January 2026

Powerlink 2027-32 Revenue Proposal

Project Pack

CP.02751 Murarrie Secondary Systems Replacement

Project Status: Unapproved

Network Requirement

H021 Murarrie Substation, located approximately 8km east of the Brisbane CBD, is a major 275/110kV substation supplying parts of the Brisbane CBD and eastern suburbs, including the Port of Brisbane. It was established in 2003 and later extended to accommodate network development in the Brisbane Metropolitan Area. It is primarily supplied through a double circuit 275kV transmission line from Belmont Substation with the circuits transformer ended by two 375MVA 275/110kV transformers.

Ageing secondary systems, which are no longer supported by the manufacturer are increasingly at risk of failing to comply with Schedule 5.1.9(c) of the National Electricity Rules, AEMO's Power System Security Guidelines and the reliability standard included in Powerlink's Transmission Authority.

A condition assessment of the Murarrie substation secondary systems identifies various secondary systems components requiring replacement commencing in 2026 [1]. In addition, there is an operational need to ensure reliability of supply upon failure of either bus coupler circuit breaker, that can be achieved by reconfiguring 3 Transformer to be bus selectable between buses 1 and 3.

Powerlink's 2025 Central scenario forecast confirms there is an enduring need to maintain electricity supply into Brisbane eastern suburbs, eastern ring of Brisbane CBD, Port of Brisbane and TradeCoast area. The removal or reconfiguration of the Murarrie Substation due to secondary system failure or obsolescence would violate Powerlink's N-1-50MW/600MWh Transmission Authority reliability standard and significantly impact the power transfer capability into the Brisbane Metropolitan Area [2].

Recommended Option

As this project is currently 'Unapproved', project need and options will be subjected to the public RIT-T consultation process to identify the preferred option closer to the time of investment.

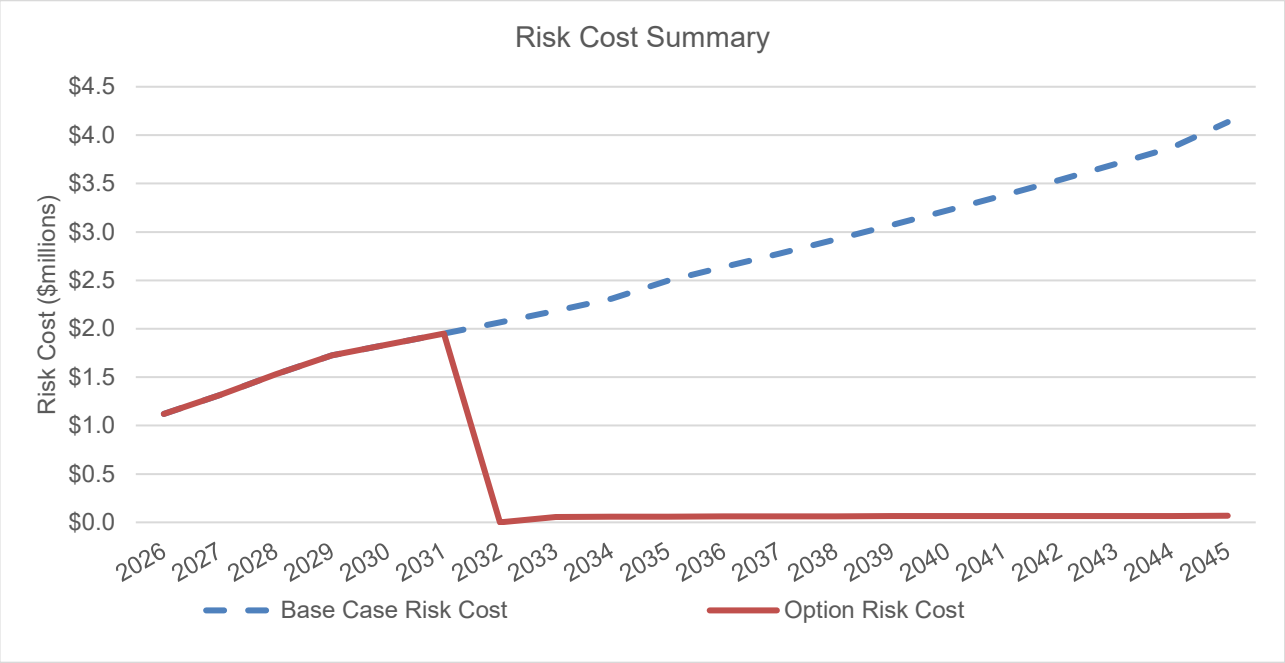
The current recommended option based on the complexity of in situ replacement and network constraints is for full replacement of secondary systems by 2028 [3] although consideration of implementation details results in a target completion of 2031 [4].

Options considered but not proposed include:

- Replacement of some secondary systems and decommission some functionality – this option would require additional transformer capacity at Belmont and additional 110kV network capacity between Belmont and Murarrie and between Belmont and the Brisbane CBD and is not cost effective.

Figure 1 shows the current recommended option reduces the forecast risk monetisation profile of the Murarrie Substation secondary systems from around $1.95 million per annum in 2031 to less than $0.05 million from 2032 [5].

Figure 1 Annual Risk Monetisation Profile ($ Real, 2025/26)



Cost and Timing

The estimated cost to replace secondary systems at Murarrie substation is $58.0m ($2025/26) [4].

Target Commissioning Date: April 2031

Document in CP.02751 Project Pack

Public Documents

1. H021 Murarrie Secondary Systems Condition Assessment Report
2. CP.02751 Murarrie Secondary Systems Replacement – Planning Statement
3. CP.02751 Murarrie Secondary Systems Replacement – Project Scope Report
4. CP.02751 Murarrie Secondary Systems Replacement – Concept Estimate
5. CP.02751 Murarrie Secondary Systems – Risk Cost Summary Report

H021 Murarrie
275kV, 110kV Substation

Secondary Systems Condition Assessment Report

Document Details			
Version Number	0.1	**Principal Author**	[redacted]
Objective ID	A3038288	**Authorised by**	[redacted]
Issue Date	06/12/2018		
Previous Document	N/A	**Team**	Sec Sys and Telecom Strategies

Date	Version	Nature of Change	Author	Authorisation
06/12/2018	1.0	Final	[redacted]	[redacted]

Table of *Contents*

1. Introduction

H021 Murarrie substation is a major 275 and 110kV substation located at 1090,1115,1137 Lytton Road, Murarrie, on the south side of the Gateway Motorway, approximately 8km from the Brisbane CBD. The substation consists of both 275kV and 110kV bays sharing a common platform and a perimeter fence. The substation was established in 2003 and later extended to accommodate the Network Development in the Metropolitan Area.

This report is pertinent to H021 Murarrie 275kV / 110kV substation secondary systems. Recommendations in this report have been based on the conditions of secondary system assets only. Network reconfigurations, refurbishment solutions and implementation methodologies have not been considered in this report. These factors should be covered by the relevant stakeholders.

H021 Murarrie 275 / 110kV substation currently consists of:

- A 275 / 110 kV substation;
- Two (2) of 275 / 110kV Transformers;
- 17 of 275kV and 110kV bays:

    - 2 x 275/110kV Transformer Ended Feeder Bays – (T2 HV and T3 HV):
        - = C01, Transformer Ended Feeder 830 (H003 – Belmont)
        - = C02, Transformer Ended Feeder 8837 (H003 – Belmont)

    - 9 x 110kV Feeder Switching Bays:
        - =D02-A10, Feeder 753 (Newstead)
        - =D05-A10, Feeder 752 (Newstead)
        - =D06-A10, Feeder 7288 (Belmont Tee Wellington Road)
        - =D09-A10, Feeder 7287 (Belmont Tee Wellington Road)
        - =D10-A10, Feeder 7274 (Doboy)
        - =D13-A10, Feeder 7273 (Doboy)
        - =D27-A10, Feeder 7272 (Doboy)
        - =D30-A10, Feeder 7270 (Lytton)
        - =D33-A10, Feeder 7271 (Lytton)

    - 2 x 110kV Transformer Switching Bays:
        - =D19-A10, T2 LV (CB 4422)
        - =D25-A10, T3 LV (CB 4432)

    - 2 x 110kV Bus Sections Switching Bays:
        - =D01-A10, 1 and 2 Bus Section (CB 4112)
        - =D21-A10, 2 and 3 Bus Section (CB 4122)

    - 2 x 110kV Capacitor Bank Switching Bays:
        - =D16-A10, Capacitor Bank #2 (CB 4822)
        - =D23-A10, Capacitor Bank #3 (CB 4832)

Figure 1 - H021 Murarrie 275/110kV Substation Aerial View

2. Site infrastructure

2.1 Substation Buildings

There are five (5) buildings at H021 Murarrie substation:

- Building “+T” (Brick building): Telecommunications, site OpsWAN server, AC and DC systems, workshop and amenities.
- Demountable Building “+5”: 275kV secondary systems, AC and DC systems.
- Demountable Building “+A”: 110kV (Bus 1) secondary systems, AC and DC systems.
- Demountable Building “+B”: 110kV (Bus 2) secondary systems, AC and DC systems.
- Demountable Building “+C”: 110kV (Bus 3) secondary systems, AC and DC systems.

Building +5 has space to accommodate another thirteen (13) standard secondary system panels, refer to drawing series A1-H-127436.

Building +A has space to accommodate another fourteen (14) standard secondary system panels, refer to drawing series A1-H-120620.

Building +B has space to accommodate approximately another five (5) standard secondary system panels, refer to drawing series A1-H-120621.

Building +C has space to accommodate another four (4) standard secondary system panels, refer to drawing series A1-H-120622.

All control buildings and communications rooms are air-conditioned, except the workshop, lunch room and amenity room of the building “+T”.

Figure 2 - H021 Murarrie Brick Building “+T”

Figure 3 - H021 Murarrie 275kV Demountable Building “+5”

Figure 4 - H021 Murarrie 110kV Demountable Building “+A”

Figure 5 - H021 Murarrie 110kV Demountable Building “+B”

Figure 6 - H021 Murarrie 110kV Demountable Building “+C”

The condition assessment of the buildings is not in scope of this report; please refer to the relevant substation condition assessment report. Based on visual inspection, the existing control buildings appear to be in serviceable condition. Depending on the secondary systems implementation methodology and the availability of spare panel spaces, existing control buildings can be utilised to accommodate new secondary systems.

3. Condition Assessment

3.1 Cable Trenches, HV Yard Control Cables and Marshalling Cubicles

The majority of control and protection cables were terminated directly between secondary systems panels and PASS-M0 switchgear control cubicles. These are integral parts of the primary plant hence their conditions are not covered in this report. In general, PASS-M0 switching bays don't have dedicated bay marshalling kiosks.

Conditions of other bay marshalling kiosks e.g. AC, DC, bus zone CTs and VT kiosks, including internal links, terminals, wirings, MCBs / fuses and cables to primary plant were visually inspected and assessed. Equipment Health Indices and recommended replacement timeframe have been detailed in the **Appendix A (Substation)**.

3.1.1 Cable Trenches

Cable trenches and substation structures are classed as HV systems assets. Condition assessments of these assets have been excluded from this report. The following photos were taken during the site inspection in August 2018 are for information purposes only.

Figure 7 - Murarrie 110kV Cable Trenches

3.1.2 HV Yard Cables

Visual inspections of cables between control buildings and yard marshalling kiosks / PASS-M0 control cubicles showed that most cables are still in fair condition and considered to be suitable for another 20-25 years of service. Cables between yard marshalling kiosks and PASS-M0 switchgear control cubicles, as well as other HV primary plant are also in fair condition. These cables should be replaced at the same time with the primary plant replacement.

3.1.3 Marshalling Cubicles

There is no conventional switching bay marshalling cubicle at this site. The PASS-M0 control cubicles serve both as the switching bay marshalling cubicles and switchgear control cubicles. The chassis of marshalling cubicles, including VT, AC and DC, are in fair condition and deemed to be suitable for another 20-25 years of service. However, door seals and air filters of some kiosks may have been degraded due to poor quality materials that have been subjected to UV light, heat and air pollution. All yard cables are not required to be replaced therefore marshalling cubicles can also be retained as is and only new door seals, air filter, which are recommended to be replaced every five / six years as part of routine maintenance.

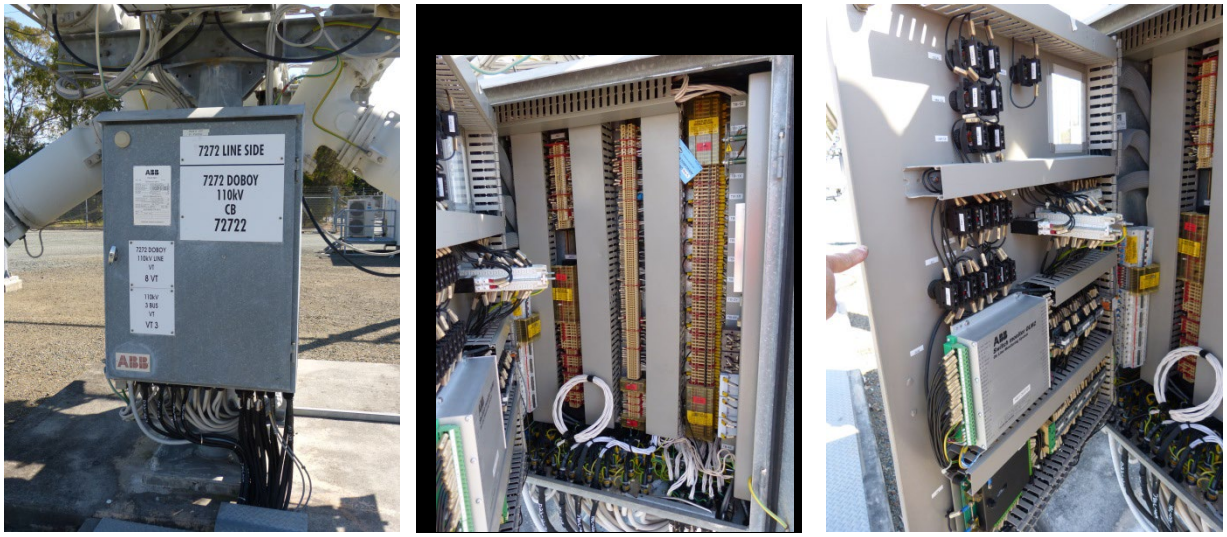


Figure 8 – Visual illustrations of a sample 110kV PASS-M0 Control Cubicle

Figure 9 – Visual illustrations of a sample 110kV Conventional VT Kiosk

3.2 Termination Racks, Bay and Non-Bay Control and Protection Equipment

Condition assessments of H021 Murarrie substation 110 and 275kV control and protection systems, including cubicles, equipment, internal components such as links, terminals, wirings, MCBs, fuses, cables are summarised in the **Appendix A (Substation)**.

3.2.1 Building Termination Racks

All demountable control buildings e.g. +5, +A, +B, +C have termination racks.

3.2.2 Secondary Systems Panels

All secondary systems panels, including auxiliary parts e.g. links, terminals and internal wirings are still in good condition and don't need to be replaced unless Powerlink's standard secondary systems solutions dictate their replacement.

Visual illustrations of the existing secondary systems panels are shown below.

+A5 - Bay =D10 - Feeder 7274 Doboy 2003

+5A4 - 275kV Bay =C02 - Fdr 8837 2008

Figure 10 - Murarrie 110kV and 275kV Secondary Systems

3.2.3 Control, Protection, Auxiliary, Ancillary, Metering and OpsWAN Equipment

3.2.3.1. Assessment Methodologies based on Risk, Cost and Performance

Health indices of secondary systems equipment have been assessed in accordance with Powerlink Quantitative Risk Assessment Frameworks and the Secondary Systems Asset Risk Model developed in [1] based on the following parameters:

- Equipment functional failure rates,
- Environmental conditions where equipment are installed,
- Equipment ages,

Equipment health indices are fundamental inputs of the secondary systems **reliability**. Fundamental inputs of the secondary systems **availability** are derived from the availability of suitable spare parts, equipment obsolesce and technical support (hardware, software and firmware). The **capability** (i.e. **performance**) of the secondary systems depends on both the systems reliability and availability.

Health indices are modelled in the range from zero (0) to ten (10), where zero represents newly installed assets and ten indicates assets that have reached the optimum replacement ages. According to [1], the optimum replacement ages for Powerlink's secondary systems assets signify an optimal replacement time period just before the secondary systems availability and reliability start to transition to a rapidly declined trajectory. Assets with condition scores close to ten represent moderate increase of functional failures, but longer outage duration and significantly higher risk of impacting systems availability and reliability due to equipment obsolescence.

