January 2026

Powerlink 2027-32 Revenue Proposal

Project Pack

CP.02922 Calvale Selective Primary Plant Replacement

Project Status: Unapproved

Network Requirement

The Calvale 275/132kV Substation was established in the mid-1980's to connect the new Callide B Power Station to the 275kV network via feeder 871 towards Gladstone and the local 132kV network via Callide A 132kV Substation. The substation was extended in 1998 to connect Callide C Power Station and new feeders to Tarong Substation, including two feeder reactor bays. In 2013, two new bays were established to reinforce the network between Calvale and Stanwell due to thermal constraints arising from increased demand on the Central Queensland Network. As a result of substation extensions with load growth and system augmentation, a mixture of primary plant is currently established at Calvale, ranging from 1988 through to 2013 vintage.

The primary plant from the original substation construction is now approaching 40 years old and requires selective replacement. A number of instrument transformers are oil filled and in porcelain housing and due to their age, now have an increased probability of explosive failures with catastrophic safety consequences. Selected circuit breakers are also approaching end of life and maintenance records show a history of SF6 leaks and failures in the air compressor system [1].

In addition, power flows change following the closure of Gladstone Power Station will lead to 275kV bus rating limitations as more power will exit the northern end of the switchyard towards the Gladstone load centre [2].

Powerlink's 2025 Central scenario load forecasts confirm an enduring need for an ongoing supply of bulk electricity to the Biloela and Moura area. The removal or reconfiguration of the Calvale Substation would violate Powerlink's N-1-50MW/600MWh Transmission Authority reliability standard and significantly impact the power transfer capability between central and north Queensland [2].

In addition, there is an enduring need for a 275kV switching substation to marshall generation from existing and new sources in the area and feed into the 275kV network between Stanwell (Rockhampton), Gladstone and southern Queensland. An outage of a critical 275kV transmission line due to primary plant failure at Calvale Substation will result in altered dispatch outcome in the National Electricity Market (NEM) and higher total system costs. Powerlink has undertaken market modelling to quantify the changes in costs for market participants due to those different dispatch outcomes [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 objective is to address the asset condition issues identified with the selected primary plant and to undertake bus uprating works to meet future demand requirements.

The current recommended option involves the replacement of selected 275kV primary plant and replacement works to uprate the 275kV busbars and remove bus zone CT feeder rating limitations by September 2033 [3].

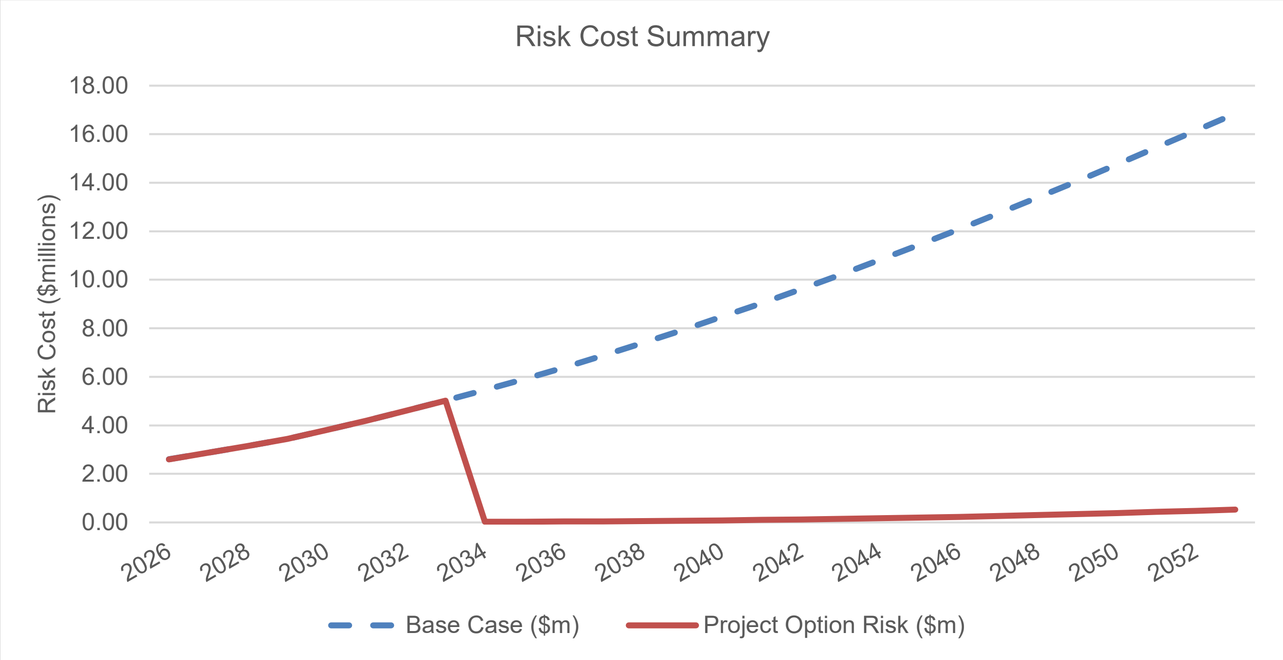
Options considered but not proposed include:

- Do Nothing – rejected due to non-compliance with reliability obligations;
- Full primary plant replacement – expected to be greater overall cost;
- Reduced scope replacement and reinforce 132kV supply from Blackwater – requires significant 132kV network augmentation and is not economic; and

- Non-network option – no viable non-network options have been identified at this time.

Figure 1 shows the current recommended option reduces the forecast risk monetisation profile of the Calvale Substation primary plant from around $5.0 million per annum in 2033 to less than $0.05 million from 2034 [5]. In addition to this benefit of reduction in risk cost there are benefits available from lower cost market dispatch outcomes due to improved reliability and availability of Calvale 275kV Substation primary plant.

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



Cost and Timing

The estimated cost to replace selected 275kV primary plant and uprate the 275kV busbars is $39.2 million ($2025/26) [4].

Target Commissioning Date: September 2033.

Documents in CP.02922 Project Pack

Public Documents

1. H024 Calvale Substation Condition Assessment Report
2. CP.02922 Calvale Selective Primary Plant Replacement – Planning Statement
3. CP.02922 Calvale Selective Primary Plant Replacement – Project Scope Report
4. CP.02922 Calvale Selective Primary Plant Replacement – Concept Estimate
5. CP.02922 Calvale Selective Primary Plant Replacement – Risk Cost Summary Report

SITE CONDITION ASSESSMENT REPORT

H024 CALVALE

Asset Category:	Substation Primary	Author:	[redacted]	Authorisation:	[redacted]
Reviewed by:	[redacted]		Review Date:	17/02/2020	
Activity:	Condition assessment -275/132 kV primary substation plant and site infrastructure, incl. civil components – SITE BASED				
Document Type:	Report	Team:	Substation team		
Authorisation date:		Date of site visit:	8&9/1/2020		

Date	Version	Objective ID	Nature of Change	Author	Authorisation
24/02/2020	1	A3320203	Original Issue	[redacted]	[redacted]
28/10/2025	2	A6063579	Desktop Update	[redacted]	[redacted]

Note: *Where indicator symbol ☼# is used (# referring to version number) it indicates a change/addition was introduced to that specific point in the document. If the indicator symbol ☼# is used in a section heading it means the whole section was added/ changed.*

IMPORTANT: - The condition assessment report provides an overview of the condition of all structures and equipment (excluding protection relays, control systems and telecommunication equipment)as stated in the scope and high level recommendations for their timely replacement. As it is snapshot in time and subject to the accuracy of prediction methodology, it is valid for 3 years from site visit date or issue date (whichever is later) stated above.

