2023-27
POWERLINK QUEENSLAND REVENUE PROPOSAL

Project Pack – PUBLIC

CP.02727
Gladstone South Secondary Systems Replacement

CP.02727 – Gladstone South Secondary Systems Replacement

Project Status: Not Approved

1. Network Requirement

The 132kV Gladstone South Substation, approx. 110km south-east of Rockhampton, was established in 1960s (original substation T152) and added to in 2002 (newer adjacent substation T019). The substation is a critical part of the 132kV network in the Gladstone area and an essential supply point for Energy Queensland loads and Queensland Alumina Limited (QAL) loads. An outage of this asset would leave up to 170MW of customer load per day at risk[2].

A Condition Assessment (CA) carried out in July 2018 identified that most secondary systems assets will reach the end of their technical service lives by 2023[1]. The equipment is, or is becoming, obsolete with no support from the manufacturer and limited spares available. Beyond their 20 year nominal service life, secondary systems suffer increased failure rates. Increasing failure rates, along with the increased time to rectify the faults due to equipment obsolescence, significantly affects the availability and reliability of these systems. There is therefore a need for Powerlink to address this emerging risk to ensure ongoing compliance with Schedule 5.1.9(c) of the National Electricity Rules (NER) and AEMO's Power System Security Guidelines (V95, 2019).

Planning Report forecasts confirm there is an enduring need to maintain electricity supply to the Gladstone area and QAL. The removal or reconfiguration of the Gladstone South Substation due to secondary system failure or obsolescence would violate Powerlink's Transmission Authority reliability obligations (N-1-50MW/maximum 600MWh unserved energy)[7].

2. Recommended Option

As this project is currently 'Not Approved', the project need and options have been consulted on as part of the public Regulatory Investment Test for Transmission (RIT-T) consultation process. The preferred option, described in the Project Assessment Conclusions Report (July 2020), is to replace all secondary systems at Gladstone South Substation by 2023[6].

The following options were also considered:

- Do Nothing – rejected due to non-compliance with reliability obligations.
- Partial staged replacement of secondary systems – rejected based on outcome of economic assessment of RIT-T.
- Non-Network Option parameters identified – no feasible non-network options were identified.

Figure 2-1 shows the current recommended option may reduce the forecast risk monetisation profile of the Gladstone South Substation secondary systems by over $2m per annum from 2024. The recommended option will extend the asset life by 20 years.

Where a 'Do Nothing' scenario is adopted, the forecast level of risk associated with the asset rapidly escalates from approximately $200k per annum in 2023 to an estimated $2m per annum in 2024 and continues to rise each year thereafter. The significant increase in risk cost in 2023 coincides with the depletion of available spares, which result in financial risks to replace the failed secondary systems in an unplanned (emergency) manner and network risks (unserved energy) from concurrent network outages due to equipment failures.[3]

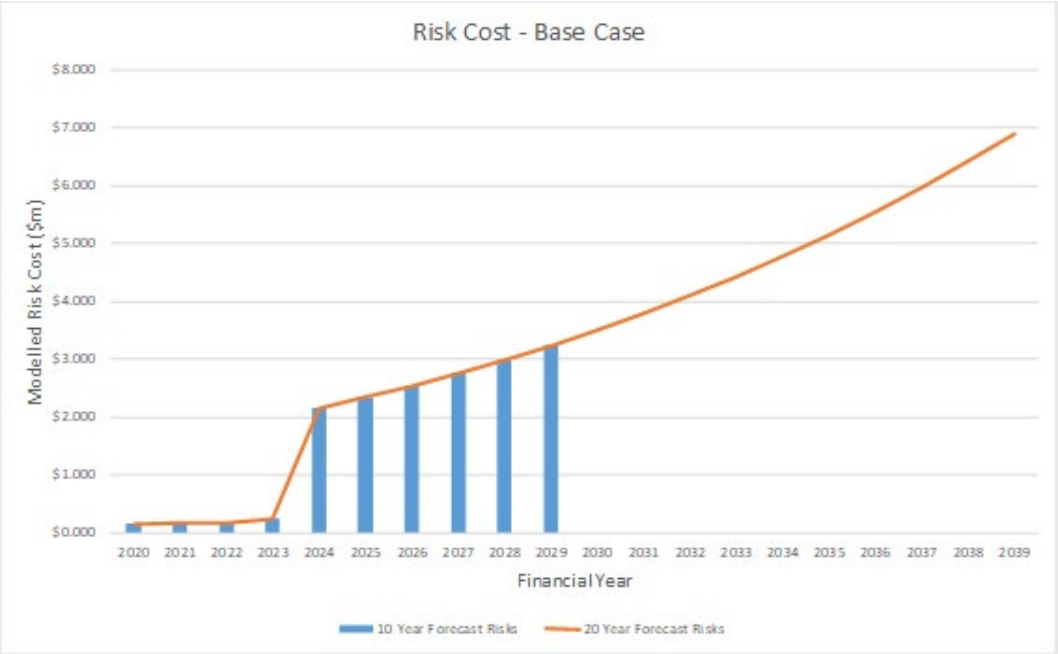

Figure 2-1 Annual Risk Monetisation Profile (Nominal)

3. Cost and Timing

The estimated cost to replace the secondary systems at Gladstone South Substation is $16.8m ($2019/20 Base)[5].

Target Commissioning Date: March 2024

Note: The target commissioning date has been extended to enable the incremental cutover of secondary systems per bay while maintaining the shortest possible return to service (two hours) duration to minimise customer impacts.

4. Documents in CP.02727 Project Pack

Public Documents

1. Secondary Systems Condition Assessment Report – T152 & T019 Gladstone South 132kV
2. Gladstone South and QAL West Planning Report
3. Base Case Risk and Maintenance Costs Summary Report - CP.02727 Gladstone South Secondary Systems Replacement and CP.02728 QAL West Secondary System Replacement
4. Project Scope Report CP.02727 T152 Gladstone South Secondary Systems Replacement
5. CP.02727 T152 Gladstone South Secondary Systems Replacement Project Management Plan – Proposal
6. Project Assessment Conclusions Report - Addressing the secondary systems condition risks in the Gladstone South area

Supporting Documents

7. Asset Reinvestment Criteria - Framework
8. Asset Management Plan 2021

T152 & T019 Gladstone South 132kV

Secondary Systems Condition Assessment Report

Document Details			
Version Number	2.0	**Principal Author**	[redacted]
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Date	Version	Nature of Change	Author	Authorisation
22/04/2014	1.0	New document	[redacted]	[redacted]
06/07/2018	2.0	Major updates	[redacted]	[redacted]
08/07/2019	3.0	Health index update	[redacted]	[redacted]

This report will be only valid for three years from the date when it is issued.

Table of Contents

1. Introduction

This report is pertinent to T019 and T152 Gladstone South substations 132kV secondary systems and associated site infrastructure. It is provided to assist with determining the future strategy and scope for refurbishment and replacement works of Gladstone South 132kV secondary systems.

The assessment has been formulated with the assistance of data extracted from SAP, SPF, Forced Outage Database (FOD), reliability analysis, discussion with maintenance staff and a site inspection. Photographs of items are included in the text and all photographs taken during the site visit have been retained for future reference.

T019 and T152 Gladstone South substation are essential points of supply for Ergon and QAL (Queensland Alumina Limited) loads. Gladstone South substation is part of Powerlink's 132kV network. T019 Gladstone South was built in the early 1960s as a 132kV supply point for transformation to the distribution network and as a major connection to QAL. As a result of rising fault level and the general condition of T019 substation, a new substation T152 Gladstone South Sub was rebuilt on an adjacent site in 2002.

Secondary systems for 132kV bus zones, 132kV bus couplers and 10 x 132kV Feeders, and metering for Feeder 7102, 7101, 7103 and 7147 at T152 Gladstone South were installed in 2003. Secondary systems for 5th Harmonic Filter and 132kV 1 Cap were installed at T152 Gladstone South in 2010 and 2006 respectively. Revenue Meters for Transformer 3 and Transformer 6 were originally located at T019 Gladstone South. They were replaced at T152 Gladstone South in 2016. The only left secondary system at T019 Gladstone South is the transformer cooling control DRMCC DR E3 which was replaced in 2014.

T019 and T152 Gladstone South Substation Network Diagram

2. Site infrastructure

Both T019 and T152 Gladstone South are located in the suburbs of Gladstone South Township.

T019 Substation consists of one yard of 132kV and Ergon owned 66kV equipment. Powerlink owns two transformer bays, 1 x harmonics filter bay, AC changeover panel, AC/DC distribution boards, onsite generator and a concrete control building which is shared with Ergon. Associated secondary systems for transformers and the harmonics filter are housed in the control building of T152 substation.

T019 Gladstone South Sub houses the following bays:-

- 3 transformer bay
- 6 transformer bay
- Double tuned 5/7 ^{h} harmonic filter bay

T152 Gladstone South Substation contains one fenced yard of 132kV equipment, including:-

- 4 x bus zones;
- 3 x bus couplers;
- 10 x feeder bays;
- 1 x capacitor bank;
- Communication building T;
- Demountable control building K.

T152 and T019 Gladstone South substation yard bird view

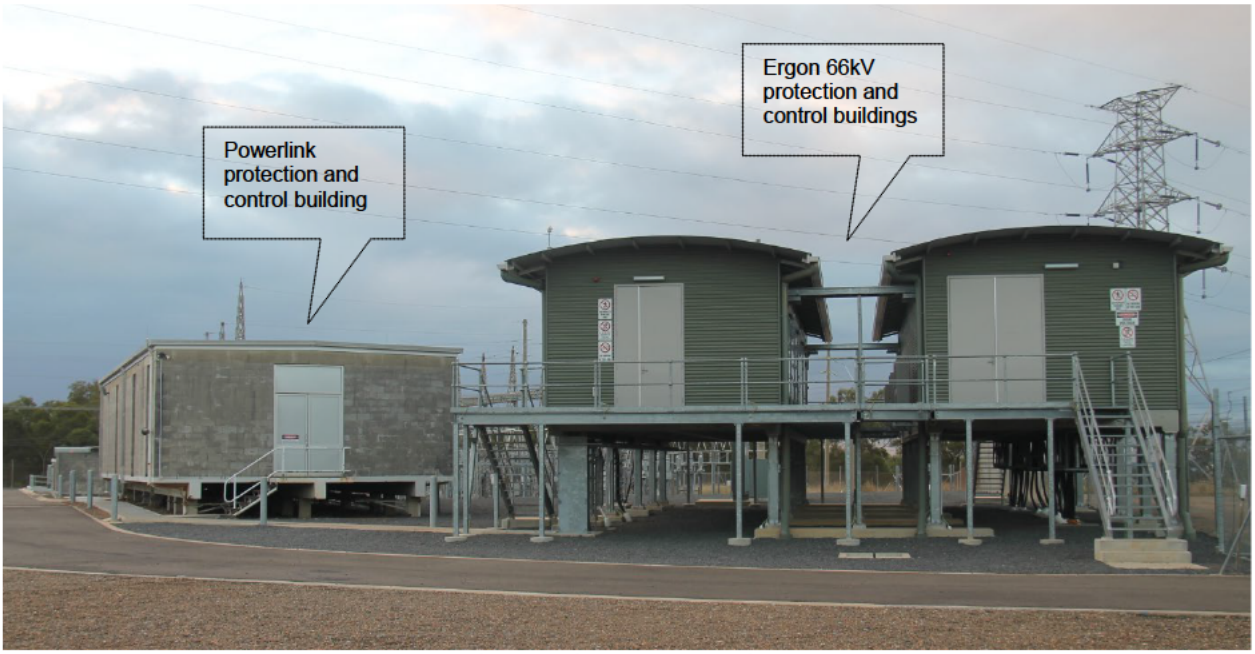
3. Condition Assessment

3.1 Buildings

The condition assessment of buildings is developed in a separate document and carried out by Substation Strategies. The following details for buildings are for information only.

3.1.1 T019 Gladstone South 66kV control building

The main building at T019 is one level concrete construction. It used to house Ergon 66kV protection and control panels, and Powerlink revenue metering panels. Powerlink revenue metering panels were placed at T152 in 2016. Ergon had recently replaced their secondary systems for 66KV network in 2 x new demountable buildings. Currently there are no Powerlink secondary systems housed in the control building at T019.



T019 Gladstone South 132/66kV control building

3.1.2 T152 Gladstone South 132kV control building

There are two demountable buildings at T152 Gladstone South Substation. One is Communications & Amenities Building +T which houses communication equipment, lunch room, workshop and toilet facilities. Another is a demountable building which accommodates all 132kV Powerlink secondary systems. Both buildings were built in 2003 and are air conditioned.

T152 Sub building T and K

3.2 Trench, marshalling cubicles and control cables

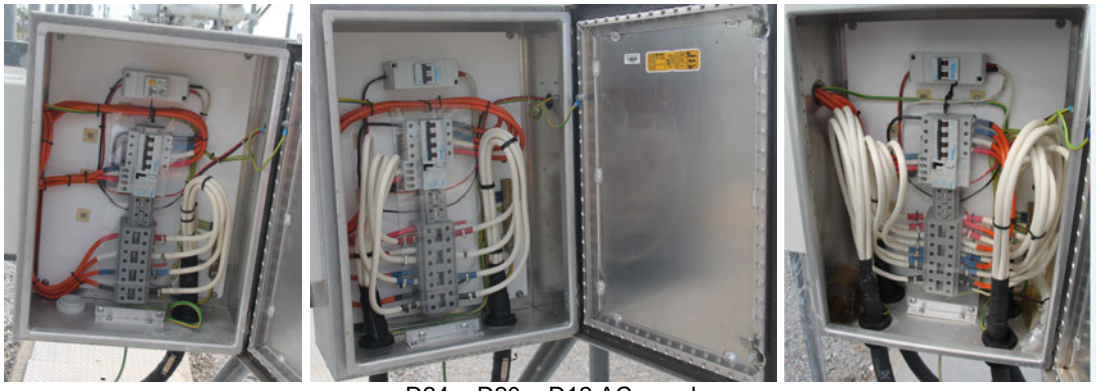
Conditions of trenches are not included in this report and are addressed in Substation Condition Assessment Report.

Trenches at T152

PASS (Plug and Switch System) M0 hybrid primary equipment is used across the substation except the harmonics filter bay at T152 Gladstone South Substation. Associated marshalling cubicles for hybrid PASS M0 primary plant are not in the scope of this secondary system condition assessment (see relevant substation condition assessment for detail).

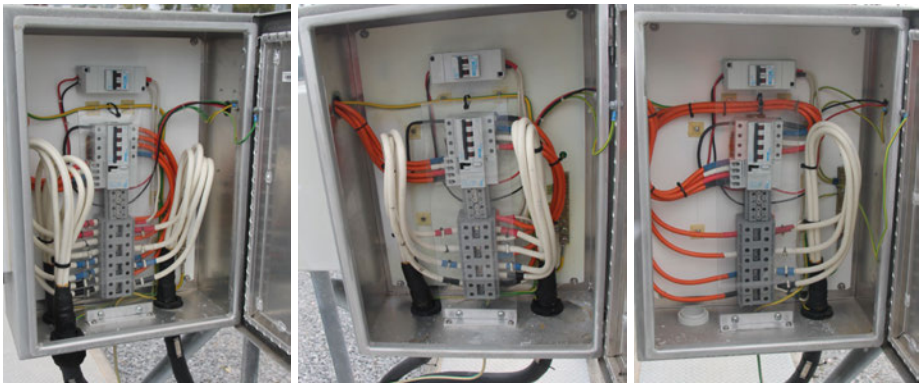
OML2 (On Line Monitoring) data acquisition unit for Pass M0 hybrid primary plants are utilized to monitor the condition of primary plants. These modules have experienced high failures and should be bypassed as part of any major primary or secondary system replacement (Pass M0 1 Cap has OLM2 already removed).

Conventional marshalling cubicles for AC supply were commissioned in 2002 and are in fair condition. There are no condition-driven replacements required till 2042.



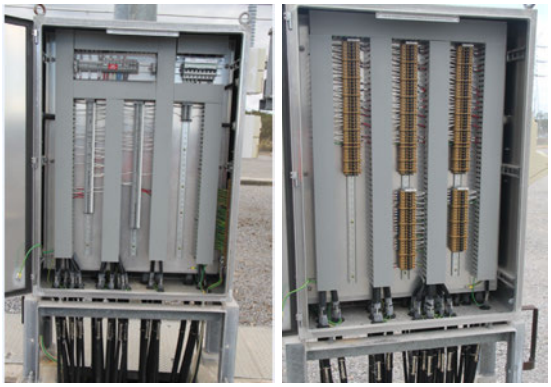
=D24, =D20, =D12 AC supply

=D08, =D02, =D03 AC supply



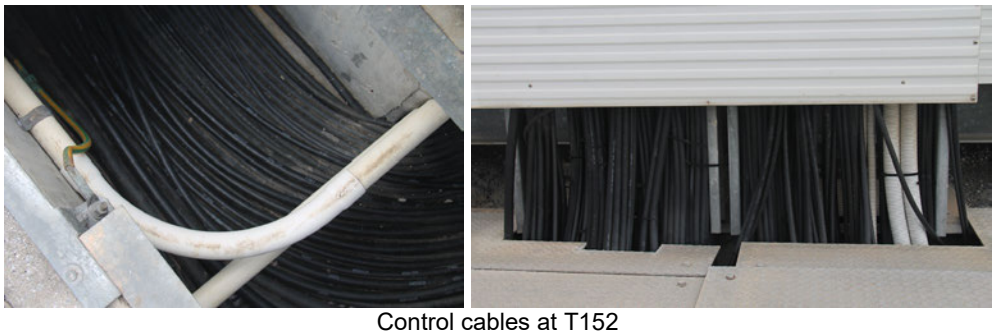
=D09, =D15, =D21 AC supply

The marshalling cubicle for the harmonic filter was built in 2010 and is in good condition.



Harmonic filter marshalling cubicle

The sheath of control cable from the primary plant to marshalling box becomes faded due to sun exposition. The control cables between marshalling cubicles and the control building are in fair condition. There are no condition-driven replacements required till 2042.

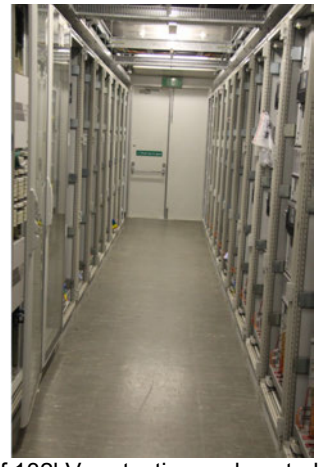


Control cables at T152

3.3 Protection and control bays

3.3.1 Protection and control panels

There are no spaces available in the existing demountable building for future secondary system replacement.



Inside of 132kV protection and control building

Secondary systems at T152 Gladstone South are housed in a type of swing frame panel. Panel and associated wirings for the coupler are in fair condition. However, there are safety in design concerns on this type of swing frame panel, such as isolation issues and potential termination falling loose risks. Updates on the panel to address these issues should be considered with major secondary systems replacement.

The panel arrangement does not allow crews to work on 2 x opposite panels at the same time due to limited panel clearance (less than 600mm). Control measures need to be in place to mitigate associated risks.

3.3.2 132kV Bus zones and coupler bays

Secondary systems for 132kV bus zones and couplers are detailed in a table below.

132kV Bus and coupler	Relay & control	Model	Startup Date	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index
1 Bus	X Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Y Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	No	Limited	8.07
2 Bus	X Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Y Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	No	Limited	8.07
3 Bus	X Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Y Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	No	Limited	8.07
4 Bus	X Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Y Protection	B30	2003	No	Yes	Limited	8.07
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	No	Limited	8.07
Coupler 411	CBF X	C60	2003	No	Yes	Yes	8.07
	CBF Y	SEL-351-1	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	No	Limited	8.07
Coupler 412	CBF X	C60	2003	No	Yes	Yes	8.07
	CBF Y	SEL-351-1	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	Yes	Limited	8.07
Coupler 413	CBF X	C60	2003	No	Yes	Yes	8.07
	CBF Y	SEL-351-1	2003	Yes	Yes	Yes	8.07
	Bay Controller	C50	2003	No	No	Limited	8.07

B30 relays provide duplicate current differential schemes to protect all 4 x bus zones at T152 Gladstone South. These relays were commissioned in 2003 and have become obsolete. Spares are expected to be comsumed within 5 years. C50 RTUs are used as bay controllers for bus zones to provide control functions. C50 RTUs have become obsolete and Powerlink have to rely on limited spares to maintain their operation. Health Index indicates that all secondary systems will reach the end of tehcinical asset life and need to be replaced by 2023.

1 and 2 Bus zone protection and control panels

3 and 4 Bus zone protection and control panels

C60 and SEL-351 provide CB management for all three 132kV bus couplers. These devices were installed in 2003 and have provided reliable operation. C50 RTUs are used as bay controllers for bus couplers to provide control functions. C50 RTUs have become obsolete and Powerlink have to rely on limited spares to maintain their operation. Health Index indicates that all secondary systems will reach the end of tehcinical asset life and need to be replaced by 2023.

1-2, 2-3 and 3-4 bus coupler CB management and control panel

3.3.3 132kV transformer bays

Secondary systems for transformer bays are detailed in a table below.

Transformer	Relay & control	Model	Startup Date (Year)	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index
7269 Transformer 6 Feeder	X Protection	T60	2003	No	Yes	Yes	7.99
		F35	2003	No	Yes	Yes	7.99
	Y Protection	SEL-387-5	2003	Yes	Yes	Yes	7.99
	Bay Controller	C50	2003	No	No	Limited	7.99
	Transformer control	DRMCC DR-E3	2003	Yes	Yes	Yes	7.99
7268 Transformer 3 Feeder	X Protection	T60	2003	No	Yes	Yes	7.99
		F35	2003	No	Yes	Yes	7.99
	Y Protection	SEL-387-5	2003	Yes	Yes	Yes	7.99
	Bay Controller	C50	2003	No	No	Limited	7.99

Biased current differential relays T60 and SEL-387 at T152 are used to protect transformer 3 & 6 at T019. F35 provides thermal protection in case of transformer overloaded for N-1 scenario. These devices were installed in 2003 and have provided reliable operations. Bay controller C50 RTUs have become obsolete and Powerlink have to rely on limited spares to maintain their operation. Health Index indicates that all secondary systems will reach the end of technical asset life and need to be replaced by 2023.

3 & 6 Transformer protection and control panels

DRMCC DR-E3 control device is used for the transformer cooling control and was replaced in 2014. Powerlink has experience high failures of this type of equipment. The control unit is housed in a transformer cubicle in the yard of T019. This could reduce the asset life of equipment operated in non-air conditioning and dusty environment. Powerlink is phasing out this type of equipment with a more reliable solution. This device should be replaced with a conventional method under any major secondary systems replacement.

Transformer cooling control unit

3.3.4 132kV feeder bays

Secondary systems for feeder bays are detailed in a table below.

132kV Feeder	Relay & control	Model	Startup Date (Year)	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index
7101	X	L90 (3 Ended)	2003	No	Yes	Yes	8.04
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.04
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	8.04
	Bay control	C50	2003	No	No	Limited	8.04
7102	X	L90 (3 Ended)	2003	No	Yes	Yes	7.95
	Y	SEL-311-C	2008	Yes	Yes	Yes	5.55
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.95
	Bay control	C50	2003	No	No	Limited	7.95
7103	X	L90 (3 Ended)	2003	No	Yes	Yes	8.02
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.02
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	8.02
	Bay control	C50	2003	No	No	Limited	8.02
7104	X	P442	2003	No	Yes	Yes	7.94
	Y	SEL-311-C	2003	Yes	Yes	Yes	7.94
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.94
	Bay control	C50	2003	No	No	Limited	7.94
7105	X	P442	2003	No	Yes	Yes	7.93
	Y	SEL-311-C	2003	Yes	Yes	Yes	7.93
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.93
	Bay control	C50	2003	No	No	Limited	7.93
7147	X	L90 (3 Ended)	2003	No	Yes	Yes	8.02
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.02
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	8.02
	Bay control	C50	2003	No	No	Limited	8.02
7169	X	L90 (3 Ended)	2003	No	Yes	Yes	7.98
	Y	SEL-311-C	2003	Yes	Yes	Yes	7.98
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.98
	Bay control	C50	2003	No	No	Limited	7.98
760	X	P546	2012	Yes	Yes	Yes	6.23
		P591	2012	No	Yes	Yes	3.43
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.03
	Bay control	C50	2003	No	No	Limited	8.03

L90 and SEL-311C protection relays are used to protect feeder 7101, 7102, 7103, 7147 and 7169. These relays were installed in 2003. Health Index indicates that these equipment will reach the end of useful asset life and should be replaced to maintain their reliable operations by 2023.