Delaying replacement of secondary systems assets beyond the optimal replacement timeframe does not always result in higher mal-tripping of network elements, but lower secondary systems availability and reliability. It is important to note that not every functional failure will necessarily result in an outage to a network element, but it does represent the loss of some of the normal functions of the protection and control system[1] and can contribute to forced outage events of network elements. This model in [1] projects that the effect of extending the mean replacement age of Powerlink's secondary system assets from 20 years to 25 years is a near doubling of the annual duration of secondary systems functional outages due to functional failures. In addition, delaying the mean replacement ages of secondary system assets beyond the optimal replacement time would increase the yearly operation and maintenance cost for secondary system assets and additional demands on field staff resources. This conclusion is based on Powerlink data and is a direct reflection of Powerlink's environment, including the types of relays purchased, the conditions in which they are installed, the maintenance regime used, and the quantity of spares held.

The recommended replacement timing for secondary systems assets has been optimised based on the secondary systems capability, associated network risks and cost. This report recommends the optimal replacement timing for secondary systems assets and equipment based on the above principles and condition assessment data. It does not specify any specific requirements for replacement methodologies or solutions. A cost effective solution that satisfies Powerlink's requirements will be required to address the conditions of assets listed in the Appendix A.

[1] *The functions that could be unavailable include auto-reclose, automatic voltage control, emergency voltage control, protection signalling, SCADA, remote control or others.*

Depending on fundamental inputs and systems performance, the optimal replacement timing is also recommended for groups of secondary systems assets with lower health indices (e.g. acceptable reliability) but lack of spares and technical support (e.g. low availability). These assets can often be grouped together based on their reliability and availability for strategic and opportunistic replacement in order to maximise cost benefits and asset lifecycle management benefits.

3.2.3.2. 275kV and 110kV Substation Secondary Systems Assets Conditions

Murarrie 275 and 110kV secondary systems comprise mostly digital (microprocessor type) protection and control equipment manufactured approximately between 2001 and 2018. There is a small number of modern electro-mechanical relays still being used for high impedance protection e.g. bus zone and reactor MFAC protection relays. It's important to note that there are some relatively new relays that may have been replaced as part of remote end protection upgrade and faulty relay replacement during operation.

A number of equipment models have been phased out or superseded by the newer models. It means that like-for-like equipment replacement may not be practically possible for some models. Upgrade to newer models is always possible as long as it is carried out under appropriately planned secondary systems outages e.g. planned secondary systems refurbishment projects.

Figure 11 - Murarrie 275kV and 110kV – Typical Substation Secondary Systems Equipment

OpsWAN systems and equipment at this site were installed at various stages since 2003. OpsWAN systems are still functioning and have an important role in operation and maintenance efficiencies. They are considered as auxiliary sub-systems of the power systems. Generally, their condition and performance generally cannot be used to trigger secondary systems refurbishment projects. Therefore, OpsWAN systems and equipment should be opportunistically refurbished as part of the secondary systems replacement projects.


275kV Building +5


110kV Building +A


110kV Building +B


110kV Building +C

Figure 11 - Murarrie 275kV & 110kV Substation OpsWAN Systems and Equipment

3.2.4 Auxiliary Supply

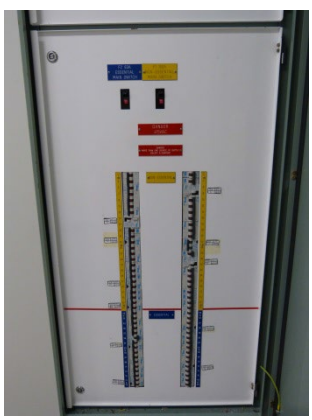
3.2.4.1. AC Auxiliary Supply

AC auxiliary supplies, including station transformers and backup diesel generator/s are classed as HV primary systems assets. Condition assessments of HV primary systems assets have been excluded from this report. The following notes were recorded and visually illustrated for information purposes only.

The 400/230 VAC changeover cubicle inside the building +T (brick building) was installed in November 2002. Each control building has a dedicated building AC distribution board.

Diesel Generators


AC Changeover


275kV building +5


110kV building +A


110kV building +B


110kV building +C

Figure 14 - Murarrie 275kV and 110kV AC Supply, Changeover and AC Distribution

3.2.4.2. DC Batteries and Chargers

The brick building +T (telecoms and OpsWAN building) has duplicated A & B 50V DC batteries and chargers only - no 125V DC batteries and chargers.

All demountable buildings, e.g. +5, +A, +B, +C have duplicated X & Y 125VDC secondary systems batteries and chargers, but no 48V DC batteries and chargers. Telecommunications equipment e.g. Muxes in these buildings are supplied from 125 / 48V DC/DC converters.

- 110kV demountable building +A – X and Y 125V DC batteries and chargers:
  - Batteries: 2017
  - Battery charger and monitoring system: 2009
- 110kV demountable building +B – X and Y 125V DC batteries and chargers:
  - Batteries: 2017.
  - Battery charger and monitoring system: 2009
- 110kV demountable building +C – X and Y 125V DC batteries and chargers:
  - Batteries: 2017.
  - Battery charger and monitoring system: 2009
- 275kV demountable building +5 – X and Y 125V DC batteries and chargers:
  - Batteries: 2006.
  - Battery charger and monitoring system: 2009
- Telecoms and OpsWAN brick building +T – A and B 50V DC batteries and chargers:
  - Batteries: 2016.
  - Battery charger and monitoring system: 2009

The replacement of batteries and chargers in building +5 (275kV building) has already been included in OR 01650 project.

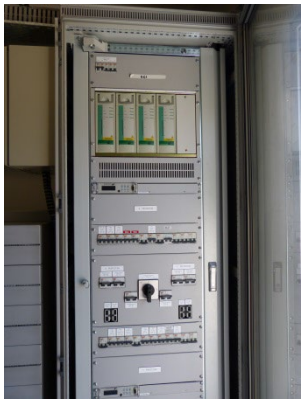


Building +A – 125VDC Batteries and Chargers


Building +B – 125VDC Batteries and Chargers



Building +C - 125VDC Batteries and Chargers



Building +5 - 125VDC Batteries and Chargers



Building +T - 50VDC
Batteries and Chargers
Murarrie 275kV and 110kV DC Batteries and Chargers

4. Conclusion

This report comprehensively details the conditions of secondary systems assets at Murarrie 275kV, 110kV Substation. Equipment health indices and optimal replacement timeframe have been recommended in the Appendix A. The primary objective of the recommended secondary systems refurbishment project is to maintain the current network reliability and availability and to minimise operation and compliance risks associated with secondary systems assets at Murarrie substation.

5. Attachments

- **Appendix A** – H021 Murarrie 275KV & 110KV Substation Secondary Systems Equipment Health Indices and Recommended Replacement Timeframe.


H021 Appendix A.pdf

- CIGRE 2018 - B3 - 205 - Modelling Substation control and Protection Asset Condition for Optimal reinvestment Decision Based on Risk, Cost and Performance.


B3 - 205 - Modelling Substation control an

6. References

[1] "Modelling Substation control and Protection Asset Condition for Optimal reinvestment Decision Based on Risk, Cost and Performance", CIGRE PARIS 26-31 August 2018, T Vu, M. Pelevin, D. Gibbs, J.Horan, C. Zhang.

7. Appendix A

APPENDIX A - H021 MURARRIE 275KV & 110KV SUBSTATION SECONDARY SYSTEMS - EQUIPMENT HEALTH INDICES AND RECOMMENDED REPLACEMENT TIMEFRAME

Notes:
(a): Subject to Powerlink's O&M Safety Requirements, Current Standard Solutions and Implementation Methodologies, it may be more beneficial to align with the recommended replacement timeframe of sedondary systems equipment
(b): Recommended Timeframe is based on majority of Equipment Health Indices
(c): Based on Visual Inspection and Subject to the decision of the Control Building and Secondary Systems Panels. A number of New Cables may be requried if location of control building or secondary systems panels is changed.
(d): As a minimum requirement, Rubber Seals, Air filter and Terminals and Links are required to be repaired by the recommended timeframe. New Marshalling Kiosks should be considered if Exsiting Cables are to be reaplaced.

BAY	C&P PANEL				SECONDARY SYSTEMS EQUIPMENT					X-PROT		Y-PROT		AUX & CTRL		REVENUE METERING		OPSWAN		CABLES (HI)	YARD MARSHALLING KIOSKS (HI)	RECOMMENDED REPLACEMENT TIMMING (Based on Trigger Conditions only, Exclude considerations for Solutions, implementation methodologies)			
Function	Panel Decripion	Panel No.	Year	HI	Functional Loc.	Description	Manufacturer	Model number	Obsolescence (Yes / No)	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	C&P PANELS (Chassis)	Sec Sys Equipment & Auxiliary Components	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)
1 BUS	110kV 1 Buszone CBF Bus Trip Buszone 1 RTU	+A1	2003	4.57	H021-SSS-1BU4-BAYCONT	1 BUS ZONE BAY CONTROL UNIT	FOXBORO		Y					14.54	7.27					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-1BU4-XPROT	1 BUS ZONE X PROTECTION	GE		Y	14.54	7.27														
					H021-SSS-1BU4-XPROT	1 BUS ZONE X PROTECTION	RMS		Y	14.54	7.27														
					H021-SSS-1BU4-YPROT	1 BUS ZONE Y PROTECTION	GE		Y			14.54	7.27												
					H021-SSS-1BU4-YPROT	1 BUS ZONE Y PROTECTION	RMS		Y			14.54	7.27												
2 BUS	110kV 2 Buszone CBF Bus Trip Buszone 2 RTU	+B1	2003	4.57	H021-SSS-2BU4-BAYCONT	2 BUS ZONE BAY CONTROL UNIT	FOXBORO		Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-2BU4-XPROT	2 BUS ZONE X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-2BU4-XPROT	2 BUS ZONE X PROTECTION	RMS		Y	14.58	7.29														
					H021-SSS-2BU4-YPROT	2 BUS ZONE Y PROTECTION	GE		Y			14.58	7.29												
					H021-SSS-2BU4-YPROT	2 BUS ZONE Y PROTECTION	RMS		Y			14.58	7.29												
3 BUS	110kV 3 Buszone CBF Bus Trip Buszone 3 RTU	+C1	2003	4.57	H021-SSS-3BU4-BAYCONT	3 BUS ZONE BAY CONTROL UNIT	FOXBORO		Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-3BU4-XPROT	3 BUS ZONE X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-3BU4-XPROT	3 BUS ZONE X PROTECTION	RMS		Y	14.58	7.29														
					H021-SSS-3BU4-YPROT	3 BUS ZONE Y PROTECTION	GE		Y			14.58	7.29												
					H021-SSS-3BU4-YPROT	3 BUS ZONE Y PROTECTION	RMS		Y			14.58	7.29												
1-2 Bus Section CB 4112 (=D01)	110kV Bus Section 1 Bus -2 Bus (Bay = D01)	+A3	2003	4.57	H021-SSS-411--BAYCONT	1 BUS SECTION BAY CONTROL UNIT	FOXBORO		Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-411--XPROT	1 BUS SECTION X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-411--YPROT	1 BUS SECTION Y PROTECTION	SCHWEITZER		Y			14.58	7.29												
2-3 Bus Section CB 4122 (=D21)	110kV Bus Section 2 Bus -3 Bus (Bay =D21)	+B5	2003	4.57	H021-SSS-412--BAYCONT	2 BUS SECTION BAY CONTROL UNIT	FOXBORO		Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-412--XPROT	2 BUS SECTION X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-412--YPROT	2 BUS SECTION Y PROTECTION	SCHWEITZER		Y			14.58	7.29												
T2 TFMR LV CB 4122 (=D19)	110kV T2 TFMR LV CB4422 (Bay =D19)	+B12	2008	3.14	H021-SSS-442--BAYCONT	2 TRANSFORMER CONTROL UNIT	FOXBORO		Y					10.50	5.25					3.14	3.14	> 2043	2028/29 (b)	> 2043 (c)	> 2043 (d)
					H021-SSS-442--XPROT	2 TRANSFORMER X PROTECTION	GE		Y	9.98	4.99														
					H021-SSS-442--YPROT	2 TRANSFORMER Y PROTECTION	SCHWEITZER		Y			8.83	4.42												
T3 TFMR LV CB 4122 (=D25)	110kV T3 TFMR LV CB4422 (Bay =D25)	+C12	2006	3.71	H021-SSS-443--BAYCONT	3 TRANSFORMER CONTROL UNIT	FOXBORO		Y					11.30	5.65					3.71	3.71	> 2041	2026/27 (b)	> 2041 (c)	> 2041 (d)
					H021-SSS-443--XPROT	3 TRANSFORMER X PROTECTION	GE		Y	11.30	5.65														
					H021-SSS-443--YPROT	3 TRANSFORMER Y PROTECTION	SCHWEITZER		Y			11.30	5.65												
CAP 2 CB 4822 (=D16)	110kV CAP 2 CB 4822 (=D16)	+A9	2005	4.00	H021-SSS-482--BAYCONT	2 CAPACITOR BAY CONTROL UNIT	FOXBORO		Y					12.13	6.06					4.00	4.00	> 2040	2025/26 (b)	> 2040 (c)	> 2040 (d)
					H021-SSS-482--POWAVE	2 CAPACITOR POINT ON WAVE	ABB		Y					12.13	6.06										
					H021-SSS-482--XPROT	2 CAPACITOR X PROTECTION	ABB		N	12.13	6.06														
					H021-SSS-482--XPROT	2 CAPACITOR X PROTECTION	GE		Y	12.13	6.06														
					H021-SSS-482--XPROT	2 CAPACITOR X PROTECTION	ABB		N	11.68	5.84														
					H021-SSS-482--YPROT	2 CAPACITOR Y PROTECTION	SCHWEITZER		Y			12.13	6.06												
CAP 3 CB 4832 (=D23)	110kV CAP 3 - CB 4832 (=D23)	+C7	2005	4.00	H021-SSS-483--BAYCONT	3 CAPACITOR BAY CONTROL UNIT	FOXBORO		Y					12.28	6.14					4.00	4.00	> 2040	2025/26 (b)	> 2040 (c)	> 2040 (d)
					H021-SSS-483--POWAVE	3 CAPACITOR POINT ON WAVE	ABB		Y					12.28	6.14										
					H021-SSS-483--XPROT	3 CAPACITOR X PROTECTION	ABB		N	18.31	9.16														
					H021-SSS-483--XPROT	3 CAPACITOR X PROTECTION	ABB		N	12.28	6.14														
					H021-SSS-483--XPROT	3 CAPACITOR X PROTECTION	GE		Y	12.28	6.14														
					H021-SSS-483--YPROT	3 CAPACITOR Y PROTECTION	SCHWEITZER		Y			12.28	6.14												
T2 TFMR HV	275kV T2 TFMR HV	+5A3	2008	3.14	H021-SSS-542--BAYCONT	2 TRANSFORMER BAY CONTROL UNIT	FOXBORO		Y					10.50	5.25					3.14	3.14	> 2043	2028/29 (b)	> 2043 (c)	> 2043 (d)
					H021-SSS-542--XPROT	2 TRANSFORMER X PROTECTION	GE		Y	9.78	4.89														
					H021-SSS-542--XPROT	2 TRANSFORMER X PROTECTION	GE		Y	9.66	4.83														
					H021-SSS-542--XPROT	2 TRANSFORMER X PROTECTION	AREVA		N	8.83	4.42														
					H021-SSS-8837-PSSITA1	8837 SITA1 H021 TO H003 DIG PROT SIG	DEWAR		Y	9.23	4.62														
					H021-SSS-8837-PSSITA2	8837 SITA2 H021 TO H003 DIG PROT SIG	RFL ELECTRONICS		Y	11.33	5.66														
					H021-SSS-542--YPROT	2 TRANSFORMER Y PROTECTION	SCHWEITZER		Y			8.83	4.42												
					H021-SSS-8837-PSSITB1	8837 SITB1 H021 TO H003 DIG PROT SIG	DEWAR		Y			9.23	4.62												
					H021-SSS-8837-PSSITB2	8837 SITB2 H021 TO H003 DIG PROT SIG	RFL ELECTRONICS		Y			11.33	5.66												
T3 TFMR HV	275kV T3 TFMR HV	+5A1	2006	3.71	H021-SSS-543--BAYCONT	3 TRANSFORMER BAY CONTROL UNIT	FOXBORO		Y					11.30	5.65					3.71	3.71	> 2041	2026/27 (b)	> 2041 (c)	> 2041 (d)
					H021-SSS-543--XPROT	3 TRANSFORMER X PROTECTION	GE		Y	11.30	5.65														
					H021-SSS-543--XPROT	3 TRANSFORMER X PROTECTION	GE		Y	11.30	5.65														
					H021-SSS-543--XPROT	3 TRANSFORMER X PROTECTION	AREVA		N	11.30	5.65														
					H021-SSS-830--PSSITA1	F830 SIT A1 H021 TO H003 DIG PROT SIG	DEWAR		Y	11.31	5.65														
					H021-SSS-830--PSSITA2	F830 SIT A2 H021 TO H003 DIG PROT SIG	RFL ELECTRONICS		Y	11.33	5.66														
					H021-SSS-543--YPROT	3 TRANSFORMER Y PROTECTION	SCHWEITZER		Y			11.30	5.65												
					H021-SSS-830--PSSITB1	F830 SIT B1 H021 TO H003 DIG PROT SIG	RFL ELECTRONICS		Y			11.33	5.66												
					H021-SSS-830--PSSITB2	F830 SIT B2 H021 TO H003 DIG PROT SIG	DEWAR		Y			11.31	5.65												
FDR 7270 (=D30)	110kV FDR 7270 (LYTTON) - CB 72702	+A6	2003	4.57	H021-SSS-7270-BAYCONT	FEEDER 7270 BAY CONTROL UNIT	FOXBORO		Y					14.54	7.27					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-7270-XPROT	FEEDER 7270 X PROTECTION	GE		Y	14.54	7.27														
					H021-SSS-7270-YPROT	FEEDER 7270 Y PROTECTION	SCHWEITZER		Y			14.54	7.27												