CONTENTS

EXECUTIVE SUMMARY

This report provides an overview assessment of the condition of the Powerlink owned primary plant at H024 Calvale Substation, as per defined scope below. The report is intended to assist with determining the future strategies for refurbishment and replacement of primary substation plant. The report may contain some recommendations/suggestions related to condition-based maintenance activities.

The assessment has been formulated based on the data extracted from the computerised maintenance management system (SAP) including:

- notifications and work orders, dissolved gas analysis (DGA) and other test and measurement results,
- equipment age information combined with available photos,
- historical data analysis,
- information available in the previous condition assessment report (A3320203), and
- site inspection on 8th and 9th of January 2020 and civil condition assessment report dated 31/01/2020 (Objective Id.A3296102).

The summary of recommendations is contained in Table 21 presented in Section 3 of this report.

1. INTRODUCTION

This desktop condition assessment is based on a site visit conducted on 8th to 9th January 2020, information provided in civil engineering condition assessment report dated 31st January 2020 and available design data and drawings, SAP data and information provided by the maintenance service providers up to end of October 2025.

1.1 System information

H024 Calvale Substation was established in the mid-1980s. It is located in Central Queensland area and has 275 and 132kV operating voltages in one yard. Calvale Substation performs a vital switching function for the flow of energy between Central-West Queensland and load centres in Southern Queensland (SQ) and Gladstone.

The 275/132kV systems at Calvale substation were originally built in 1988 to connect 2 x generator units at H30 Callide B Power Station, Wurdong feeder 871 and T022 Callide A feeder 7161 (Bay =C03 and =C05).

- The substation was extended in 1998 to connect H050 Callide C Power Station and Tarong substation (Bay =C06 and =C07) including 2 x feeder reactor bays. Due to the network configuration these are now connected to Halys substation.
- Thermal constraints with the Central Queensland area placing increasing demands on the Central Queensland Network. As part of the reinforcement works between Calvale and Stanwell, two new bays =C01 and =C02 were established at Calvale in 2013.
-
- As T022 Callide A substation was decommissioned in 2029/2020 additional 132 kV diameters including 132 kV bus were established at Calvale to enable supply to Biloela and Moura.

As a result of substation extensions with load growth and system augmentation, a mixture of HV primary plant is currently established at Calvale, ranging in age from 1988 through to 2013. There has also been a mixture of select primary plant replacements within these bays that have occurred due to conditional failures.

[redacted]

Figure 1 Single Line Diagram

Figure 2 - Aerial photo of Calvale substation

[redacted]

Figure 3 - H024 Calvale general arrangement

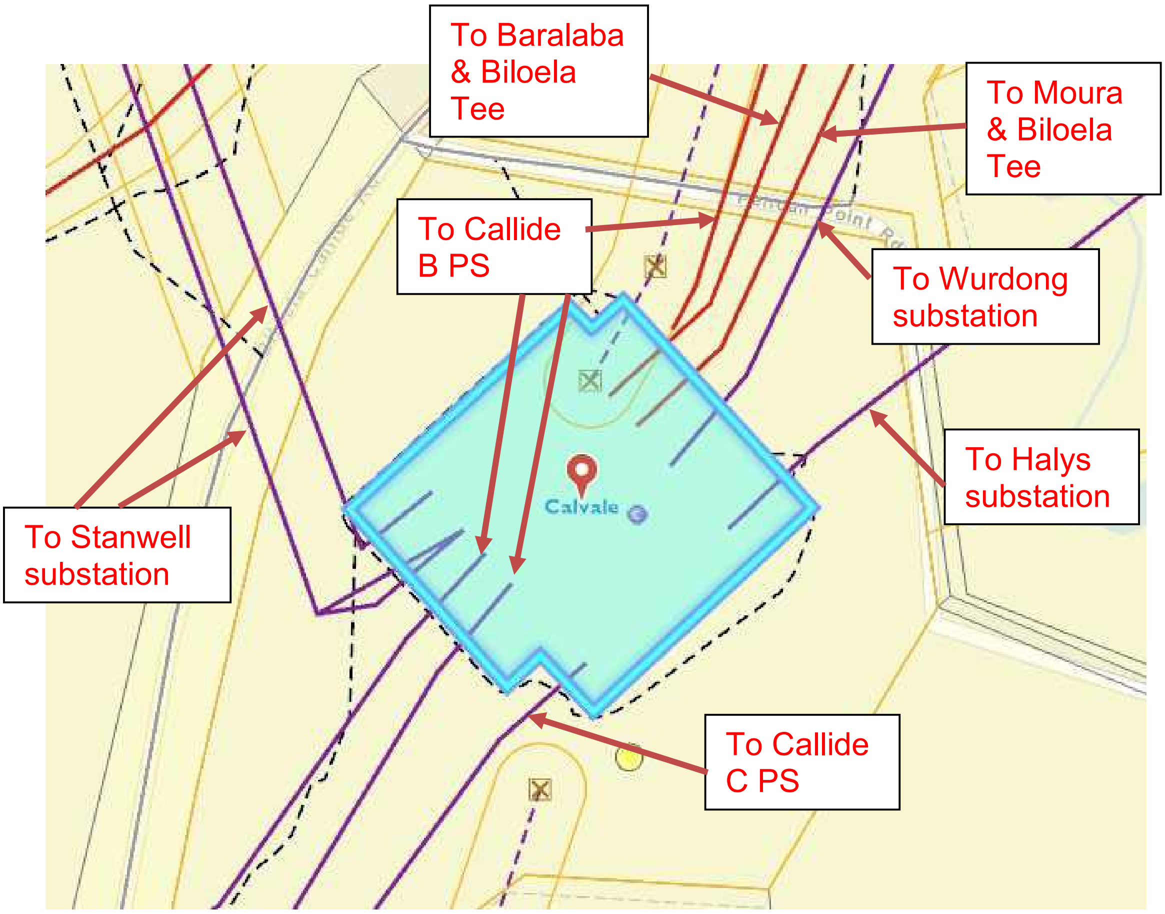


Figure 4 - Location of substation GIS

1.2 Asset Age

The original assets were installed in 1988. Subsequent development on site during the period 1988 to 2013 includes the addition of 275kV and 132kV feeder bays.

Capital additions or replacements in the last 20 years include.