Feeder 7101 and 7102 protection and control panels

Feeder 7103 and 7147 protection and control panels

Feeder 7147 and 7169 protection and control panels

P442 and SEL-311C provide X and Y protection scheme to protect feeder 7104 and 7105. These devices were installed at 2003. Health Index indicates that these devices will reach the end of technical asset life and need to be replaced by 2023.

Feeder 7104 and 105 protection and control panels

P546 and SEL-311C relays are utilised to protect Calliope River feeder 760. P546 was commissioned in 2010 and there is no condition-driven replacement required within 10 years. SEL-311-C was installed in 2003 and needs to be replaced by 2023 according to associated health index.

Feeder 760 protection and control panel

C50 RTUs are utilised to provide bay control functionality for all feeders. They were installed in 2003. Health Index indicates that they will reach the end of technical asset life and need to be replaced by 2023.

Feeder 7268 and 7269 are protected by associated Transformer secondary systems due to the short length of transmission line. As such there are no dedicated secondary systems for Feeder 7268 and 7269.

3.3.5 132kV Capacitor Banks

Secondary systems for capacitor banks are detailed in the following table.

132kV Cap	Relay & control	Model	Startup Date (Year)	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index
1 Cap	X	C60	2006	No	Yes	Yes	6.23
		SPAJ140C	2006	Yes	Yes	Yes	6.23
		SPAJ160C	2006	Yes	Yes	Yes	6.23
	Y	SEL-351-1	2006	Yes	Yes	Yes	6.23
	POW	ABB E213	2006	Yes	Yes	Yes	6.23
	Bay control	C50	2006	No	No	Limited	6.23

C60, SPAJ140C, SPAJ160C and C50 are used to provide protection, CB management and control functionalities. These devices carried our reliable performance and in fair condition. C50 RTUs have become obsolete. Powerlink had a last purchase in 2014 and are relying on the limited number of spares for the maintenance. Health Index shows that all protection relays will need to be replaced in 2027/2028 excpet the C50 RTU which needs to be replaced by 2023 due to its obsolescence.

1 CAP protection and control panel

3.3.6 132kV Harmonics Filter Bay

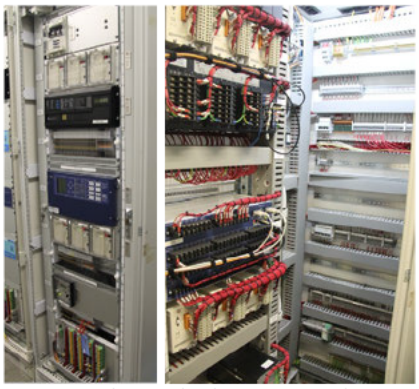
Secondary systems for 132kV harmonics filter bay are shown in a table below.

132kV Harmonics Filter	Relay & control	Model	Startup Date (Year)	Still Manufactured?	Manufacture Support?	*PLQ Spares	Remaining Asset Life (Year)	Health Index
Harmonic Filter	X	MFAC34	2010	Yes	Yes	Yes	13.05	4.31
		SPAJ160C	2010	Yes	Yes	Yes	13.05	4.31
		C60	2010	No	Yes	Yes	12.51	4.58
	Y	SEL-451	2010	Yes	Yes	Yes	13.05	4.31
		SPAJ160C	2010	Yes	Yes	Yes	13.05	4.31
	POW	ABB E213	2010	Yes	Yes	Yes	12.99	4.34
	Bay control	C50	2010	No	No	Limited	9.50	6.08

***PLQ Spares**: Limited – Spares will be depleted within 5 years
Yes – The estimated time of depletion is more than 5 years.

Double tuned 5/7 ^{h} harmonics filter was installed at T019 to reduce the harmonics distortion in Gladstone area in 2010. High impedance current differential relay MFAC34, SPAJ160C, C60,SEL-451 relays and C50 RTU are used to protect associated primary plants. These devices were installed in 2010 and in fair condition. C50 RTUs have become obsolete. Powerlink had a last purchase in 2014 and are relying on the limited number of spares for the maintenance.

Health Index shows that all protection relays will need to be replaced in 2030/2031 except the C50 RTU which needs to be replaced by 2023 due to its obsolescence.



Harmonics filter protection and control panel

3.3.7 Power system monitoring

Power Quality Monitoring (PQM) was installed at T152 Gladstone South under CP.02297 Power Quality Monitoring in 2017. The PQM is used to monitor harmonics level, voltage sag/swell and transients to ensure that the power supply meets requirements of NER and customer agreements.

Power Quality Monitoring panel

The PQM device is housed in a swing frame panel and in good condition.

3.4 Metering

Metering devices are detailed in a table below.

Metering	Model	Startup Date (Year)	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index
REVMET1	EDMI 2000-04x0 (Revenue)	2003	No	Yes	Yes	8.07
F7102	EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07
REVMET2	EDMI 2000-04x0 (Revenue)	2015	No	Yes	Yes	5.06
F7101	EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07
REVMET3	EDMI 2000-04x0 (Revenue)	2003	No	Yes	Yes	8.07
F7103	EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07
REVMET4	EDMI 2000-0400 (Revenue)	2003	No	Yes	Yes	8.07
F7147	EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07
REVMET5	MK6E	2016	Yes	Yes	Yes	1.25
T3	MK6E	2016	Yes	Yes	Yes	1.25
REVMET6	MK6E	2016	Yes	Yes	Yes	1.25
T6	MK6E	2016	Yes	Yes	Yes	1.25

Metering for QAL feeders at T152 substation was commissioned in 2003 (except the revenue meter for Feeder 7101 which was installed in 2015) when T152 sub was built. Health index indicates that these meters will reach the end of useful asset life and need to be replaced by 2023.

Metering devices for Feeder 7102, 7101, 7103 and 7147 at T152

Metering devices for Transformer 3 and 6 were replaced under OR.00240 in 2016 and are in good condition. However, as Powerlink's long term telecommunication strategy is to move to packed switched technologies, the metering interrogation needs to be moved from the dialling up to IP based service.

Metering panels for T3 and T6

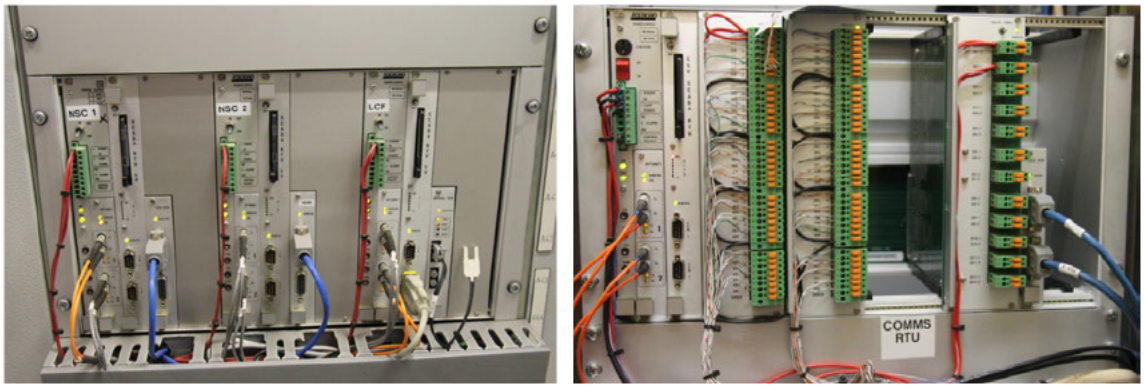
3.5 Non-bays

Secondary systems for non-bays are detailed in a table below.

NBay	Relay & control	Model	Startup date (Year)	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index
Central control	Common/ Comms RTU	C50	2003	No	No	Limited	8.07
SCADA RTU	NSC1	C50	2003	No	No	Limited	8.07
	NSC2	C50	2003	No	No	Limited	8.07
Local Control	LCF RTU	C50	2003	No	No	Limited	8.07
	HMI	Z90D7	2016	Yes	Yes	Yes	5.33
OpsWAN	Switch	[redacted]	2010	Yes	Yes	Yes	8.95
	Server Port	[redacted]	2010	Yes	Yes	Yes	8.95
	Router	[redacted]	2018	Yes	Yes	Yes	8.95
	Server		2010	Yes	Yes	Yes	8.95
Timing		Tekron	2003	Yes	Yes	Yes	8.38

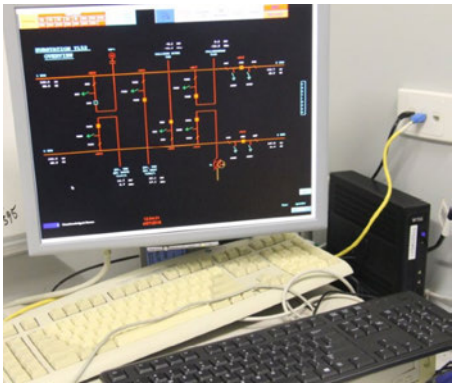
3.5.1 SCADA, Control and OpsWAN

T152 has NSC1 RTU and NSC2 RTU to implement dual SCADA paths based on Conitel SCADA protocol. Conitel protocol has become obsolete and Powerlink is phasing it out to maintain reliable SCADA system. 1 x LCF RTU C50 is located in the OptoNet ring for HMI interface and 1 x C50 RTU is use for comms alarms. C50 RTUs are used as bay controllers for bus zones to provide control functions. C50 RTUs have become obsolete and Powerlink have to rely on limited spares to maintain their operation. Health Index indicates that all secondary systems will reach the end of technical asset life and need to be replaced by 2023.



NSC1, NSC2, LCF and COMMS RTU

Sunworkstation Ultra 5 was replaced with Zenon application in 2016.



Local control facilities

Full OpsWAN was refurbished by OR.01695 OpsWAN Refurbishment in 2010 and associated switches and server are in fair condition. However, because of the short asset life, they need to be replaced to maintain reliable operation with major secondary system replacement.

Substation master & OpsWAN cubicle

3.5.2 Auxiliary supply

AC supplies and associated distribution boards are located at T019 Gladstone South Substation.

AC supplies and associated distribution boards

The 415VAC auxiliary supplies are derived from Ergon network. Suitable monitoring and changeover arrangement are available for the site. Standby diesel generator is available on the

site. However note that this is not in the scope of the secondary system condition assessment (see relevant substation condition assessment for detail).

Diesel generator

Dual 125VDC batteries were installed in 2003 and located in the control building. Replacement has been planned to be carried out under OR.02029 by 2018.

Dual 125VDC system

48VDC dual systems were installed in 2003 and they are located in the comms building. Replacement has been planned to be carried out under OR.02029 by 2018.

Dual 48VDC System

4. Telecommunications

Communication systems at T152 Gladstone South consist of fibre optic and Microwave Radio technology with [redacted] PDH and [redacted] SDH MUX equipment. They have been providing reliable services for protection and control systems. [redacted] no longer manufacturers the PDH equipment, and support for hardware replacement is provided by [redacted] MPLS network was installed to provide IP based services at T152 Gladstone South in 2013 and are in good condition.

PDH and SDH equipment

MPLS network panel

5. Summary of Asset Health

The asset health of major equipment of Gladstone South secondary system assets is determined by an assessment of the equipment aging profile, reliability, conditions (including the condition of panel wirings, control cables and marshalling cubicles) and obsolescence. Asset health index and approximate remaining life of equipment at Gladstone South are summarized in the table below.

Bay	Relay & control	Model	Startup Date	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index	Recommendation		
								Panel	Control cable	Marshalling kiosk
1 Bus	X Protection	B30	2003	No	Yes	Limited	8.07	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Y Protection	B30	2003	No	Yes	Limited	8.07			
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	No	Limited	8.07			
2 Bus	X Protection	B30	2003	No	Yes	Limited	8.07	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Y Protection	B30	2003	No	Yes	Limited	8.07			
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	No	Limited	8.07			
3 Bus	X Protection	B30	2003	No	Yes	Limited	8.07	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Y Protection	B30	2003	No	Yes	Limited	8.07			
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	No	Limited	8.07			
4 Bus	X Protection	B30	2003	No	Yes	Limited	8.07	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Y Protection	B30	2003	No	Yes	Limited	8.07			
		CB Fail trip rack	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	No	Limited	8.07			
Coupler 411	CBF X	C60	2003	No	Yes	Yes	8.07	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
	CBF Y	SEL-351-1	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	No	Limited	8.07			
Coupler 412	CBF X	C60	2003	No	Yes	Yes	8.07			
	CBF Y	SEL-351-1	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	Yes	Limited	8.07	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
Coupler 413	CBF X	C60	2003	No	Yes	Yes	8.07			
	CBF Y	SEL-351-1	2003	Yes	Yes	Yes	8.07			
	Bay Controller	C50	2003	No	No	Limited	8.07			
7269 Transformer 6 Feeder	X Protection	T60	2003	No	Yes	Yes	7.99	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
		F35	2003	No	Yes	Yes	7.99			
	Y Protection	SEL-387-5	2003	Yes	Yes	Yes	7.99			
	Bay Controller	C50	2003	No	No	Limited	7.99			
	Transformer control	DRMCC DR-E3	2003	Yes	Yes	Yes	7.99			
7268 Transformer 3 Feeder	X Protection	T60	2003	No	Yes	Yes	7.99	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
		F35	2003	No	Yes	Yes	7.99			
	Y Protection	SEL-387-5	2003	Yes	Yes	Yes	7.99			
	Bay Controller	C50	2003	No	No	Limited	7.99			
7101	X	L90 (3 Ended)	2003	No	Yes	Yes	8.04			
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.04			
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	8.04	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
	Bay control	C50	2003	No	No	Limited	8.04			
7102	X	L90 (3 Ended)	2003	No	Yes	Yes	7.95			
	Y	SEL-311-C	2008	Yes	Yes	Yes	5.55			
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.95			
	Bay control	C50	2003	No	No	Limited	7.95	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
7103	X	L90 (3 Ended)	2003	No	Yes	Yes	8.02			
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.02			
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	8.02			
	Bay control	C50	2003	No	No	Limited	8.02			
7104	X	P442	2003	No	Yes	Yes	7.94	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
	Y	SEL-311-C	2003	Yes	Yes	Yes	7.94			
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.94			
	Bay control	C50	2003	No	No	Limited	7.94			
7105	X	P442	2003	No	Yes	Yes	7.93			
	Y	SEL-311-C	2003	Yes	Yes	Yes	7.93	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.93			
	Bay control	C50	2003	No	No	Limited	7.93			
7147	X	L90 (3 Ended)	2003	No	Yes	Yes	8.02			
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.02			
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	8.02	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
	Bay control	C50	2003	No	No	Limited	8.02			
7169	X	L90 (3 Ended)	2003	No	Yes	Yes	7.98			
	Y	SEL-311-C	2003	Yes	Yes	Yes	7.98			
	Protection Signalling	DM1200 Digital	2003	No	Yes	Limited	7.98			
	Bay control	C50	2003	No	No	Limited	7.98	Conduct swing frame panel updates with major secondary system replacement	To be replace by 2042	AC supply kiosk to be replaced by 2042
760	X	P546	2012	Yes	Yes	Yes	6.23			
		P591	2012	No	Yes	Yes	3.43			
	Y	SEL-311-C	2003	Yes	Yes	Yes	8.03			
	Bay control	C50	2003	No	No	Limited	8.03			

Bay	Relay & control	Model	Startup Date	Still Manufactured?	Manufacture Support?	*PLQ Spares	Health Index	Recommendation		
								Panel	Control cable	Marshalling kiosk
1 Cap	X	C60	2006	No	Yes	Yes	6.23	Swing frame to be updated in 2026	To be replace by 2046	To be replace by 2046
		SPAJ140C	2006	Yes	Yes	Yes	6.23			
		SPAJ160C	2006	Yes	Yes	Yes	6.23			
	Y	SEL-351-1	2006	Yes	Yes	Yes	6.23			
	POW	ABB E213	2006	Yes	Yes	Yes	6.23			
	Bay control	C50	2006	No	No	Limited	4.31			
Harmonic Filter	X	MFAC34	2010	Yes	Yes	Yes	4.31	Swing frame to be updated in 2030	To be replaced by 2050	To be replaced by 2050
		SPAJ160C	2010	Yes	Yes	Yes	4.58			
		C60	2010	No	Yes	Yes	4.31			
	Y	SEL-451	2010	Yes	Yes	Yes	4.31			
		SPAJ160C	2010	Yes	Yes	Yes	4.34			
	POW	ABB E213	2010	Yes	Yes	Yes	6.08			
	Bay control	C50	2010	No	No	Limited	5.25			
REVMET1		EDMI 2000-04x0 (Revenue)	2003	No	Yes	Yes	8.07	Conduct swing frame panel updates with major secondary system replacement		N/A
		EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07			
REVMET2		EDMI 2000-04x0 (Revenue)	2015	No	Yes	Yes	5.06			
		EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07			
REVMET3		EDMI 2000-04x0 (Revenue)	2003	No	Yes	Yes	8.07			
		EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07			
REVMET4		EDMI 2000-0400 (Revenue)	2003	No	Yes	Yes	8.07			
		EDMI 2000-04x0 (Check)	2003	No	Yes	Yes	8.07			
REVMET5		MK6E	2016	Yes	Yes	Yes	1.25	Conduct swing frame panel updates+ with major secondary system replacement by 2056	To be replaced by 2056	N/A
		MK6E	2016	Yes	Yes	Yes	1.25			
REVMET6		MK6E	2016	Yes	Yes	Yes	1.25			
		MK6E	2016	Yes	Yes	Yes	1.25			
Central control	Common/ Comms RTU	C50	2003	No	No	Limited	8.07	Conduct swing frame panel updates with major secondary system replacement	to be replaced by 2042	N/A
SCADA RTU	NSC1	C50	2003	No	No	Limited	8.07			
	NSC2	C50	2003	No	No	Limited	8.07			
Local Control	LCF RTU	C50	2003	No	No	Limited	8.07			
	HMI	Z90D7	2016	Yes	Yes	Yes	5.33			
OpsWAN	Switch	[redacted]	2010	Yes	Yes	Yes	8.95			
	Server Port		2010	Yes	Yes	Yes	8.95			
	Router		2018	Yes	Yes	Yes	8.95			
	Server		2010	Yes	Yes	Yes	8.95			
Timing		Tekron	2003	Yes	Yes	Yes	8.38			

6. Recommendations

The main recommendations on secondary system refurbishment and replacement at T019 and T152 Gladstone South are as follows.

Stage 1: Undertake replacements on followings secondary systems by 2023:

- All protection and control equipment of
  - 1, 2, 3 and 4 Bus zone
  - Bus coupler 411, 412 and 413
  - Transformer 3 and 6
  - Feeder 7101, 7102, 7103, 7104,7105, 7147 and 7169
  - Bypass the OLM2 module
  - Conduct panel updates according to SU0020
- Replace Y protection and bay controller of Feeder 760 and update the panel according to SU00200 and bypass the OLM2 module
- Replace the bay controller of 132kV harmonics filter bay
- Replace metering devices for F7102, F7101, 7103 and 7147 based on IP
- Upgrade the dialling up service to IP based for Transformer 3 and 6 metering
- Replace NSC1, NSC2 and LCF RTU
- Replace OpsWAN
- Replace GPS timing clock

Stage 2: Carry out following secondary systems replacements by 2027

- X protection equipment of Feeder 760
- All protection and control equipment of 1 Cap including panel updates according to SU0020

Stage 3: Carry out following secondary systems replacements by 2031:

- All protection devices for 132kV harmonics filter and update the panel according to SU00200

Stage 4: Carry out following secondary systems replacements by 2037:

- Metering devices for Transformer 3 and Transformer 6

7. References

(1) National Electricity Rules (NER) Version 92, AEMC, 30/05/2017

Technology and Planning – Network Planning

August 2018

Gladstone South and QAL West Planning Report

Prepared by: Grid Planning
Report number: T18/23

Table of Contents

1 Executive summary

Gladstone South and QAL West substations are located in the Gladstone transmission network and are critical 132kV substations for supplying local customer loads. Powerlink's condition assessment of the aging secondary systems assets at 132kV Gladstone South and QAL West substations has highlighted that the majority are now obsolete, have been in service for more than 15 years and are nearing the end of its technical service life. The majority of the substation's protection, control and supervisory systems are no longer supported by their respective manufacturers nor do they hold spare replacement units. The condition assessment recommends replacement of the majority of the secondary systems in both substations by 2023. This also includes minor remote end works.

Under the National Electricity Rules, TNSPs are required to provide sufficient secondary systems, including redundancies, to ensure the transmission system is adequately protected. This places an obligation on Powerlink to undertake actions that address risks arising from obsolete and aging secondary system assets at Gladstone South and QAL West substations.

The transmission line condition assessment report BS1170 Gladstone South to Callemondah has identified significant levels of deterioration, with a number instances of grade 4 corrosion on structure members, conductor hardware, bolts and nuts. Built Section 1170 is made up of Feeder 760 and 7169. It is estimated that BS 1170, without any refurbishment, life extension or increased maintenance, will reach its technical end of life within the next 3 years.

The following feeders and transformers identified in the condition assessment were technically assessed from a planning perspective to determine whether there is an enduring need.

Gladstone South Substation:

- Feeder 7101 Gladstone South - QAL
- Feeder 7102/1/2 Gladstone South-QAL - QAL West
- Feeder 7103/1/2 Gladstone South -QAL -QAL West
- Feeder 7147/1/2 Gladstone South - QAL - QAL South
- Feeder 7169 Gladstone South - Callemondah
- Feeder 7104 Gladstone South – Callide A
- Feeder 7105 Gladstone South – Callide A
- Feeder 760 Calliope River - Gladstone South
- Transformers 3 and 6 (both 100 MVA)

QAL West Substation:

- Transformer 6 and 7 (both 47 MVA)
- Feeder 7102/2 Gladstone south - QAL West tee
- Feeder 7103/2 Gladstone south- QAL West tee

Planning studies have determined that these feeders and transformers have an ongoing need to meet the load in the area. These studies have indicated that to maintain Powerlink's reliability obligations and connection arrangements; there is an ongoing requirement for Gladstone South and QAL West substation in its current configuration, with the exception of Feeders 7105 and 7104 (Callide A – Gladstone South).

Reconfiguration works to disconnect Feeders 7104 and 7105 is scheduled for completion in 2019 (as part of Project CP.01546 Callide A / Calvale 132kV Network Reinvestment). These lines have not reached end of life and have potential for re-use. There is no ongoing need for 7104 and 7105 in its current capacity between Gladstone South and Callide A. However, Planning has investigated several alternative options. Once decommissioned, 7104 or 7105 could be teed into a Boyne Island feeder (7145) to allow for more operational flexibility and power transfer capability. Alternatively, possible bridging of future ex 7104 and ex 7105 to the energised 760 and 7169 outside Gladstone South to increase operational flexibility with bus outages has been examined. These options have been considered to be credible options from a technical and require further economic assessment.

2 Background

Gladstone South and QAL West substations are located in the Gladstone zone. Gladstone South Substation supports the QAL and Energy Queensland (EQ/Ergon) loads. The area around the town of Gladstone is a heavy industrial area which is described as energy intensive and includes industry of high economic significance to Queensland. This commenced with the establishment of the alumina refinery in 1967 (QAL), the Gladstone Power Station in 1976 and the Boyne Island Smelter in 1982. Gladstone Power Station supported the industrial development of Central Queensland and has also played a major role supplying load to South East Queensland via the 275kV network connecting Central Queensland.