APPENDIX A - H021 MURARRIE 275KV & 110KV SUBSTATION SECONDARY SYSTEMS - EQUIPMENT HEALTH INDICES AND RECOMMENDED REPLACEMENT TIMEFRAME

Notes:
(a): Subject to Powerlink's O&M Safety Requirements, Current Standard Solutions and Implementation Methodologies, it may be more beneficial to align with the recommended replacement timeframe of secondary systems equipment
(b): Recommended Timeframe is based on majority of Equipment Health Indices
(c): Based on Visual Inspection and Subject to the decision of the Control Building and Secondary Systems Panels. A number of New Cables may be required if location of control building or secondary systems panels is changed.
(d): As a minimum requirement, Rubber Seals, Air filter and Terminals and Links are required to be replaced by the recommended timeframe. New Marshalling Kiosks should be considered if Exsiting Cables are to be replaced.

RECOMMENDED REPLACEMENT TIMMING (Based on Trigger Conditions only, Exclude considerations for Solutions, implementation methodologies)

BAY	C&P PANEL				SECONDARY SYSTEMS EQUIPMENT					X-PROT		Y-PROT		AUX & CTRL		REVENUE METERING		OPSWAN		CABLES (HI)	YARD MARSHALLING KIOSKS (HI)	C&P PANELS (Chassis)	Sec Sys Equipment	CABLES	YARD MARSHALLING KIOSKS
Function	Panel Decription	Panel No.	Year	HI	Functional Loc.	Description	Manufacturer	Model number	Obsolescence (Yes / No)	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	C&P Panels	Sec Sys Equipment & Auxiliary Components	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)
FDR 7271 (=D33)	110kV FDR 7271 (LYTTON) - CB 72712	+C5	2003	4.57	H021-SSS-7271-BAYCONT	FEEDER 7271 BAY CONTROL UNIT	FOXBORO	[redacted]	Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-7271-XPROT	FEEDER 7271 X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-7271-YPROT	FEEDER 7271 Y PROTECTION	SCHWEITZER		Y			14.58	7.29												
FDR 7272 (=D27)	110kV FDR 7272 (DOBOY) - CB 72722	+C3	2003	4.57	H021-SSS-7272-BAYCONT	FEEDER 7272 BAY CONTROL UNIT	FOXBORO		Y					14.57	7.28					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-7272-XPROT	FEEDER 7272 X PROTECTION	GE		Y	14.57	7.28														
					H021-SSS-7272-YPROT	FEEDER 7272 Y PROTECTION	SCHWEITZER		Y			14.57	7.28												
FDR 7273 (=D13)	110kV FDR 7273 (DOBOY) - CB 72732	+B4	2003	4.57	H021-SSS-7273-BAYCONT	FEEDER 7273 BAY CONTROL UNIT	FOXBORO		Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-7273-XPROT	FEEDER 7273 X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-7273-YPROT	FEEDER 7273 Y PROTECTION	SCHWEITZER		Y			14.58	7.29												
FDR 7274 (=D10)	110kV FDR 7274 (DOBOY) - CB 72742	+A5	2003	4.57	H021-SSS-7274-BAYCONT	FEEDER 7274 BAY CONTROL UNIT	FOXBORO		Y					14.53	7.26					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-7274-XPROT	FEEDER 7274 X PROTECTION	GE		Y	14.53	7.26														
					H021-SSS-7274-YPROT	FEEDER 7274 Y PROTECTION	SCHWEITZER		Y			14.53	7.26												
FDR 7287 (=D09)	110kV FDR 7287 (BELMONT - TEE WELLINGTON ROAD) - CB 72872	+B11	2005	4.00	H021-SSS-7287-BAYCONT	FEEDER 7287 BAY CONTROL UNIT	FOXBORO		Y					12.21	6.10					4.00	4.00	> 2040	2025/26 (b)	> 2040 (c)	> 2040 (d)
					H021-SSS-7287-XPROT	FEEDER 7287 X PROTECTION	GE		Y	12.21	6.10														
					H021-SSS-7287-YPROT	FEEDER 7287 Y PROTECTION	SCHWEITZER		Y			12.21	6.10												
FDR 7288 (=D06)	110kV FDR 7288 (BELMONT - TEE WELLINGTON ROAD) - CB 72882	+A8	2005	4.00	H021-SSS-7288-BAYCONT	FEEDER 7288 BAY CONTROL UNIT	FOXBORO		Y					12.01	6.01					4.00	4.00	> 2040	2025/26 (b)	> 2040 (c)	> 2040 (d)
					H021-SSS-7288-XPROT	FEEDER 7288 X PROTECTION	GE		Y	12.01	6.01														
					H021-SSS-7288-YPROT	FEEDER 7288 Y PROTECTION	SCHWEITZER		Y			12.01	6.01												
FDR 752 (=D05)	110kV FDR 752 (NEWSTEAD) - CB 7522	+B3	2003	4.57	H021-SSS-752--BAYCONT	FEEDER 752 BAY CONTROL UNIT	FOXBORO		Y					14.58	7.29					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-752--XPROT	FEEDER 752 X PROTECTION	GE		Y	14.58	7.29														
					H021-SSS-752--YPROT	FEEDER 752 Y PROTECTION	SCHWEITZER		Y			14.58	7.29												
FDR 753 (=D02)	110kV FDR 752 (NEWSTEAD) - CB 7532	+A4	2003	4.57	H021-SSS-753--BAYCONT	FEEDER 753 BAY CONTROL UNIT	FOXBORO		Y					14.53	7.26					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-753--XPROT	FEEDER 753 X PROTECTION	GE		Y	14.53	7.26														
					H021-SSS-753--YPROT	FEEDER 753 Y PROTECTION	SCHWEITZER		Y			14.53	7.26												
FDR 830 (=C01)	275kV Feeder 830 (BELMONT) - CB 8302	+5A2	2006	3.71	H021-SSS-830--BAYCONT	FEEDER 830 BAY CONTROL UNIT	FOXBORO		Y					11.30	5.65					3.71	3.71	> 2041	2026/27 (b)	> 2041 (c)	> 2041 (d)
					H021-SSS-830--XPROT	FEEDER 830 X PROTECTION	MICOM		Y	11.30	5.65														
					H021-SSS-830--YPROT	FEEDER 830 Y PROTECTION	SCHWEITZER		Y			11.30	5.65												
					H021-SSS-830--PSPITY	F830 PIT Y +IAR H021-H003 DIG PROT SIG	DEWAR		Y			11.31	5.65												
	+5B2 - 275kV Comms and MUX	+5B2			H021-SSS-830--XPROT	FEEDER 830 X PROTECTION	ALSTOM		Y	11.30	5.65														
FDR 8837 (=C02)	275kV Feeder 8837 (BELMONT) - CB 88372	+5A4	2008	3.14	H021-SSS-8837-BAYCONT	FEEDER 8837 BAY CONTROL UNIT	FOXBORO		Y					10.50	5.25					3.14	3.14	> 2043	2028/29 (b)	> 2043 (c)	> 2043 (d)
					H021-SSS-8837-XPROT	FEEDER 8837 X PROTECTION	MICOM		Y	8.83	4.42														
					H021-SSS-8837-YPROT	FEEDER 8837 Y PROTECTION	SCHWEITZER		Y			9.47	4.74												
					H021-SSS-8837-PSPITY	8837 PIT Y H021 TO H003 DIG PROT SIG	DEWAR		Y			9.23	4.62												
	+5B2 - 275kV Comms and MUX	+5B2			H021-SSS-8837--XPROT	FEEDER 8837 X PROTECTION	ALSTOM		Y	8.83	4.42														
REVMET 4, 6 8 (FDRs 7273, 752, 7287)	110kV REVENUE METERING PANEL - FDRs 7273, 752 and 7287	+B6	2005	4.00	H021-SSS-METR-REVMET6	FDR 752 ENERGY METERING (REVENUE)	EDMI		Y							12.81	6.40			4.00	4.00	> 2040	2025/26 (b)	> 2040 (c)	> 2040 (d)
					H021-SSS-METR-REVMET6	FDR 752 ENERGY METERING (REVENUE)	EDMI		Y							9.57	4.79								
					H021-SSS-METR-REVMET4	FDR 7273 ENERGY METERING (REVENUE)	EDMI		Y							13.97	6.98								
					H021-SSS-METR-REVMET4	FDR 7273 ENERGY METERING (REVENUE)	EDMI		Y							13.97	6.98								
					H021-SSS-METR-REVMET8	FDR 7287 ENERGY METERING (REVENUE)	EDMI		Y							10.82	5.41								
					H021-SSS-METR-REVMET8	FDR 7287 ENERGY METERING (REVENUE)	EDMI		Y							10.82	5.41								
REVMET 2, 3 (FDRs 7271, 7272)	110kV REVENUE METERING PANEL - FDRs 7271 and 7272	+C6	2003	4.57	H021-SSS-METR-REVMET2	FDR 7271 ENERGY METERING (REVENUE)	EDMI		Y							14.58	7.29			4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-METR-REVMET2	FDR 7271 ENERGY METERING (REVENUE)	EDMI		Y							8.46	4.23								
					H021-SSS-METR-REVMET3	FDR 7272 ENERGY METERING (REVENUE)	EDMI		Y							13.97	6.98								
					H021-SSS-METR-REVMET3	FDR 7272 ENERGY METERING (REVENUE)	EDMI		Y							13.97	6.98								
REVMET 4, 6 8 (FDRs 7270, 7274, 753 and 7288)	110kV REVENUE METERING PANEL - FDRs 7270, 7274, 753 and 7288	+A7	2004	4.29	H021-SSS-METR-REVMET1	FDR 7270 ENERGY METERING (REVENUE)	EDMI		Y							18.35	9.18			4.29	4.29	> 2039	2024/25 (b)	> 2039 (c)	> 2039 (d)
					H021-SSS-METR-REVMET1	FDR 7270 ENERGY METERING (REVENUE)	EDMI		Y							14.54	7.27								
					H021-SSS-METR-REVMET5	FDR 7274 ENERGY METERING (REVENUE)	EDMI		Y							13.97	6.98								
					H021-SSS-METR-REVMET5	FDR 7274 ENERGY METERING (REVENUE)	EDMI		Y							13.97	6.98								
					H021-SSS-METR-REVMET7	FDR 753 ENERGY METERING (REVENUE)	EDMI		Y							12.81	6.40								
					H021-SSS-METR-REVMET7	FDR 753 ENERGY METERING (REVENUE)	EDMI		Y							12.73	6.36								
					H021-SSS-METR-REVMET9	FDR 7288 ENERGY METERING (REVENUE)	EDMI		Y							10.91	5.45								
					H021-SSS-METR-REVMET9	FDR 7288 ENERGY METERING (REVENUE)	EDMI		Y							10.91	5.45								

APPENDIX A - H021 MURARRIE 275KV & 110KV SUBSTATION SECONDARY SYSTEMS - EQUIPMENT HEALTH INDICES AND RECOMMENDED REPLACEMENT TIMEFRAME

Notes:
(a): Subject to Powerlink's O&M Safety Requirements, Current Standard Solutions and Implementation Methodologies, it may be more beneficial to align with the recommended replacement timeframe of sedondary systems equipment
(b): Recommended Timeframe is based on majority of Equipment Health Indices
(c): Based on Visual Inspection and Subject to the decision of the Control Building and Secondary Systems Panels. A number of New Cables may be requried if location of control building or secondary systems panels is changed.
(d): As a minimum requirement, Rubber Seals, Air filter and Terminals and Links are required to be repalced by the recommended timeframe. New Marshalling Kiosks should be considered if Exsiting Cables are to be reaplaced.

