capacitors to support the operation of Murraylink and to rectify the degradation in the converter filter capacitors.

4.11.2 Background/Problem

The Capacitors are an essential equipment component for filtering harmonics from the AC connections of the convertor stations, to meet the power quality requirements of the National Electricity Rules (Rules). The capacitors are installed in banks in the harmonic filters at each convertor station. There is a total of 508 capacitors units installed across the different filter banks within each converter station.

This project to secure adequate stores of Capacitor arises from a mixture of:

- Good procurement practices, which drives purchasing along commercially economic quantities to minimise costs;
- Balancing the need to having prudent store of critical inventory to meet operational requirements and minimise down-time of the asset; and,
- Management of supply risk by regularly securing critical stock (past endeavours have shown marked variability in delivery of these long lead-time items into Australia, leaving the business potentially underequipped for maintenance activities).

Recent Capacitor test records indicate that, 160 capacitors units have now degraded to the point where they require replacement. This is an average Capacitor failure rate of 32 Capacitor units per annum or 3.1%, out of a total of 1016 Capacitors in service.

Replacement of degraded Capacitors will commence in 2017, however replacement is expected to lag behind the degradation rate due to the limited available outage time. As a result, an operational deficit is expected between the number of degraded units and the number of units replaced in any period. As the service life of the existing Capacitors increases there is an expected on-going need to replace degraded capacitors at the same rate

Recent purchases of capacitors indicate a lead time for supply of replacement Capacitor units of approximately 12 months. This would be the expected outage duration of Murraylink should adequate spares holding not be maintained.

4.11.3 *Impacts to Operations, Maintenance or Safety*

As a result of this work an increased maintenance requirement in order to effect the replacements as failures increase is expected to occur.

This OPEX increase has been included in the adjacent submissions and is estimated as:

OPEX Estimate		
No	**Description**	**$pa ($2016)**
1	Additional Maintenance	$15,039 p.a. ~3.1% failure rate

4.11.4 *Justification under the NER*

This strategic sourcing project for Capacitors is required to meet the following capital and operating expenditure objectives set out in clause 6A.6.7(a) and 6A.6.6(a) of the National Electricity Rules (the Rules):

(1) meet the expected demand for prescribed transmission services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;

(3) maintain the quality, reliability and security of supply of prescribed transmission services; and

(4) maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

The expenditure for the sourcing program is justified under clauses 6A.6.7 (1), (3) and (4), being required to maintain the efficient operability (minimise turnaround times on outages) and the security of supply in the provision of prescribed transmission services.

4.11.5 *Evaluation of Alternatives*

The following table outlines the Alternate Options considered.

Alternatives			
No	**Description**	**Outcome**	**$**
1	Capacitor Purchase (OEM)	Chosen: Purchase of replacement units.	$1.8m
2	Capacitor Purchase (non-OEM)	Not Chosen: Purchase of non-OEM replacement units requires detailed change management with little cost	N/A

		saving achieved.	
3	Do Nothing	Not Chosen: Increasing rates of failure and reduction in spares holding would eventually result in outages of circa 10 months in order to source new units	N/A

4.11.6 *Funding and Estimating*

The following table represents the estimated project execution costs:

Forecast Cost						
No	**Description**	**Yr1 (2019)**	**Yr2 (2020)**	**Yr3 (2021)**	**Yr4 (2022)**	**Yr5 (2023)**
1	Capacitor Purchases	$954,304	$185,584	$185,584	$185,584	$185,584
2	APA Management	$95,430	$18,558	$18,558	$18,558	$18,558
	Forecast Annual Expenditure	$1,049,734	$204,142	$204,142	$204,142	$204,142

Basis of Estimate:

Historic degradation rates and operational experience has demonstrated that adequate stores of Capacitors need to be maintained to minimise the down time of the system.

This was used to determine the required volume of units with recent quotes from the EOM used to provide financial values.

Assumptions and Calculations Used in Financial Analysis:

Analysis / measurement is preformed every three years and hence procurement outlays an aligned with the results of these surveys.

Note these are 2016$ and have not been inflated.

4.11.7 *Prudency and Efficiency of Expenditure*

The requirement for AER acceptance of capital expenditure specified in 6A.6.7(c) of the National Electricity Rules (the Rules) That is, the costs must be:

- efficient in achieving the objectives;
- be such as would be incurred by a prudent service provider; and

- represent a realistic expectation of the costs to achieve the requirement.

The proposed expenditure is prudent, in that it is necessary to maintain Murraylink in service and avoid extended outage times while spares are procured.

The purchase costs to secure the relevant inventory are those quoted by the original equipment manufacturer and are consistent with their original design specification for this system.