The Gladstone zone comprises the area south of Raglan Substation, north of Gin Gin Substation and east of Calvale Substation. It is expected that this zone will continue to be a heavy industrial area with coal seam gas compression and export facilities being established in the Gladstone area.

Boyne Island Aluminium Smelter, Queensland Alumina Limited (QAL) and Rio Tinto Alcan's (RTA) Yarwun alumina refineries make up the majority of the load in the Gladstone area and these loads are directly connected to the Powerlink network. The 275/132kV transformers at Boyne Island also help supply the major smelter load. Railway loads are directly connected to the Powerlink's network at Raglan and Callemondah substations. The Distribution Network Service Provider (DNSP) Energy Queensland also supplies other load in the area from Gladstone South and Gladstone North substations.

Central Queensland is a net exporter of electricity via the 275kV network from Broadsound, Calvale and Calliope River substations. In late 2009, Powerlink established the Larcom Creek 275/132kV and the Yarwun 132kV substations in the Gladstone State Development Area (GSDA) in response to ongoing load growth in the Gladstone zone. Yarwun substation supplies the RTA Yarwun Alumina Refinery and Ergon's Boat Creek Substation.

The major 132kV injection point in the Gladstone zone sub-transmission system is Calliope River 275/132kV Substation. The 132kV sub-transmission system provides supply to bulk supply points within the Gladstone area.

The Gladstone South site consists of two substations:

The original Gladstone South substation (T019) was built in the early 1960s as a 132kV supply point for transformation to the distribution network and as major connection to Energy Queensland (EQ). The transformers, metering and harmonic filter bank are retained at T019 substation site, which consists of Transformer 3 and Transformer 6 which supply EQ customers. A newer substation on an adjacent site, T152, was constructed in 2002 to manage the rising fault level at the original substation and the general condition of the substation.

T153 QAL West substation is located on the QAL site in the suburb of South Trees, east of the Gladstone area. QAL West Substation is essentially a point of transformation from 132 kV to 11 kV to supply QAL West load. The substation consists of two transformer ended feeder bays, Transformer 6 and Transformer 7 off Feeder 7102 and Feeder 7103.

2.1 Geographical Overview

Figure 1 shows a geographical view of Gladstone South and QAL West substations location within the Gladstone area. The figure shows the existing 275kV and 132kV transmission networks in the area but omits the distribution networks.

Figure 1: Geographical view of the QAL and Gladstone South transmission network

2.2 Existing Arrangement of Gladstone South and QAL West Substation

The Gladstone South 132 kV switchyard consists of two yards. T019, which consist of Transformer 3 and Transformer 6 which supplies EQ customers. The newer substation on an adjacent site is T152, and is critical to the 132kV switching capability to support all QAL loads, refer Figure 2.

Gladstone South is a U bus arrangement with 3 bus sections and 4 buses (buses 1, 2, 3, 4). There are 15 active bays which consist of 2 transformer bays, 3 coupler bays, 8 feeder bays and 2 capacitor bank bays. There is an overhead connection between T152 and T019 to Transformers 3 and 6. Transformer 3 was constructed in 1997 and transformer 6 was constructed in 2001, both of which are owned by Powerlink.

The T153 QAL West substation has 2 transformer ended bays which drops to the voltage to 11kV, Transformer 6 was constructed in 2003 and Transformer 7 was constructed in 2002 which are owned by Powerlink. Refer Figure 3.

Figure 2: Aerial view of Gladstone South

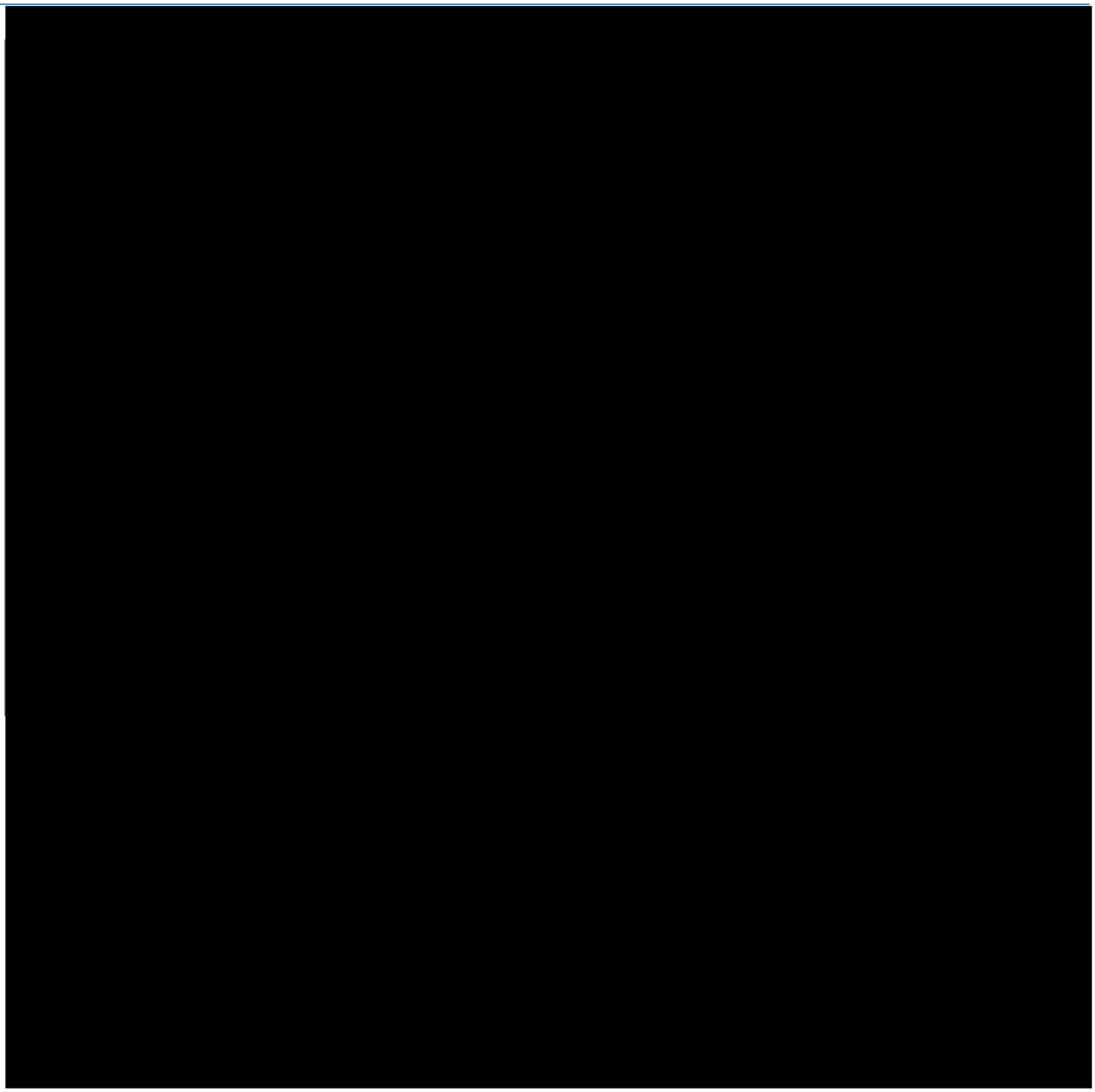


Figure 3: Single line diagram of 275kV Gladstone South and QAL West Substation

3 Load Forecast and Future Supply Requirement of H010

Figure 3 shows the existing 132kV connection configuration of Gladstone South and QAL West substations. Gladstone South and QAL West substations are critical to the 132kV network supplying local customer loads which include EQ and QAL. Powerlink has a contractual arrangement with QAL to ensure supply, and it is likely that the customer will extend its contract beyond 2027. It is expected that there will be a relatively flat load growth which aligns with the view of Gladstone forecast.

Gladstone South Substation Transformers 3 and 6 (132/66kV 100MVA) supports the EQ load. Figure 4 shows the load duration curve for EQ during the period 2016-2017. The 2016-2017 maximum demand was approximately 63 MW. For 50% of the year, the load is at or above approximately 25 MW. Both transformers have an ongoing need to supply the EQ load.

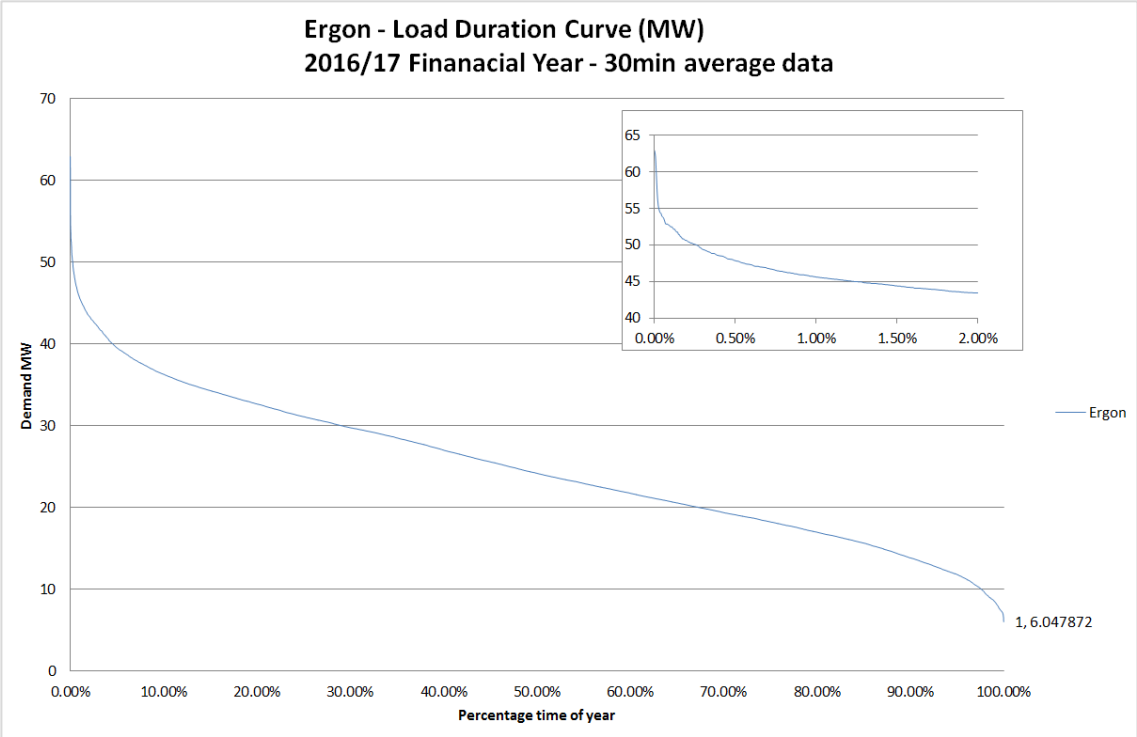


Figure 4: Load Curve for EQ at Gladstone South

Figure 5, indicates the load duration curve of all the QAL loads. It can been seen that the maximum load during 2016-2017 is approximatley 104 MW. At 50% of the year, the load is at or above approxmately 89MW. The tranfer capacity to the load is critical and has an ongoing need to supply QAL.

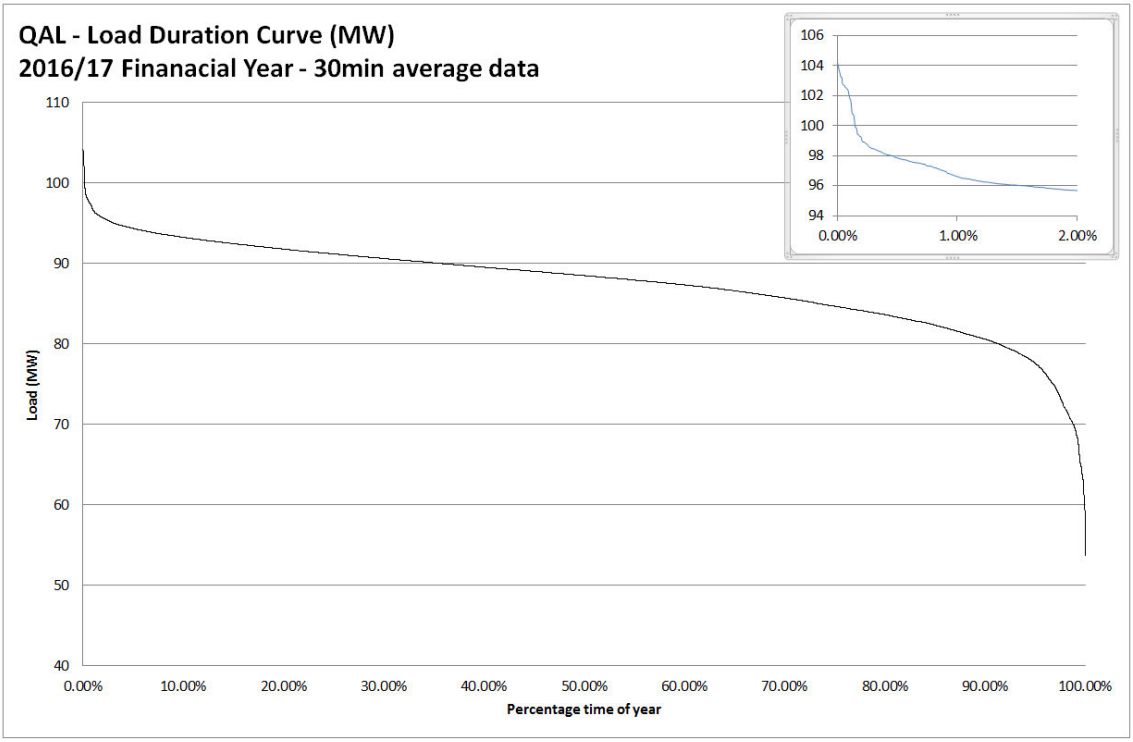


Figure 5: Load Curve for QAL at Gladstone South

At QAL West Substation, Transformer 6 and Transformer 7, 132kV/11kV 47MVA, support the total maximum load of approximately 65MW during 2017-2018. Both transformers have an ongoing need to supply this load.

Holistically the Gladstone area consists of multiple load points (Gladstone PS, Boyne Island, Larcom Creek, Calliope River, Raglan, Gladstone South, QAL, Callemondah, QAL West, QAL south and Yarwun). Below, Figure 6 shows the historical load and the expected relatively flat load growth to 2026.

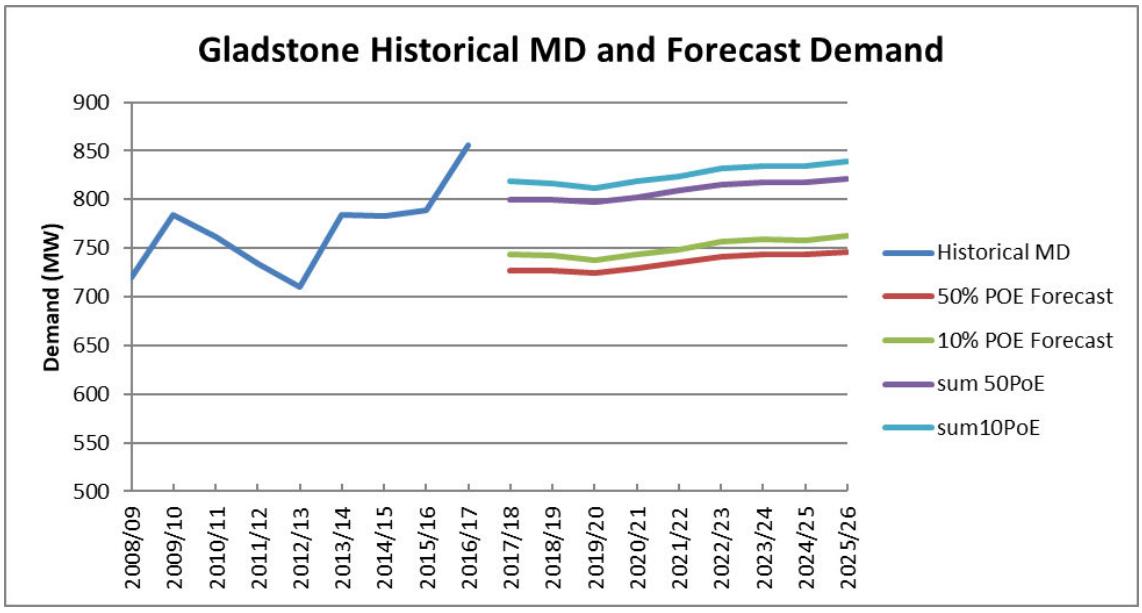


Figure 6: Historical and forecast 132kV demand forecast for Gladstone Area

4 Secondary systems plant asset condition

The Condition Assessment report has been split into a number of stages and the findings are based on the age of the asset and that the majority of secondary system assets are now obsolete.

GLADSTONE SOUTH (reference 1)

Stage 1: Address obsolete and age based drivers of following secondary systems plant by 2023

- All protection and control equipment for:
  - 1, 2, 3 and 4 Bus zone
  - Bus coupler 4112, 4122 and 4132
  - Transformer 3 and 6
  - Feeder 7101, 7102, 7103, 7104, 7105, 7147 and 7169
  - Bypass the OLM2 module
- Y protection and bay controller of Feeder 760 and bypass the OLM2 module
- Bay controller of 132kV harmonics filter bay
- Metering devices for Feeders 7102, 7101, 7103 and 7147 based on Internet Protocol (IP)
- Upgrade the dialling up service to IP based for Transformer 3 and 6 metering
- NSC1, NSC2 and LCF RTU
- OpsWAN
- GPS timing clock

Stage 2: Address obsolete and age based drivers of following secondary systems plant by 2027

- X protection equipment of Feeder 760
- All protection and control equipment of 1 Cap

Stage 3: Address obsolete and age based drivers of following secondary systems plant by 2031

- All protection devices for 132kV harmonics filter

Stage 4: Address obsolete and age based drivers of following secondary systems plant by 2037

- Metering devices for Transformer 3 and Transformer 6

QAL WEST (reference 2)

Stage 1: Address obsolete and age based drivers of following secondary systems plant by 2019

- Dual 125VDC battery banks

Stage 2: Address obsolete and age based drivers of following secondary systems plant by 2021

- All OpsWAN equipment

Stage 3: Address obsolete and age based drivers of following secondary systems plant by 2023

- All protection and control equipment for:
  - Transformer 6 and 7
  - Secondary systems for Feeder 7102 and 7103
- Transformer cooling and OLTC control PLC SCL500 for both transformers with a conventional method
- Existing Conitel protocol of SCADA system with DNP/IP
- NSC1, NSC2 and LCF RTU
- HMI Sun workstation
- Common RTU
- GPS timing clock

Stage 4: Address obsolete and age based drivers of following secondary systems plant by 2032

- All control cables

As the secondary equipment ages, breakdown of these systems can result in mal-operation or failure to operate. Spurious tripping of plant and equipment can lead to loss of supply or market impacts under conditions where other items of plant are already out of service due to planned maintenance or breakdowns. Failure of plant to operate may result in non-credible contingencies such as cascading failure as a result of neighbouring plant clearing the fault. Furthermore, where spare replacement units are not available, there may be prolonged outage of equipment while secondary system functionality is restored, placing load at risk upon the occurrence of another fault.

5 Transmission Lines Condition Assessment

The transmission line condition assessment report BS1170 Gladstone South to Callemondah has, identified significant levels of deterioration with a number instances of grade 4 corrosion on structure members, conductor hardware, bolts and nuts reported. These towers are located in a harsh environment, exposed to sea salt as well as heavy industrial pollution. The circuits are a key connection to a major Powerlink customer (QAL). The condition based drivers require works on the built section by 2019. Refer reference 4.

6 Options Considered

This section highlights options which are considered technically and/or economically feasible and infeasible to address the above identified condition based secondary systems plant issues. The “do nothing” option is discussed first and then two alternative options were assessed as having the potential to meet the required reliability obligations for supply to the Gladstone South and QAL West area.

1. Do Nothing
2. Maintain Gladstone South and QAL West network configuration
3. Decommission 7104 and bridge with 760; decommission 7105 and bridge with 7169
4. Teed connection of future ex 7105 with 7145
5. Non-Network options

Multiple alternative scenarios were assessed but were not considered to be credible options from a technical and economic point of view.

6.1 Do Nothing

Under Queensland legislation, Powerlink has the responsibility to plan for Queensland’s future transmission needs, including the interconnection with other networks. These planning obligations are prescribed by Queensland’s Electricity Act 1994 (the Act), the National Electricity Rules (NER) and Powerlink’s Transmission Authority, issued by the Queensland Government.

The Transmission Authority requires that Powerlink plans and develops the transmission grid in accordance with good electricity practice, with regard to the value end users of electricity place on the quality and reliability of electricity services.

The ‘Do Nothing’ is not an acceptable option as the primary drivers (asset age and obsolete) and associated safety, reliability and compliance risks would not be addressed. It is not consistent with good industry practice and Powerlink’s obligations to comply with the requirements of the National Electricity Rules and the Electricity Networks Access Code.

The various legislative and regulatory instruments place obligations on Powerlink as a Transmission Network Service Provider (TNSP). The “Do Nothing” option over the long term would result in breaching those obligations and is thus unacceptable.

6.2 Maintain Gladstone South and QAL West Network Configuration with future reconfiguration works at Callide A

Gladstone South switchyard supports EQ load and all QAL loads including QAL West by facilitating the 132kV connection. At present the 132kV injection from Calliope River 760,

Callemondah's feeder 7169 and the double circuit from Callide A 7104 and 7105, supports the customer loads and provides operational flexibility to this area. To the QAL loads, there are 4 feeders:

- Feeder 7101 Gladstone South - QAL (bus 2 at Gladstone South)
- Feeder 7102/1/2 Gladstone South - QAL - QAL West (bus 3 at Gladstone South)
- Feeder 7103/1/2 Gladstone South - QAL - QAL West (bus 1 at Gladstone South)
- Feeder 7147/1/2 Gladstone South - QAL - QAL South (bus 4 at Gladstone South)

Powerlink has a connection agreement with QAL which specifies 4 connection points at Gladstone South, hence all four of these feeders have an enduring need. Powerlink also has an obligation to provide a certain level of supply to all QAL loads.

There is no ongoing need for 7104 and 7105 in its current capacity to connect Gladstone South and Callide A. Reconfiguration works to disconnect Feeders 7104 and 7105 is scheduled for completion in 2019 (as part of Project CP.01546 Callide A / Calvale 132kV Network Reinvestment).

Gladstone South switchyard historically experiences numerous bus outages per year due to the bus coupler arrangement and iPASS primary plant. With the removal of 7104 and 7105, the operational flexibility in the area will result in reduced reliability during maintenance and extended outages. This configuration however does meet planning criteria and N-1 reliability.

With both 7104 and 7015 decommissioned, the critical contingency to meet all QAL and customer load is the outage of either 760 Calliope River to Gladstone South, 761 Calliope River to Callemondah or 7169 Callemondah to Gladstone South. With either of these contingences OOS, the network does meet reliability criteria of N-1. However due to Gladstone South bus arrangement and potential bus outages, there are impacts upon operational flexibility and potential maintenance/extended outages.

At both Gladstone South (T019) and QAL West (T153) two transformers are required at each site to support both the EQ loads and QAL loads, to meet Powerlink's transmission authority that no more than 600MWh of energy is at risk for a single network element outage.