BAY	C&P PANEL				SECONDARY SYSTEMS EQUIPMENT					X-PROT		Y-PROT		AUX & CTRL		REVENUE METERING		OPSWAN		CABLES (HI)	YARD MARSHALLING KIOSKS (HI)	RECOMMENDED REPLACEMENT TIMMING (Based on Trigger Conditions only, Exclude considerations for Solutions, implementation methodologies)			
																						C&P PANELS (Chassis)	Sec Sys Eqiupment	CABLES	YARD MARSHALLING KIOSKS
Function	Panel Decripion	Panel No.	Year	HI	Functional Loc.	Description	Manufacturer	Model number	Obsolescence (Yes / No)	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	C&P Panels	Sec Sys Equipment & Auxiliary Components	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)
"+4" COMMON & OPSWAN	BUILDING +4 COMMON RTU AND OPSWAN	+T	2010	2.57	H021-SSS-NBAY-INVERTT	DC - AC INVERTER BUILDING "T"	LATRONICS	[redacted]	N									14.00	10.00	2.57	2.57	> 2045	2030/31 (b)	> 2045 (c)	> 2045 (d)
					H021-SSS-NBAY-LCFT	LOCAL CONTROL FACILITY BUILDING "T"	WYSE		Y					0.42	0.42										
					H021-SSS-NBAY-OWHUBT	OPSWAN HUB BUILDING "T"	CISCO		Y									7.63	7.63						
					H021-SSS-NBAY-OWHUBT	OPSWAN HUB BUILDING "T"	RUGGEDCOM		N									4.09	4.09						
					H021-SSS-NBAY-OWPRINTT	OPSWAN PRINTER BUILDING "T"	HEWLETT PACKARD		Y									8.00	8.00						
"+A" MASTER LCF NSC & OPSWAN	BUILDING +A SUBSTATION MASTER LCF NSCs and OPSWAN CUBIBLE	+A24	1999	5.71	H021-SSS-NBAY-INTSWITA	SUB INTERROGATION SWITCH BUILDING "A"	COMMUNITRON		Y									18.00	9.00	5.71	5.71	> 2034	2019/20 (b)	> 2034 (c)	> 2034 (d)
					H021-SSS-NBAY-INVERTA	DC - AC INVERTER BUILDING "A"	LATRONICS		N					7.00	3.50										
					H021-SSS-NBAY-LCFA	LOCAL CONTROL FACILITY BUILDING "A"	SUN		Y					14.00	10.00										
					H021-SSS-NBAY-LCFA	LOCAL CONTROL FACILITY BUILDING "A"	WYSE		Y					0.42	0.42										
					H021-SSS-NBAY-LCFINT	LOCAL CONTROL FACILITY INTERFACE	FOXBORO		Y					14.58	7.29										
					H021-SSS-NBAY-NSCLINK1	NSC LINK 1	FOXBORO		Y					14.58	7.29										
					H021-SSS-NBAY-NSCLINK2	NSC LINK 2	FOXBORO		Y					14.58	7.29										
					H021-SSS-NBAY-OWCOVRTA	OPSWAN CONVERTER BUILDING A	PHOENIX		N									7.00	3.50						
					H021-SSS-NBAY-OWHUBA	OPSWAN HUB BUILDING "A"	RUGGEDCOM		N									7.63	7.63						
					H021-SSS-NBAY-OWHUBA	OPSWAN HUB BUILDING "A"	PERLE		N									7.63	7.63						
					H021-SSS-NBAY-OWNTWKA	OPSWAN NETWORK BUILDING "A"	PERLE		N									0.00	0.00						
					H021-SSS-NBAY-TIMINGA	TIMING SYSTEM BUILDING "A"	TEKRON		Y					14.58	7.29										
"+B" OPSWAN	BUILDING +B OPSWAN CUBICLE	+B14	2003	4.57	H021-SSS-NBAY-LCFB	LOCAL CONTROL FACILITY BUILDING "B"	COMPAQ		Y					14.00	10.00					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-NBAY-LCFB	LOCAL CONTROL FACILITY BUILDING "B"	COMPAQ		Y					13.66	10.00										
					H021-SSS-NBAY-LCFB	LOCAL CONTROL FACILITY BUILDING "B"	WYSE		Y					0.42	0.42										
					H021-SSS-NBAY-INTSWITB	SUB INTERROGATION SWITCH BUILDING "B"	COMMUNITRON		Y							14.58	7.29								
					H021-SSS-NBAY-INVERTB	DC - AC INVERTER BUILDING "B"	LATRONICS		N									7.00	3.50						
					H021-SSS-NBAY-OWCOVRTB	OPSWAN CONVERTER BUILDING B	PHOENIX		N									7.00	3.50						
					H021-SSS-NBAY-OWHUBB	OPSWAN HUB BUILDING "B"	RUGGEDCOM		N									7.63	7.63						
					H021-SSS-NBAY-OWHUBB	OPSWAN HUB BUILDING "B"	PERLE		N									7.63	7.63						
"+C" OPSWAN	BUILDING +C OPSWAN CUBICLE	+C14	2003	4.57	H021-SSS-NBAY-INVERTC	DC - AC INVERTER BUILDING "C"	LATRONICS		N					7.00	3.50					4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-NBAY-LCFC	LOCAL CONTROL FACILITY BUILDING "C"	COMPAQ		Y					14.00	10.00										
					H021-SSS-NBAY-LCFC	LOCAL CONTROL FACILITY BUILDING "C"	COMPAQ		Y					13.66	10.00										
					H021-SSS-NBAY-LCFC	LOCAL CONTROL FACILITY BUILDING "C"	WYSE		Y					0.42	0.42										
					H021-SSS-NBAY-OWHUBC	OPSWAN HUB BUILDING "C"	RUGGEDCOM		N									7.63	7.63						
					H021-SSS-NBAY-OWHUBC	OPSWAN HUB BUILDING "C"	PERLE		N									7.63	7.63						
					H021-SSS-NBAY-TIMINGC	TIMING SYSTEM BUILDING "C"	TEKRON		Y					12.10	6.05										
					H021-SSS-NBAY-OWCOVRTC	OPSWAN CONVERTER BUILDING C	PHOENIX		N									7.00	3.50						

APPENDIX A - H021 MURARRIE 275KV & 110KV SUBSTATION SECONDARY SYSTEMS - EQUIPMENT HEALTH INDICES AND RECOMMENDED REPLACEMENT TIMEFRAME

Notes:
(a): Subject to Powerlink's O&M Safety Requirements, Current Standard Solutions and Implementation Methodologies, it may be more beneficial to align with the recommended replacement timeframe of sedondary systems equipment
(b): Recommended Timeframe is based on majority of Equipment Health Indices
(c): Based on Visual Inspection and Subject to the decision of the Control Building and Secondary Systems Panels. A number of New Cables may be requried if location of control building or secondary systems panels is changed.
(d): As a minimum requirement, Rubber Seals, Air filter and Terminals and Links are required to be repalced by the recommended timeframe. New Marshalling Kiosks should be considered if Exsiting Cables are to be reaplaced.

BAY	C&P PANEL				SECONDARY SYSTEMS EQUIPMENT					X-PROT		Y-PROT		AUX & CTRL		REVENUE METERING		OPSWAN		CABLES (HI)	YARD MARSHALLING KIOSKS (HI)	RECOMMENDED REPLACEMENT TIMMING (Based on Trigger Conditions only, Exclude considerations for Solutions, implementation methodologies)			
																						C&P PANELS (Chassis)	Sec Sys Eqiupment	CABLES	YARD MARSHALLING KIOSKS
Function	Panel Descripion	Panel No.	Year	HI	Functional Loc.	Description	Manufacturer	Model number	Obsolescence (Yes / No)	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	Eff. Age	HI	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	C&P Panels	Sec Sys Equipment & Auxiliary Components	C&P Panels to HV Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)	Yard Marshalling Kiosks (CB, MK, CT, VT, AC, DC, COOLING)
"+5" OPSWAN	BUILDING +5 COMMON RTU AND OPSWAN	+5B1	2006	3.71	H021-SSS-NBAY-LCF5	LOCAL CONTROL FACILITY BUILDING +5	HEWLETT PACKARD	[redacted]	Y					11.00	10.00					3.71	3.71	> 2041	2026/27 (b)	> 2041 (c)	> 2041 (d)
					H021-SSS-NBAY-LCF5	LOCAL CONTROL FACILITY BUILDING +5	WYSE		Y					0.42	0.42										
					H021-SSS-NBAY-OWCOVRT5	OPSWAN CONVERTER BUILDING 5	PHOENIX		N									7.00	3.50						
					H021-SSS-NBAY-OWINVRT5	OPSWAN INVERTER BUILDING +5	LATRONICS		N									11.00	5.50						
					H021-SSS-NBAY-OWNTWK5	OPSWAN NETWORK BUILDING +5	ALLOY		Y									7.63	7.63						
					H021-SSS-NBAY-OWNTWK5	OPSWAN NETWORK BUILDING +5	PERLE		N									7.63	7.63						
					H021-SSS-NBAY-RTUCOM5	COMMON RTU BUILDING +5	FOXBORO		Y					11.30	5.65										
					H021-SSS-NBAY-TIMING5	TIMING SYSTEM BUILDING +5	TEKRON		Y					11.30	5.65										
"+T" OPSWAN & COMMS RTU	BUILDING +T OPSWAN CAMERA AND COMMS RTU	+T	2003	4.57	H021-SSS-NBAY-OWCAM1	OPSWAN CAMERA 1	CANON		Y									14.00	10.00	4.57	4.57	> 2038	2023/24 (b)	> 2038 (c)	> 2038 (d)
					H021-SSS-NBAY-OWCAM2	OPSWAN CAMERA 2	CANON		Y									14.00	10.00						
					H021-SSS-NBAY-RTUCOM	COMMON RTU	FOXBORO		Y					14.58	7.29										
					H021-SSS-NBAY-OWSERV	OPSWAN SERVER	Esis		N									0.00	0.00						
110kV PQM	110kV PQM	+C11	2016	0.86	H021-SSS-NBAY-PWRQUAL1	POWER QUALITY MONITOR 1	UNIPOWER		Y					1.12	0.56					0.86	0.86	> 2051	2036/37 (b)	> 2051 (c)	> 2051 (d)
					H021-SSS-NBAY-PWRQUAL2	POWER QUALITY MONITOR 2	UNIPOWER		Y					1.12	0.56										

Planning Report	23/08/2025
Title	CP.02751- Murarrie Secondary Systems Replacement
Zone	Moreton
Need Driver	Emerging compliance risks arising from condition and obsolescence of Murarrie's 110kV ageing secondary systems.
Network Limitations and statutory requirements	Murarrie Substation is required to meet Powerlink Queensland's N-1 50MW/600MWh Transmission Authority reliability standard within the Brisbane area.
Pre-requisites	None

Executive Summary

Ageing and obsolete secondary systems at Murarrie 110kV Substation, as defined in Reference [1], are increasingly at risk of failing to comply with Schedule 5.1.9(c) of the National Electricity Rules and AEMO's Power System Security Guidelines[1].

Powerlink's Central scenario forecast confirms there is an enduring need to maintain electricity supply to industrial, commercial and residential loads supplied from the Murarrie Substation. These loads include the Brisbane eastern suburbs, eastern ring of Brisbane CBD, Port of Brisbane and TradeCoast area.

The removal or reconfiguration of the Murarrie 110kV Substation due to secondary system failure/obsolesce would violate Powerlink's N-1-50MW/600MWh Transmission Authority reliability standard.

Therefore, there is an enduring need to maintain the current function and capacity of the Molendinar Substation by replacing the at-risk secondary systems.

[1] AEMO, Power System Operating Procedure SO_OP_3715, Power System Security Guidelines, V95, 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)).

Table of Contents

1. Introduction

Murarrie Substation (H021) was established in 2003 and together with Belmont Substation provides injection points to the Powerlink and Energy Queensland eastern 110kV sub-transmission ring. This network supplies residential, industrial and commercial loads within the Brisbane area including the eastern Brisbane suburbs, eastern ring of the Brisbane CBD, Port of Brisbane and TradeCoast area.

Figures 1a and 1b shows the existing Powerlink 275kV and 110kV transmission network supplying the greater Brisbane area. An Energex 110kV sub-transmission system extends from both Belmont and Murarrie substations to supply bulk supply points and the distribution network within the eastern Brisbane area.

Figure 2 shows the system diagram for the eastern portion of the Powerlink 275kV and 110kV network, and the Energex 110kV sub-transmission system. Murarrie Substation provides three key supply injections into the Energex system:

- Energex bulk supply point Doboy Substation (SSDBD) supplying residential, commercial and light industrial loads within the eastern Brisbane area.
- Energex bulk supply points Lytton substations (SSLBS and SST114). The Murarrie to SSLBS system is the 110kV sub-transmission feed to the Brisbane Port and TradeCoast areas.
- A number of Energex bulk supply points supplying the eastern Brisbane suburbs and Brisbane CBD. This network is also supported by Belmont Substation. The Energex 110kV sub-transmission network supplies key bulk supply points including Newstead (SSNSD), Wellington Road (SSWRD), Charlotte Street (SSCST), Ann Street (SSAST), and Victoria Park (SSVPK).

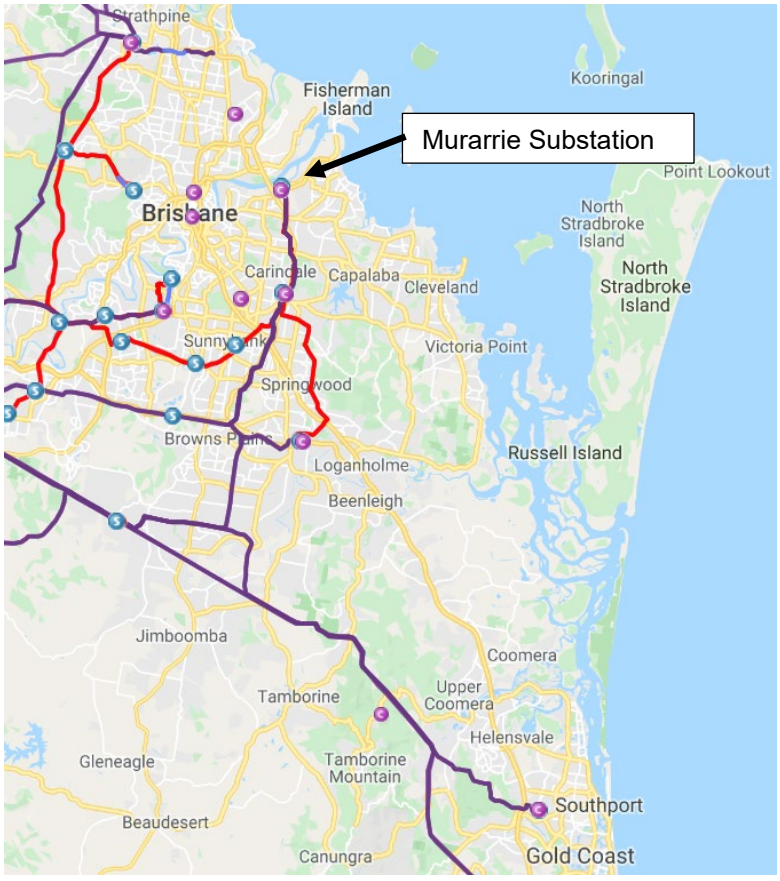


Figure 1a. Geographic location of H021 Murarrie Substation

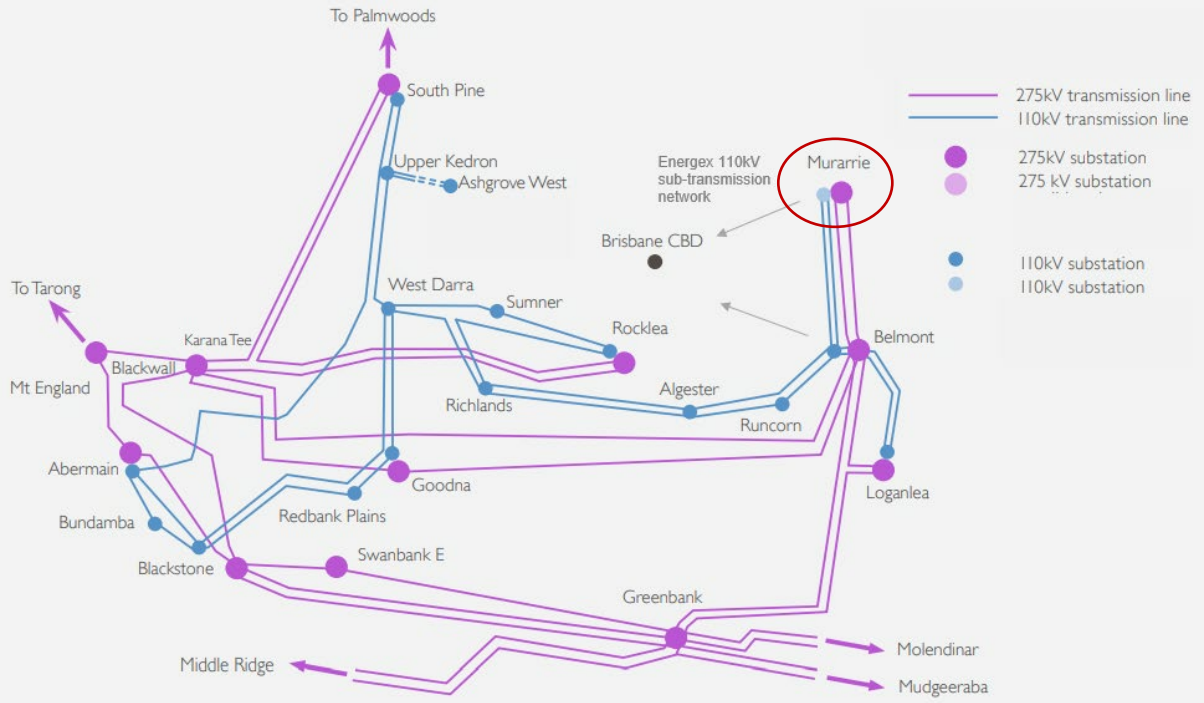


Figure 2b. Powerlink Transmission Network within the Metropolitan Brisbane Area

[redacted]

Figure 3. Powerlink and Energex 275kV and 110kV System Diagram (Eastern Ring)

The condition assessment [1] confirms end of technical service life, with many components no longer supported by the manufacturer and limited spares available. Increasing failure rates, along with the increased time to rectify 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).

In addition to the site-specific impacts of obsolescence at Murarrie Substation, 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. Running multiple secondary systems to failure across the network increases the likelihood of concurrent systemic faults with significant implications for network reliability and safety.

This report assesses the impact that removal of the functionality enabled by the at-risk secondary systems would have on the performance of the network and Powerlink's statutory obligations. It also establishes the indicative requirements of any potential alternative solutions to the current services provided by Murarrie Substation.

2. H021 Murarrie Substation configuration

The Murarrie Substation consists of:

1. Two 275/110kV transformer ended feeders from Belmont Substation, and

2. A 110kV switchyard which provides 2 x 275/110kV transformer bays, 9 x 110kV feeder (including 3 Doboy transformer bays) for Energex and 1 capacitor bank bay.

Figure 3 shows the existing connection configuration of the Murarrie Substation and the scope of works being addressed.

Figure 4. Murarrie 275/110kV Substation Line Diagram

3. Murarrie Demand Forecasts

Murarrie Substation supplies residential, industrial and commercial loads within the eastern part of the Brisbane area.