- CP. 01151 Calvale & Callide B Secondary System Replacement
- CP. 01060 Calvale 275kV Transformer (System Spare)
- CU.00022 Calvale JR1 Upgrade – CS Energy
- CP.02152 Calvale Stage 2 Sec Sys Replacement (NR)
- CP.00856 Calvale Transformer Replacement
- OR.00926 Calvale – Tarong BS 1034 Access Track Refurbishment
- CP.00655 Calvale/Tarong Transm Reinforcement
- CP.01546 Callide A - Calvale 132kV Network Reinvest
- CP.01705 Calvale - Stanwell 275kV DCST Line
- CP.01830 Calvale – Stanwell Easement Acquisition
- CP.02152 Calvale Stage 2 Sec Sys Replacement (NR)
- CP.02888 Calvale to Banana Range Easement Acquisition
- CP.02897 Calvale Calliope River Easement Acquisition

1.3 Ratings

Fault levels calculated in February 2025 are:

- 275 kV – 26.43 kA L-G
- 132 kV – 9.76 kA L-G
- 19.1 kV –10.17 kA 3-Phase

All equipment at this site is rated adequately for these calculated fault levels.

Table 1 - H024 Calvale Ratings

Functional Loc.	Description	Start-up date	Bay Continuous Rating	Bay Fault Current Rating	Fault Current Period	Comments on Rating
H024-C01-501-	275KV 1 COUPLER BAY	10/05/2013	1500A	40KA	1.0s	The continuous rating is below standard and limited by secondary thermal limit. It is sufficient for the feeder. The fault rating is to standard and sufficient.
H024-C01-855-	855 FEEDER BAY	10/05/2013	2500A	40KA	1.0s	To standard and sufficient.
H024-C01-BLF-	275KV BLANK FEEDER BAY	19/09/2013	-	-	-	
H024-C02-502-	275KV 2 COUPLER BAY	10/05/2013	2500A	40KA	1.0s	To standard and sufficient.
H024-C02-8873-	8873 FEEDER BAY	10/05/2013	2500A	40KA	1.0s	To standard and sufficient.
H024-C02-BLF-	BLANK FEEDER BAY	19/09/2013	-	-	-	
H024-C03-503-	275KV 3 COUPLER BAY	01/07/1987	1600A	31.5kA	1.0s	The continuous rating is below standard and limited by secondary thermal limit. The fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated for this bay. The rating is sufficient.
H024-C03-541-	275kV 1 TRANSF BAY	01/07/1984	1600A	31.5kA	1.0s	The continuous rating is below standard and limited by secondary thermal limit. The fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C03-8874-	8874 FEEDER BAY	25/10/2013	2500A	31.5kA	1.0s	The continuous current rating is to standard and sufficient. The bay fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C04-504-	275KV 4 COUPLER BAY	01/07/1987	1600A	31.5kA	1.0s	The continuous rating is below standard and limited by secondary thermal limit.

Functional Loc.	Description	Start-up date	Bay Continuous Rating	Bay Fault Current Rating	Fault Current Period	Comments on Rating
						The fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C04-542-	275KV 2 TRANSF BAY	01/07/1987	1275A	31.5kA	1.0s	The continuous rating is below standard and limited by interplant connections. It is sufficient for transformer maximum rating. The fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C04-851-	851 FEEDER BAY	01/07/1987	1000A	31.5kA	1.0s	The continuous rating is below standard and limited by combined CT/VT. This rating limits the 851 feeder. The fault rating is below standard and limited by combined CT/VT, CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C05-505-	275KV 5 COUPLER BAY	01/07/1987	2500A	31.5kA	1.0s	Continuous current to standard and sufficient. The fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C05-852-	852 FEEDER BAY	01/07/1987	1000A	31.5kA	1.0s	The continuous rating is below standard and limited by combined CT/VT. This limits the feeder rating. The fault rating is below standard and limited by combined CT/VT, CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C05-871-	871 FEEDER BAY	01/07/1987	2500A	31.5kA	1.0s	The continuous rating to standard and sufficient. The fault rating is below standard and limited by CTs and isolator. The ES fault current is not calculated. The rating is sufficient.
H024-C06-506-	275KV 6 COUPLER BAY	01/07/1998	2500A	31.5kA	1.0s	Continuous rating to standard and sufficient. The fault rating is below standard and limited by CTs and isolator. The rating is sufficient.

Functional Loc.	Description	Start-up date	Bay Continuous Rating	Bay Fault Current Rating	Fault Current Period	Comments on Rating
H024-C06-853-	853 FEEDER BAY	28/02/2000	2400A	31.5kA	1.0s	The continuous rating is below standard and limited by secondary thermal limit. The rating is sufficient. The fault rating is below standard and limited by CTs and isolator. The rating is sufficient.
H024-C06-8810-	8810 FEEDER BAY	01/07/1998	2500A	31.5kA	1.0s	Continuous current rating to standard and sufficient. The fault rating is below standard and limited by ES and isolator. The rating is sufficient.
H024-C07-507-	275KV 7 COUPLER BAY	01/07/1998	2500A	31.5kA	1.0s	Continuous current rating to standard and sufficient. The fault rating is below standard and limited by CTs, ES and isolator. The rating is sufficient.
H024-C07-854-	854 FEEDER BAY	05/03/2000	2400A	31.5kA	1.0s	The continuous rating is below standard and limited by secondary thermal limit. The rating is sufficient. The fault rating is below standard and limited by CB, ES and isolator. The rating is sufficient.
H024-C07-8811-	8811 FEEDER BAY	01/07/1998	2500A	31.5kA	1.0s	Continuous current rating to standard and sufficient. The fault rating is below standard and limited by CB, ES and isolator. The rating is sufficient.
H024-D01-441-	132kV 1 TRANSF BAY	29/03/2019	2500A	40kA	-	To standard and sufficient.
H024-D02-7159	7159 FEEDER BAY	12/04/2019	100A	25kA	-	The continuous rating is below standard and limited by secondary thermal limit. It limits the feeders rating. Fault rating is below standard and limited by CTs. The rating is sufficient.
H024-D03-7109	7109 FEEDER BAY	06/06/2019	1200A	40kA	-	The continuous rating is below standard and limited by secondary thermal limit. It limits the feeders rating. Fault rating is to standard.
H024-D04-442-	132kV 2 TRANSF BAY	01/07/1987	2000A	31.5kA	1.0s	The continuous rating is below standard and limited by isolator. It is sufficient for the transformers rating. Fault rating is limited by the earth switch and below standard.

Functional Loc.	Description	Start-up date	Bay Continuous Rating	Bay Fault Current Rating	Fault Current Period	Comments on Rating
H024-D04-7110	7110 FEEDER BAY	01/07/1987	1200A	31.5kA	1.0s	The continuous rating is below standard and limited by secondary thermal limit. It is sufficient for the feeders rating. Fault rating is below standard and limited by earth switch. Fault rating is sufficient.
H024-E03-1311	33kV UNDERGROUND CABLE BS 1311	01/07/1987	345A	10kA	1.0s	Continuous current is sufficient for the local supply transformer. The fault rating is **not** sufficient for the substation.
H024-E03-253-	19kV 3 STN TRANSFORMER BAY	01/07/1984	-	-	-	Continuous current and fault ratings not calculated for this bay.
H024-KC—KC1-	275kV 1 BUS	05/07/1999	3490 A			Sufficient
H024-KC—KC2-	275kV 2 BUS	05/07/1999	3490 A			Sufficient
H024-KD—KD3-	132kV 3 BUS	29/03/2019		40kA	1.0s	Continuous current not calculated for this bay. Fault level is to standard.