4.11.8 Recommendations

It is recommended to implement this strategic procurement initiative to source critical inventory of Capacitors to:

- Ensure effective procurement of commercially economic quantities that minimise overall costs;
- Maintain critical inventory for the efficient maintenance of the system; and,
- Minimise supply risk (delivery times) by establishing a staged regular supply-chain so critical inventory can be effectively maintained.

The estimated costs have been included in the operating and capital expenditure forecasts for the Murraylink Regulatory submissions.

A Other Minor Capital Works Detailed Breakdown

ID	System	Component	Replace/Refurbish Interval		$ Each	# Units	$ Total	% Efficiency saving	% of work done in 5 yr period	Adjusted Costs	2019	2020	2021	2022	2023
SIB001	Room Ventilation Fans	Electric Motor	10	year	$3,000	40	$120,000	100%	40%	$48,000	$ -	$ -	$ -	$ -	$ 48,000.00
										$0					
SIB002	Building Ventilation	Electric Motor	10	year	$6,000	10	$60,000	100%	100%	$60,000	$ -	$ -	$ -	$ -	$ 60,000.00
										$0					
SIB003	Fan Coils	Fan Motor	7	year	$4,000	40	$160,000	100%	100%	$160,000	$ -	$ -	$ -	$ -	$ -
SIB004	Fan Coils	Corrosion	15	year	$8,000	40	$320,000	100%	60%	$192,000	$ -	$ -	$ -	$ -	$ -
										$0					
SIB005	Liquid Chiller 1	Pump	7	year	$7,000	2	$14,000	100%	100%	$14,000	$ -	$ -	$ -	$ -	$ -
SIB006	Liquid Chiller 1	Compressor	15	year	$10,000	2	$20,000	100%	100%	$20,000	$ -	$ -	$ -	$ -	$ -
SIB007	Liquid Chiller 1	Fan motor	7	year	$4,000	2	$8,000	100%	60%	$4,800	$ -	$ -	$ -	$ -	$ -
										$0					
SIB008	Liquid Chiller 2	Pump	7	year	$7,000	2	$14,000	100%	100%	$14,000	$ -	$ -	$ -	$ -	$ -
SIB009	Liquid Chiller 2	Compressor	15	year	$10,000	2	$20,000	100%	100%	$20,000	$ -	$ -	$ -	$ -	$ -
SIB010	Liquid Chiller 2	Fan motor	7	year	$4,000	2	$8,000	100%	100%	$8,000	$ -	$ -	$ -	$ -	$ -
										$0					
SIB011	Chilled Water Piping	Corrosion	15	year	$50,000	2	$100,000	100%	40%	$40,000	$ -	$ -	$ -	$ -	$ -
SIB012	Chilled Water Piping	Valves	15	year	$2,000	60	$120,000	100%	40%	$48,000	$ -	$ -	$ -	$ -	$ -
SIB013	Chilled Water Piping	Lagging	10	year	$10,000	2	$20,000	100%	40%	$8,000	$ -	$ -	$ -	$ -	$ 8,000.00
SIB014	Chilled Water Piping	Water	3	year	$6,000	2	$12,000	100%	40%	$4,800	$ -	$ -	$ 4,800.00	$ -	$ -
										$0					
SIB015	Expansion Vessel	Corrosion	8	year	$5,000	2	$10,000	100%	40%	$4,000	$ 4,000.00	$ -	$ -	$ -	$ -
										$0					
SIB016	Fire System	Inergen Pressure Vesse	10	year	$65,000	2	$130,000	100%	50%	$65,000	$ -	$ -	$ -	$ -	$ 65,000.00
SIB017	VESDA Scanner	Chassis	10	year	$8,000	4	$32,000	100%	100%	$32,000	$ -	$ -	$ -	$ -	$ 32,000.00
										$0					
SIB019	Valve Cooling System	Pump	7	year	$10,000	4	$40,000	100%	100%	$40,000	$ -	$ -	$ -	$ -	$ -
SIB019a	Valve Cooling System	Pump	7	year	$3,000	2	$6,000	100%	100%	$6,000	$ -	$ -	$ -	$ -	$ -
SIB020	Valve Cooling System	Electric Motor	9	year	$3,000	4	$12,000	100%	100%	$12,000	$ -	$ -	$ 12,000.00	$ -	$ -
SIB021	Valve Cooling System	Blocking Valve	15	year	$7,000	4	$28,000	100%	100%	$28,000	$ -	$ -	$ -	$ -	$ -
SIB022	Valve Cooling System	Proportional Valve Mot	15	year	$7,000	4	$28,000	100%	100%	$28,000	$ -	$ -	$ -	$ -	$ -