Figure 4 shows that the maximum demand for loads supplied from Murarrie, including portion of load supplied by the 110kV network between Belmont and Murarrie substations. These loads are forecasted to experience continuous growth in the coming years.

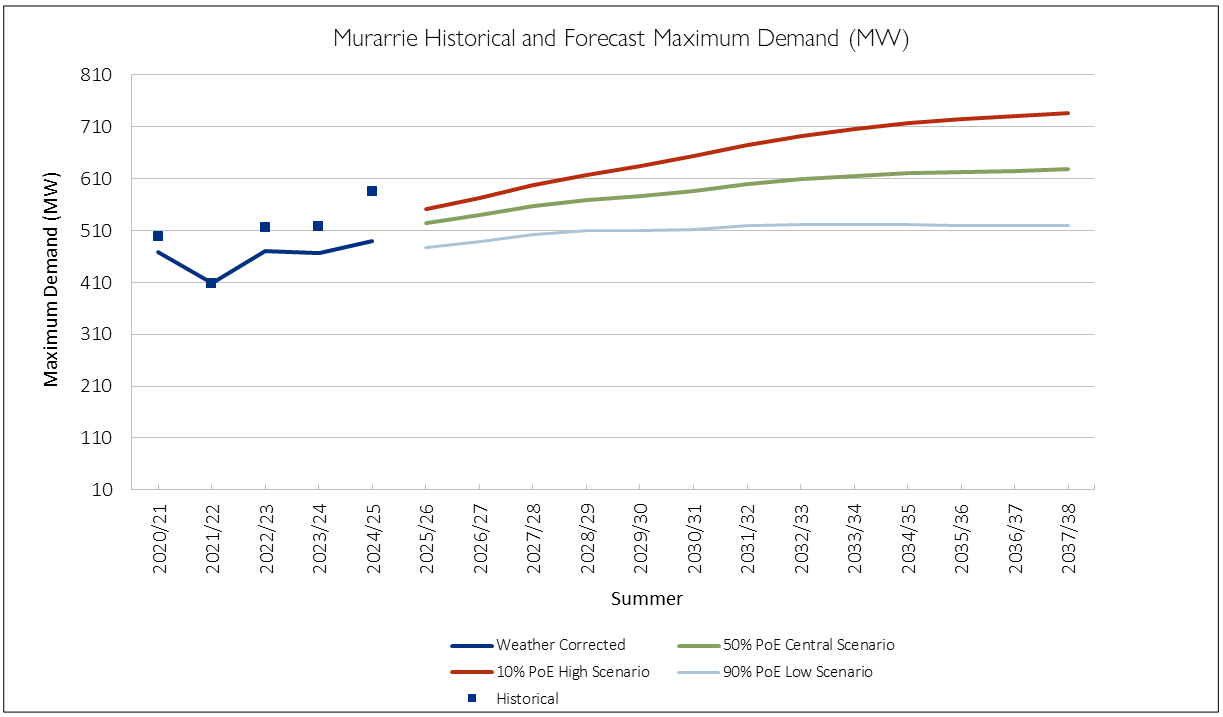


Figure 5. Murarrie Historic Load and Forecast Demand

Figure 5 shows the historical load duration curve for delivered (i.e. includes the contribution of rooftop PV) loads connected to Murarrie's 110kV network. The maximum delivered load is close to 600MW.

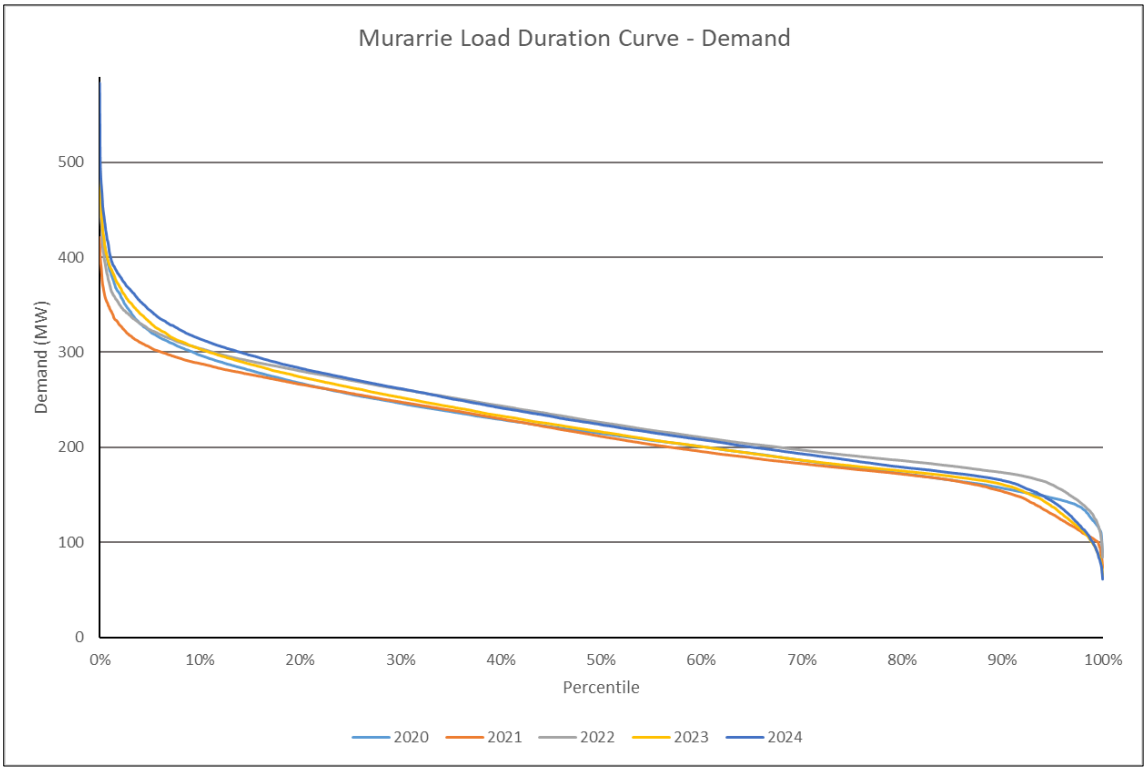


Figure 6 - Murarrie Load Duration Curves

The peak delivered demand, is in excess of 500MW. With consideration of rooftop PV within the Energex network supplied from Murarrie, the maximum customer load is even higher.

The average summer day load profile for 2024/25 at Murarrie Substation is shown in Figure 5. Generation from rooftop PV is added to the load to show the underlying load. Figure 5 shows that rooftop PV meets up to 50MW of underlying demand.

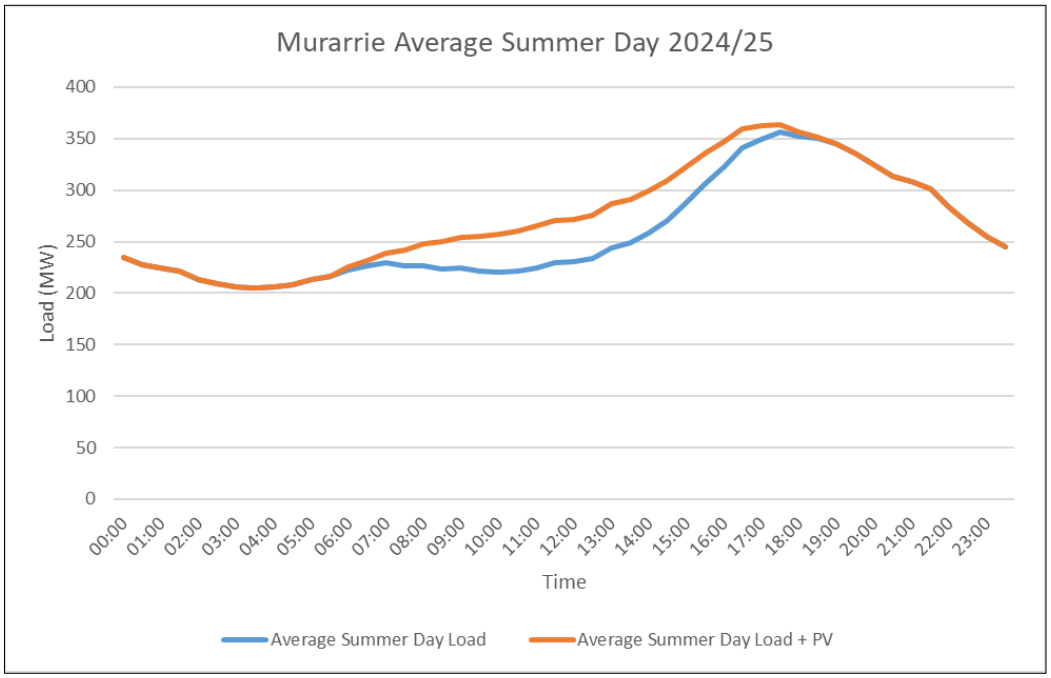


Figure 7 - Murarrie daily demand profile

There are no new large block loads committed in the area supplied from the Murarrie Substation. However, there is potential for load growth in addition to that shown in Figure 5 as the full impact of the preparedness for the 2032 Olympic games becomes better understood.

4. Statement of Investment Need

Murarrie 275/110kV substation is a major injection point into the Powerlink and Energex 110kV sub-transmission network supplying residential, commercial and industrial loads within eastern Brisbane. These loads include Brisbane CBD, Brisbane Port and the TradeCoast area.

Therefore, addressing the risks arising from the condition of the secondary systems by removing the functionality of the Murarrie Substation would have a major impact on the performance of this network and the reliability of supply to associated loads.

Therefore, replacement of the secondary systems at Murarrie 110kV Substation is required to allow continued operation of the substation and avoid system failures that would result in loss of load exceeding Powerlink's N-1-50MW / 600MWh Transmission Authority reliability standard.

5. Network Risk

Table 1 summarises the results of analysis to determine the load and energy at risk for loads connected to the Murarrie Substation at 110kV. The contribution from Rooftop PV is considered in adjacent columns to demonstrate the impact of load supplied by the rooftop PV.

Table 1. Murarrie Load and Energy at Risk

At Risk	Contingency	Metric*	2024/25	2024/25 + PV	2034/35	2034/35 + PV
Brisbane CBD East, Doboy BS, Lytton BS	275/110kV 2T sec sys and outage of 3T caused by (3T sec sys or trip or 830 trip)	Max (MW)	238	291	319	390
		Average (MW)	4	13	19	53
		24h Energy Unserved Max (MWh)	1917	3105	2485	4113
		24h Energy Unserved Average (MWh)	99	312	460	1268
Brisbane CBD East, Doboy BS, Lytton BS	275/110kV 3T sec sys and outage of 2T caused by (2T sec sys or 8837 trip)	Max (MW)	238	291	319	390
		Average (MW)	4	13	19	53
		24h Energy Unserved Max (MWh)	1917	3105	2485	4113
		24h Energy Unserved Average (MWh)	99	312	460	1268
Lytton BS	Loss of 110kV feeder 7270 sec sys and outage of 7271 caused by (sec sys or 7121 trip) Loss of 110kV feeder 7271 sec sys and outage of 7270 caused by (sec sys or 7120 trip)	Max (MW)	116	135	150	212
		Average (MW)	62	70	85	103
		24h Energy Unserved Max (MWh)	2141	2441	2807	3439
		24h Energy Unserved Average (MWh)	1498	1689	2039	2483
Doboy BS	Loss of 7272 sec sys and outage of 7273 or 7274 caused by (sec sys or 7273 trip or sec sys or 7274 trip) Note: there are 3 combinations to consider	Max (MW)	33	57	57	122
		Average (MW)	0.2	2	2	9
		24h Energy Unserved Max (MWh)	229	565	438	861
		24h Energy Unserved Average (MWh)	6	45	50	205
Proportion of (Doboy and Lytton)	Outage of 2-3 Bus coupler 4122 due to sec followed by outage of 3T caused by sec sys or trip)	Max (MW)	98	115	123	160
		Average (MW)	52	59	63	81
		24h Energy Unserved Max (MWh)	1826	2089	2098	2634

At Risk	Contingency	Metric*	2024/25	2024/25 + PV	2034/35	2034/35 + PV
		24h Energy Unserved Average (MWh)	1249	1418	1513	1943
Proportion of (CBD East Ring + Lytton + Doboy)	Outage of 2-3 Bus coupler 4122 due to sec followed by outage of 2T caused by sec sys or trip)	Max (MW)	129	136	185	185
		Average (MW)	3.7	4.0	11.9	12.1
		24h Energy Unserved Max (MWh)	1200	1336	1442	1531
		24h Energy Unserved Average (MWh)	89	97	285	290
Brisbane CBD East Ring	Loss of Newstead 110kV feeders 752 sec sys and outage of 753 caused by (sec sys or 753 trip) Loss of Newstead 110kV feeders 753 sec sys and outage of 752 caused by (sec sys or 752 trip)	Max (MW)	64	84	113	150
		Average (MW)	0.05	0.2	0.4	2
		24h Energy Unserved Max (MWh)	196	503	351	830
		24h Energy Unserved Average (MWh)	1	5	9	52
Brisbane CBD East Ring	Loss of one Murarrie to Newstead 110kV feeder (752/753) and one 110kV Tingalpa Tee point feeder (7287/7288)	Max (MW)	64	84	113	150
		Average (MW)	0.05	0.2	0.4	2
		24h Energy Unserved Max (MWh)	196	503	351	830
		24h Energy Unserved Average (MWh)	1	5	9	52
Brisbane CBD East Ring	Loss of both Murarrie-Tingalpa Tee 110kV feeders	Max (MW)	138	158	187	224
		Average (MW)	2	4	4	14
		24h Energy Unserved Max (MWh)	973	1480	1155	1990
		24h Energy Unserved Average (MWh)	37	100	92	334

* Maximum load at risk assumes intact system conditions which excludes pre-contingent load transfers through the Energex distribution system. In practice, pre-contingent operational switching may also mitigate the impact of possible outages described above but figures are indicative of Network Risk.

6. Non Network Options

Murarrie substation is the 275kV bulk supply point for multiple Energy Queensland bulk supply points including Doboy, Lytton and the eastern inner city Brisbane areas.

To fully replace the 275kV injection, non-network solutions must be capable of meeting up to 300 MW and 2,500 MWh of energy each day. This assumes that the embedded rooftop PV remains connected.

Potential non-network solutions may be able to provide supply to individual 110kV injection points, and this may reduce the scope of the secondary systems replacement project. Non-network requirements for individual bays would be as detailed within Table 1 above.

Powerlink is currently not aware of any Demand Side Solutions (DSM) in the area supplied by Murarrie Substation. However, Powerlink will consider any proposed non-network solutions that may be able to contribute to the requirement functionality provided by Murarrie substation.

7. Network Options

7.1 Proposed Option to address the identified need

To address the emerging age and obsolescence of the Murarrie 110kV Substation secondary systems it is recommended that all secondary systems reaching end of life be replaced. This ensures that Powerlink's Transmission Authority reliability standard is maintained.

Details of the condition assessment for the Murarrie 110kV Substation secondary systems and their recommended replacement timing can be found in Reference 1.

This option ensures that reliability of supply and asset condition criteria are met.

Powerlink considers the proposed network solution will not have any material inter-network impact, and as such does not need to formally consult with other Market Participants..

7.2 Option Considered but Not Proposed

This section discusses alternative options that Powerlink has investigated but does not consider technically and/or economically feasible to address the above identified issues and thus are not considered credible options.

7.2.1 Do Nothing

"Do Nothing" would not be an acceptable option as the primary driver (secondary systems condition and obsolescence) and associated safety, reliability and compliance risks are not addressed.

Furthermore, the "Do Nothing" option would not be consistent with good industry practice and would result in Powerlink breaching their obligations with the requirements of the System Standards of the National Electricity Rules and its Transmission Authority.

7.2.2 Reinforcement of Belmont substation and associated 110kV system

The reinforcement of the existing Belmont 275/110kV Substation and associated 110kV sub-transmission system, to replace the functionality provided by Murarrie substation was examined, but was not considered economically feasible due to the significantly higher cost compared to the secondary systems works proposed for Murarrie Substation. In addition, some level of partial secondary systems work at Murarrie substation would need to be performed.

This option would also not cater for the Industrial loads of Lytton and Doboy.