The standard bay continuous ratings for a 275kV and 132 kV bays are 2500A and 1600A, respectively. There are a number of circuits that are limited by the primary or secondary rating and network planning engineers are to confirm requirement of enduring need and if the upgrade will be required. It is understood that significant augmentations at this site maybe required as part of Central Queensland re-enforcement project.

The BS1311 cable is underrated for the current fault level rating. It is recommended that this cable is upgraded to be sufficient for the sites current and future fault rating. Some other equipment at this site is also not rated for fault currents in accordance with the current Powerlink standard but are adequately rated for the calculated fault levels at present. This should be taken into account when augmentation projects in this area are considered.

1.4 Scope of condition assessment report

The site condition assessment is restricted to Powerlink owned high voltage equipment and associated support structure and site infrastructure at H024 Calvale substation with the **exclusion** of:

- Power Transformer No.1
- Power Transformer No.2
- 275kV Line Reactor No.1
- 275kV Line Reactor No.2
- 132kV feeder bays D1, D2, D3 & D4-7161 (constructed in 2019 under CP.01546)
- 132 kV Bus Bay (start-up date in 2019)
- 275kV Diameter C01 & C02 (constructed in 2013 under CP.01705)
- Protection and control systems which are subject to a separate condition assessment report.

2. CONDITION ASSESSMENT

2.1 Buildings

2.1.1 Building layout and usage

There is one control building and a work shed on this site. The original control building is brick construction with a steel metal roof and was commissioned in 1987. This building houses Powerlink 275/132kV control panels, the 125V and 50V DC supply systems and telecommunication equipment. It consists of a control/relay room, communications room, battery room, amenities room and toilet. The control, battery and comms rooms are all air conditioned. The majority of windows have bars installed. The building is reasonably well maintained, and no significant issues were noticed during site inspection in 2020.
Asbestos is not present in the control building, however it was found in various objects around the yard (Digital Asbestos Register). Asbestos may be present in other areas that were not accessed while compiling the register.

Figure 5 - Control Building 1

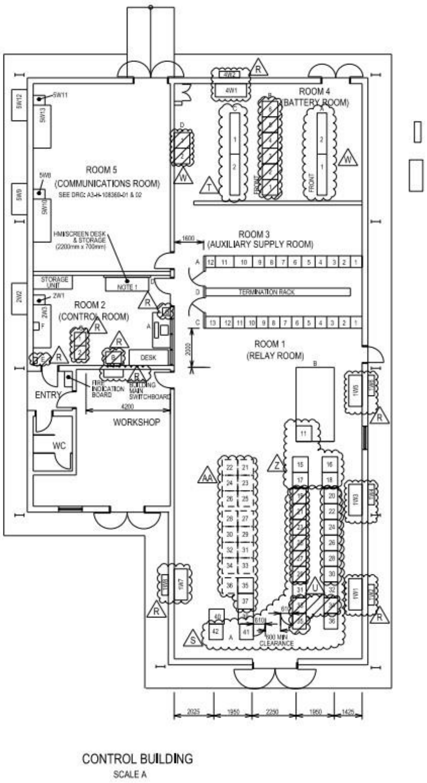


Figure 6 - Control building 1 layout

A storage shed is located in vicinity of the control building. The shed exterior is in good condition, and no issues were noted during site inspection in 2020.

Figure 7 - Work Shed

There are no permanent water tanks within the yard. Two water tanks are positioned outside the yard at the wash-down station. The tanks are made from polyethylene and were in good condition during site inspection in 2020.

Figure 8 - Water tanks

Recommendation: Based on the condition it is recommended that this brick building is fit for purpose for another 40 years with regular maintenance.

2.2 Primary Plant Bays

2.2.1 H024-C03-503- 275kV 3 COUPLER BAY

The equipment for this bay is listed in the Table 2, including a health index value for each item.

The original equipment comprising circuit breaker, isolators and current transformers were installed in early to mid-1988.

Table 2 - C03-503 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment	Construction year	HI
H024-C03-503--5030-1	Earth Switch	Merlin Gerin	DR	20011036	1976	5
H024-C03-503--5030-2	Earth Switch	Merlin Gerin	DR	20011037	1976	5
H024-C03-503--5032	Circuit Breaker	Mitsubishi	250-SFM-40B	20005046	1987	8
H024-C03-503--5032CTA	Current Transformer	Haefely	IOSK300/1050	20005072	1987	8
H024-C03-503--5032CTB	Current Transformer	Haefely	IOSK300/1050	20005071	1987	8
H024-C03-503--5032CTC	Current Transformer	Haefely	IOSK300/1050	20005070	1987	8
H024-C03-503--5038	Isolator	Egic	DR	20005094	1987	5
H024-C03-503--5039	Isolator	Egic	DR	20005095	1987	5

Figure 9 – Circuit Breaker

Figure 10 – Circuit breaker cubicle

The circuit breaker in this bay is a Mitsubishi 250–SFM-340B manufactured in 1987 and installed in 1988. It has pneumatic operating mechanism with air and spring used for energy storage and SF6 gas for insulating medium. SFM type Mitsubishi CBs of this vintage have asbestos impregnated washers of friable nature associated with the heater inside the mechanism box which have been removed. Mitsubishi does not produce this type of circuit breaker anymore and sourcing of spare parts has become a major issue. Wiring inside the mechanism box is cracked due to UV penetrating through viewing window. Maintenance records show that this CB had issues with unloader valve and pressure relief valve of the air compressor system. In 2023 pole discrepancy times were found to be out of specification which were attributed to a high resistance of the trip coil. The resistance of the trip coils is marginally outside of manufacturer specification (tested at 34.7Ω with manufacturer specification indicating an acceptable range of 31.35Ω - 34.65Ω). During re-testing the CB pole discrepancy was within nominal pole discrepancy times and was returned to service. The degradation of the trip coil will cause slow trips and pole discrepancies to occur more frequently. The recorded trip timing tests conducted in 2023 are all within specifications. Recently in 2025 the Kajo compressor was found to be leaking oil and was replaced in the same year. PI data monitoring of the SF6 pressure indicates that there are no leaks present. This CB has been in service for 38 years and it is estimated that it has a remaining service life of 3 years.

The Haefely oil filled current transformers are in satisfactory condition considering they have been in service for 38 years and the DGA/moisture in oil analysis is satisfactory. There are no identified issues with oil seal integrity. Considering their age and the fact these have porcelain housing, it is recommended to replace these in 3 years. Current transformers with paper and oil have an increased probability of explosive failure occurring after 36 years in service.

The two isolators, 5038 and 5039 installed in this bay are in good condition and maintenance records show some minor issues that required the heater and heater switches to be replaced. The earth switches are in good condition as well and have had no defects raised against them.

The associated structures and foundations in this bay have a remaining service life of 20 years.

Recommendation: Based on the above observations, it is recommended that CB and CTs incl. structures and foundations are replaced within the next 3 years preferably using dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.2 H024-C03-541- 275kV 1 TRANSFORMER BAY

The equipment for this bay is listed in the Table 3, including a health index value for each item.