Planning has investigated the viability of the feeder configurations examined in the condition assessment for Gladstone South and QAL West, refer figure 7. Planning studies indicate that there is an ongoing need for the following feeders and plant to remain in the Queensland network:

- Feeder 7101 Gladstone South - QAL
- Feeder 7102/1/2 Gladstone South - QAL - QAL West
- Feeder 7103/1/2 Gladstone South - QAL - QAL West
- Feeder 7147/1/2 Gladstone South - QAL - QAL South
- Feeder 7169 Gladstone South - Callemondah
- Feeder 760 Calliope River – Gladstone South
- Feeder 761 Calliope River - Callemondah
- Transformer 3 and 6 Gladstone South
- Transformer 6 and 7 QAL West

There is no ongoing need for the following feeders to meet Powerlink's reliability obligations:

- Feeder 7104 Gladstone South – Callide A
- Feeder 7105 Gladstone South – Callide A

Figure 7. Gladstone South layout

6.3 Decommission F7104 and bridge with F760; decommission F7105 and bridge with F7169

Grid Planning has investigated several alternative options for the use of future ex 7104 and ex 7105. The bus configuration at Gladstone South will result in feeder or bus outages at Gladstone south affecting the supply to the customer loads of EQ and all QAL. There is a possibility that the future decommissioned Feeder 7104 and 7105 may be bridged onto 760 and 7169 to allow for more operational flexibility outside of Gladstone South switchyard. This arrangement will see 760 and 7169 now connected to an additional bus, hence bus outages due to iPASS maintenance or planned bus outages on one bus may not affect the supply to the customer loads of EQ and all QAL and provides better support for the U bus arrangement, refer Figure 8.

Figure 8: Bridging 7169 and 760 with ex Callide A Feeders

This option would require the secondary systems plant associated with future ex 7104 and ex 7105 to be used for a bridged tee connection to 760 and 7169. This scenario sees increased functionality and operational capacity to facilitate flow to all QAL and EQ loads. This scenario meets and is above the planning criteria of N-1-50MW.

6.4 Teed Connection of 7105 with 7145

From Planning studies, there is a potential that future decommissioned Feeder 7105 could be teed to 7145 which runs between Calliope River and Boyne Island. Gladstone South to Callide A and the Calliope River to Boyne Island feeders undercross each other approximately 5km from Gladstone South. The advantage of this arrangement would see additional operational flexibility in the Gladstone South area; however it does increase reliability risk to Boyne Island inherent in a teed arrangement.

This option would require the secondary systems plant associated with future ex Feeder 7105 to be used for the tee connection to Feeder 7145. This scenario sees increased functionality and operational capacity to facilitate flow to all QAL and EQ loads, though may impact upon Boyne Island. This scenario meets and is above the planning criteria of N-1-50MW. Refer Figure 9.

Figure 9: Teed connection ex F7105 to F7145 Calliope River- Boyne Island

6.5 Non-Network options

Gladstone South Substation solely supplies the power flow to the loads at all QAL and local EQ customers. To meet EQ loads, a non-network solution for Gladstone South would need to provide an additional 132kV to 66kV injection, specifically by considering the requirement of Transformers 3 and 6. The non-network solutions would require up to ~65MW at Gladstone South to support the Energy Queensland 66kV network load to meet 2017 maximum demand. This is required to ensure compliance with Powerlink's planning criteria to ensure 'no more than 600MWh of energy is to be lost at any time'.

To meet all QAL loads, a non-network solution for Gladstone South would need to supply ~105MW to support the load based on 2017 max demand.

At QAL West, a non-network solution would require additional 132kV to 11kV injection, specifically by considering the requirement of Transformers 6 and 7, and up to ~65MW to support its load, based on 2017 max demand.

Planning does not consider that a non-network solution is viable from a technical or economic perspective However, any non-network proposals that can contribute significantly towards reducing the network requirement with be assessed during the RIT-T consultation process.

7 Conclusion

In conclusion, this planning report has investigated the enduring need for Gladstone South and QAL West Substation and its 132kV feeders and the transformers at each site. This study was based on the driver that much of the Secondary Systems plant at Gladstone South and QAL West has been in service for more than 15 years; it is approaching the end of its technical life and is obsolete. Transmission line condition assessment identified condition based drivers impacting upon BS1170, Feeder 760 and 7169. Planning studies indicate that there is an enduring need for the identified feeders and transformers to remain in-service to meet Powerlink's reliability and security obligations. Identified age and obsolete issues of the secondary systems plant equipment should be addressed by 2023, and 2020 for Feeder 760 and 7169.

There is an ongoing need for:

- Feeder 7101 Gladstone South - QAL
- Feeder 7102/1/2 Gladstone South tee QAL and QAL West
- Feeder 7103/1/2 Gladstone South tee QAL and QAL West
- Feeder 7147/1/2 Gladstone South tee QAL and QAL South
- Feeder 7169 Gladstone South - Callemondah
- Feeder 760 Calliope River – Gladstone South
- Transformer 3 and 6 Gladstone South
- Transformer 6 and 7 QAL West

There is no ongoing need for the following feeders to support the local loads:

- Feeder 7104 Gladstone South – Callide A
- Feeder 7105 Gladstone South – Callide A

Planning has identified alternative uses for these feeders to increase operational flexibility in the area. These include teeing future ex 7105 to 7145 Calliope River - Boyne Island and the potential bridging of future ex 7104 and future ex 7105 with 760 Calliope River – Gladstone South and 7169 Callemondah – Gladstone South. These scenarios could increase reliability in the area, but may also impact upon reliability risks. These scenarios meet and are above the planning criteria of N-1-50MW.

8 References

1. "T152 and T19 Gladstone South 132kV Secondary systems plant Condition Assessment Report", Powerlink. A2948691

2. "T153 QAL West 132kV Secondary systems plant Condition Assessment Report", Powerlink. A2955560

3. Transmission Annual Planning Report 2018

4. "Transmission Line Condition Assessment Report BS 1170 Gladstone South to Callemondah", Powerlink, A2456173

Base Case Risk and Maintenance Costs Summary Report

CP.02727 Gladstone South Secondary Systems Replacement and
CP.02728 QAL West Secondary Systems Replacement

Version Number	Objective ID	Date	Description
1.0	A3307622	05/02/2020	Original document.
2.0	A3307622	06/02/2020	Figure 2 forecast period extended to 20 years.
3.0	A3307622	14/02/2020	VCR values adjusted to comply with the new guidelines

1 Purpose

The purpose of this model is to quantify the base case risk cost profiles and maintenance costs for the secondary systems at Gladstone South and QAL West substations which are candidates for reinvestment under CP.02727 and CP.02728. Base case risk costs and maintenance costs have been analysed over a ten year study horizon.

2 Base Case Risk Analysis

2.1 Risk Categories

Four main categories of risk are assessed within Powerlink's risk approach; safety, network, financial, and environmental.

2.2 Secondary systems analysis

This section analyses the risks presented by the relevant secondary systems at Gladstone South and QAL West substations.

Table 1 - Risks associated with at risk secondary systems

	Mode of failure	
Equipment	**Peaceful**	**Explosive**
Secondary systems	Network risks (unserved energy due to concurrent network element outages)[1]. Financial risks to attend site and replace failed secondary systems in an emergency manner[2].	N/A

The risk cost approach assumes adherence to AEMO's 24 hour rule outlined within their system security guidelines. Under this rule, Powerlink will switch out a network element if a failed secondary system cannot be returned to service within 24 hours. Consequently, the safety and environmental risks are significantly lowered under this modelling approach and not modelled.

[1] At the beginning of the modelled period, the network risk for Gladstone South is dominated by Feeder 7147 to QAL South which is a radial supply. Throughout the modelled period, the contribution of Feeder 7147 to the total risk reduces as the condition of other equipment deteriorates and the probability of failure increases.
[2] Secondary systems spares are modelled as being available until equipment reaches 20 years of age. After this time, the cost to replace obsolete spares in an emergency manner increase significantly and the modelled financial risk steps.

2.3 Base case risk cost

The modelled and extrapolated total base case risk costs are shown in the following figures.

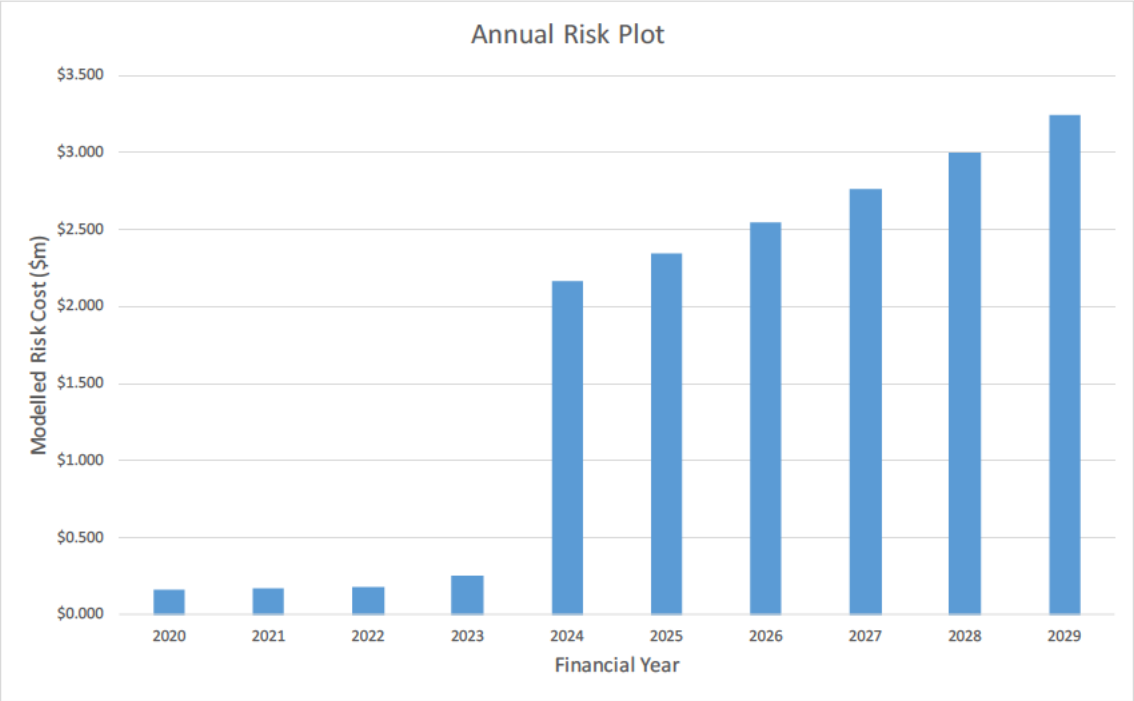


Figure 1 – Gladstone South and QAL West secondary systems total risk

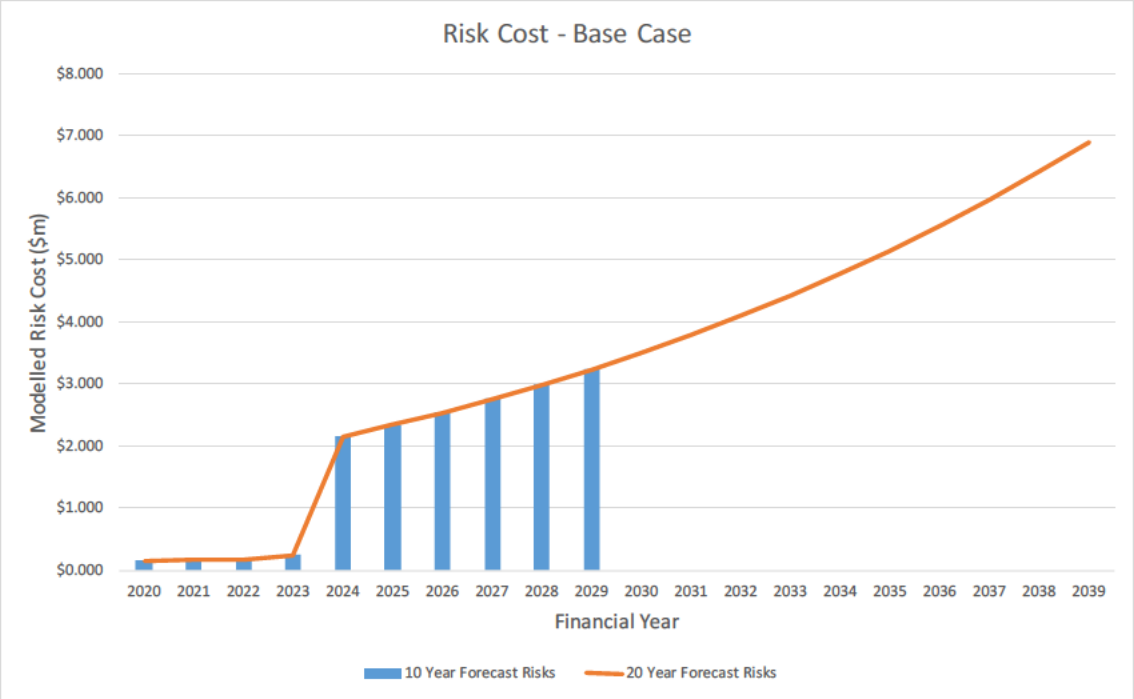


Figure 2 – Gladstone South and QAL West secondary systems risk (10 and 20 years)

2020 modelled risk $0.158m | 2029 modelled risk $3.243m | 2039 modelled risk $6.9m

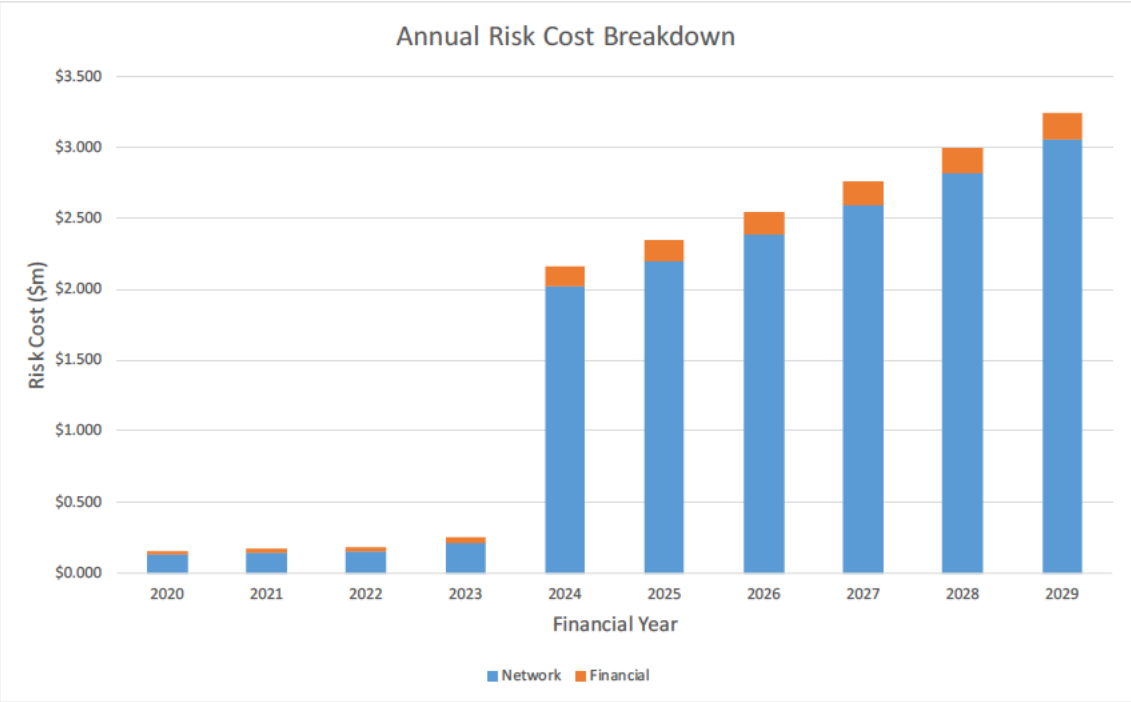


Figure 3 – Gladstone South and QAL West secondary systems risk by risk category

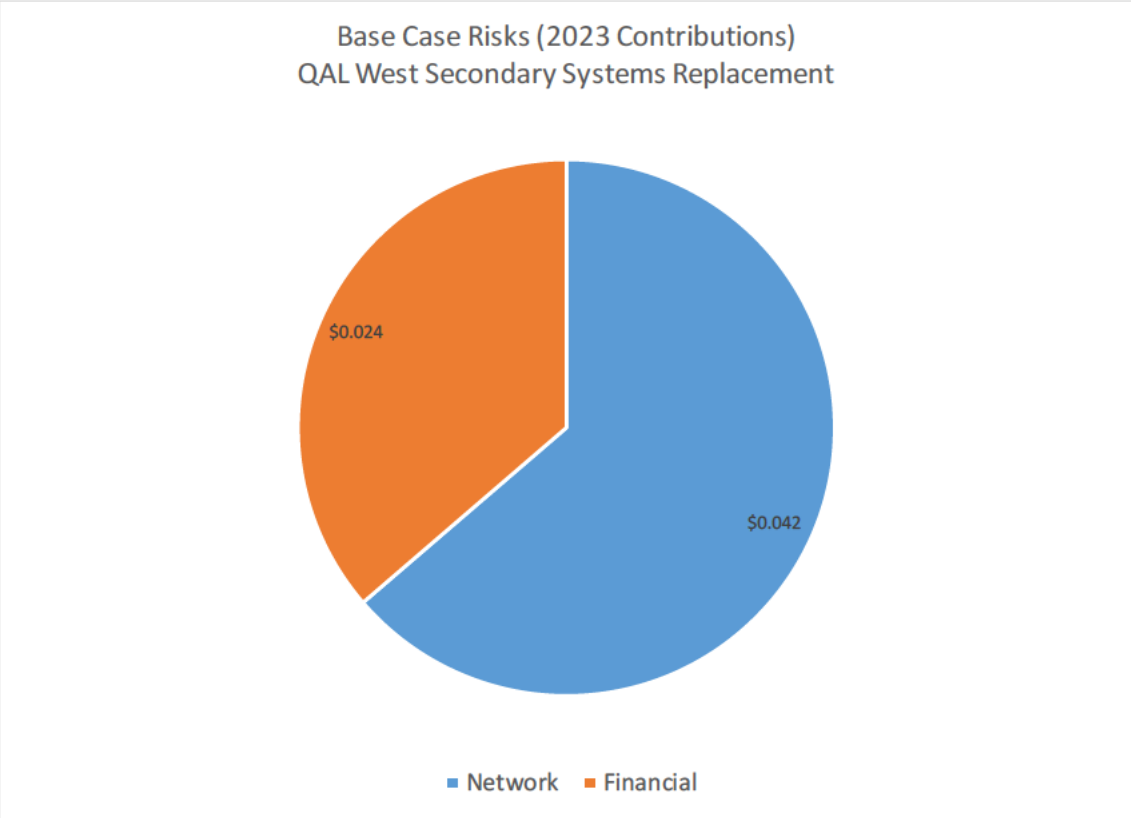


Figure 4 - QAL West 2023 risk by risk category

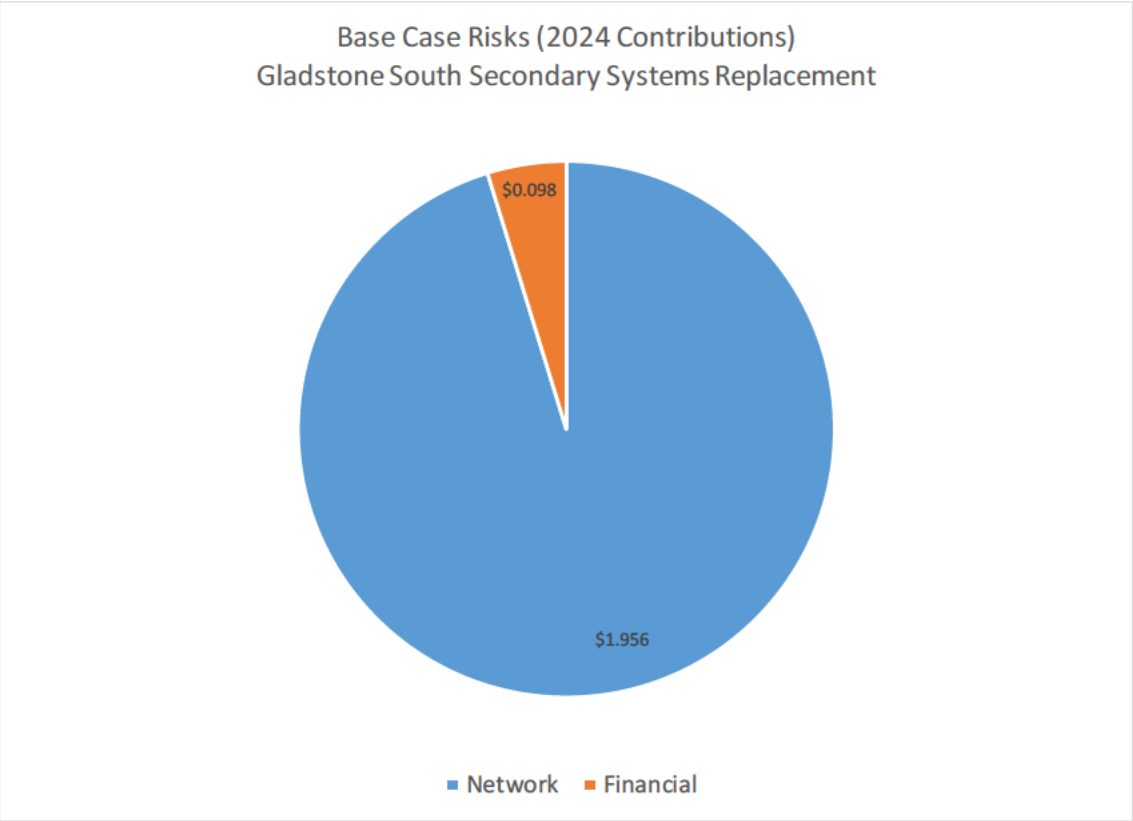


Figure 5 - Gladstone South 2024 risk by risk category

2.4 Base case risk statement

The main base case risks for the secondary systems at Gladstone South and QAL West substations are network risk (unserved energy) due to failed secondary systems, and financial risk to replace failed secondary systems items in an unplanned (emergency) manner.

3 Maintenance costs

Two categories of maintenance costs are included in Powerlink's base case approach; routine maintenance and corrective / condition based maintenance.

The routine and corrective / condition based maintenance costs and total base case costs (maintenance plus risk) are shown in figures below.