7.2.3 Establishment of Cross River 110kV ring from South Pine Substation

The reinforcement of the existing South Pine to Nudgee 110kV network within Brisbane north, and installation of cross river cable to replace the functionality provided by Murarrie substation was examined, but was not considered economically feasible due to the significantly higher costs. This option would require establishing 275kV at Nudgee (most likely at a new substation site – Elliott Road) and still maintaining partial secondary systems work at Murarrie substation.

7.2.4 Decommission some functionality of Murarrie Substation

Table 1 shows that the 275/110kV injection into Murarrie and 110kV feeder and transformer bays are critical for Powerlink maintaining the N-1-50MW/600MWh Transmission Authority reliability standard.

There are two 110kV 50MVAr capacitor bank bays at Murarrie. Both are switched to maintain acceptable voltage profile and reactive power dispatch within the Brisbane south area. Both have been switched in up to 5% of time and either capacitor bank has been switched in greater than 30% of time. These statistics would not include the full extent to which these capacitor banks would be switched in post-contingent.

Figure 4 shows that the maximum demand supplied from Murarrie is forecast to experience continuous growth in the coming years. Therefore, there is a growing need for this capacitive compensation. Reactive power needs to be supplied locally.

In addition, Murarrie is not in a central location where reactive power is more readily shared between locations, but at the remote end of the 275kV network. This is where reactive power injection is most effective.

Given the scarcity and value of land it is also very unlikely that large-scale battery energy storage systems will locate in the vicinity of Murarrie and replace the enduring need for these capacitor banks.

8. Recommendations

Powerlink has assessed the condition of the secondary systems at Murarrie Substation and concludes they are at end of technical service life.

It is therefore recommended that all secondary systems be replaced.

Retaining Murarrie Substation will allow Powerlink to continue to meet its required reliability obligations (N-1-50MW / 600MWh).

Powerlink is currently unaware of any feasible alternative options to minimise or eliminate the load at risk at Murarrie but will, as part of the formal RIT-T consultation process, seek non-network solutions that can contribute significantly to ensuring it continues to meet its reliability of supply obligations.

9. References

1. H021 Murarrie Secondary Systems Condition Assessment Report

2. 2025 Transmission Annual Planning Report (A6049612)

3. Asset Planning Criteria - Framework (ASM-FRA-A2352970)

4. Powerlink Queensland’s Transmission Authority T01/98

Appendix A - Network Risk Methodology

Murarrie 275kV Injection - Brisbane CBD East Ring, Doboy BS and Lytton BS

CBD East Ring consists of: Newstead SS, Charlotte St SS, Ann St SS, Wellington Rd SS, QR Mayne SS, Vic Park SS, McLachlan St. SS, Coorparoo SS.

With an outage of both 275kV/110 kV transformers, load must be reduced to the secure capacity of the 110kV network from Belmont (7287 & 7288) (i.e. total load to be less than 436 MVA (10minute rating).

Lytton BS

Lytton load is a radial connection, loss of both 110kV feeders into Lytton from Murarrie (7270 and 7271) will cause loss of this load.

Doboy BS

The 3 transformers at Doboy each have an emergency rating of 100 MVA. For an outage of a 2nd transformer, the load must be further curtailed to the continuous rating (~90MW).

110kV feeders (752 & 753) - Brisbane CBD East Ring

CBD East Ring consists of: Newstead SS, Charlotte St SS, Ann St SS, Wellington Rd SS, QR Mayne SS, Vic Park SS, McLachlan St. SS, Coorparoo SS.

Loss of 752 and 753 (parallel feeders from H021 Murarrie to SSNDS Newstead), load must be reduced to the secure capacity of the 110kV cables network from Tingalpa Tee (7287/3 & 7288/3) (i.e. total load to be less than 378 MVA (10minute rating).

Loss of either 752 or 753 (parallel feeders from H021 Murarrie to SSNDS Newstead) and loss of either 7288 or 7287 (parallel tee feeders feeding SSWRD Wellington Road from H021 Murarrie and H003 Belmont) will overload the remaining tee feeder supplying SSWRD Wellington Rd from H021 Murarrie and H003 Belmont, requiring the same load curtailment.

Loss of 7287 and 7288 (parallel feeders from Belmont), load must be reduced to the secure capacity of the 110kV network from H021 Murarrie to SSNDS Newstead (752 & 753) i.e. total load to be less than 304 MVA (10minute rating).

Sustained outage of Murarrie 2-3 Bus Coupler CB4122 (Secondary System failure)

Considering an outage of 2-3 Bus coupler due to sec sys failure. The system needs to be configured for the next even. This needs to consider an outage of either 275/110kV 2T or 3T. To avoid coupling the bus at H21 remotely the following CBs would need to be opened: bus coupler 7x22 and 3x12 Lytton and 3x12 at Doboy.

This results in ½ of Lytton load and 1/3 of Doboy load supplied at Murarrie by 3Bus and 3T.

1 Bus and 2 Bus supplies the balance of the load via 2T.

Supply for 1Bus & 2Bus will come from Belmont 110kV 7287 and 7288 feeders along with 2T. To be secure for loss of 2T, Tingalpa tee (7287/3 & 7288/3, combined emergency rating of 478.2MVA) will be the limiting factor supplying loads to SSWRD, SSCST, SSAST, SSMLS, SSVPK, SSQR22 Mayne, SSNSD, 2/3 of SSDBS, ½ of SSLBS.

Additionally, F834 (204.6MVA) will be limiting factor supplying SSMLS, SSVPK, SSQR22 Mayne, SSNSD, 2/3 of SSDBS, ½ of SSLBS.

- Outage of CB4122 AND loss of 3T = ½ of Lytton load and 1/3 of Doboy load

- Outage of CB4122 only (in preparation of loss of 2T) = sum of
    - (SSMLS, SSVPK, SSQR22 Mayne, SSNSD, 2/3 of SSDBS, ½ of SSLBS) > 204.6MVA, plus
    - (SSWRD, SSCST, SSAST, SSMLS, SSVPK, SSQR22 Mayne, SSNSD, 2/3 of SSDBS, ½ of SSLBS) > 478.2MVA,
        - If load supplied by F834 is greater than 204.6MVA it is assumed to be 204.6MVA (this avoids double counting as it's already included in first part of sum)
- Proportional PV is calculated in a similar manner, i.e. proportion of PV for load at risk if constrained by F834 plus proportion of PV if constrained by 7287/3+7288/3.

Inclusion of Rooftop PV

Installed rooftop PV capacity is obtained for each substation. Energy generated by rooftop PV is unknown for some substations, particularly those owned by Energy Queensland. In these instances, an efficiency factor is calculated based on a reference substation (H021 Murarrie for this document). The efficiency factor is calculated by dividing the energy generated by the capacity of the PV. The PV generated for each substation is calculated by multiplying this efficiency factor by the installed PV capacity of the substation in question.

AER - Revenue Reset 2027-2032

Project Scope Report

CP.02751

Murarrie Secondary System Replacement

Concept – Version 3

Document Control

Change Record

Issue Date	Revision	Prepared by	Reviewed by	Approved by	Background
23/12/2019	1	[redacted]			Initial version
13/03/2020	2	[redacted]			Add reconfiguration 3 Trf
24/03/2025	3	[redacted]	[redacted]	[redacted]	Added WAMPAC and Trench CVT replacement

Related Documents

Issue Date	Responsible Person	Objective Document Name
7/12/2018	[redacted]	CP XXXXX - H021 Murarrie 275kV and 110kV Sec Sys Replacement - Project Initiation Form (A3038688)

Document Purpose

The purpose of this Project Scope Report is to define the business (functional) requirements that the project is intended to deliver. These functional requirements are subject to Powerlink's design and construction standards and prevailing asset strategies, which will be detailed in documentation produced during the detailed scoping and estimating undertaken by DTS (or OSD), i.e. it is not intended for this document to provide a detailed scope of works that is directly suitable for estimating.

Project Contacts

Project Sponsor	[redacted]
Connection & Development Manager	[redacted]
Strategist – HV/Digital Asset Strategies	[redacted]
Planner – Main/Regional Grid	[redacted]
Manager Projects	[redacted]
Project Manager	TBA
Design Manager	TBA

Project Details

1. Project Need & Objective

Murarrie Substation is a 275/110kV substation located approximately 8km north-east of the Brisbane CBD. Established in 2003, the substation consists of both 275kV and 110kV bays sharing a common platform and a perimeter fence.

A condition assessment indicates that the secondary systems is reaching the end of its technical asset life and recommends staged replacement of the equipment in 2024, 2026 and 2028 respectively. In addition, there is an operational need to ensure reliability of supply upon failure of either bus coupler that can be achieved by reconfiguring 3 Transformer to be bus selectable between busses 1 and 3.

Due to high rates of premature failure and the difficulty of managing network risks under unplanned outages, Trench CVTs between 14 to 22 years of age will be replaced.

The objective of this project is the complete replacement of the secondary systems equipment and reconfiguration of 3 Transformer at Murarrie Substation by 2028.

This project will follow the two (2) stage approval process.

2. Project Drawing

H021 MURARRIE

Figure 1 Murarrie Operating Diagram

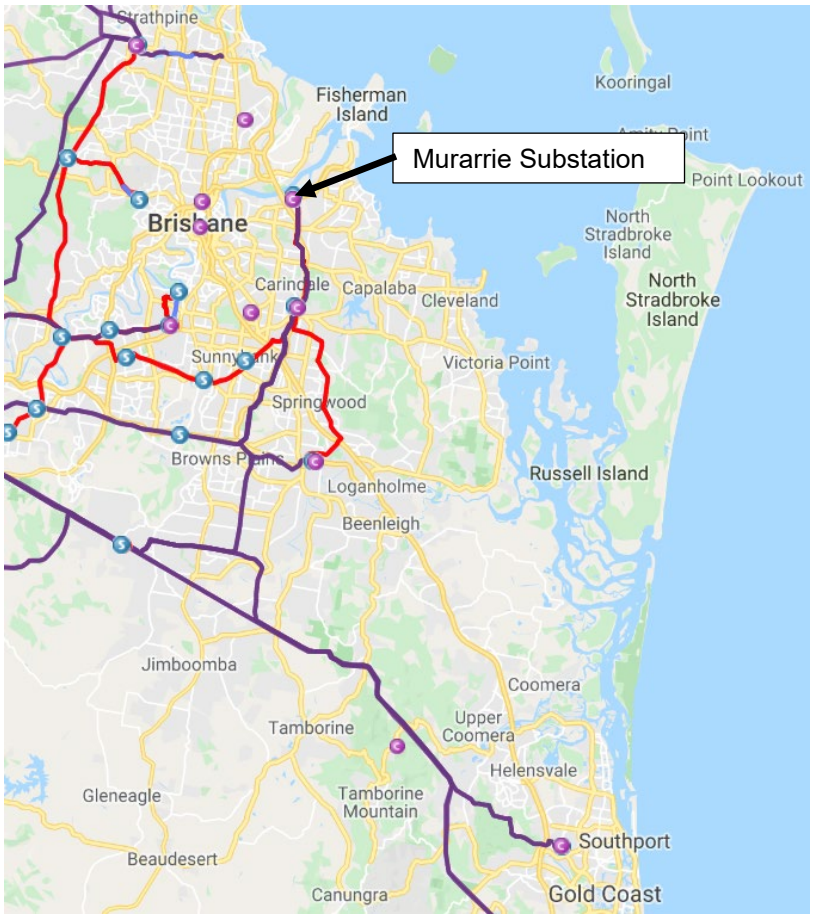


Figure 2 Murarrie Locality Map

3. Deliverables

This project will follow the two stage approval process. The following deliverables are to be provided for the purposes of options analysis as required under the RIT-T:

1. A report (e.g. Concept Estimate Report) detailing the works to be delivered, high level staging, resource requirements and availability, and outage requirements and constraints for each option
2. A class 5 estimate (minimum) for each option
3. A basis of estimate document and risk table, detailing the key estimating assumptions and delivery risks for each option
4. Outline staging and outage plans for each option
5. A completed table detailing customer and Powerlink works per Attachment 1
6. As this project will follow the two (2) stage approval process, provide a separate estimate for stage 2 development phase costs which include project planning, design and preliminary works. Also provide the schedule and time information to align with 2-stage approval

4. Project Scope

4.1. 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 7 Special Considerations*.

Briefly, the project consists of the complete replacement of the secondary systems, and reconfiguration of 3 Transformer connections at Murarrie Substation.

4.1.1. Option Summary

Two credible options have been identified to address the project need are shown in Table 1. Estimates are required for each option to inform the feasibility of the project and to develop the basis for external consultation under the Regulatory Investment Test for Transmission (RIT-T).

Table 1 – Option Summary

Option	Description	Commission Date
1	Staged replacement of secondary systems	2026, 2027, 2028
2	Full replacement of secondary systems	2028

4.1.2. Option 1 Staged replacement of secondary systems

4.1.2.1. H021 Murarrie Substation Works

Design, procure, construct and commission the following secondary systems:

- Replace all secondary systems for 110kV 1, 2 and 3 Bus, 1-2 Bus Section, 2-3 Bus Section, Feeders 7270, 7271, 7272, 7273, 7274, 752, 753, Building +B, +C, +T Opswan, replace Building +A Master LCF NSC & Opswan, and revenue metering on feeders 7271 & 7272, by 2026.
- Replace all secondary systems for T3 Transformer, Cap bank 2 and 3, Feeders 7287, 7288 and 830, revenue metering on feeders 7273, 7287 & 752, and Building +5 RTU & Opswan by 2027.
- Replace all secondary systems for Feeder 8837, T2 Transformer, revenue metering on feeders 7270, 7274, 7288 & 753, and Building +4 Common RTU & Opswan by 2028.
- Install new cabling from the new control building to the existing marshalling kiosks.
- Reconfigure 3 transformer bay equipment to achieve remote transformer switching selectability between bus 1 and bus 3.
- A new WAMPAC scheme to be implemented for feeders 7270, 7271, 7272, 7273, and 7274.
- The PASS CT's are susceptible to IR test failure. Include replacement of the CT's within the scope of work and replace as necessary; and
- 14VT, 15VT, 24VT, and 26VT are to be replaced to support the Trench CVT replacement program in the southern region.
- Decommission and recover all redundant equipment and update drawing records, SAP records, config files, etc. accordingly.

4.1.2.2. SSLBS Lytton Substation Works

Modify protection, control, automation and communications systems for feeders 7270 and 7271.

4.1.2.3. SSDBS Doboy Substation Works

Modify protection, control, automation and communications systems for feeders 7272, 7273 and 7274.

4.1.2.4. H002 Belmont Substation Works

Modify protection, control, automation and communications systems for feeders 7287, 7288, 830 and 8837.

4.1.2.5. SSWRD Wellington Road Substation Works

Modify protection, control, automation and communications systems for teed feeders 7287 and 7288.

4.1.2.6. SSNSD Newstead Substation Works

Modify protection, control, automation and communications systems for feeders 752 and 753.

4.1.3. Option 2 Full replacement of secondary systems

4.1.3.1. H021 Murarrie Substation Works

Design, procure, construct and commission the following secondary systems:

- Replace all secondary systems at Murarrie Substation by 2028.
- Install new cabling from the new control building to the existing marshalling kiosks.
- Reconfigure 3 transformer bay equipment to achieve remote transformer switching selectability between bus 1 and bus 3.
- A new WAMPAC scheme to be implemented for feeders 7270, 7271, 7272, 7273, and 7274.
- The PASS CT's are susceptible to IR test failure. Include replacement of the CT's within the scope of work and replace as necessary.
- 14VT, 15VT, 24VT, and 26VT are to be replaced to support the Trench CVT replacement program in the southern region.
- Decommission and recover all redundant equipment and update drawing records, SAP records, configuration files, etc. accordingly.

4.1.3.2. SSLBS Lytton Substation Works

Modify protection, control, automation and communications systems for feeders 7270 and 7271.

4.1.3.3. SSDBS Doboy Substation Works

Modify protection, control, automation and communications systems for feeders 7272, 7273 and 7274.

4.1.3.4. H002 Belmont Substation Works

Modify protection, control, automation and communications systems for feeders 7287, 7288, 830 and 8837.

4.1.3.5. SSWRD Wellington Road Substation Works

Modify protection, control, automation and communications systems for feeders 7287 and 7288.

4.1.3.6. SSNSD Newstead Substation Works

Modify protection, control, automation and communications systems for feeders 752 and 753.

4.1.4. Telecoms Works

As necessary to meet the requirements of the new secondary system.