The original equipment comprising of a circuit breaker, isolators, voltage transformer and current transformers were installed in 1987. The surge arrestors were replaced in 2019.

Table 3 - C03-541 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment	Construction year	HI
H024-C03-541--1TRFSAA	Surge Arrestor (Gapless)	ABB	PEXLIM 240KV 10KA	20094407	2017	2
H024-C03-541--1TRFSAB	Surge Arrestor (Gapless)	ABB	PEXLIM 240KV 10KA	20094408	2017	2
H024-C03-541--1TRFSAC	Surge Arrestor (Gapless)	ABB	PEXLIM 240KV 10KA	20094409	2017	2
H024-C03-541--5410	Earth Switch	Merlin Gerin	DR	20011042	1976	6
H024-C03-541--5410-1	Earth Switch	Merlin Gerin	DR	20011043	1976	6
H024-C03-541--5410-2	Earth Switch	Merlin Gerin	DR	20011044	1976	6
H024-C03-541--5410-3	Earth Switch	Merlin Gerin	DR	20011045	1976	6
H024-C03-541--5411	Isolator	Egic	DR	20005091	1987	5
H024-C03-541--5412	Circuit Breaker	Mitsubishi	250-SFM-40B	20005045	1987	8
H024-C03-541--5412CTA	Current Transformer	Haefely	IOSK300/1050	20005453	1992	8
H024-C03-541--5412CTB	Current Transformer	Haefely	IOSK300/1050	20005068	1987	7
H024-C03-541--5412CTC	Current Transformer	Haefely	IOSK300/1050	20005076	1986	8
H024-C03-541--5413	Isolator	Egic	DR	20005092	1987	5
H024-C03-541--5417	Isolator	Egic	DR	20005093	1987	5
H024-C03-541--7VTB	Capacitor Voltage Transformer	Haefely	CVE300/1050	20005129	1983	7

The CB in this bay was installed in 1988 and was manufactured by Mitsubishi. It has a pneumatic operating mechanism with air and spring used for energy storage and SF6 gas for insulating medium. This type of CB is no longer manufactured by Mitsubishi. The maintenance records show minor issues with wiring inside the mechanism box is cracked due to UV penetrating through viewing window and shielding installed on the cables to prevent UV damage. This model of breakers also has asbestos impregnated washers of friable nature associated with the heater inside the mechanism box which have been removed. The opening trip times #1 indicate that the breaker is marginally outside of manufacturer specifications, however the opening time #2 is within this spec. This model of CB has been updated by the manufacturer since its manufacture and as such no spare parts are available. This CB has been in service for 38 years and it is estimated that it has a remaining service life of 3 years.

Figure 13 - Circuit Breaker

Figure 11 - CVT

Figure 12 - CTs

The oil filled current transformers are in reasonable condition physically considering they have been in service for between 33 - 38 years. This model of CTs have been identified to have a high failure rate and as such are on yearly oil testing. The A & C phase CT test results have identified that overheating <300 degrees Celsius has developed. There were no identified issues with oil seal integrity when inspected on site. Considering their age, oil test reports and the fact these have porcelain housing, it is recommended to replace the CTs in 3 years to manage safety risks associated with their potential catastrophic failures. Current transformers with paper and oil have an increased probability of explosive failure occurring after 36 years in service.

The capacitor voltage transformer is oil filled and manufactured by Haefely. No defects have been raised against this CVT, however due to the CVT being 42 years old, it has been deemed to have reached end of technical life. This model is only in service at Calvale and Broadsound substations with 82% of the in-service population being retired due to poor condition. It is expected that failure of this CVT could occur within the next 5 years and should be replaced within this timeframe.

The EGIC isolators installed in this bay are in good condition however maintenance records have indicated that these isolators have experienced motor and gear box issues. The rectification works have so far been successful with no re-occurring issues developing.

The earth switches installed in this bay are manufactured by Merlin Gerin and are 49 years old. This design of earth switch has been identified to have long operation rods that are easily bent when operated. 5410-3 earth switch had modifications made to these under an OR project to rectify this issue however works are still outstanding on ES 5410-2.

The associated structures and foundations in this bay have a remaining service life of 20 years.

Recommendation: Based on the above observations, it is recommended that the isolator, earth switch, CB, CT and CVT including structures and foundations are replaced within the next 3 years preferably using a dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.3 *H024-C03-8874- 8874 FEEDER BAY*

The equipment for this bay is listed in the Table 4, including health index value for each item.

This bay was built in 1988, with some of original equipment replaced in various years.

Table 4 - C03-8874 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment	Construction year	HI
H024-C03-8874-6VTA	Capacitor Voltage Transformer	Trench Limited	TEMP287C	20058388	2007	7
H024-C03-8874-6VTB	Capacitor Voltage Transformer	Trench Limited	TEMP287C	20058391	2007	7
H024-C03-8874-6VTC	Capacitor Voltage Transformer	Trench Limited	TEMP287C	20058390	2007	7
H024-C03-8874-88740	Earth Switch	Merlin Gerin	DR	20011059	1976	6
H024-C03-8874-88740-1	Earth Switch	Merlin Gerin	DR	20011060	1976	6
H024-C03-8874-88740-2	Earth Switch	Merlin Gerin	DR	20011061	1976	6
H024-C03-8874-88740-3	Earth Switch	Merlin Gerin	DR	20011062	1976	6
H024-C03-8874-88741	Isolator	Egic	DR	20005097	1987	5
H024-C03-8874-88742	CIRCUIT BREAKER (SF6 SPRING Multivol)	MITSUBISHI	250-SFM-40B	20005047	1987	8
H024-C03-8874-88743	Isolator	Egic	DR	20011976	1987	5
H024-C03-8874-88747	Isolator	Egic	DR	20005096	1987	5
H024-C03-8874-8874CTA	Current Transformer	Haefely	IOSK300/1050	20012039	1987	8
H024-C03-8874-8874CTB	Current Transformer	Haefely	IOSK300/1050	20005074	1987	8
H024-C03-8874-8874CTC	Current Transformer	Haefely	IOSK300/1050	20005073	1987	8
H024-C03-8874-874SAA	Surge Arrestor (Gapless)	Siemens	3EL2 240-2PM32-4KA1	20074194	2011	4
H024-C03-8874-8874SAB	Surge Arrestor (Gapless)	Siemens	3EL2 240-2PM32-4KA1	20074195	2011	4
H024-C03-8874-8874SAC	Surge Arrestor (Gapless)	Siemens	3EL2 240-2PM32-4KA1	20074196	2011	4

The circuit breaker in this bay is a Mitsubishi 250–SFM-340B manufactured in 1987 and installed in 1988. It has pneumatic operating mechanism with spring used for energy storage and SF6 gas for insulating medium. SFM type Mitsubishi CBs of this vintage have asbestos impregnated washers of friable nature associated with the heater inside the mechanism box which has been removed. Mitsubishi does not produce this type of circuit breaker anymore and sourcing of spare parts has become a major issue. Wiring inside the mechanism box is cracked due to UV penetrating through viewing window. Maintenance records show that this CB had issues with pressure relief valve of the air compressor system. The trip time tests have all tested within specification. This CB has been in service for 37 years and it is estimated that this CB has a remaining service life of 3 years.