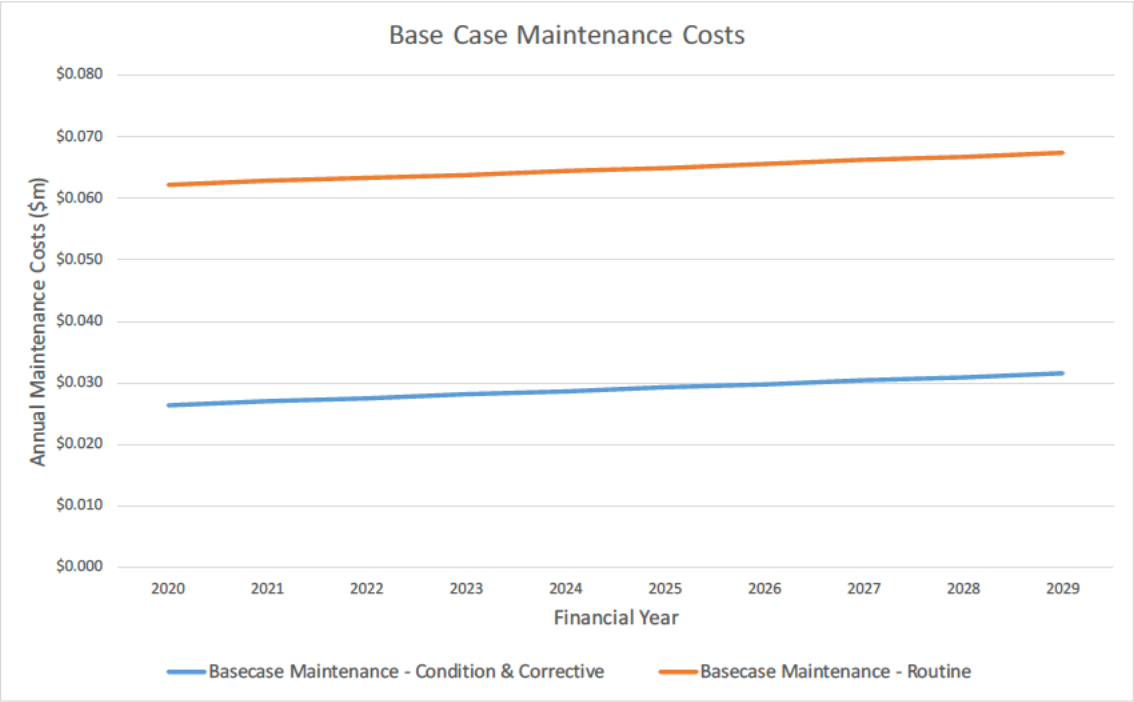


Figure 6 - Base case maintenance Costs 2020 - 2029

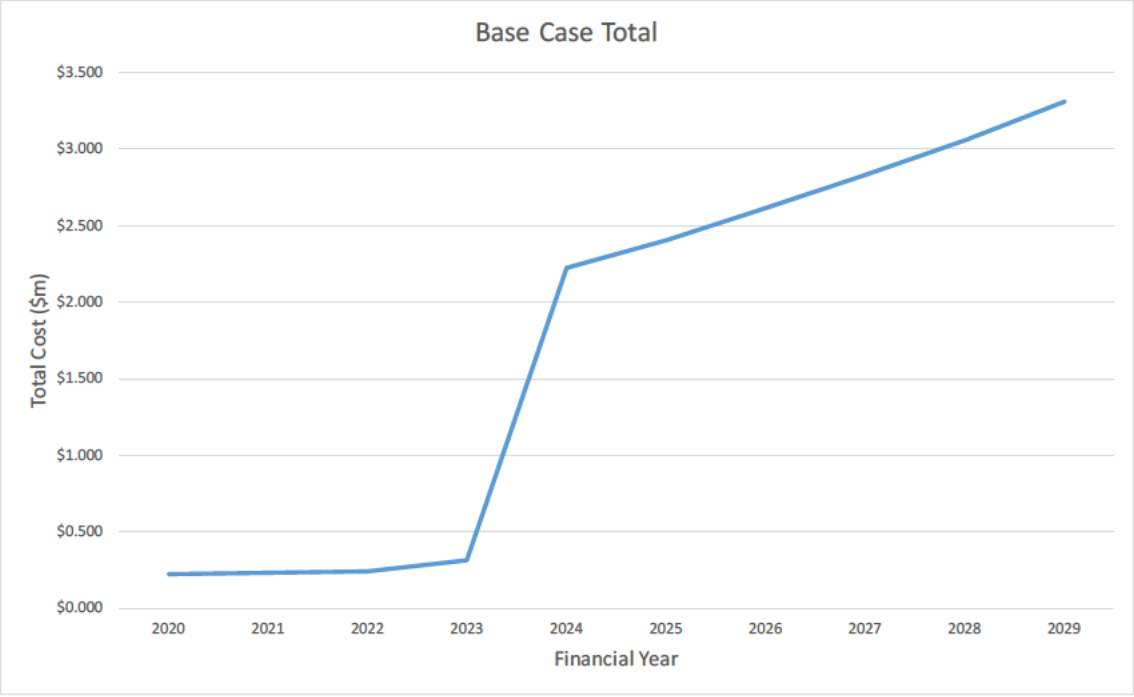


Figure 7 - Base case total costs (maintenance + risk cost) 2020 to 2029

4 Input participation

Sensitivity analysis was carried out on the model to determine the participation factors for key inputs to the risk models (i.e. which inputs affect the risk calculations the most).

The figures below show the input values and the percentage change of the total modelled risk for a change in an individual input (for example if VCR in the Gladstone South secondary systems replacement risk model is increased by 10%, the calculated risk will increase by ~1% after secondary systems items become obsolete).

The VCR used for the network risk cost model was the "very large business customers" metals value published in AEMO's 2019 VCR report (i.e. $19860/MWh). This value has been used since the combined Gladstone South and QAL loads are predominantly the QAL (metals) load.

Table 2: Input values, secondary systems model

	Item	Value	Unit
Network	VCR	19860	$/MWh
	Plant restoration time with spares	1	Day
	Plant restoration time with no spares	1	Weeks
Financial	Emergency replacement cost with spares	0.01	$million
	Emergency replacement cost with no spares	0.1	$million

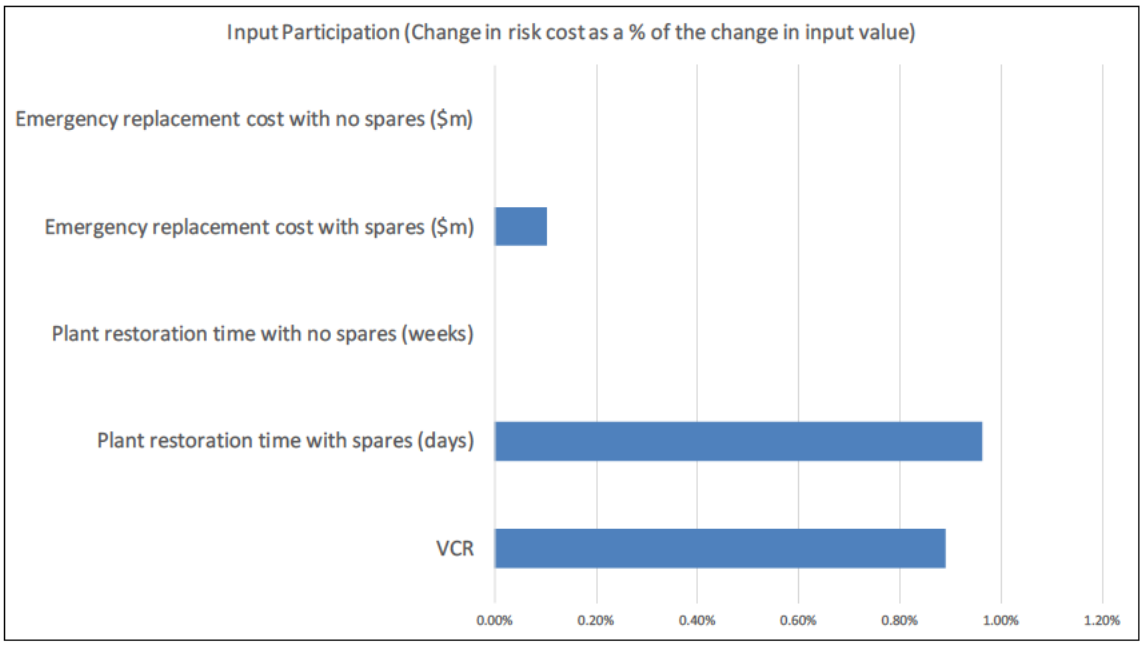


Figure 8 - Participation factors, secondary systems model – pre secondary systems obsolescence - Gladstone South

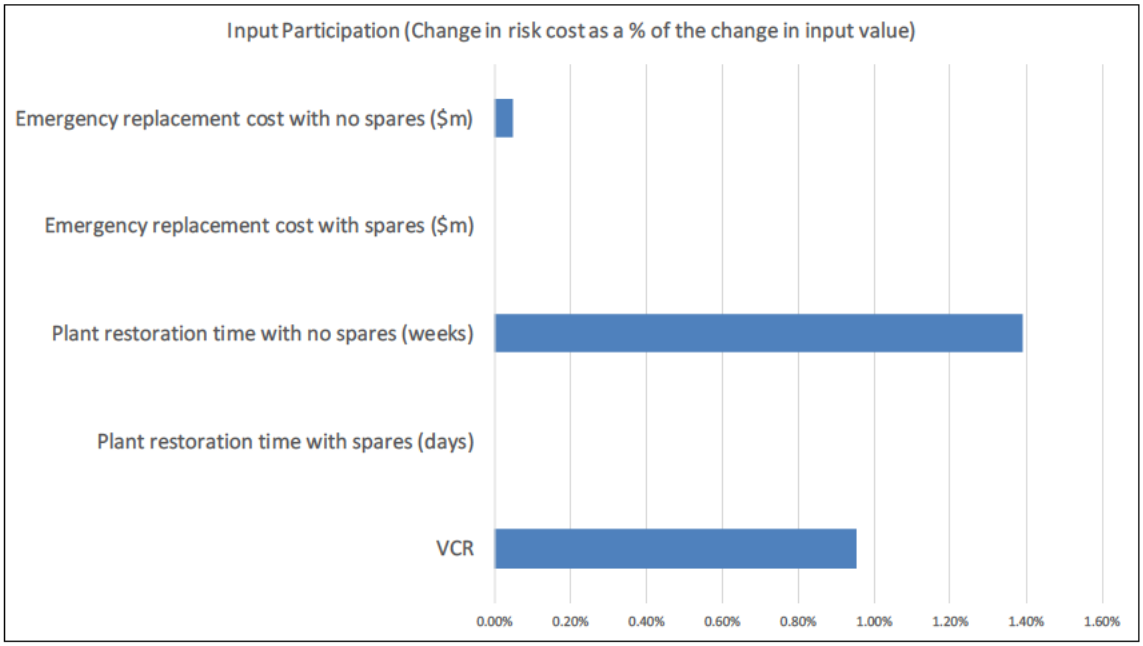


Figure 9 - Participation factors, secondary systems model – post secondary systems obsolescence – Gladstone South

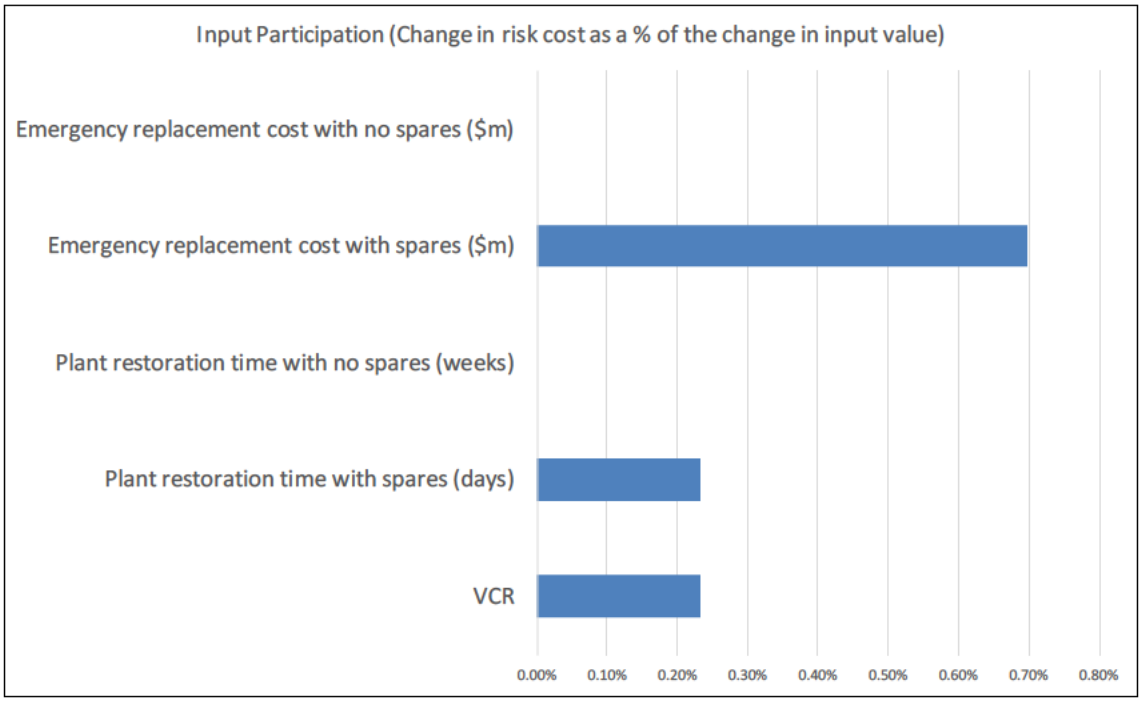


Figure 10 - Participation factors, secondary systems model – pre secondary systems obsolescence – QAL West

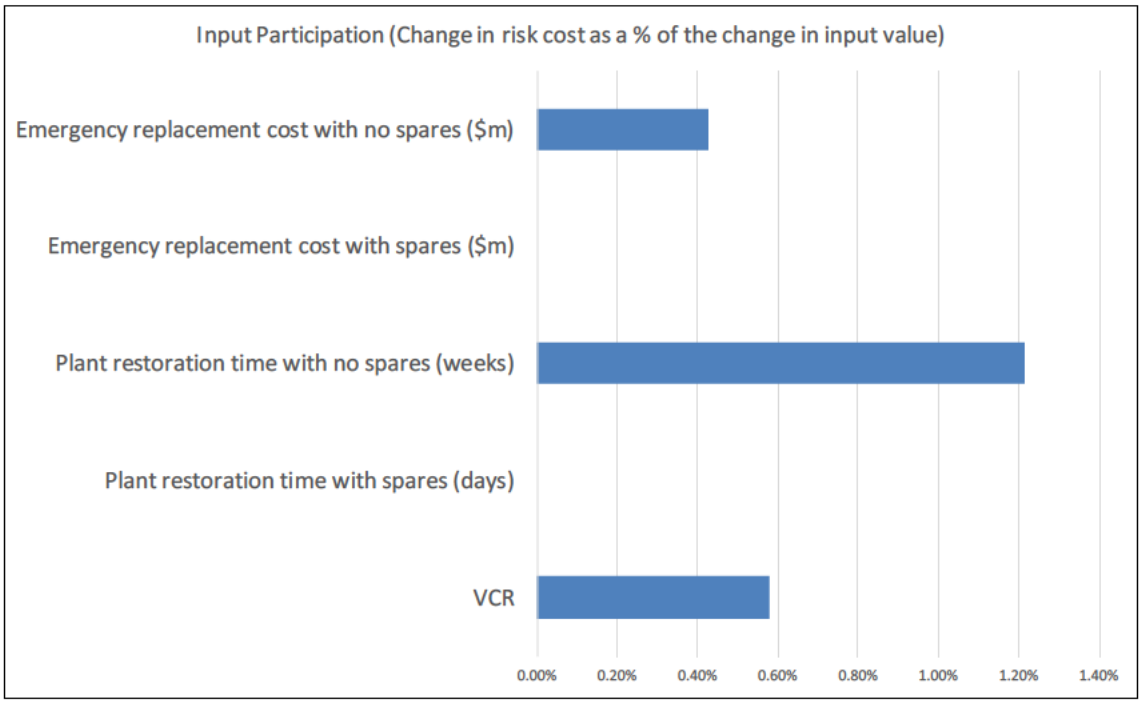


Figure 11 - Participation factors, secondary systems model – post secondary systems obsolescence – QAL West

5 Option Risk and Maintenance Costs

5.1 Option summary

A single reinvestment option is being considered to deal with the condition issues of the secondary systems at Gladstone South and QAL West substations; a replacement of all secondary systems by 2024.

5.2 Option analysis

The total risk and maintenance costs for the secondary systems replacement option are shown in Table 3 below. The full set of figures are available in spreadsheet format (Objective ID A3307615).

Table 3: Annual costs for Replacement Option

	2020	2021	2022	2023	2024	2025	...	2029	...	2039
Annual Risk ($m)	$0.158	$0.169	$0.180	$0.252	$2.055	$0.084		$0.098		$0.183
Annual Maintenance ($m)	$0.062	$0.063	$0.063	$0.064	$0.064	$0.065		$0.067		$0.074
Total ($m)	$0.220	$0.231	$0.243	$0.316	$2.120	$0.149		$0.166		$0.258

Project Scope Report

CP.02727

T152 Gladstone South Secondary Systems Replacement

Proposal - Version 2

Document Control

Change Record

Issue Date	Revision	Prepared by	Reviewed by	Approved by	Background
25 Sep 2019	V2	[redacted]	Historical	Historical	Proposal initial issue
13 Jun 2019	V1	[redacted]	Historical	Historical	Concept initial issue

Related Documents

Issue Date	Responsible Person	Objective Document Name
6 Jul 2018	[redacted]	T019 and T152 Gladstone South Substation Secondary Systems Condition Report July 2018 [A2955560]
Aug 2018	[redacted]	Gladstone South and QAL West Secondary Systems Planning Report [A2982233]

1. PROJECT DETAILS

1.1. Project Need

The Gladstone South site consists of two substations and includes both the T019 and T152 switchyards. It is an essential point of supply for both Ergon and Queensland Alumina Limited (QAL) loads. The T152 substation includes four bus zones with three bus section CBs, eight feeder bays, one harmonic filter bay, one cap bank bay, and two 132/66kV transformer bays that supply the Ergon 66kV distribution network. The power transformers, associated instrument transformers and harmonic filter bank are located at T019 substation site with all other plant and the main control building located at T152.

Network planning studies have determined an ongoing need for all connecting feeders to meet the transfer capability in the Gladstone South area, with the exception of the Callide A - Gladstone South feeders 7104 and 7105. Feeders 7104 and 7105 are planned to be disconnected by 2020 under project CP.01546 Callide A / Calvale 132kV Network Reinvestment. Planning studies also confirm an ongoing need for two 132/66kV transformers to support the Ergon demand at Gladstone South.

Secondary systems for the 132kV bus zones, bus couplers, feeders, transformers, and the F7101, F7102, F7103 and F7147 revenue metering were established at T152 in 2003. The harmonic filter and 1 cap bank secondary systems are established at T152 and were installed in 2010 and 2006 respectively. Replacement metering was installed for 3T and 6T transformers at T152 in 2016. The transformer cooling control systems installed in transformer control cubicles were replaced in 2014, are the only secondary systems remaining at T019. There are no secondary systems or any other Powerlink owned equipment inside the control building at T019.

A condition assessment of the Gladstone South secondary systems has identified that the majority of secondary systems requires replacement due to obsolescence of protection and control devices including protection relays, transducers and protection signalling equipment due to unavailability of spare parts and lack of technical support.

The objective of this project is to ensure ongoing reliability of supply from Gladstone South by replacing the majority of secondary systems by 31 October 2023.

1.2. Project Contacts

Project Sponsor	[redacted]	[redacted]
Manager Connections Contracts (Ergon)	[redacted]	[redacted]
Manager Connections Contracts (QAL)	[redacted]	[redacted]
Strategist - Digital Asset Strategies	[redacted]	[redacted]
Project Manager	[redacted]	[redacted]

1.3. Project Scope

1.3.1. Original Scope

The following scope presents a functional overview of the desired outcomes of the project. The proposed solution presented in the estimate must be developed with reference to the remaining sections of this Project Scope Report, in particular *Section 1.7 Matters to Consider*.

Briefly, the project consists of replacing the majority of the secondary systems at T019 and T152 Gladstone South substations.

1.3.2. Options - T019 and T152 Gladstone South Substation Works

Four credible options have been identified to address project CP.02727 need.

The outcome of the economic assessment at the concept estimate stage identified Option 3 to be the least cost alternative and therefore the preferred option to progress to proposal level estimating.

Table 1 - Options summary

Option	Asset Strategy	Stage I	Comm. Date	Stage II	Comm. Date
1	Staged replacement	Partial replacement of secondary systems equipment into a new building	2023	Partial replacement of secondary systems equipment	2030
2	Staged replacement including lines enabling works	Partial replacement of secondary systems equipment into a new building	2023	Partial replacement of secondary systems equipment	2030
3	Full Replacement	Full replacement of all secondary systems equipment into a new building	2023	N/A	
4	Full Replacement including lines enabling works	Full replacement of all secondary systems equipment into a new building	2023	N/A	

1.3.3. Option 3 - Full Replacement

Option 3 involves cutover of all protection and control secondary systems equipment from the existing +A building to a new building by 2023.

Substation Works - T152 Gladstone Substation

Design, procure, construct and commission the following works:-

- a new 132kV control building for a staged cutover of secondary systems panels from the existing +A building to the new building;

- associated switchyard civil works including new cable trenches and cable termination kiosks as appropriate;
- replacement of the secondary systems panels to the current standard into the new control building for the following bays -
  - 1, 2, 3 and 4 bus zone;
  - bus couplers 411, 412 and 413;
  - 3T and 6T transformers (Feeder 7268 and 7269 are protected by 3T and 6T secondary systems);
  - feeders 760, 7101, 7102, 7103, 7147 and 7169;
  - 1 cap bank; and
  - 5 harmonic filter
- bypass of OLM2 module (on-line monitoring) for all PASS-M0 bays including integration of CB SF6 alarm signals into control systems SCADA where required;
- replacement of revenue metering for feeders 7101, 7102, 7103 and 7147 based on implementation of IP interface;
- upgrade of revenue metering for 3T and 6T transformers to IP interface;
- replacement of all C50 RTUs associated with OptoNet ring including NSC1, NSC2, LCF and Comms RTUs;
- replacement of all OpsWAN equipment;
- replacement of GPS timing system;
- upgrade of SCADA protocols to DNP over TCP/IP;
- decommissioning of secondary systems for feeder 7104 and 7105 bays;
- review and upgrade of telecoms infrastructure as required to support replacement secondary systems;
- update of EMS with required changes;
- decommissioning and removal of all obsolete panels;
- decommissioning and removal of all obsolete OLM2 modules;
- recovered secondary system devices to be returned to store for spares if they have not reached the end of economic life;
- recovery of the existing demountable building;
- recovered +A building to be assessed and if suitable for future projects, returned to the appropriate location. If not suitable should be sold and recovered budget used to offset project costs; and
- update of SAP, CMS and drawings in SPF accordingly.

Substation Works - Remote End Substations

Minimal works are planned for the remote ends. The scope is limited to minor works including adjustment to CT ratios and protection settings consequential to the replacement of secondary systems in the selected bays at Gladstone South.

Remote ends impacted include T021 QAL substation which includes customer owned secondary systems equipment, T153 QAL West and T182 QAL South secondary systems, T101 Callemondah and H067 Calliope River secondary systems.

1.3.4. Key Scope Assumptions

The following assumptions should be considered in the estimating of this scope:

- The existing +A control building is fully utilised by the existing secondary systems equipment.
- Inspection of the control cables identifies that most cables (installed 2002) are in fair condition and considered to be suitable for ongoing service, and as such, replacement of the cables is not a scope requirement for this project.
- The majority of control and protection cables are terminated directly between secondary systems panels and PASS-M0 switchgear control cubicles and are integral parts of the primary plant. Consideration shall be given towards cost effective reuse of the existing cabling and switchyard termination arrangements in establishing the replacement secondary systems.
- The new 132kV control building should be located to minimise the length of field cables and to not prohibit or make difficult replacement of high voltage equipment.
- Planning studies confirm no enduring need for feeders 7104 and 7105 and therefore the secondary systems for bays =D12 and =D13 are not be replaced. These bays are to be decommissioned under this project.
- There is no condition-based driver for replacement of the dual 125VDC and 48VDC battery systems originally installed in 2003 as they have recently been replaced under OR.02029.
- The 415 VAC auxiliary supplies are derived from the Ergon network. The AC distribution and changeover boards and standby diesel generator are located at T019. The current arrangement is satisfactory according to AM-POL-0053 AC and DC Supplies policy.

1.4. Variations to Scope (post project approval)

Not applicable.

1.5. Project Timing

1.5.1. Project Approval Date

The anticipated date for project approval is May 2020.

1.5.2. Site Access Date

T019 and T152 Gladstone South are existing Powerlink operational sites and access to these sites is immediately available.

1.5.3. Commissioning Date

The latest date for the commissioning of the new assets included in this scope and the decommissioning and removal of redundant assets, where applicable, is 31 October 2023.

1.6. Matters to Consider

The following issues are important to consider during the implementation of this project:

- the estimate should consider the implications of relevant workplace health & safety legislation in delivering the proposed solution, and identify any alternative solutions that meet the functional requirements included in the scope whilst having the potential to facilitate improvements in safety during construction, or as built, and:
  - include such alternative solutions as a fully costed option for further investigation;
  - include an assessment of the risks associated with each option identified, after all available and applicable mitigating actions have been implemented; and
  - include an allowance for any specific safety related activities required in the delivery phase of the project;
- any existing assets to be removed and disposed of as part of this scope must be identified within the estimate together with the forecast early asset write off amounts at time of disposal;
- plant and equipment identified as suitable to be recovered for use as spares or returned to stores should be packaged and transported to an appropriate storage location, with a suitable allowance for the cost included in the estimate;
- a high level project implementation plan including staging and outage plans (as per Section 1.10) should be considered and produced as part of the estimate; and
- Ergon Energy also operates 66kV plant located on the T019 site, with shared access arrangements.