4.1.5. Easement/Land Acquisition & Permits Works

Not applicable

4.1.6. Key Scope Assumptions

Not applicable

4.1.7. Variations to Scope (post project approval)

Not applicable

5. Key Asset Risks

Feeder control and protection has the earliest need for replacement as identified by the condition assessment report and should be prioritised.

Asset risk management shall be in accordance with the Asset Risk Management Process Guideline (A4870713).

6. Project Timing

6.1. Project Approval Date

The anticipated date by which the project will be approved is 30 October 2025 subject to satisfactory completion of the RIT-T.

6.2. Site Access Date

Murarrie is an existing Powerlink site. Access is already available.

6.3. 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 December 2028.

7. Special Considerations

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 requirement included in the scope whilst having the potential to facilitate improvement in safety during construction.
- Any existing assets to be removed as part of this scope must be identified within the estimate together with the forecast asset write off amount at time of disposal.
- A high level project implementation plan including staging and outage plans should be considered and produced as part of the estimate.

8. Asset Management Requirements

Equipment shall be in accordance with Powerlink equipment strategies.

Unless otherwise advised Deni Mauro will be the Project Sponsor for this project. The Project Sponsor must be included in any discussions with any other areas of Strategy & Business Development.

9. Asset Ownership

The works detailed in this project will be Powerlink Queensland assets.

The asset boundary with Energy Queensland (Energex) is indicated on the operating diagram.

10. 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.

11. Options

Estimates are required for each of the 2 options as described in Section 4.1.1.

12. Division of Responsibilities

A division of responsibilities document will be required to cover the changes to the interface boundaries with Energy Queensland. The Project Manager will be required to draft the document and consult with the Project Sponsor who will arrange sign-off between Powerlink and the relevant customer.

13. Related Projects

Project No.	Project Description	Planned Comm Date	Comment
Pre-requisite Projects			
Co-requisite Projects			
CP.02984	Trench CVT Replacement	Dec 2028	
Other Related Projects			
CP.02813	Telecommunications Network Consolidation RAN4	Dec 2029	
C.02822	OpsWAN and MPLS Replacement RAN4	Dec 2028	

CP.02751 Murarrie Secondary Systems Replacement

Concept Estimate

Table of Contents

1. Executive Summary

This concept estimate has been developed based on the CP.02751 H021 Murarrie 110kV Secondary Systems Replacement PSR.

Murarrie Substation is a 275/110kV substation located approximately 8km north-east of the Brisbane CBD. Established in 2003, the substation consists of both 275kV and 110kV switchyards connected by two 375MVA transformers.

A condition assessment indicates that the secondary systems is reaching the end of its technical asset life and recommends replacing the entire secondary systems to address the project need.

An operational requirement has been identified for inclusion in the scope of works: the reconfiguration of the 110kV connection of Transformer 3 to be bus-selectable between Bus 1 and Bus 3. This is intended to ensure supply reliability in the event of a failure of either bus coupler. Additionally, it will facilitate the completion of secondary systems works within the network outage constraints applicable to H021 Murarrie Substation.

Additionally, due to high rates of premature failure and the difficulty of managing network risks under unplanned outages, Trench CVTs between 14 to 22 years of age will be replaced.

The objective of this project is the reconfiguration of the 110kV Transformer 3 connection, the complete replacement of the secondary systems equipment and the replacement of selected Trench CVTs at H021 Murarrie Substation by 2028.

The assessment behind this proposal has established that the project can be delivered by April 2031.

The project will follow the two (2) stage approval process.

1.1 Project Estimate

No escalation costs have been considered in this estimate.

		Total ($)
Estimate Class	5	
Base Estimate – Un-Escalated (2025/2026)		58,023,754
TOTAL		**58,023,754**

1.2 Project Financial Year Cash Flows

No escalation costs have been considered in this estimate.

DTS Cash Flow Table	Un-Escalated Cost ($)
To June 2025	530,975
To June 2026	73,008
To June 2027	73,008
To June 2028	73,008
To June 2029	14,372,632
To June 2030	21,989,382
To June 2031	16,392,902
To June 2032	4,413,684
To June 3033	105,153
TOTAL	**58,023,754**

2. Project and Site-Specific Information

2.1 Project Dependencies & Interactions

This project is dependent on the completion delivery of the following projects:

Project No.	Project Description	Planned Commissioning Date	Comment
Dependencies			
Interactions			
CP.02813	Telecommunications Network Consolidation RAN4	June 2032	SDH and PDH Multiplexer replacement program.
CP.02822	OpsWAN and MPLS Replacement RAN4	June 2032	OpsWAN and MPLS Router replacement program.
Other Related Projects			
CP.02984	Trench CVT Replacement – South Phase 1	December 2027	Statewide CVT Replacement

2.2 Site Specific Issues

- H021 Murarrie substation is located 8km northeast of the Brisbane CBD on Lytton Road which is a major heavy vehicle transport corridor and has a constant high volume of traffic flow. Traffic control will be required for the safe access and egress from site for the new control rooms and equipment deliveries.
- H021 Murarrie substation is surrounded by a Marine Park.
- Asbestos containing material (ACM) has been identified at H021 Murarrie substation in the ground fill throughout the substation yard. Any ground disturbing works should proceed with this in mind, and appropriate precautions implemented.
- The Brisbane area is subject to the following average number of days of rain. Consideration was given to this when developing the project schedule.

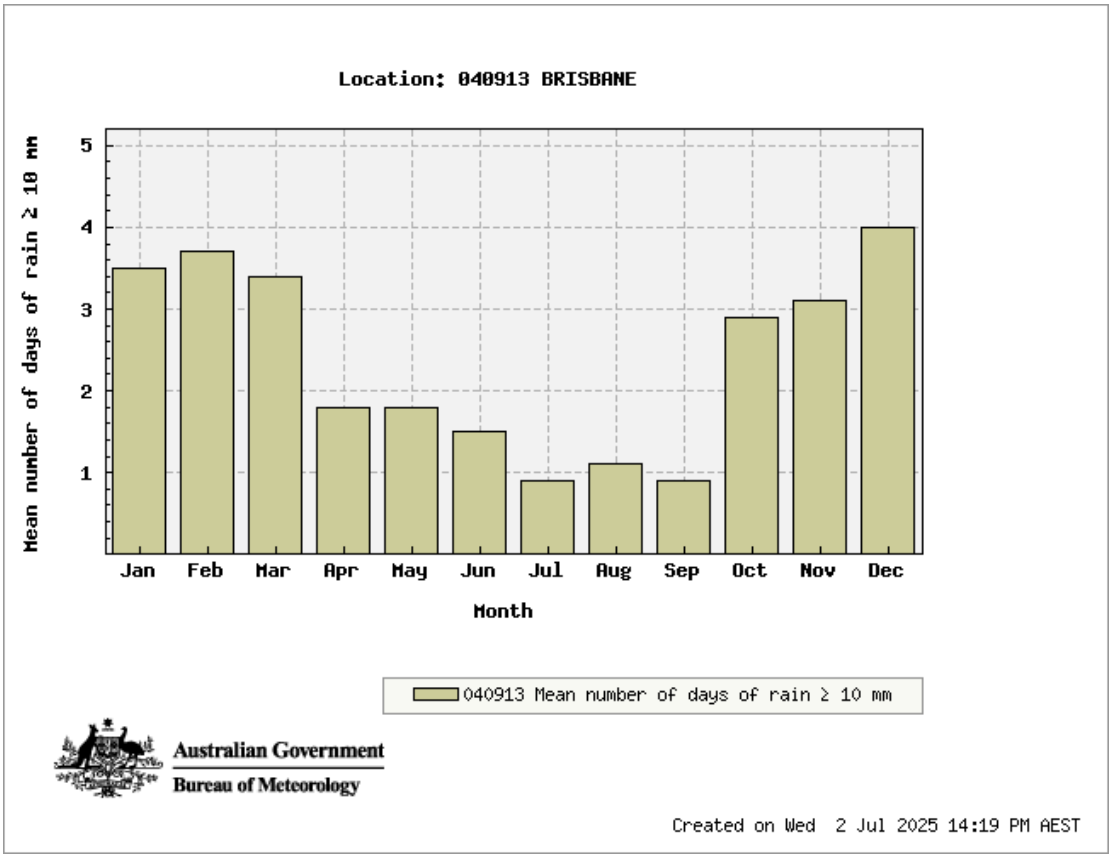


Figure 1 - Number of Days of Rain >10mm Brisbane (Source: Bureau of Meteorology 2nd July 2025)

3. Project Scope

3.1 Substation Works

Design, procure, construct and commission replacement of the H021 Murarrie secondary systems and associated auxiliary equipment.

Establish new secondary systems panels and associated common control, protection and monitoring equipment in new buildings replacing buildings +A , +B, +C and +5. These require;

- New foundations for the new control building and marshalling kiosks.
- Trenching from the control building to the existing trenches in the yard including cable pits.
- Underground conduits where cables are leaving or entering trenches or trenches are not suitable.
- All new secondary systems field cabling shall be installed from new control room to existing marshalling kiosks.
- Replacement of the secondary systems and auxiliary equipment for the following assets:
    - 1BUS, 2BUS, 3BUS
    - 1-2 Bus Section, 2-3 Bus Section
    - 275kV Fdr 830, 8837
    - 110kV Fdr 7270, 7271, 7272, 7273, 7274, 752, 753, 7287, 7288
    - 275kV T2, T3 HV
    - 110kV T2, T3 LV

  - 2CAP, 3CAP
  - Revenue Metering for feeders 7271, 7272, 7273, 7287, 752, 7270, 7274, 7288 and 753.
  - Building +5, +A, +B, +C, +T OpsWAN
- Establishment of WAMPAC schemes for feeders 7270, 7271, 7272, 7273, and 7274.
- Replacement of PASS M0 Current Transformers for the 15 PASS M0 units.
- All Current Transformer (CT) link terminals associated with CT circuits, are to be replaced with a new physical disconnect terminal, as per Standards Update, SU0049.
- Removal of redundant control buildings and support structures.
- Decommission and recover all redundant equipment.
- Update drawing records, SAP records, config files, etc. accordingly.

Reconfigure T3 Bay

Reconfigure 3 transformer bay equipment to achieve remote transformer switching selectability between 1BUS and 3BUS.

- Convert existing 110kV 3 Transformer bay (in =D25) to 2 x Circuit Breakers diameter bay, bus selectable, including additional equipment:
  - 1 x 110kV Dead Tank Circuit Breaker
  - 3 x 110kV Isolator, 2 x Earth Switch
  - Reused (Recommission) existing 1 x 110kV CVT =D25-T13
  - Existing PASS M0 Hybrid Circuit Breaker to be reused

Trench CVT Replacement

- 14VT, 15VT, 24VT, and 26VT are to be replaced.

Remote Ends

Coordinate modification of protection, control, automation and communications systems for:

- Feeders 7287, 7288, 830 and 8837 from H003 Belmont substation.
- At the following Energex substations (free-issue of secondary systems relays):
  - SSLBS Lytton – Fdr 7270, 7271
  - SSDBS Doboy – Fdr 7272, 7273, 7274
  - SSWRD Wellington Road – Fdr 7287, 7288
  - SSNSD Newstead – Fdr 752, 753

Figure 2 - H021 Murarrie Equipment Replacement

3.2 Telecommunication Works

An allowance has been made for telecommunications work. This includes the design, procure, construct and commissioning of the following equipment:

- Powerlink standard SDH equipment.
- Powerlink standard PDH equipment.
- Powerlink standard MPLS routers.
- Fibre optic cable, pits and associated termination panels.
- Voice gateways and associated interface panels.

3.3 Major Scope Assumptions

The following key assumptions were made for this Project Estimate.

- Minor Secondary Systems work only is expected to integrate the remote end substation with the new H021 Murarrie Secondary Systems. All works at the remote end substations will be completed by the MSP.
- Powerlink Internal Design teams and Design Services Panel will carry out the design work.
- Estimate is based on Powerlink architectures, standards and equipment in place and available at the time of development.
- No Restricted Access Zone will be deployed on this site during construction.
- Outages will be available on request. Please refer to Section 4.2 Network Impacts for further details.
- MSP resources will be available to complete the works.
- Procurement of long lead items align with project deliver requirements.
- Energy Queensland Design and construction resources will be available when required for remote end works. Timely agreement of Division of Responsibility (DOR) between Energy Queensland and Powerlink for all the works involved.

The following assumptions have been made with respect to Secondary Systems design:

- Design standard of the new secondary systems will be SDM9.3.
- All new secondary systems and auxiliary equipment will fit within two (2) new control buildings.
- There will be space within the new control buildings to house panels for WAMPAC schemes.
- Bay Marshalling kiosks to be re-used.
- New cables will be required between the new control building termination racks and bay marshalling kiosks.
- AC Changeover board is fit for purpose and will be re-used.
- New relays considered for the upgrade of the remote sites will be suitable for the customer's needs and requirements.
- All existing panels and equipment located in existing buildings shall be decommissioned, buildings removed from site and redundant secondary systems cabling to be removed.

The following assumptions have been made with respect to Civil design:

- The existing substation platform and yard drainage system drains freely and is fit for purpose.
- The existing internal substation roads are fit for purpose.
- New building foundations will comprise of mass foundations.
- Drainage for any new pits shall be provided into the existing drainage system or off the substation platform.
- The CVTs will be replaced utilising existing foundations with new structures or adaptor plates.

3.4 Scope Exclusions

- Easement acquisitions work, including permits, approvals, development applications or the like. All works are within Powerlink-owned land.
- No allowance is included for any Energy Queensland projects that may impact Powerlink works.
- Additional time and cost for Design, Planning and Implementation of any restoration plans required for outages is not included in this estimate.
- No major modification to the earth grid is included in this estimate.
- Remove rock or unsuitable material, including asbestos and other contaminants.
- This estimate does not include any costs for repairing or modification to the primary plants or secondary systems not listed to be replaced under the scope. That also includes the replacement of bushing CTs on PASS M0 circuit breakers, breaker's control cubicles and associated CT links.
- No modification and upgrading of the internal roads, lights, fences and gates.
- No modification on the existing transmission lines is considered in this estimate.
- Replacement of the 50V DC battery system.
- No allowance has been made for Live Substation work.
- Substation Electrical Design team has determined that a bench extension is not required.

4. Project Execution

4.1 Project Schedule

This project will follow the two (2) stage approval process.

A high-level Project Schedule has been developed for the project stages:

Milestone	High-Level Timing
Request for Class 5 Estimate	September 2027
Class 5 Project Proposal Submission	November 2027
Request for Class 3 Estimate	January 2028
Class 3 Project Proposal Submission	July 2028
Stage 1 Approval (PAN1) includes funds for design & ITT preparation	August 2028
RIT-T (assumed 26 weeks)	October 2028 – April 2029
Project Development Phase 1 & Phase 2	August 2028 – February 2029
ITT Submission (8 Weeks)	February 2029 – April 2029
Evaluate Tender, Reconcile Estimate and Submit PMP for Stage 2 Approval	April 2029
Stage 2 Approval (PAN2)	June 2029
Execute Delivery (including award SPA Contract)	June 2029
MSP/SPA Site Establishment	July 2029
SPA Civil Works and Construction	July 2029 – December 2030
Staged Bay Construction and Commissioning	July 2029 – August 2031
Project Commissioning	August 2031
Final Decommissioning & Removal of Redundant Assets	August 2031 – September 2031

4.2 Network Impacts

Powerlink Net Ops – Operating Manual 02 – SE QLD provides the following recommendations for outages of H031 Molendinar feeders and transformers.

- Outages for 2T and 3T are to avoid Summer and can only one can be taken out at a time.
- H021 Transformers cannot be out of service with H003 Belmont Transformers 4T and 6T, and Fdrs 7287 & 7288.
- Feeders 752 and 753 can only be taken out one at a time and cannot be out of service with Fdrs 7287 & 7287.
- Feeders 7287 and 7288 can only be taken out one at a time, outages are to avoid the summer period.
- Load at Risk – Southern Brisbane City Loop.
- No other time of year restrictions.

4.3 Resourcing

Design for the project will be completed by internal design resources with support from external design partners. The construction works will be completed by a combination of the Maintenance Service Providers and Substation Panel contractors.