The Trench oil filled voltage transformer has been in service for 18 years and their has been no notifications raised indicating that the oil colour has deteriorated or weeping occurring from the seals. This model of CVTs however has been noted to have a high failure rate due to the loss of EMU hermetic seal, which results in moisture ingress into the bottom of the EMU tank, shorting the windings, and causing a loss of secondary voltage. It is estimated that these voltage transformers have a remaining service life of 3 years. The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

The current transformers were manufactured in 1987 and are currently 38 years old. These post type CTs are oil filled with porcelain housing which pose a safety risk to personnel on site should catastrophic failure occur. Oil test results on all three phases since 2015 has indicated that overheating <300 degrees Celsius has been occurring. It is estimated that these instrument transformers have a remaining service life of 3 years.

The isolators are all manufactured by EGIC in 1987 making them 38 years old. Isolator 88743 has required adjustments due to contacts being out of alignment however, aside from this there have been no other defects raised on any isolators in this bay. The isolators are not expected to require replacement within the next 15–20 year period.

The earth switches installed in this bay are 49 years old and are the model that have been identified to have long operation rods that are easily bent when operated. 88740-1 ES has had modifications made to prevent this with the others not having been affected yet. Aside from this the earth switches are considered to be in good condition with no replacement expected within the next 15-year period.

Recommendation: Based on the above observations, it is recommended that CVTs, CB and CTs incl. structures and foundations are replaced within the next 3 years preferably using a dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.4 H024-C04-504- 4 COUPLER BAY

The equipment in this bay is listed in Table 5, including health index value for each item.

The original equipment comprising circuit breaker, isolators and current transformers was installed in early to mid-1989.

Table 5 - C04-504 Equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment	Construction year	HI
H024-C04-504--5040-1	Earth Switch	Merlin Gerin	DR	20011038	1976	6
H024-C04-504--5040-2	Earth Switch	Merlin Gerin	DR	20011039	1976	6
H024-C04-504--5042	Circuit Breaker	Mitsubishi	250-SFM-40B	20005052	1987	8
H024-C04-504--5042CTA	Current Transformer	Haefely	IOSK300/1050	20005065	1987	8
H024-C04-504--5042CTB	Current Transformer	Haefely	IOSK300/1050	20005064	1986	8
H024-C04-504--5042CTC	Current Transformer	Haefely	IOSK300/1050	20005063	1987	8
H024-C04-504--5048	Isolator	Egic	DR	20005086	1987	6
H024-C04-504--5049	Isolator	Egic	DR	20005087	1987	6

The CTs in this bay are oil filled and in porcelain housing and are 38 years old. The oil test results are satisfactory, however Powerlink data show there is an increased probability of explosive failures after 36 years in service. Therefore, to minimise risk of personnel on site it is recommended that these CTs be replaced within 3 years.

The CB in this bay was manufactured in 1987 by Mitsubishi and is currently 38 years old. It has a pneumatic operating mechanism with air and spring used for energy storage and SF6 gas for insulating medium. This type of CB is no longer manufactured by Mitsubishi. This model of breaker has asbestos impregnated washers of friable nature associated with the heater inside the mechanism box which have been removed. It has been identified in recent years that the Kaji compressor is leaking which required the replacement of seals in 2025. The Kaji compressor is no longer supported and any further issues may be difficult to obtain spare parts for. The trip time tests have also all tested within specification. It is estimated that there is approximately 3 years of service life remaining for this circuit breaker. The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

The isolators installed on site are manufactured by EGIC and are 38 years old. Both isolators are unable to be operated remotely, with switching only available manually. Due to the restricted access zones on site this has been unable to be repaired. It is expected that with sufficient motor refurbishment during the next outage the isolator will not require replacement within the next 10-year period.

The earth switches are in good condition with the only defect being raised against them in relation to 5040-2 earth switch requiring modification to the interlock alignment. It is expected that they will not require replacement within the next 15-20 year period.

Recommendation: Based on the above observations, it is recommended that CB and CT including structures and foundations are replaced within the next 3 years preferably using a dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.5 H024-C04-542- 275kV 2 TRANSFORMER BAY

The equipment for this bay is listed in the Table 6, including health index value for each item. All original equipment is still in service excluding the CTs and CVT which were all replaced in 2023.

Table 6 - C04-542 Equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C04-542--2SAA	Surge Arrestor (Gapless)	Asea	XAQ300A2/240	20005114	1986	8
H024-C04-542--2SAB	Surge Arrestor (Gapless)	Asea	XAQ300A2/240	20005113	1986	8
H024-C04-542--2SAC	Surge Arrestor (Gapless)	Asea	XAQ300A2/240	20005112	1986	8
H024-C04-542--5420	Earth Switch	Merlin Gerin	DR	20011046	1976	6
H024-C04-542--5420-1	Earth Switch	Merlin Gerin	DR	20011047	1976	6
H024-C04-542--5420-2	Earth Switch	Merlin Gerin	DR	20011048	1976	6
H024-C04-542--5420-3	Earth Switch	Merlin Gerin	DR	20011049	1976	6
H024-C04-542--5421	Isolator	Egic	DR	20005083	1987	6
H024-C04-542--5422	Circuit Breaker	Mitsubishi	250-SFM-40B	20005051	1987	8
H024-C04-542--5422CTA	Current Transformer (Sf6 - Gas)	ABB	TG300	20134511	2020	1
H024-C04-542--5422CTB	Current Transformer (Sf6 - Gas)	ABB	TG300	20134497	2020	1
H024-C04-542--5422CTC	Current Transformer (Sf6 - Gas)	ABB	TG300	20134498	2020	1
H024-C04-542--5423	Isolator	Egic	DR	20005084	1987	6
H024-C04-542--5427	Isolator	Egic	DR	20005085	1987	6
H024-C04-542--8VTB	Capacitor Voltage Transformer	Ge Grid Solutions India	CCV 300	20129402	2020	1

Similar to the other Mitsubishi 250–SFM-340B circuit breakers in this substation, there are a number of issues identified in the maintenance records. Air compressor unit and pressure relief valve in this CB were replaced. The maintenance record indicated that the Kaji air compressor had a number of low oil levels.

The trip seals of the CB have also been replaced on B & C phases. The trip time tests have all tested within specifications. Mitsubishi does not produce this type of circuit breaker anymore and sourcing of spare parts is not practical. Wiring inside the mechanism box is cracked due to UV penetrating through the viewing window. This CB has been in service for 38 years and it is estimated that it has a remaining service life of 3 years.

The Instrument transformers are newly replaced in 2023 and are in good condition.

The isolators installed on site are manufactured by EGIC in 1987 and are 38 years old. Like the other EGIC isolators on site these have had issues with operating electrically and have required refurbishment of the motor to make them operational again. It is expected that they will not require replacement within the next 10-year period.

The earth switches installed in this bay are the Merlin Green model that as mentioned previously are easily bent when operated. A refurbishment design has been created for these earth switches and have been installed in this bay. It is expected that they will not require replacement within the next 10-year period.