1.7. Asset Management Requirements

Equipment shall be in accordance with Powerlink equipment strategies.

Unless otherwise advised [redacted] will be the Project Sponsor for this project. The Project Sponsor must be included in any discussions with any other areas of Strategy and Business Development.

[redacted] will provide the primary customer interface with Ergon Energy and [redacted] the primary interface with QAL. The Project Sponsor should be kept informed of any discussions with the customer.

1.8. Asset Ownership

The works detailed in this project will be Powerlink Queensland assets. The asset boundary with Ergon is the outgoing 66kV terminals of the 132/66/11kV transformers.

1.9. System Operation Issues

Operational issues that should be considered as part of the scope and estimate include:

- interaction of project outage plan with other outage requirements;
- likely impact of project outages upon grid support arrangements; and
- likely impact of project outages upon the optical fibre network.

A project outage plan should be submitted in accordance with "Outage Management Process – Procedure (A463506)", on form "Outage Plan – Projects (A523847)". The Project Outage Plan must include both HV and Telecoms outages.

1.10. Options

Costs associated with the decommissioning and removal of secondary systems for F7104 and F7105 bays are to be separately identifiable within the overall total estimate.

1.11. Division of Responsibilities

Division of responsibilities documents are required to cover the changes to the interface boundaries with Ergon Energy at Gladstone South and QAL at QAL site(s). The Project Manager is required to draft the documents and consult with the Project Sponsor to arrange sign-off between Powerlink and Ergon Energy and Powerlink and QAL.

1.12. Related Projects

Project No.	Project Description	Planned Comm Date	Comment
Pre-requisite Projects			
Co-requisite Projects			
CP.02728	QAL West Secondary Systems Replacement	Oct 2022	Staging for CP.02727 and CP.02728 should be coordinated to minimise customer impacts
Other Related Projects			
OR.02029	COM10 DC System Upgrade - North	Aug 2019	Includes planned replacement of 125VDC and 50VDC systems at T152 Gladstone South
CP.01546	Callide A / Calvale 132kV Network Reinvestment	Dec 2020	Includes disconnection of feeders F7104 / 7105 at T022 Callide A
CP.02766	T019 Gladstone South Fence & Infrastructure Upgrades	Dec 2020	
CP.02694	BS1170 Callemondah - Gladstone South Line Refit	Oct 2022	Staging for CP.02727 and CP.02694 should be coordinated to minimise customer impacts

1.13. Project Drawings

T019 and T152 Gladstone South Substations

T152 Gladstone South Substation

T152 and T019 Gladstone South Substations

2. PROPERTY & EASEMENT INFORMATION

2.1. Established Sites - T019 and T152 Gladstone South Substations

2.1.1. Site Accessibility

These are existing Powerlink substations and site access is currently available. Ergon Energy also operates 66kV plant located on the T019 site, with shared access arrangements.

2.2. Remote End Established QAL Sites - T021 QAL, T153 QAL West and T182 QAL South Substations

2.2.1. Site Accessibility

These are existing Powerlink substations located on QAL sites with shared access arrangements. The agreed access protocols must be observed when accessing these sites.

2.3. Remote End Established Aurizon Site - T101 Callemondah Substation

2.3.1. Site Accessibility

This an existing Powerlink substation located on an Aurizon site with shared access arrangements. The agreed access protocol must be observed when accessing this site.

2.4. Remote End Established Site - H067 Calliope River Substation

2.4.1. Site Accessibility

This an existing Powerlink substation. Accordingly site access is currently available.

CP.02727

T152 Gladstone South Secondary Systems Replacement

Project Management Plan - Proposal

Record ID	A3163993	
Authored by	Project Manager	[redacted]
Reviewed by	Team Leader	[redacted]
Approved by	Manager Projects	[redacted]

Version History

Version	Date	Section(s)	Summary of amendment
1	23/08/2019	1-4 only	Created for Concept
2	20/12/2019	1-4 only	Created for Proposal

Table of Contents

1. Executive Summary

Project Background:

The Gladstone South site consists of two substations and includes both the T019 and T152 switchyards. It is an essential point of supply for both Ergon and Queensland Alumina Limited (QAL) loads. The substation includes four bus zones with three-bus section CBs, eight feeder bays, one harmonic filter bay, one cap bank bay, and two 132/66kV transformer bays that supply the Ergon 66kV distribution network. The power transformers, associated instrument transformers and harmonic filter bank are located at T019 substation site with all other plant and the main control building located at T152.

Network planning studies have determined an ongoing need for all connecting feeders to meet the transfer capability in the Gladstone South area, with the exception of the Callide A - Gladstone South feeders 7104 and 7105. Feeders 7104 and 7105 planned to be disconnected by 2020 under project CP.01546 Callide A / Calvale 132kV Network Reinvestment. Planning studies also confirm an ongoing need for two 132/66kV transformers to support the Ergon demand at Gladstone South.

Secondary systems for the 132kV bus zones, bus couplers, feeders, transformers, and the F7101, F7102, F7103 and F7147 revenue metering established at T152 in 2003. The harmonic filter and 1-cap bank secondary systems established at T152 and installed in 2010 and 2006 respectively. Replacement metering installed for 3T and 6T transformers at T152 in 2016. The transformer cooling control systems installed in transformer control cubicles replaced in 2014, are the only secondary systems remaining at T019.

A condition assessment of the Gladstone South secondary systems has identified that the majority of secondary systems requires replacement due to obsolescence of protection and control devices including protection relays, transducers and protection signalling equipment due to unavailability of spare parts and lack of technical support.

Project Objective:

The objective of this project is to ensure ongoing reliability of supply from Gladstone South by replacing the secondary systems at T152 by October 2023.

Project Delivery:

The project involves the cutover of all protection and control secondary systems equipment from the existing control building to a new demountable building. A high-level project-staging plan and schedule developed in consideration of customer reliability of supply requirements and interactions with other projects underway in the area. The project delivery strategy is based as follows:

- Internal Design possible Design Partners
- Construction by SPA
- FAT, SAT and Commissioning by MSP (Ergon)

The expected project commissioning date is April 2024.

The project high-level staging plan and schedule was developed in consultation with customers and internal teams. To achieve the shortest possible return to service durations to minimise customer impacts, project staging is based on incremental cutover of x and y secondary systems for each bay.

2. Project Definition

2.1 Project Scope

Briefly, the project consists of replacing the secondary systems at T152 Gladstone South substations.

2.1.1 Substation T152 Gladstone South Substation

Four Options proposed during the Concept stage with option three chosen.

Option	Asset Strategy	Stage I	Comm.	Stage II	Comm. Date
~~1~~	~~Staged replacement~~	~~Partial replacement of secondary systems equipment into a new building~~	~~Date~~	~~Partial replacement of secondary systems equipment~~	~~2030~~
~~2~~	~~Staged replacement including lines enabling works~~	~~Partial replacement of secondary systems equipment into a new building~~	~~2023~~	~~Partial replacement of secondary systems equipment~~	~~2030~~
3	Full Replacement	Full replacement of all secondary systems equipment into a new building	2023	N/A	
~~4~~	~~Full Replacement including lines enabling works~~	~~Full replacement of all secondary systems equipment into a new building~~	~~2023~~	~~N/A~~	

Chosen Option 3 - Full Replacement

Option 3 involves cutover of all protection and control secondary systems equipment from the existing +K building to a new building by 2023.

Substation Works - T152 Gladstone South Substation

Design, procure, construct and commission the following works:-

- a new 132kV control building for a staged cutover of secondary systems panels from the existing +K building to the new building;
- a new cable termination rack such that cables terminated directly between the existing secondary systems panels and marshalling kiosks / PASS-M0 switchgear control cubicles can be rerouted from the existing control building to new cable termination rack without need to re-run cables to the yard marshalling kiosks and PASS-M0 control cubicles;
- new cable trenches to the new cable termination rack and run cables from the new cable termination rack to the new control building as appropriate;
- replacement of the secondary systems panels to the current standard into the new control building for the following bays -
    - 1, 2, 3 and 4 bus zone;
    - bus couplers 411, 412 and 413;
    - 3T and 6T transformers (Feeder 7268 and 7269 are protected by 3T and 6T secondary systems);
    - feeders 760, 7101, 7102, 7103, 7147 and 7169;

  - 1 cap bank; and
  - 5 harmonic filter.
- bypass of OLM2 module (on-line monitoring) for all PASS-M0 bays including integration of CB SF6 alarm signals into control systems SCADA where required;
- replacement of revenue metering for feeders 7101, 7102, 7103 and 7147 based on implementation of IP interface;
- upgrade of revenue metering for 3T and 6T transformers to IP interface;
- replacement of all C50 RTUs associated with OptoNet ring including NSC1, NSC2, LCF and Comms RTUs;
- replacement of all OpsWAN equipment;
- replacement of GPS timing system;
- upgrade of SCADA protocols to DNP over TCP/IP;
- decommissioning of secondary systems for feeder 7104 and 7105 bays;
- review and upgrade of telecoms infrastructure as required to support replacement secondary systems;
- update of EMS with required changes;
- decommissioning and removal of all obsolete panels;
- decommissioning and removal of all obsolete OLM2 modules;
- recovered secondary system devices to be returned to store for spares if they have not reached the end of economic life;
- recovery of the existing demountable building;
- recovered building to be assessed and if suitable for future projects returned to the appropriate location. If not suitable should be sold and recovered budget used to offset project costs; and
- update of SAP, CMS and drawings in SPF accordingly.

Substation Works - Remote End Substations

Minimal works planned for the remote ends. The scope is limited to minor works including adjustment to CT ratios and protection settings consequential to the replacement of secondary systems in the selected bays at Gladstone South.

Remote ends impacted include T021 QAL substation, which includes customer owned secondary systems equipment, T153 QAL West, and T182 QAL South secondary systems, T101 Callemondah and H067 Calliope River secondary systems:

2.1.2 Transmission Lines / Transmission Lines Refit

Not applicable.

2.1.3 Telecommunications

As per Scope above

2.1.4 Revenue Metering

The project includes the modification of revenue metering.

2.1.5 Other Project Works

Not applicable.

2.2 Exclusions

Exclusions as follow:

- All primary plant replacement; and
- Any temporary power required for Customers

2.3 Assumptions

- QAL outages will be available for the secondary system cutovers;
- CP.02694 T152 line refit project works are completed prior to requiring any outages;
- Decommissioning 7104 & 7105 under CP.01546 works completed prior to CP.02727 commencing;
- [redacted] relays will be utilised;
- QAL Red Dam feeder will be available to be out of service;
- All milestone dates in section 4.1 achieved; and
- Have only allowed for decommissioning of secondary systems and no primary plant or overhead conductors.

2.4 Project Interaction

Interactions with other projects:

Project Number and Description	Interaction (Pre-requisite/ Co-requisite/ Dependent/ Related)	Planned Commissioning Date	Comment
CP.02694	Yes	2021	To be completed prior to CP.02727
CP.01546	Yes	2020	To be completed prior to CP.02727
CP.02728	Yes	TBA	Timing to suit CP.02727
CP.02766	Yes	TBA	Timing will overlap

2.5 Project Risk

Project risks identified during Project Proposal phase are detailed and managed in Project Server.

3. Project Financials

3.1 Project Estimate

3.1.1 Estimate Summary

Estimate Components (A1)			Un-Escalated $	Escalated $
Base Estimate	Cost Estimate		16,478,815	18,133,980
	Estimate Allowance		252,513	277,876
Contingency (Unknown Risk)	*(A)*	[redacted]		
Mitigated Risk (Known Risk)	*(B)*			
Contingency Total Proposed	***(A+B)***			
Total Proposed Approval				

3.1.2 Asset Write-Off Table

CP.02727 Asset Write-off. Values current at 30th June 2020

Functional Location	Description	Asset	Subnumber	Book val.	Write-off %	Write-off Value	Currency
T152-SSS-411-	132kV 1-2 BUS SECTION BAY	108982	0	45,822.31	100%	$ 45,822.31	AUD
T152-SSS-412-	132kV 2-3 BUS SECTION BAY	108983	0	46,891.66	100%	$ 46,891.66	AUD
T152-SSS-413-	132kV 3-4 BUS SECTION BAY	108984	0	43,175.71	100%	$ 43,175.71	AUD
T152-SSS-481-	132kV 1 CAPACITOR BAY	113928	0	48,932.20	100%	$ 48,932.20	AUD
T152-SSS-495-	132KV 5 HARMONIC FILTER BAY - 50MVAR	120493	0	198,646.85	100%	$ 198,646.85	AUD
T152-SSS-7101	7101 FEEDER BAY	108985	0	50,607.75	100%	$ 50,607.75	AUD
T152-SSS-7102	7102 FEEDER BAY	108986	0	50,439.11	100%	$ 50,439.11	AUD
T152-SSS-7103	7103 FEEDER BAY	108987	0	50,703.75	100%	$ 50,703.75	AUD
T152-SSS-7104	7104 CALLIDE A 132kV FEEDER BAY	108988	0	52,302.90	100%	$ 52,302.90	AUD
T152-SSS-7105	7105 CALLIDE A 132kV FEEDER BAY	108989	0	52,134.58	100%	$ 52,134.58	AUD
T152-SSS-7147	7147 FEEDER BAY	108990	0	80,795.18	100%	$ 80,795.18	AUD
T152-SSS-7169	7104 CALLEMONDAH 132kV FEEDER BAY	108991	0	48,510.33	100%	$ 48,510.33	AUD
T152-SSS-7268	7268 FEEDER BAY	108992	0	46,357.00	100%	$ 46,357.00	AUD
T152-SSS-7269	7269 FEEDER BAY	108993	0	45,787.04	100%	$ 45,787.04	AUD
T152-SSS-760-	760 GLADSTONE P.S. 132kV FEEDER BAY	108994	0	47,940.38	100%	$ 47,940.38	AUD
T152-SSS-METR-REVMET1	FDR 7102 ENERGY METERING (REVENUE)	110056	0	13,462.25	100%	$ 13,462.25	AUD
T152-SSS-METR-REVMET2	FDR 7101 ENERGY METERING (REVENUE)	110057	0	13,443.63	100%	$ 13,443.63	AUD
T152-SSS-METR-REVMET3	FDR 7103 ENERGY METERING (REVENUE)	110058	0	13,270.45	100%	$ 13,270.45	AUD
T152-SSS-METR-REVMET4	FDR 7147 ENERGY METERING (REVENUE)	110059	0	13,358.09	100%	$ 13,358.09	AUD
T152-SSS-NBAY	NON BAY	108995	0	316,899.26	100%	$ 316,899.26	AUD
					Total	$ 1,279,480.43	AUD

3.2 Approved Released Budget

The approved release budget to execute the project is as follows:

	Total $	Control Management
Base Cost	$ 18,133,980	Project Manager
Allowance	$ 277,876	Project Manager
Released Budget	**$ 18,411,856**	**Project Manager**
Contingency	[redacted]	Project Sponsor

3.3 Planned Costs (Forecasted Cash Flow)

During Project Execution, project planned cost will be managed in SAP.

ID&TS Forecasted Cash Flow Table	Incl. Estimate Allowances
To June 2020	905,550
To June 2021	3,897,939
To June 2022	4,314,413
To June 2023	4,433,273
To June 2024	4,860,681
Total	**18,411,856**

4. Project Planning Strategy

4.1 Milestones

The following milestones required by the project team to deliver the project:

Milestones	Planned Dates
Project Approval (issue of PAN) - Preliminary Works	21/03/2020
Site Access - to carry out investigations, inspections, etc	01/04/2020
Design information from QAL and Ergon Customer	01/04/2020
Start Design	01/04/2020
Develop ITT	01/04/2020
Issue ITT to SPA	06/07/2020
Project Approval (issue of PAN) – Full Approval	21/09/2020
Award SPA Contract	21/09/2020
Site Possession SPA	21/11/2020
FAT Building works complete and ready for connection	06/06/2022
Stage 1 Commission	14/12/2022
Stage 2 Commission	17/05/2023
Stage 3 Commission	25/10/2023
Stage 4 Commission	27/03/2024

4.2 Project Staging

Customer needs, outage constraints and resource availability inform the project-staging plan and as a result, project delivery delayed approximately 6 months beyond the identified project need date - October 2023.

As a result, Secondary Systems Strategies and OSD have identified a number of secondary systems equipment with condition issues and elevated risk of failure, which will require additional inspection and maintenance activities from the MSP. The project has allowed the requirements identified by the MSP.

The staging plan has been incorporated into the project schedule in Project Server.

4.3 Project Schedule

The project schedule is developed and managed within Project Server.

Project timing requested to extend past the requested commissioning date will be managed using a Project Schedule in PWA Server once project approved.

4.4 Network Impacts and Outage Planning

An Outage Plan developed via ITOA as part of the project.

The project high-level staging plan and schedule were developed in consultation with customers and internal teams. The requirements were to achieve the shortest possible return to service durations to minimise customer impacts, project staging is based on incremental cutover of x and y secondary systems for each bay while maintaining a two hour return to service.

4.5 Project Delivery Strategy

Strategy to deliver the project as follows:

Description	Responsibility							
	Main Site				Remote End(s)			
	Powerlink	Contractor	MSP – PQ	MSP - Other	Powerlink	Contractor	MSP – PQ	MSP - Other
Primary Design Systems (PSD):								
Earthworks	☒	☐	☐	☐	☐	☐	☐	☐
Civil and Structural	☒	☐	☐	☐	☐	☐	☐	☐
Electrical	☒	☐	☐	☐	☒	☐	☐	☐
Secondary Systems Design (SSD):								
Protection	☒	☒	☐	☐	☒	☐	☐	☐
Automation (Circuitry and Systems Configurations)	☒	☒	☐	☐	☒	☐	☐	☐
Telecommunication System Design (TSD):								
Data Networks	☒	☒	☐	☐	☒	☐	☐	☐
Bearer Networks	☒	☒	☐	☐	☒	☐	☐	☐
Construction:								
Earthworks	☐	☒	☐	☐	☐	☐	☐	☐
Civil	☐	☒	☐	☐	☐	☐	☐	☐
Construction (support structures, plant and equipment installation and demolition Works)	☐	☒	☒	☐	☐	☐	☒	☐
Secondary Systems Installation (loose panels installation, panel modification, IED replacement, etc)	☐	☒	☒	☐	☐	☐	☒	☐
Telecommunication Construction (including fibres)	☐	☒	☒	☐	☐	☐	☒	☐
Testing and Commissioning:								
Factory Acceptance Test	☐	☒	☒	☐	☐	☐	☒	☐
Site Acceptance Test (partial)	☐	☐	☒	☐	☐	☐	☒	☐

Description	Responsibility							
	Main Site				Remote End(s)			
	Powerlink	Contractor	MSP – PQ	MSP - Other	Powerlink	Contractor	MSP – PQ	MSP - Other
System Cut Over and Commissioning	☐	☐	☒	☐	☐	☐	☒	☐
Other:								
Revenue Metering site works	☐	☐	☒	☐	☐	☐	☒	☐

4.6 Procurement Strategy

The procurement strategy for services and selected items listed below. All other services and items procured in accordance with Powerlink's Procurement Standard.

Description	Procurement Method
Services:	
SPA – CT	ITT - Substation Panel Arrangement (SPA)
Optical Fibre System	Shortform ITT – Standing Offer arrangement with preferred/preapproved suppliers
PANTEL	Shortform ITT – Standing Offer arrangement with preferred/preapproved suppliers
MSP – OSD	RFQ
MSP – Other	RFQ – Service Level Agreement
Secondary Systems Equipment:	
IEDs	Period Contract
Panels, Kiosks, Boards and building fit-out	Shortform ITT – Standing Offer arrangement with preferred/preapproved suppliers
Control Building	Shortform ITT – Standing Offer arrangement with preferred/preapproved suppliers
DC Systems (Battery Banks and Charger)	Period Contract
Fire System	TBA
Security System	TBA

Powerlink Queensland

Project Assessment Conclusions Report

6 July 2020

Addressing the secondary systems condition risks in the Gladstone South area

Document Purpose

For the benefit of those not familiar with the National Electricity Rules (the Rules) and the National Electricity Market (NEM), Powerlink offers the following clarifications on the purpose and intent of this document:

1. The Rules require Powerlink to carry out forward planning to identify future reliability of supply requirements and consult with interested parties on the proposed solution as part of the Regulatory Investment Test for Transmission (RIT-T). This includes replacement of network assets in addition to augmentations of the transmission network.
2. Powerlink must identify, evaluate and compare network and non-network options (including, but not limited to, generation and demand side management) to identify the '*preferred option*' which can address future network requirements at the lowest net cost to electricity consumers. This assessment compares the net present value (NPV) of all credible options to identify the option that provides the greatest economic benefits to the market.
3. This document contains the results of this evaluation, and a final recommended solution to address the condition and obsolescence risks arising from the secondary systems at Gladstone South and QAL West Substations by April 2024.

Contents

Executive Summary

Gladstone South Substation, located approximately 5km southeast of the Gladstone CBD, was established in the early 1960s as a 132kV injection point for the 66kV regional distribution network owned by Ergon Energy (part of the Energy Queensland Group). A second interconnected 132kV substation was established on an adjacent site in 2002 to meet a growing demand for electricity in the local area.

The QAL West Substation, also established in 2002, is one of three injection points for the Queensland Aluminium (QAL) refinery in Gladstone.

Planning studies have confirmed there is a long-term requirement to continue to supply the existing electricity services provided by Gladstone South and QAL West Substations to support a diverse range of customer needs in the area.

The secondary systems at Gladstone South and QAL West Substations broadly perform the functions of transmission element protection, data collection, remote (and local) control and monitoring. Commissioned almost 20 years ago, most of these systems are reaching the end of their technical service lives and are no longer supported by the manufacturer, with limited spares available. Increasing failure rates, along with the increased time to rectify the faults due to the obsolescence of the equipment significantly affects the availability and reliability of these systems and their ability to continue to meet the requirements of the National Electricity Rules (the Rules).

Powerlink must therefore address the emerging risks arising from the condition of the secondary systems at Gladstone South and QAL West Substations. As the identified need of the proposed investment is to meet reliability and service standards specified within Powerlink's Transmission Authority and guidelines and standards published by the Australian Energy Market Operator (AEMO), and to ensure Powerlink's ongoing compliance with Schedule 5.1 of the Rules, it is classified as a 'reliability corrective action'[1].

This Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process prescribed under the Rules undertaken by Powerlink to address the condition risks arising from the secondary systems at Gladstone South and QAL West Substations. It contains the results of the planning investigation and the cost-benefit analysis of the credible option compared to a non-credible Base Case where the emerging risks are left to increase over time. In accordance with the RIT-T, the credible option that minimises the net present value (NPV) of costs is recommended as the preferred option.

Credible options considered

Powerlink developed two credible network options to maintain the existing electricity services, ensuring an ongoing reliable, safe and cost effective supply to customers in the area. The major difference between the credible options relates to the staging of the Gladstone South works.

By addressing the condition risks, both options allow Powerlink to meet the identified need and continue to meet the reliability and service standards specified within Powerlink's Transmission Authority, Schedule 5.1 of the Rules, AEMO guidelines and standards and applicable regulatory instruments.

Powerlink published a Project Specification Consultation Report (PSCR) in February 2020 to address the risks and obsolescence issues arising from the condition of the secondary systems at Gladstone South and QAL West Substations. No submissions were received in response to the PSCR that closed on 22 May 2020. As a result, no additional credible options have been identified as a part of this RIT-T consultation.

The two credible network options, along with their NPVs relative to the Base Case are summarised in Table 1. Both options have a negative NPV relative to the non-credible Base Case, as allowed for under the Rules for 'reliability corrective actions'. Of the two credible network options, Option 2 has the lowest cost in NPV terms.

[1] The Rules clause 5.10.2, Definitions, reliability corrective action.
NOTE. This RIT-T commenced under Version 132 of the Rules in February 2020.