5. Project Asset Classification

Asset Class	Base ($)	Base (%)
Substation Primary Plant	13,425,827	23%
Substation Secondary Systems	44,210,587	76%
Telecommunications	377,309	1%
Overhead Transmission Line	10,031	0%
TOTAL	**58,023,754**	**100**

6. References

Document name and hyperlink	Version	Date
Revenue Reset – Project Scope Report	3.0	24/03/2025

Risk Cost Summary Report

CP.02751

Murarrie Secondary Systems Replacement

Document Control

Change Record

Issue Date	Revision	Prepared by
07/01/2026	1.0	Asset Strategies

Related Documents

Issue Date	Responsible Person	Objective Document Name

Document Purpose

The purpose of this model is to quantify the base case risk cost profiles for the secondary systems at Murarrie substation which are proposed for reinvestment under CP.02751. These risk cost profiles are then included as part of the overall cost-benefit analysis (CBA) to understand the economic benefit of the proposed infrastructure upgrades. This process provides a benchmarking and internal gate process to support Powerlink in effectively identifying prioritised infrastructure upgrades.

The CBA was designed to demonstrate and quantify the value to be gained through specific infrastructure investments. To evaluate the CBA, an NPV is derived based on the present values of costs and benefits. The flow chart in Figure 4 below designates the methodology used in designing the CBA process.

Key Assumptions

In calculating the risk cost arising from a failure of the ageing secondary systems equipment at Murarrie substation, the following modelling assumptions have been made:

- Whilst the re-investment scope of secondary system upgrade projects contains a range of supporting devices (i.e network switches, revenue metering, firewalls and human machine interfaces), for simplicity of risk cost modelling only main protection relays, bay controllers and RTUs were considered.
- Spares for secondary system equipment have been assumed to be available prior to the point of expected spares depletion, which coincides with the expected technical asset life (20 years). After this point the cost and time to return the secondary system back to service increases significantly.
- When calculating network risk cost, it has been assumed that after 24 hours of any network element being protected by a single protection system (due to failure of the alternate system) the Australian Energy Market Operator (AEMO) will direct Powerlink to de-energise the network element.
- A site-specific value of customer reliability (VCR) of $20,960 has been applied when calculating network risks.

Base Case Risk Analysis

Risk Categories

For this project, two main categories of risk are assessed as per Powerlink's Asset Risk Management Framework:

- Financial Risk
- Network Risk (including market impact if applicable)

Table 1: Risk categories

Risk Category	Failure Type	Equipment in Scope
Financial Risk	Failure of the equipment resulting in emergency onsite replacement	All equipment
Network Risk	Failure of equipment resulting in de-energisation of network elements after 24 hours	Main protection relays only

Base Case Risk Cost

The modelled and extrapolated total base case risk costs are shown in Figures 1 and 2 below.

Risk costs associated with the equipment in scope are expected to increase from $1.1 million in 2026 to $2.6 million in 2036 and $4.1 million by 2045. Key highlights of the analysis include:

- Financial risk accounts for approximately 63% of the overall risk cost in 2030 with network risk accounting for the remaining 37%.
- As the probability of failure (PoF) continues to grow over time, the network risk cost grows to become a greater proportion of the overall risk. In the year 2040, financial risk is 53% of the total risk cost (≈$5.8m) compared with network risk which contributes 47%.

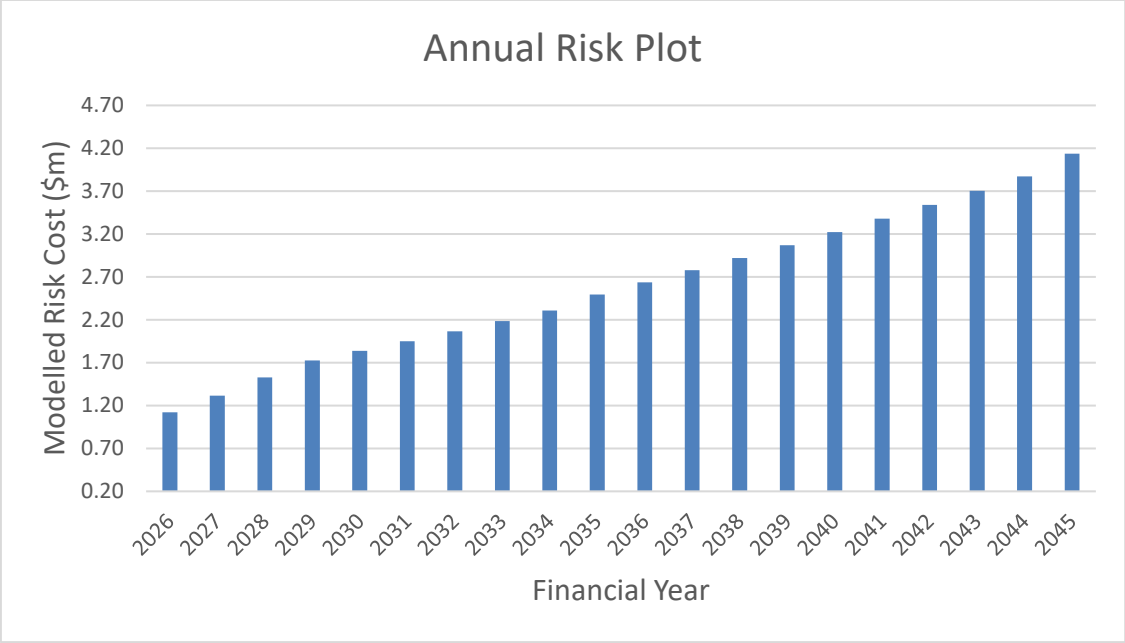


Figure 1: Total risk cost

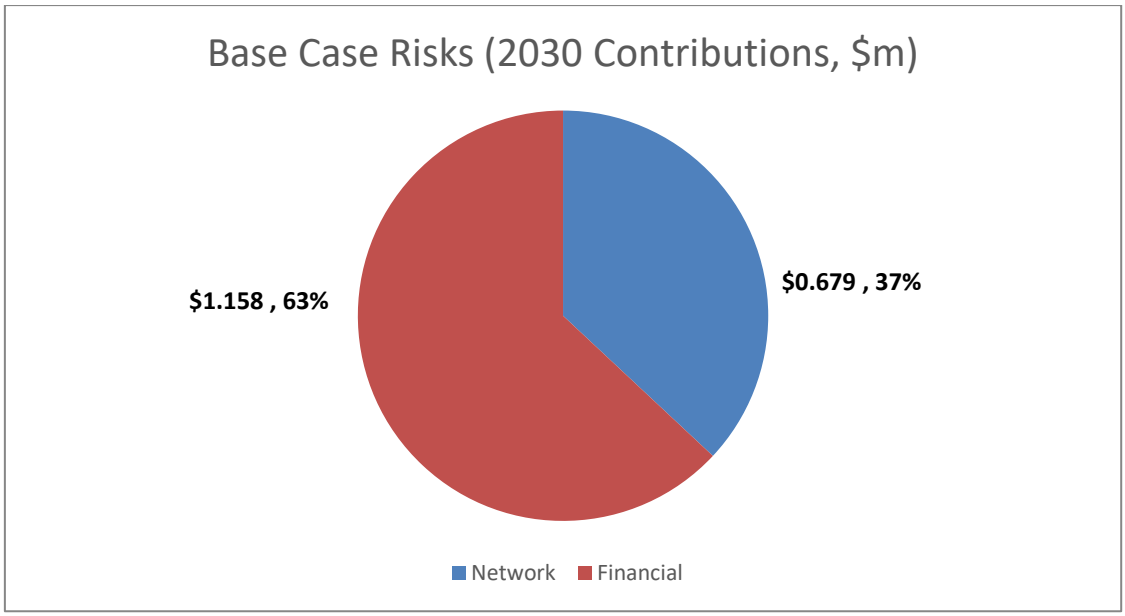


Figure 2: Base case risk cost by contributions (2030)

Option Risk Cost

For modelling purposes, the replacement of equipment at the Murarrie substation reduces the probability of failure to zero in the year after investment, resulting in a lower risk cost.

The figures below set out the total project case risk cost, and associated risk cost savings incremental to the base case.

Figure 3: Project Option Risk Cost (compared to base case)

Following the investment, risk cost grows slowly over time as it is assumed sufficient spares are available resulting in lower responsive costs and shorter outage durations.

Cost Benefit Analysis

The methodology designed for the cost benefit is set out as per Figure 4 below.

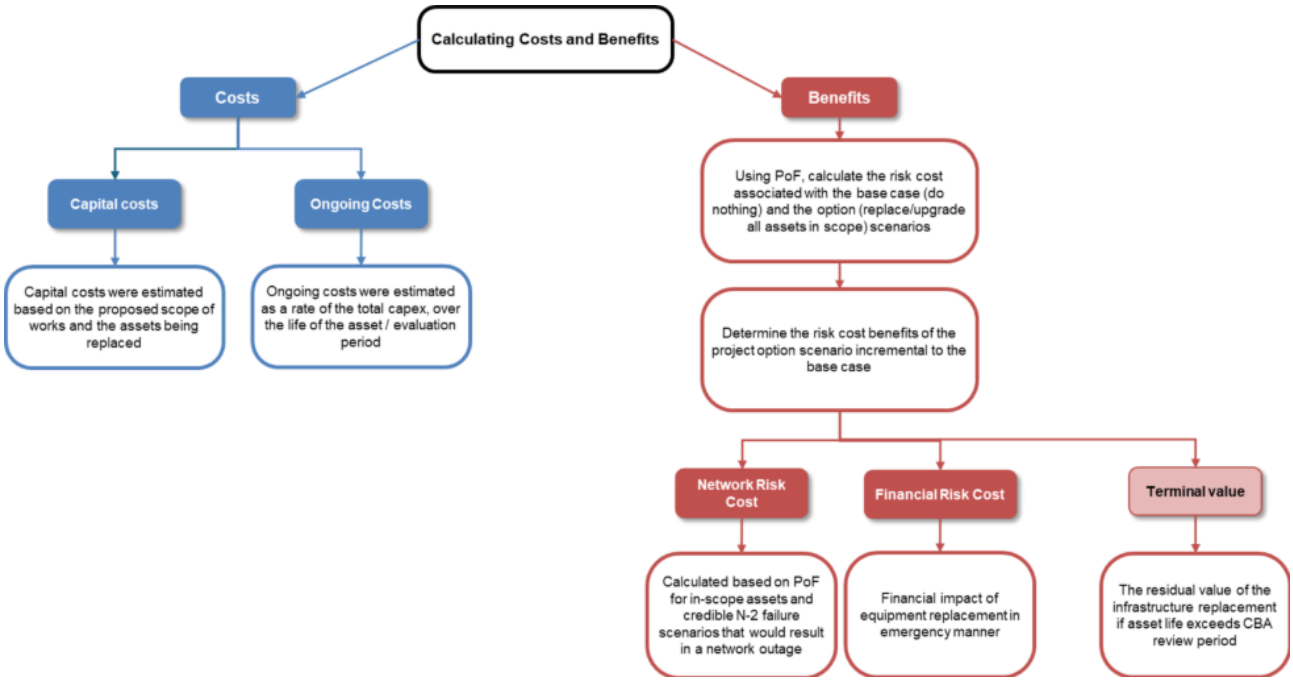


Figure 4: CBA methodology

The project is estimated to cost approximately $58.02 million resulting in a negative NPV and benefit-cost ratio (BCR) less than 1.

Table 2: Net Present Value and Benefit-Cost Ratio

		Present Value Table ($m)		
Discount rate	**%**	**3%**	**7%**	**10%**
NPV of Net Gain/Loss	$m	-21.8	-$23.3	-$22.4
Benefit-Cost Ratio	ratio	0.57	0.42	0.34

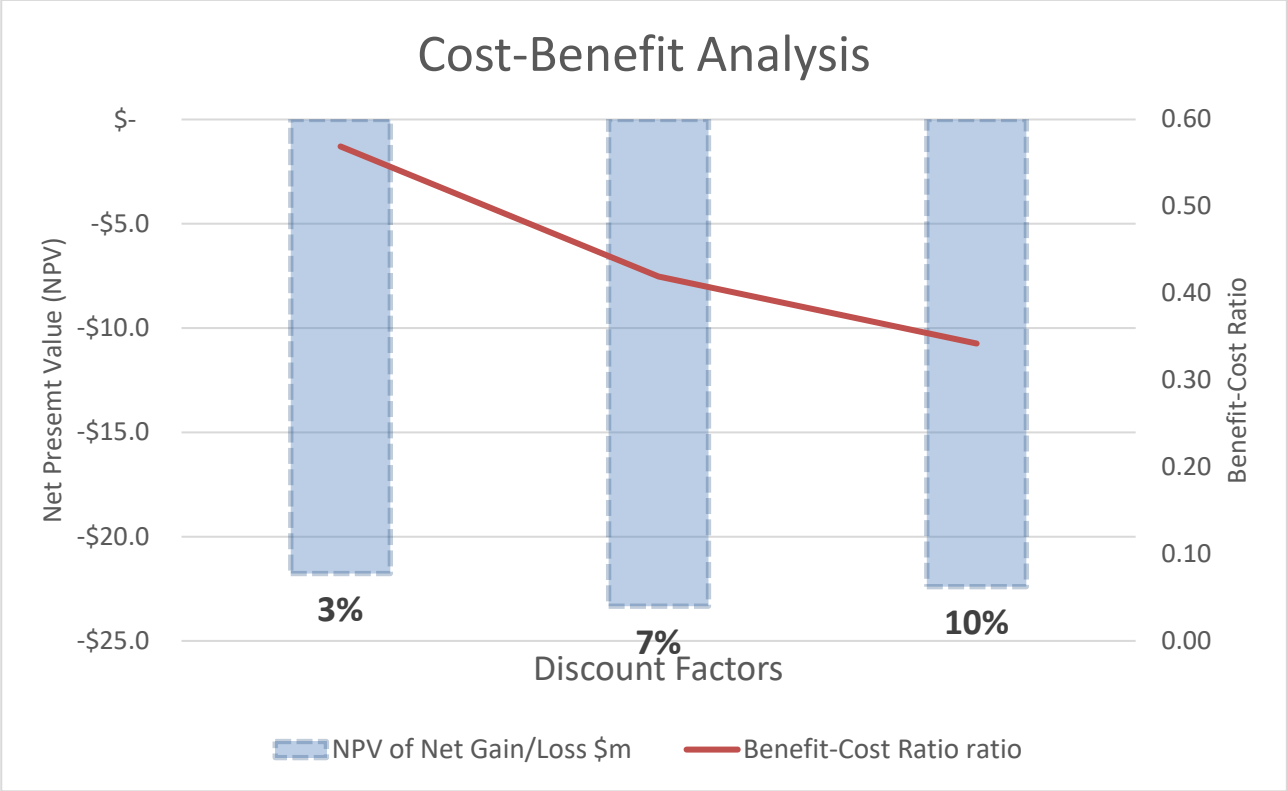


Figure 5: Cost benefit summary

Participation Factors

A sensitivity analysis was undertaken to determine the participation factors for key inputs to the risk cost models (i.e. to identify which inputs are most sensitive to overall risk cost).

The participation factor is defined as the ratio of percentage change in output (i.e. risk cost) to a percentage change in input (e.g. VCR). The participation factors for key model inputs are shown in the table below.

Due to the non-linear nature of the risk cost model (especially network risk costs, which are a function of concurrent failures), the participation factor can change depending on the magnitude of input percentage change.

The model is most sensitive to:

- **changes in the restoration time of a relay with no spares** (halving the restoration time) results in a decrease in risk cost of $0.54 million, or approximately 29.6% of the original base case risk (at 2030).
- **changes in the value of customer reliability** (halving the value) results in a decrease in risk cost of $0.34 million, or approximately 18.5% of the original base case risk (at 2030).
- **changes in bay controller emergency replacement cost** (halving the cost) results in a decrease in risk cost of $0.31 million, or approximately 16.9% of the original base risk (at 2030).

Table 3: Participation Factors

Input	Baseline value	Sensitivity value (-50%)	Change in risk cost at 2030 ($m)	Participation (%)
Network				
VCR ($/MWh)	20960	10480	-0.34	-18.5%
Restoration Time with spares – Relay (days)	2	1	-0.01	-0.4%
Restoration Time with no spares – Relay (days)	10	5	-0.54	-29.6%
Financial				
Emergency replacement cost with spares - Relay ($m)	0.02	0.01	0.00	-0.05%
Emergency replacement cost without spares – Relay ($m)	0.09	0.05	-0.27	-14.5%
Emergency replacement cost with spares – Bay Controller ($m)	0.02	0.01	0.00	0.00%
Emergency replacement cost without spares – Bay Controller ($m)	0.20	0.10	-0.31	-16.9%