The surge arrestors were manufactured by ASEA in 1986 and are currently 39 years of age. Though no defects have been raised against these surge arrestors, as the technical design life of surge arrestors are only 40 years, no guarantee can be made that they will function correctly after this period. As such it is recommended that they are replaced within the next 3 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

Recommendation: Based on the above observations, it is recommended that CB including structures and foundations are replaced within the next 3 years. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.6 H024-C04-851- 851 FEEDER BAY

The equipment for this bay is listed in the Table 7, including health index value for each item. The bay was originally commissioned in 1987, and all original equipment is still in service. The CT/VTs were additionally added in 1997 to be used for revenue metering.

Table 7 - C04-851 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C04-851--8510	Earth Switch	Merlin Gerin	DR	20011053	1976	6
H024-C04-851--8510-1	Earth Switch	Merlin Gerin	DR	20011054	1976	6
H024-C04-851--8510-2	Earth Switch	Merlin Gerin	DR	20011055	1976	6
H024-C04-851--8512	Circuit Breaker	Mitsubishi	250-SFM-40B	20005050	1987	8
H024-C04-851--8512CTA	Current Transformer	Haefely	IOSK300/1050	20005077	1986	8
H024-C04-851--8512CTB	Current Transformer	Haefely	IOSK300/1050	20005067	1986	8
H024-C04-851--8512CTC	Current Transformer	Haefely	IOSK300/1050	20005066	1986	8
H024-C04-851--8513	Isolator	Egic	DR	20005089	1987	6
H024-C04-851--8517	Isolator	Egic	DR	20005088	1987	6
H024-C04-851--851CTVTA	Combined_Ct/Vt	Haefely Trench	SVAS 300/OG	20014039	1995	6
H024-C04-851--851CTVTB	Combined_Ct/Vt	Haefely Trench	SVAS 300/OG	20014038	1995	6
H024-C04-851--851CTVTC	Combined_Ct/Vt	Haefely Trench	SVAS 300/OG	20014037	1995	6

The current transformers are oil filled and in porcelain housing and Powerlink data show there is an increased probability of explosive failures with catastrophic safety consequences after 36 years in service. As these CTs are 39 years old and recent oil test results indicate that overheating <300 degrees Celsius is occurring it is recommended that these CTs be replaced within 3 years.

Similar to the other Mitsubishi 250–SFM-340B circuit breakers in this substation, there are a number of issues identified in the maintenance records. This CB had issues with compressor oil leak, SF6 leaks, UV damaged control cable and pressure relief valves. The compressor has been replaced and the SF6 leaks were rectified in 2022 with PI data indicating that the SF6 leak was rectified. The trip time tests have all tested within specification. This CB has been in service for 38 years and it is estimated that it has a remaining service life of 3 years.

The isolators installed in this bay are manufactured by EGIC in 1987 and are 38 years old. Like the other isolators of this make and model installed on site they have issues with the isolator closing function. Engineering work arounds are required to rectify this issue. It is expected that isolator replacement within this bay will not be required in the next 10 years.

The earth switches installed in this bay are the same manufacturer and model as mentioned previously which have long operation rods that are easily bent when operated. Some of the earth switches have had an engineering solutions installed which have rectified this issue. It is not expected than replacement will be required within the next 10 years.

The combined CT/VTs in this bay were manufactured by Haefely Trench and are SF6 insulated. They are currently 30 years old and have had no condition related defects raised against them. It is expected that they will not require replacement within the next 10 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

Recommendation: Based on the above observations, it is recommended that CB and CTs including structures and foundations are replaced within the next 3 years preferably using a dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10 year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.7 H024-C05-505- 5 COUPLER BAY

The equipment in this bay is listed in Table 8, including health index value for each item.

Table 8 - C05-505 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Start-up date	HI
H024-C05-505--5050-1	Earth Switch	Merlin Gerin	DR	20011040	1976	6
H024-C05-505--5050-2	Earth Switch	Merlin Gerin	DR	20011041	1976	6
H024-C05-505--5052	Circuit Breaker	Mitsubishi	250-SFM-40B	20005048	1987	8
H024-C05-505--5052CTA	Current Transformer	Gec Alsthom - T&D Balteau	CTH245/6	20014272	1996	6
H024-C05-505--5052CTB	Current Transformer	Haefely	IOSK300/1050	20005058	1986	8
H024-C05-505--5052CTC	Current Transformer	Haefely	IOSK300/1050	20005078	1986	8
H024-C05-505--5058	Isolator	Egic	DR	20005100	1987	6
H024-C05-505--5059	Isolator	Egic	DR	20005099	1987	6

The CTs are oil filled and in porcelain housing and Powerlink data show there is an increased probability of explosive failures with catastrophic safety consequences after 36 years in service. The current age of B and C phase are 39 years old and A phase is currently 29 years old. Though recent oil test results indicate that there are no abnormal gassing occurring, because of the high catastrophic failure rate it is recommended that B and C phase of these CTs are replaced within 3 years.

Similar to the other Mitsubishi 250–SFM-340B circuit breakers in this substation, there are a number of issues identified in the maintenance records. This CB had issues with compressor oil leak, unloader valve, UV damaged control cable and SF6 gas leaks. The trip timing results of the CB have all tested within specification. This CB is currently 38 years and it is estimated that it has a remaining service life of 3 years.

Figure 15 - Wiring UV damages

Figure 14 - CB Mech box oil leak

The two isolators 5058 and 5059 installed in this bay are manufactured by EGIC and are currently 38 years old. This model of isolator has issues regarding the remote operation however there is a known engineering solution for this. It is expected that replacement of the isolators will not be required in the next 10-year period. The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

The earth switches installed in this bay are manufactured by Merlin Green and have known issues regarding the long operating rods which are prone to bending. A known engineering solution is available for this. No defects have been raised against the ES in this bay. It is expected that replacement of the earth switches will not be required in the next 10-year period.

Recommendation: Based on the above observations, it is recommended that CB and B/C phase CTs including structures and foundations are replaced within the next 3 years. If economical to do so preferably using a dead tank CB while retaining the A phase CT as a spare. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.8 H024-C05-852- 852 FEEDER BAY

The equipment for bay is listed in the Table 9, including health index value for each item. The bay was originally commissioned in 1987 with the combined CT/VT installed in 1997 for revenue metering.