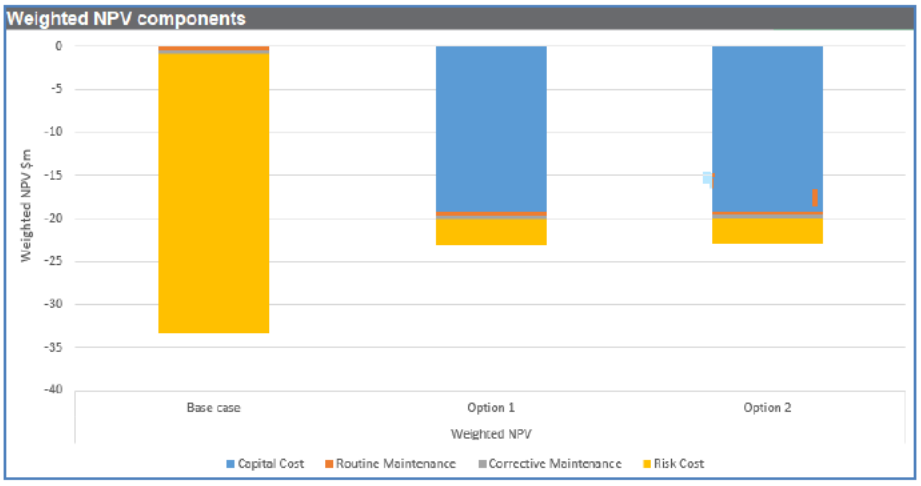
Table 1: Summary of credible network options

Option	Description	Capital costs ($m) 2019/20	Weighted NPV relative to Base Case ($m)	Ranking
1	**Gladstone South:** Partial replacement of secondary systems equipment using a new prefabricated building by April 2024*	15.9*	10.3	2
	Partial replacement of secondary systems equipment by October 2030†	2.3†		
	QAL West: Replace all secondary systems using existing building by April 2024*	6.8*		
2	**Gladstone South:** Full replacement of all secondary systems using a new prefabricated building by April 2024*	17.0*	10.4	1
	QAL West: Replace all secondary systems using existing building by April 2024*	6.8*		

* RIT-T Project
†Future modelled projects

Figure 1 shows the absolute NPVs of the Base Case and the credible network options. All credible options significantly reduce the total risks arising from the condition of the ageing and obsolete secondary systems at Gladstone South and QAL West Substations when compared to the Base Case. Option 2 has the highest NPV of the credible options.

Figure 1: Weighted NPV of Base Case and Credible Network Options



Evaluation and Conclusion

The RIT-T requires that the proposed preferred option maximises the present value of net economic benefit, or minimises the net cost, to all those who produce, consume and transport electricity. The economic analysis demonstrates that Option 2 provides the lowest cost solution and is therefore the preferred option.

In accordance with the expedited process for the RIT-T, the PSCR made a draft recommendation to implement Option 2, the full replacement of all secondary systems at both Gladstone South and QAL West substations by April 2024. The indicative capital cost of this option is $23.8 million in 2019/20 prices. Powerlink is the proponent of this network option.

Design work will commence in 2020 and construction will commence in 2022. Installation and commissioning of the new secondary systems will be completed by April 2024.

As the outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PSCR, the draft recommendation has been adopted without change as the final recommendation, and will now be implemented.

1. Introduction

This Project Assessment Conclusions Report (PACR) represents the final step of the RIT-T process[2] prescribed under the National Electricity Rules (the Rules) undertaken by Powerlink to address the condition risks and obsolescence issues arising from the secondary systems at Gladstone South and QAL West Substations . It follows the publication of the Project Specification Consultation Report (PSCR) in February 2020.

The Project Specification Consultation Report (PSCR):

- described the identified need that Powerlink is seeking to address, together with the assumptions used in identifying this need
- set out the technical characteristics that a non-network option would be required to deliver in order to address the identified need
- described the credible options that Powerlink considered may address the identified need
- discussed specific categories of market benefit that in the case of this RIT-T assessment are unlikely to be material
- presented the Net Present Value (NPV) economic assessment of each of the credible options (as well as the methodologies and assumptions underlying these results) and identified the preferred option and that Powerlink was claiming an exemption from producing a Project Assessment Draft Report (PADR)
- invited submissions and comments, in response to the PSCR and the credible options presented, from Registered Participants, the Australian Energy Market Operator (AEMO), potential non-network providers and any other interested parties.

Powerlink identified Option 2, involving the full replacement the secondary systems at both Gladstone South and QAL West Substations in new buildings by April 2024, as the preferred option to address the identified need. The indicative capital cost of this option is $23.8 million in 2019/20 prices.

The Rules clause 5.16.4(z1) provides for a Transmission Network Service Provider to claim exemption from producing a PADR for a particular RIT-T application if all of the following conditions are met:

- the estimated capital cost of the preferred option is less than $43 million
- the preferred option is identified in the PSCR noting exemption from publishing a PADR
- the preferred option, or other credible options, do not have a material market benefit, other than benefits associated with changes in involuntary load shedding[3]
- submissions to the PSCR did not identify additional credible options that could deliver a material market benefit.

There were no submissions received in response to the PSCR that closed for consultation on 22 May 2020. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation. As the conditions for exemption are now satisfied, Powerlink has not issued a PADR for this RIT-T and is now publishing this PACR, which:

- describes the identified need and the credible options that Powerlink considers address the identified need
- discusses the consultation process followed for this RIT-T together with the reasons why Powerlink is exempt from producing a PADR
- provides a quantification of costs and reasons why specific classes of market benefit are not material for the purposes of this RIT-T assessment

[2] This RIT-T consultation was commenced in June 2019 and has been prepared based on the following documents: National Electricity Rules, Version 122, 30 May 2019 and AER, Application Guidelines Regulatory investment test for transmission, December 2018.
[3] Section 4.3 Project assessment draft report, Exemption from preparing a draft report, AER, Application guidelines, Regulatory investment test for transmission, December 2018

- provides the results of the net present value (NPV) analysis for each credible option assessed, together with accompanying explanatory statements
- identifies the preferred option for investment by Powerlink and details the technical characteristics and proposed commissioning date of the preferred option.

2. Customer and non-network engagement

Delivering electricity to almost four million Queenslanders, Powerlink recognises the importance of engaging with a diverse range of customers and stakeholders who have the potential to affect, or be affected by, Powerlink activities and/or investments.

2.1 Powerlink takes a proactive approach to engagement

Powerlink regularly hosts a range of engagement forums and webinars, sharing information with customers and stakeholders within the broader community. These engagement activities help inform the future development of the transmission network and assist Powerlink in providing services that align with the long term interests of customers. Feedback from these activities is also incorporated into a number of publicly available reports.

2.2 Working collaboratively with Powerlink's Customer Panel

Powerlink's Customer Panel provides a face-to-face opportunity for customers and consumer representative bodies to give their input and feedback about Powerlink's decision making, processes and methodologies. It also provides Powerlink with a valuable avenue to keep customers and stakeholders better informed, and to receive feedback about topics of relevance, including RIT-Ts.

The Customer Panel is regularly advised on the publication of Powerlink's RIT-T documents and briefed quarterly on the status of current RIT-T consultations, as well as upcoming RIT-Ts. This provides an ongoing opportunity for the Customer Panel to ask questions and provide feedback to inform RIT-Ts, and for Powerlink to better understand the views of customers when undertaking the RIT-T consultation process.

2.3 Transmission Annual Planning Report (TAPR) – the initial stage of public consultation

Powerlink utilises the TAPR as a primary vehicle to engage and understand broader consumer, customer and industry views on key topics as part of the annual Transmission Network Forum (TNF) and to inform its business network and non-network planning objectives. TNF participants encompass a diverse range of stakeholders including customers, landholders, environmental groups, Traditional Owners, government agencies, and industry bodies.

2.3.1 Maintaining reliability of supply in the Gladstone South area

Powerlink identified in its TAPRs 2018 to 2019, an expectation that action would be required at Gladstone South and QAL West Substations to address the secondary systems condition risks and maintain reliability of supply to customers in the Gladstone zone[4].

Powerlink advised members of its Non-network Engagement Stakeholder Register (NNESR) of the publication of the TAPR, TAPR templates and the accompanying compendium of potential non-network solution opportunities (Appendix F), which set out the indicative non-network requirements to meet the identified need.

No submissions proposing credible non-network options have been received from prospective non-network solution providers in the normal course of business, in response to the publication of TAPRs or as a result of stakeholder engagement activities.

Taking into consideration the most recent analysis and understanding of the risks arising from the secondary systems at Gladstone South and QAL West, the proposed credible network options have been aligned to a common completion date of April 2024. While this completion date differs slightly from the December 2023 and December 2022 dates published in the 2019 TAPR, it better serves customers in the area by undertaking works at both sites in a similar timeframe.

[4] This relates to the standard geographic definitions (zones) identified within the TAPR.

2.4 Powerlink applies a consistent approach to the RIT-T stakeholder engagement process

Powerlink undertakes a considered and consistent approach to ensure an appropriate level of stakeholder engagement is undertaken for each individual RIT-T. Please visit Powerlink's website for detailed information on the types of engagement activities that may be undertaken during the consultation process. These activities focus on enhancing the value and outcomes of the RIT-T process for customers, stakeholders and non-network providers. Powerlink welcomes feedback from all stakeholders to further improve the RIT-T stakeholder engagement process.

3. Identified need

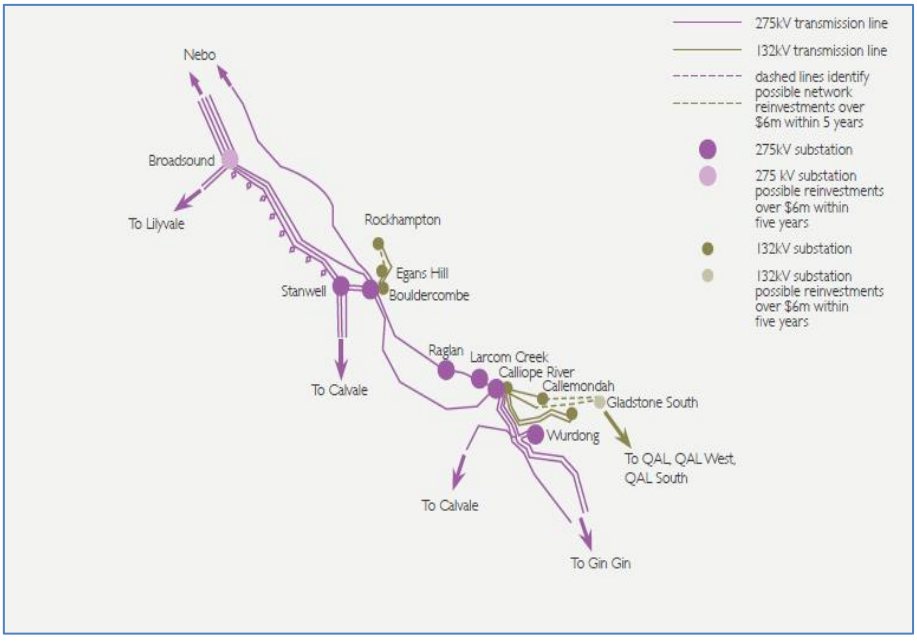
This section provides an overview of the existing arrangements at Gladstone South and QAL West substations and describes the increasing risk to Powerlink of being unable to maintain compliance with relevant standards, applicable regulatory instruments and the Rules, which are designed to ensure Powerlink's customers continue to receive safe, reliable and cost effective electricity services.

3.1 Geographical and network need

Gladstone South Substation, located approximately 5km south east of Gladstone CBD, was established in the early 1960s to provide a bulk supply point for the regional distribution network owned by Ergon Energy (part of the Energy Queensland Group) and support the load growth arising from Queensland Aluminium (QAL). In 2002, the site was expanded and upgraded with the addition of an interconnected substation on an adjacent site. The QAL West Substation, also established in 2002, is one of three injection points for the QAL refinery in Gladstone.

The Gladstone zone transmission network is shown in Figure 3.1.

Figure 3.1: Gladstone zone transmission network



3.2 Description of identified need

With peak demand in the Gladstone area forecast to remain at current levels[5], it is vital that electricity supply be maintained to address these demands. The 2019 TAPR highlights the need to address the condition-based risks of the secondary systems at the two substations.

[5] *Powerlink's Transmission Annual Planning Report* 2019

Powerlink's Transmission Authority requires it to plan and develop the transmission network "in accordance with good electricity industry practice, having regard to the value that end users of electricity place on the quality and reliability of electricity services". It allows load to be interrupted during a critical single network contingency, provided the maximum load and energy:

- will not exceed 50MW at any one time; or
- will not be more than 600MWh in aggregate[6].

Planning studies have confirmed that in order to continue to meet the reliability standard within Powerlink's Transmission Authority, the services currently provided by Gladstone South and QAL Substations are required for the foreseeable future to meet ongoing customer requirements.

Schedule 5.1 of the Rules sets minimum standards for network service providers on the availability and operation of protection systems, whilst Schedule 5.1.9 (c) specifically requires Powerlink provide protection systems to ensure that a fault is automatically disconnected[7]. Powerlink's condition assessment of the secondary systems at Gladstone South and QAL West Substations indicates that most are reaching the end of their technical service lives, they are no longer supported by the manufacturer and there are limited spares available. Increasing failure rates, along with the increased time to rectify the faults due to equipment obsolescence, significantly affects the availability and reliability of these systems.

There is a need for Powerlink to address this emerging risk to ensure ongoing compliance with Schedule 5.1 of the Rules, relevant standards and applicable regulatory instruments, which are designed to ensure Powerlink's customers continue to receive safe, reliable and cost effective electricity services.

As the proposed investment is for meeting reliability and service standards arising from Powerlink's Transmission Authority and to ensure Powerlink's ongoing compliance with Schedule 5.1 of the Rules, it is a 'reliability corrective action' under the Rules[8]. A reliability corrective action differs from that of an increase in producer and consumer surplus (market benefit) driven need in that the preferred option may have a negative net economic outcome as it is required to meet an externally imposed obligation on the network business.

3.3 Assumptions and requirements underpinning the identified need

The secondary systems at Gladstone South and QAL West broadly perform the functions of transmission element protection, data collection, remote (and local) control and monitoring. In performing these functions secondary systems:

- protect the public, the environment, the transmission network and substation primary plant from damage due to faults or mal-operation
- allow remote and local automatic or manual control of primary plant
- enable the remote and local monitoring of primary and secondary plant and equipment

The Rules place specific requirements on Powerlink as a Transmission Network Service Provider (TNSP) to:

> *"Provide sufficient primary protection systems and back-up protection systems (including breaker fail protection systems) to ensure that a fault of any fault type anywhere on its transmission system or distribution system is automatically disconnected"[9].*

The importance of protection systems is further reinforced in the Rules, which require TNSPs to ensure:

> *"all protection systems for lines at a voltage above 66 kV, including associated intertripping, are well maintained so as to be available at all times other than for short periods (not greater than eight hours) while the maintenance of a protection system is being carried out"[10].*

[6] Transmission Authority No. T01/98, section 6.2(c)
[7] The Rules Schedule 5.1.9(c)
[8] The Rules clause 5.10.2 ,Definitions, reliability corrective action
[9] The Rules clause S5.1.9(c)
[10] The Rules clause S5.1.2.1 (d)

As required by the Rules[11], AEMO has published the Power System Security Guidelines (PSS Guidelines) to clarify the Rules regarding unplanned outages of the protection systems. In the event of an unplanned outage of a secondary system, the PSS Guidelines require that the primary network assets be taken out of service if the fault cannot be rectified within 24 hours[12]. Both the Rules and the PSS Guidelines indicate that exceeding 24 hours to rectify a protection fault is not good practice, obligating Powerlink to take action to ensure the restoration period of unplanned outages of secondary systems does not reasonably exceed 24 hours.

Similar to protection requirements, AEMO's Power System Data Communication Standard specifies that the total period of critical outages over a 12 month period must not exceed 24 hours for remote control and monitoring functions[13]. This relates to both the reliability of the equipment (i.e. how often the device fails) and the repair time. It follows that the repair time for any single fault on this equipment must not exceed 24 hours if there are no other faults during the 12 month period.

Powerlink must therefore plan (have systems and processes in place) to safely resolve all protection, remote control and monitoring system problems and defects within 24 hours.

Analysis has shown that operating a secondary system beyond 20 years of effective age significantly impacts its ability to perform within acceptable limits[14]. Delaying replacement of secondary system assets beyond this optimal 20 year timeframe places the network at risk due to the limited supply of suitable spares, which prolongs the duration of any emergency corrective maintenance associated with replacing failed components beyond the 24 hour limit. In the case of protection systems, extended outages beyond 24 hours will result in the need to switch out network assets, placing the supply of electricity to customers at risk[15].

With an increasing likelihood of faults arising from ageing secondary systems remaining in service at Gladstone South and QAL West Substations and limited supply of suitable spares, Powerlink must undertake reliability corrective action if it is to continue to meet its jurisdictional obligations and the standards for reliability of supply set out by AEMO and the Rules.

3.4 Description of asset condition and risks

Powerlink has undertaken a comprehensive condition assessment of the secondary systems at Gladstone South and QAL West using an asset health index modelled from zero to ten, where zero represents new assets and ten indicates that the asset requires urgent action to address the increasing risk of unavailability and unreliable operation. This has identified that a significant amount of secondary system equipment is reaching the end of its technical service life.

The condition of the at-risk secondary systems at Gladstone South and QAL West substations is summarised in Table 3.1.

[11] The Rules clause 4.11.2 (c)
[12] AEMO, Power System Operating Procedure SO_OP_3715, Power System Security Guidelines, V95, 23 September 2019 (the Rules require AEMO to develop and publish Power System Operating Procedures pursuant to clause 4.10.1(b) of the Rules, which Powerlink must comply with per clause 4.10.2(b)).
[13] AEMO, Power System Data Communication Standard, Section 3 Reliability and Section 6 Maintenance. (This standard has been made by AEMO under clause 4.11.2(c) of the Rules and incorporates the standards and protocols referred to in clause 4.11.1)
[14] Cigre, Study Committee B3, Paper B3_205_2018, "Modelling Substation Control and Protection Asset Condition for Optimal Reinvestment Decision Based on Risk, Cost and Performance" by T. Vu, M. Pelevin, D. Gibbs, J. Horan, C. Zhang (Powerlink Queensland)
[15] AEMO, Power System Operating Procedure SO_OP_3715, Power System Security Guidelines, V95, 23 September 2019

Table 3.1: Gladstone South and QAL at-risk secondary systems

Bay	Construction year	Health index average
4x Bus Zones Protection and Control	2003	8.1
3x Bus Couplers Protection and Control	2003	8.1
8x Feeder Bays Protection and Control	2002 - 2012	8.0
4x Transformers Bays Protection and Control	2002-2003	8.3
1x Capacitor Bay Protection and Control*	2006	6.2
1x Harmonic Filter Protection and Control*	2010	3.8
4x Feeder Metering	2003	8.1
Non-bay secondary systems (includes OpsWAN, SCADA, GPS timing system, 125VDC battery chargers)	2002– 2010	8.5

*Gladstone South Substation only

Most of the secondary systems at Gladstone South were installed in 2002/03 as part of the establishment of the second interconnected substation. The secondary systems associated with the harmonic filter were established in 2010 and the capacitor bank in 2006. The systems at QAL West were installed in 2002, when the substation was first commissioned. There have also been a number of selective secondary system component installations in later years due to capital works at remote substation ends, or the replacement of failed components. This has reduced the average health index, whilst the majority of equipment has a health index higher than the average given in Table 3.1.

The impact of equipment obsolescence is an important consideration when determining if remedial action is required. Currently, over 60% of the secondary systems equipment is obsolete. This is expected to increase to an unsupportable level beyond April 2024.

Notwithstanding the assessed condition of the asset, Powerlink's ongoing operational maintenance practices are designed to monitor equipment condition and ensure any emerging safety and reliability risks are proactively managed.

3.5 Consequences of failure in an obsolete system

The duration of a fault is not only dependent on the nature and location of the fault, but also on the availability of a like for like replacement of the failed component. If a like for like replacement is available (i.e. same hardware and firmware as the failed device), then the replacement is often not complex and can generally be rectified within the timeframes specified by AEMO. If a like for like replacement is not available, then replacement is operationally and technically more complex due to:

- physical differences with the mounting and installation
- development and testing of new configurations and settings
- cabling, connectivity and protocol differences
- interoperability between other devices on site, and with remote ends (if applicable)
- non-standard settings / configuration requirements
- legislative requirements for professional engineering certification

All of the above complexities add time to fault resolution, typically resulting in a fault duration well in excess of 24 hours.

Given the specific nature of the Rules' obligations and the AEMO requirements relating to protection, control and monitoring systems, accepted good industry practice is often to replace the current ageing and obsolete secondary systems when they reach the end of their technical service lives, rather than letting them run to failure. Due to the condition and obsolescence issues with the secondary systems at Gladstone South, there is a significant risk of breaching the mandated obligations and requirements if the secondary systems (excluding those associated with the capacitor bank) are left to operate beyond April 2024.

A summary of the equipment condition issues and associated possible consequences of failure of the equipment is given in Table 3.2.

Table 3.2: Summary of equipment condition issues and potential consequences of failure

Equipment	Condition/Issue	Potential consequence of failure
Protection and Control for High Voltage Bay	Obsolescence and limited availability of spares; no longer supported by the manufacturer Increasing failure rates due to ageing electronic components	Failure to operate or slow clearance resulting in Rules violation, plant damage, safety and supply risks Prolonged outages of equipment placing load at risk and resulting in less reliable supply to customers Unable to comply with Power System Data Communication Standard Unable to comply with the Power System Security Guidelines Increased failures resulting in less reliable supply to customers
Metering Equipment	Obsolescence and limited availability of spares; no longer supported by the manufacturer Increasing failure rates due to ageing electronic component	Unable to restore metering installation upon malfunction within the 2 business day requirement of the Rules[16]
SCADA System	Obsolescence and limited availability of spares; no longer supported by the manufacturer Increasing failure rates due to ageing electronic components	Unable to comply with Power System Data Communication Standard Increased failures resulting in less reliable supply to customers

3.5.1 Fleet-wide implications of obsolescence

In addition to the site specific impacts of obsolescence at Gladstone South and QAL West, it is also important to note the compounding impact of equipment obsolescence occurring across the fleet of secondary systems assets installed in the Powerlink network. When a particular equipment type or model is no longer supported by the manufacturer, and limited spares are available to service the fleet of assets, running multiple secondary systems to failure across the network increases the likelihood of concurrent systemic faults that would overwhelm Powerlink's capacity to undertake corrective maintenance or replacement projects. This would leave Powerlink in breach of the Rules, the AEMO standards and its jurisdictional obligations.

4. Submissions received

There were no submissions received in response to the PSCR that was open for consultation until the 22 May 2020[17]. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation.

[16] The Rules, clause 7.8.10 Metering installation malfunctions
[17] Members of Powerlink's Non-network Engagement Stakeholder Register were also advised of the PSCR publication.

5. Credible options assessed in this RIT-T

Powerlink has developed two credible network options to address the secondary system condition risks and compliance obligations at Gladstone South Substation and QAL West substations. A summary of these options is given in Table 5.1.

Table 5.1: Summary of credible options

Option	Description	Capital costs ($m) 2019/20	Indicative average O&M Costs ($m p.a.) 2019/20
1	**Gladstone South:** Partial replacement of secondary systems equipment using a new prefabricated building by April 2024*	15.9*	0.063
	Partial replacement of secondary systems equipment by October 2030†	2.3†	
	QAL West: Replace all secondary systems using existing building by April 2024*	6.8*	
2	**Gladstone South:** Full replacement of all secondary systems using a new prefabricated building by April 2024*	17.0*	0.060
	QAL West: Replace all secondary systems using existing building by April 2024*	6.8*	

*Proposed RIT-T project
†Modelled capital project

All credible options address the major risks resulting from the deteriorating condition of ageing and obsolete secondary systems at Gladstone South and QAL West substations. Addressing these risks will allow Powerlink to meet its reliability of supply and safety obligations under the Rules, its Transmission Authority, the Electricity Act 1994 and other applicable regulatory instruments, by the replacement of the deteriorated protection systems and associated equipment.