SIB023	Valve Cooling System	Pressure Vessel Inspec	7	year	$6,000	2	$12,000	100%	100%	$12,000	$ -	$ -	$ -	$ -	$ -
SIB024	Valve Cooling System	Motor Start Contactors	10	year	$800	4	$3,200	100%	100%	$3,200	$ -	$ -	$ -	$ -	$ 3,200.00
										$0					
SIB025	Reactor Cooling Syster	Pump	7	year	$10,000	4	$40,000	100%	100%	$40,000	$ -	$ -	$ -	$ -	$ -
SIB026	Reactor Cooling Syster	Electric Motor	9	year	$3,000	4	$12,000	100%	100%	$12,000	$ -	$ -	$ 12,000.00	$ -	$ -
SIB027	Reactor Cooling Syster	Blocking Valve	15	year	$7,000	4	$28,000	100%	100%	$28,000	$ -	$ -	$ -	$ -	$ -
SIB028	Reactor Cooling Syster	Proportional Valve Mot	15	year	$7,000	2	$14,000	100%	100%	$14,000	$ -	$ -	$ -	$ -	$ -
SIB029	Reactor Cooling Syster	Pressure Vessel Inspec	7	year	$6,000	2	$12,000	100%	100%	$12,000	$ -	$ -	$ -	$ -	$ -
SIB030	Reactor Cooling Syster	Motor Start Contactors	10	year	$500	4	$2,000	100%	100%	$2,000	$ -	$ -	$ -	$ -	$ 2,000.00
SIB030a	Reactor Cooling Syster	Pipe Lagging	17	year	$0	1	$0	100%	100%	$0	$ -	$ 29,260.00	$ -	$ -	$ -
										$0					
SIB031	Cooling Tower	Electric Motor	10	year	$2,500	106	$265,000	100%	80%	$212,000	$ -	$ -	$ -	$ -	$ 212,000.00
SIB032	Cooling Tower	Motor Start Contactors	10	year	$400	106	$42,400	100%	80%	$33,920	$ -	$ -	$ -	$ -	$ 33,920.00
										$0					
SIB033	Transformer	Cooling Fan motors	15	year	$7,000	12	$84,000	100%	80%	$67,200	$ -	$ -	$ -	$ -	$ -
SIB034	Transformer	Motor Start Contactors	10	year	$400	2	$800	100%	80%	$640	$ -	$ -	$ -	$ -	$ 640.00
										$0					
SIB035	Split system air cond	Compressor & Head Unit	4	year	$4,000	12	$48,000	100%	100%	$48,000	$ 48,000.00	$ -	$ -	$ -	$ 48,000.00
										$0					
SIB036	Work Station Computer	Hardware	4	year	$800	6	$4,800	100%	100%	$4,800	$ 4,800.00	$ -	$ -	$ -	$ 4,800.00
SIB037	Work Station Computer	Software	10	year	$5,000	6	$30,000	100%	100%	$30,000	$ -	$ -	$ -	$ -	$ 30,000.00
SIB038	Motor Control Centres	Motor Start Contactors	10	year	$400	5	$1,800	100%	100%	$1,800	$ 180.00	$ 180.00	$ 180.00	$ 180.00	$ 180.00
SIB039	Motor Control Centres	Control Relays	10	year	$400	33	$13,040	100%	100%	$13,040	$ 1,304.00	$ 1,304.00	$ 1,304.00	$ 1,304.00	$ 1,304.00
SIB040	Motor Control Centres	Switches	10	year	$200	30	$5,980	100%	100%	$5,980	$ 598.00	$ 598.00	$ 598.00	$ 598.00	$ 598.00
SIB041	Access Ramp upgrade						$0	100%	100%	$0	$ -	$ 17,380.00	$ -	$ -	$ -
SIB042	Test Gear						$0	100%	100%	$0	$ -	$ 81,400.00	$ -	$ -	$ -
SIB043	Control System	Interface Boards	10	year	$1,000	95	$95,440	100%	100%	$95,440	$ 9,544.00	$ 9,544.00	$ 9,544.00	$ 9,544.00	$ 9,544.00
									Materials / Resources		$ 68,426.00	$ 139,666.00	$ 40,426.00	$ 11,626.00	$ 559,186.00
									APA Margin		$ 6,842.60	$ 13,966.60	$ 4,042.60	$ 1,162.60	$ 55,918.60
									Total Cost		$ 75,268.60	$ 153,632.60	$ 44,468.60	$ 12,788.60	$ 615,104.60

B OEM Provided Quotes/Obsolescent Notices (confidential)

B.1 IGBT's

161025
OPP-16-500254 - Mu

B.2 VSDs

Product LC Status
Statement_ACS600 S

161025
OPP-16-500149 - Mu

C Fire Protection System

C.1 Front End Engineering Design Document

Murraylink Fire Suppression (FEED).

C.2 Fire System Specification

Murraylink Fire Suppression (TECH S