The proposed network options have not been discussed by AEMO in its most recent National Transmission Network Development Plan (NTNDP)[18] or the draft 2020 Integrated System Plan (ISP) published in December 2019.

An additional option considered but not progressed due to economic reasons is listed in Appendix 1.

5.1 Option 1: Two stage replacement of the secondary systems by April 2024 and October 2030

This option seeks to optimise the service life of the systems by replacing those secondary systems identified in table 3.1, excluding the secondary systems associated with the capacitor bank and harmonic filter at Gladstone South, by April 2024. The capacitor bank and harmonic filter secondary systems are replaced in a second stage by October 2030.

Powerlink is the proponent of this option.

[18] Clause 5.16.4(b)(4) of the Rules requires Powerlink to advise whether the identified need and or solutions are included in the most recent NTNDP. The 2018 NTNDP is the most recent NTNDP.

Table 5.2: Main project components for the Option 1

Option 1	Works	Indicative cost ($million, 2019/20)
RIT - Project		
Replace selected Gladstone South secondary systems by April 2024	Replacement of the following protection, control and monitoring systems in a new building: • 4x bus zones • 3x bus coupler bays • 8x feeder bays • 4x transformer bays • Selected metering equipment • Selected non-bay equipment	15.9
Replace QAL West Secondary System by April 2024	Replace QAL West Secondary System	6.8
Modelled Capital Project		
Replace capacitor bank and harmonic filter secondary systems by October 2030	Replacement of the following protection, control and monitoring systems in the new building: • 1x capacitor bank bay • 1x harmonic filter	2.3
TOTAL		**25.0**

5.2 Option 2: Single stage replacement of all secondary systems by April 2024

This option seeks to minimise mobilisation costs by replacing all secondary systems identified in Table 3.1 by April 2024.

Table 5.4: Main project components for Option 2

Option 2	Works	Indicative cost ($million, 2019/20)
RIT - Project		
Replace all Gladstone South secondary systems by April 2024	Replacement of the following protection, control and monitoring systems in a new building: • 4x bus zones • 3x bus coupler bays • 8x feeder bays • 4x transformer bays • 1x capacitor bank bay • 1x harmonic filter • Selected metering equipment • Selected non-bay equipment	17.0
Replace QAL West Secondary System by April 2024	Replace QAL West Secondary System	6.8
TOTAL		**23.8**

5.3 Material inter-network impact

Powerlink does not consider that any of the credible options being considered will have a material inter-network impact, based on AEMO's screening criteria[19].

[19] In accordance with Rules clause 5.16.4(b)(6)(ii). AEMO has published guidelines for assessing whether a credible option is expected to have a material inter-network impact.

6. Materiality of Market Benefits

The rules require that all categories of market benefits identified in relation to a RIT-T be quantified, unless the TNSP can demonstrate that a specific category is unlikely to be material.

6.1 Market benefits that are material for this RIT-T assessment

Powerlink considers that changes in involuntary load shedding (i.e. the reduction in expected unserved energy) between options and the Base Case, set out in this PACR, may impact the ranking of the credible options under consideration, or the relativity of the credible options to the Base Case, and that this class of market benefit could be material. These benefits have been quantified and included within the cost benefit and risk cost analysis as network risk.

6.2 Market benefits that are not material for this RIT-T assessment

The AER has recognised a number of classes of market benefits may not be material in the RIT-T assessment and so do not need to be estimated[20]. Other than market benefits associated with involuntary load shedding, Powerlink does not consider any other category of market benefits to be material, and had not estimated them as part of this RIT-T.

More information on consideration of individual classes of market benefits can be found in the PSCR.

7. Base Case

7.1 Modelling a Base Case under the RIT-T

Consistent with the RIT-T Application Guidelines the assessment undertaken in this PACR[21] compares the costs and benefits of credible options to address the risks arising from an identified need, with a Base Case[22].

As characterised in the RIT-T Application Guidelines, the Base Case itself is not a credible option to meet the identified need. Specifically, the Base Case reflects a state of the world in which the condition and obsolescence issues arising from the ageing assets are only addressed through standard operational activities, with escalating safety, financial, environmental and network risks.

To develop the Base Case, the existing condition and obsolescence issues are managed by undertaking operational maintenance only, which results in an increase in risk levels as the condition and availability of the asset deteriorates over time. These increasing risk levels are assigned a monetary value that is used to evaluate the credible options designed to offset or mitigate these risk costs.

The Base Case for Gladstone South and QAL West secondary systems therefore includes the costs of work associated with operational maintenance and the risk costs associated with the failure of the assets. The costs associated with equipment failures are modelled in the risk cost analysis and are not included in the operational maintenance costs.

The Base Case acts as a benchmark and provides a clear reference point in the cost-benefit analysis to compare and rank the credible options against each other, over the same timeframe.

7.2 Gladstone South QAL West Case risk costs

Powerlink has developed a risk modelling methodology consistent with the RIT-T Application Guidelines and the AER Industry practice application note for asset replacement planning[23]. A document giving an overview of the methodology is available on Powerlink's website[24] and the principles of the methodology have been used to calculate the risk costs of the Gladstone South QAL Base Case. The document includes the modelling methodology and general assumptions underpinning the analysis.

[20] AER, Application guidelines, Regulatory investment test for transmission, December 2018
[21] The economic assessment was also presented in the PSCR.
[22] AER, Application Guidelines, Regulatory Investment Test for Transmission, December 2018
[23] AER, Industry practice application note, Asset replacement planning, January 2019
[24] The risk costs are calculated using the principles set out in the Powerlink document, Overview of Asset Risk Cost Methodology, May 2019

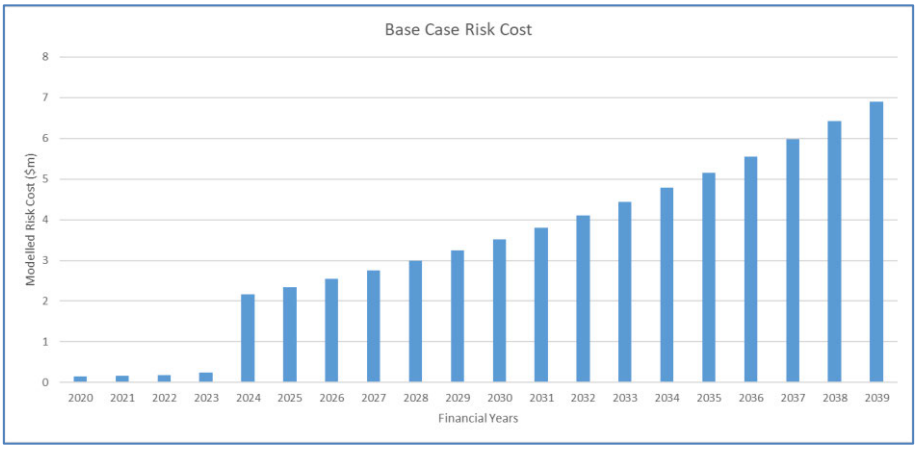
7.3 Base Case assumptions

In calculating the potential unserved energy (USE) arising from a failure of the ageing and obsolete secondary systems at Gladstone South and QAL West substations, the following modelling assumptions have been made:

- spares for secondary system items have been assumed to be available prior to the point of expected spares depletion, as after this point, the cost and time to return the secondary system back to service increases significantly
- historical load profiles have been used when assessing the likelihood of unserved energy under concurrent failure events
- unserved energy generally accrues under concurrent failure events, and consideration has been given to potential feeder trip events within the wider area
- the network risk cost model has used the VCR values as published in the AER 2019 Value of Customer Reliability Review Final Report.[25]

The 20 year forecast of risk costs for the Base Case is shown in Figure 7.1.

Figure 7.1: Modelled Base Case risk costs



Based upon the assessed condition of the ageing secondary systems at Gladstone South and QAL West, the risk costs are projected to increase from $0.16 million in 2020 to $6.90 million in 2039. The main areas of risk cost are network risks that involve reliability of supply through the failure of deteriorated secondary systems modelled as probability weighted unserved energy[26], and financial risk costs associated mostly with the replacement of failed assets in an emergency. These risks increase over time as the condition of equipment further deteriorates, more equipment becomes obsolete and the likelihood of failure rises.

7.4 Modelling of Risk in Options

Each option is scoped to mitigate the key risks arising in the Base Case and to maintain compliance with all statutory requirements, the Rules and AEMO standards. The residual risk is calculated for each option based upon the individual implementation strategy of the option. This is included with the capital and operational maintenance cost of each option to develop the NPV inputs.

[25] AER - Values of Customer Reliability Review - Final Report - December 2019.
[26] As the analysis for this RIT commenced before the December 2019 VCR update, Unserved Energy is modelled using a Value of Customer Reliability (VCR) consistent with that published by AER in their *Value of Customer Reliability Review, Final Report*, 2014.

8. General modelling approach adopted for net benefit analysis

8.1 Analysis period

The RIT-T analysis has been undertaken over a 20 year period, from 2020 to 2039. A 20 year period takes into account the size and complexity of the secondary system replacement options. There will be remaining asset life by 2039, at which point a terminal value is calculated to correctly account for capital costs under each credible option.

8.2 Discount rate

Under the RIT-T, a commercial discount rate is applied to calculate the NPV of costs and benefits of credible options. Powerlink has adopted a real, pre-tax commercial discount rate of 5.90%[27] as the central assumption for the NPV analysis presented in this report.

Powerlink has tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound discount rate of 3.47%[28] and an upper bound discount rate of 8.33% (i.e. a symmetrical upwards adjustment).

8.3 Description of reasonable scenarios

The RIT-T analysis is required to incorporate a number of different reasonable scenarios, which are used to estimate market benefits. The number and choice of reasonable scenarios must be appropriate to the credible options under consideration, and they must reflect any variables or parameters that are likely to affect the ranking of the credible options, where the identified need is reliability corrective action[29].

Powerlink has considered discount rate, capital cost and risk cost sensitivities individually and in combination and found that the discount rate parameter has an impact on the ranking of results. Powerlink has developed three reasonable scenarios and applied weighting to the NPVs calculated under the high, central and low scenarios, as illustrated in Table 8.1.

Table 8.1: Reasonable scenario assumed

Key parameter	High Scenario	Central scenario	Low scenario
Capital cost	100% of base capital cost estimate	100% of base capital cost estimate	100% of base capital cost estimate
Discount rate	8.33%	5.90%	3.47%
Weighting	1/3	1/3	1/3

[27] This indicative commercial discount rate has been calculated on the assumptions that a private investment in the electricity sector would hold an investment grade credit rating and have a return on equity equal to an average firm on the Australian stock exchange, as well as a debt gearing ratio equal to an average firm on the Australian stock exchange.
[28] A discount rate of 3.47% is based on the AER's Final Decision for Powerlink's 2017-2022 transmission determination, which allowed a nominal vanilla WACC of 6.0% and forecast inflation of 2.45% that implies a real discount rate of 3.47%. See AER, Final Decision: Powerlink transmission determination 2017-2022 | Attachment 3 – Rate of return, April 2017, p 9.
[29] AER, Final Regulatory Investment Test for Transmission, June 2010, version 1, paragraph 16, p. 7

9. Cost benefit analysis and identification of the preferred option

9.1 NPV Analysis

Table 9.1 shows the NPV and the corresponding ranking of each credible option relative to the Base Case.

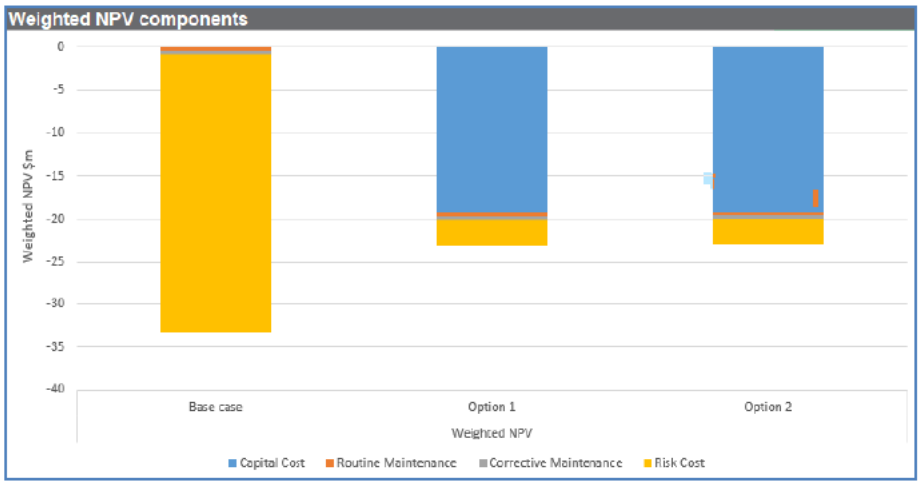
Table 9.1: NPV of credible options relative to base case ($m, 2019/20)

Option	Weighted NPV relative to Base Case ($m)	Ranking
Option 1 Two stage replacement of secondary systems by April 2024 and October 2030	10.264	**2**
Option 2: Single stage replacement of all secondary systems by April 2024	10.367	**1**

Both credible network options address the identified need on an enduring basis. Option 2 has the highest weighted NPV relative to the Base Case and is ranked first.

Figure 9.1 sets out the weighted NPV component of capital cost, maintenance cost and risk cost for the Base Case and each credible option. Option 2 has lower capital cost and maintenance cost components compared to Option 1, resulting in overall higher weighted net present value. Note that the non-credible Base Case consists of maintenance cost and risk cost and does not include any capital expenditure.

Figure 9.1: NPV of the Base Case and each credible option (NPV $m, 2019/20)



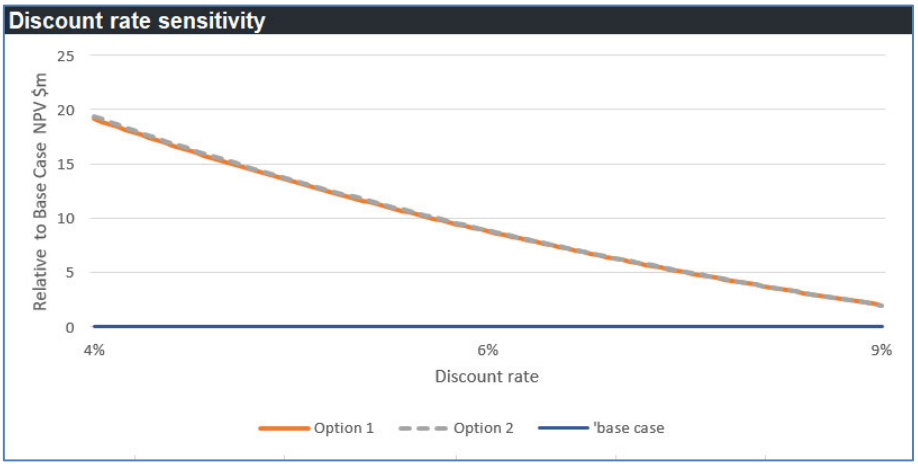
9.2 Sensitivity analysis

Powerlink has investigated the following sensitivities on key assumptions:

- a range from 3.47% to 8.33% discount rate
- a range from 75% to 125% of base capital expenditure estimates
- a range from 75% to 125% of base risk cost estimates

Option 2 is preferred for discount rates below 8.2% while Option 1 is preferred for discount rate greater than 8.2%. In the calculation of weighted NPV, Option 2 results in higher NPV compared Option 1.

Figure 9.2.1 Discount rate sensitivity



Sensitivity analysis of the NPVs relative to the Base Case shows that when varying capital expenditure and risk costs, there is no material change between the option rankings.

Figure 9.2.2 Capital cost sensitivity

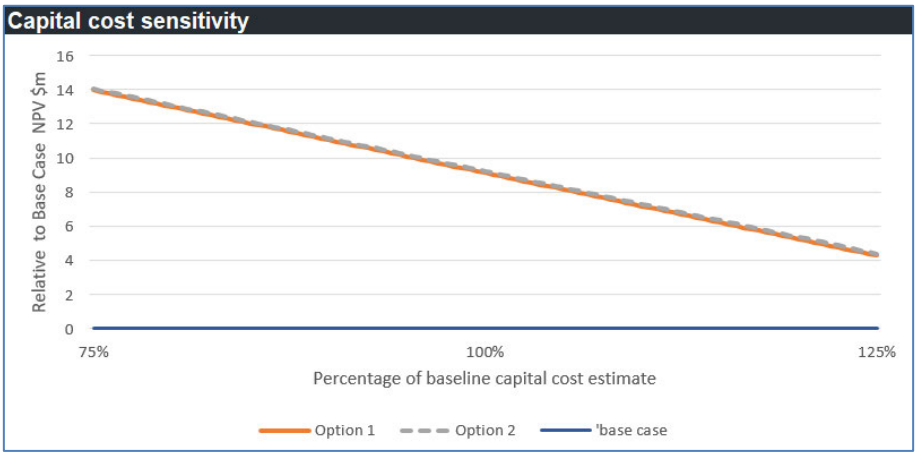
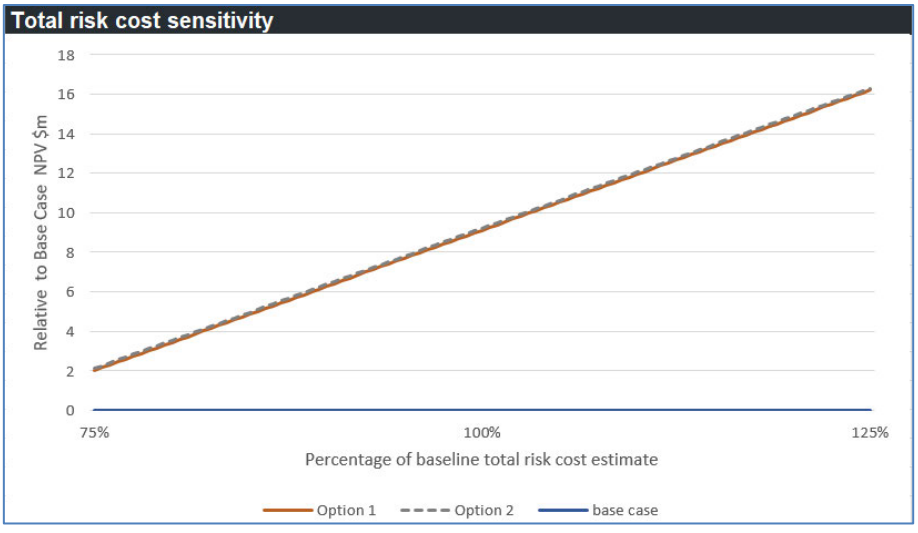


Figure 9.2.3 Risk cost sensitivity



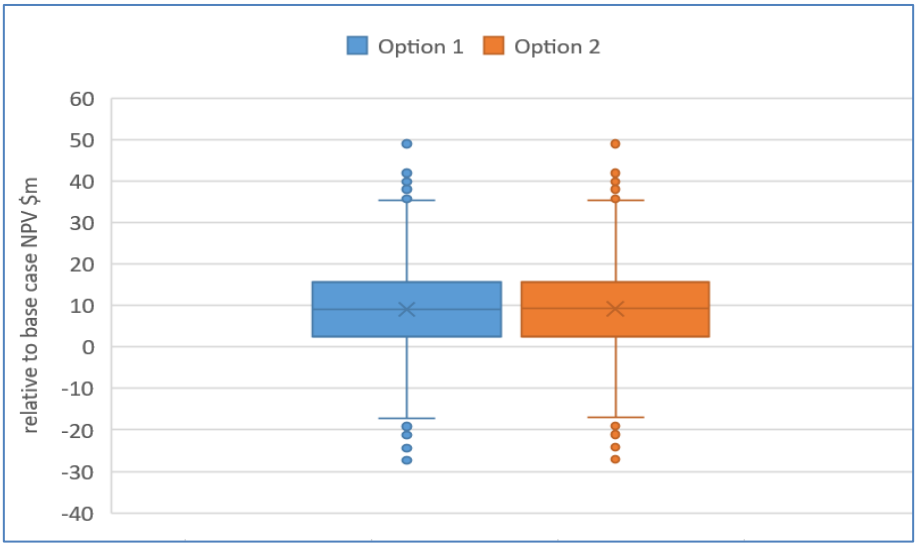
9.3 Sensitivity to multiple parameters

A Monte Carlo simulation was performed with multiple input parameters (including capital cost, discount rate and risk cost) generated for the calculation of the NPV for each option. This process is repeated over 5000 iterations, each time using a different set of random variables from the probability function.

The sensitivity analysis output is presented as a distribution of possible NPVs for each option, as illustrated in Figure 9.3.

The Monte Carlo simulation results identify that Option 2 has similar statistical dispersion in comparison to Option 1 and has a higher mean compared to Option 1. This confirms that the preferred option, Option 2, is robust over a range of input parameters in combination.

Figure 9.3 NPV sensitivity analysis of multiple key assumptions relative to the Base Case



10. Preferred option

Based on the conclusions drawn from the economic analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks associated with the deteriorated condition of the aged and obsolete secondary systems at Gladstone South and QAL West substations. Implementing this option will also ensure ongoing compliance with relevant standards, applicable regulatory instruments and the Rules.

Option 2 involves the full replacement of both the Gladstone South and QAL West secondary systems at an indicative capital cost of $23.8 million in 2019/20 prices. Powerlink is the proponent of this network option.

Under Option 2, design work will commence in 2020, and construction from 2022. Installation and commissioning of the new secondary systems will be completed by April 2024.

11. Conclusions

The following conclusions have been drawn from the analysis presented in this report:

- Powerlink has identified condition risks arising from the ageing and obsolete secondary systems equipment at Gladstone South and QAL West Substations as requiring action.
- S5.1.9(c) of the Rules requires a TNSP to provide sufficient primary protection systems and back-up protection systems (including breaker-fail protection systems) to ensure that a fault of any type anywhere on its transmission system is automatically disconnected.
- TNSPs must also ensure that all protection systems for lines at a voltage above 66kV are well maintained so as to be available at all times other than for short periods (less than eight hours), while the maintenance of a protection system is being carried out.
- The increasing likelihood of faults arising from the condition and obsolescence of the ageing secondary systems at Gladstone South and QAL Substations compels Powerlink to undertake reliability corrective action to meet the reliability standards set out in its Transmission Authority and ensure ongoing compliance with the Rules' standards for protection system availability.

- Studies were undertaken to evaluate two credible options. Both options were evaluated in accordance with the AER's RIT-T.
- Powerlink published a PSCR in February 2020 requesting submissions from Registered Participants, AEMO and interested parties on the credible options presented, including alternative credible non-network options, which could address the secondary systems condition risks and obsolescence issues at Gladstone South and QAL West Substations.
- The PSCR also identified the preferred option and that Powerlink was adopting the expedited process for this RIT-T, claiming exemption from producing a PADR as allowed for under the Rules Clause 5.16.4(z1) for investments of this nature.
- There were no submissions received in response to the PSCR, which was open for consultation until 22 May 2020. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation. The conditions specified under the Rules for exemption have now been fulfilled.
- The result of the cost-benefit analysis under the RIT-T identified that Option 2 is the least cost solution over the 15 year analysis period. Sensitivity testing showed the analysis is robust to variations in discount rate, capital expenditure, operational maintenance expenditure and risk costs assumptions. As a result, Option 2 is considered to satisfy the RIT-T.
- The outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PSCR. Consequently, the draft recommendation has been adopted without change as the final recommendation and will now be implemented.

12. Final Recommendation

Based on the conclusions drawn from the NPV analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks arising from the condition of the ageing and obsolete secondary systems at Gladstone South and QAL West Substations. Option 2 allows Powerlink to continue to maintain compliance with relevant AEMO standards, Powerlink's Transmission Authority and Schedule 5.1 of the Rules. Powerlink is the proponent of this option.

Option 2 involves the replacement of the secondary systems at Gladstone South and QAL West Substations in a new building by April 2024 at an indicative capital cost of $23.8 million in 2018/19 prices. Design and procurement activities will commence in late 2020 and construction in 2022.

Powerlink will now proceed with the necessary processes to implement this recommendation.

Contact us

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