Table 9 - C05-852 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C05-852--8520	Earth Switch	Merlin Gerin	DR	20011056	1998	3
H024-C05-852--8520-1	Earth Switch	Merlin Gerin	DR	20011057	1976	6
H024-C05-852--8520-2	Earth Switch	Merlin Gerin	DR	20011058	1976	6
H024-C05-852--8522	Circuit Breaker	Mitsubishi	250-SFM-40B	20005044	1987	8
H024-C05-852--8522CTA	Current Transformer	Haefely	IOSK300/1050	20005069	1986	8
H024-C05-852--8522CTB	Current Transformer	Haefely	IOSK300/1050	20005080	1986	8
H024-C05-852--8522CTC	Current Transformer	Haefely	IOSK300/1050	20005081	1986	8
H024-C05-852--8523	Isolator	Egic	DR	20005082	1987	6
H024-C05-852--8527	Isolator	Egic	DR	20005098	1987	6
H024-C05-852--852CTVTA	Combined_Ct/Vt	Haefely Trench	SVAS 300/OG	20014034	1995	6
H024-C05-852--852CTVTB	Combined_Ct/Vt	Haefely Trench	SVAS 300/OG	20014035	1995	6
H024-C05-852--852CTVTC	Combined_Ct/Vt	Haefely Trench	SVAS 300/OG	20014036	1995	6

The current transformers (CTs) visually appear in reasonable condition as identified by their maintenance records. These CTs are oil filled and in porcelain housing and Powerlink data show there is an increased probability of explosive failures after 36 years in service. The oil test results indicate that overheating <300 degrees Celsius is occurring in A phase. As the CTs are 39 years old and due to the safety consequences related to catastrophic failure it is recommended that these CTs be replaced within 3 years.

Similar to the other Mitsubishi 250–SFM-340B circuit breakers in this substation, there are a number of issues identified in the maintenance records. This CB had issues with compressor oil leaks, unloader leak, trip seal leaks and UV damaged control cable. The compressor leak became so substantial that it required a full rebuild in 2020. The trip seals were also replaced in the same year. The PI data indicates that there are no SF6 leaks currently present. The opening time trip on #1 is marginally outside of specification but tests ok on trip #2. All other tests are within specification. This CB is 38 years old and it is estimated that it has a remaining service life of 3 years.

The isolators installed in this bay are manufactured by EGIC and are currently 38 years old. This model of isolators have issues regarding the remote operation however there is a known engineering solution for this. No other defects have been raised against the isolators in this bay. It is expected that replacement of the isolators will not be required in the next 10 year period.

The model of earth switches installed in this bay have been identified to have long operation rods that are easily bent when operated. A solution is available for this problem and has been implemented on the 820-1 ES. Aside from this no other defects have been raised against the earth switches in this bay. It is expected that replacement of the earth switches will not be required in the next 10 year period.

The combined CT/VTs are manufactured by Haefely Trench, SF6 insulated and are 30 years old. The A phase CT/VT had developed a SF6 leak in 2022 which was rectified and has not re-occurred. No other defects have been raised against these instrument transformers. It is expected that no replacements will be required in the next 10 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

Recommendation: Based on the above observations, it is recommended that CB and CTs including structures and foundations are replaced within the next 3 years preferably using a dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10 year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.9 H024-C05-871- 871 FEEDER BAY

The equipment for bay is listed in the Table 10, including health index value for each item.

Table 10 - C05-871 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C05-871--4VTB	Capacitor Voltage Transformer	Haefely	CVE300/1050	20005123	1985	7
H024-C05-871--4VTSB	Capacitor Voltage Transformer	Haefely	CVE300/1050	20005133	1985	7
H024-C05-871--4VTSC	Capacitor Voltage Transformer	Haefely	CVE300/1050	20005132	1985	7
H024-C05-871--8710	Earth Switch	Merlin Gerin	DR	20011063	1976	6
H024-C05-871--8710-1	Earth Switch	Merlin Gerin	DR	20011064	1976	6
H024-C05-871--8710-2	Earth Switch	Merlin Gerin	DR	20011065	1976	6
H024-C05-871--8710-3	Earth Switch	Merlin Gerin	DR	20011066	1976	6
H024-C05-871--8711	Isolator	Egic	DR	20005090	1987	6
H024-C05-871--8712	Circuit Breaker	Mitsubishi	250-SFM-40B	20005049	1987	8
H024-C05-871--8712CTA	Current Transformer	Haefely	IOSK300/1050	20005059	1986	8
H024-C05-871--8712CTB	Current Transformer	Haefely	IOSK300/1050	20005060	1986	8

H024-C05-871--8712CTC	Current Transformer (Sf6 - Gas)	ABB	TG300	20134510	2020	1
H024-C05-871--8713	Isolator	Egic	DR	20005101	1987	6
H024-C05-871--8717	Isolator	Egic	DR	20005102	1987	6

The oil filled current transformers on A and B phase are in reasonable condition considering they 39 years of age and the DGA/moisture in oil analysis is satisfactory. There are no identified issues with oil seal integrity. Considering their age and the fact these have porcelain housing, it is recommended to replace both A and B phase CTs in 3 years to manage safety risks associated with their potential catastrophic failures. Current transformers with paper and oil have an increased probability of explosive failure occurring after 36 years in service. The C phase CT was recently replaced in 2023 and is in good condition.

The capacitor voltage transformers are oil filled with porcelain insulators and were manufactured by Haefely in 1985 making them 40 years old. No defects have been raised against these CVTs however, given their age and potential safety implications of the porcelain housing it is recommended that these are replaced in 3 years.

Similar to the other Mitsubishi 250–SFM-340B circuit breakers in this substation, there are a number of issues identified in the maintenance records. This CB had issues with compressor oil leak, UV damaged control cables and SF6 gas leaks. The SF6 leaks have been rectified with Pi data indicating that there are no SF6 leaks present currently. All trip timing tests are within specification. This CB is 38 years of age, and it is estimated that it has a remaining service life of 3 years.

The isolators installed in this bay are manufactured by EGIC and are currently 38 years old. This model of isolators have issues regarding the remote operation however there is a known engineering solution for this. The contactors on 8713 isolator were also replaced in 2023. It is expected that replacement of the isolators will not be required in the next 10-year period.

The model of earth switches installed in this bay have been identified to have long operation rods that are easily bent when operated. A solution is available for this known issue. It is expected that replacement of the earth switches will not be required in the next 10-year period.

The associated structures and foundations are in good condition and are expected to have a remaining life of 20 years.

Recommendation: Based on the above observations, it is recommended that CB, CTs and CVT including structures and foundations are replaced within the next 3 years preferably using a dead tank CB. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

2.2.10 H024-C06-506- 6 COUPLER BAY

The equipment in this bay is listed in Table 11, including health index value for each item.

Table 11 - C06-506 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C06-506--5060-1	Earth Switch	ABB Elpar	TEC	20032105	1999	3
H024-C06-506--5060-2	Earth Switch	Ngk Stanger	VSB	20014464	1998	3
H024-C06-506--5062	Circuit Breaker	ABB Sweden	HPL300B1 3PAR	20032094	1999	7
H024-C06-506--5062CTA	Current Transformer	Trench	SAS 300/9G	20082151	2015	2
H024-C06-506--5062CTB	Current Transformer	Trench	SAS 300/9G	20082152	2015	2
H024-C06-506--5062CTC	Current Transformer	Trench	SAS 300/9G	20082153	2015	2

H024-C06-506--5068	Isolator	Ngk Stanger	HCB	20014450	1998	3
H024-C06-506--5069	Isolator	ABB Elpar	SGF300p100+2E	20032099	1999	3

The circuit breaker in this bay was installed in 1998. It is an ABB model HPL HPL300B1 3PAR. It has a 240V AC operating mechanism with spring used for energy storage and SF6 for insulating medium. The maintenance records shows a history of SF6 leaks and it has been topped up several times with SF6. Gas leak found coming from B and C phase gauges in 2016. In 2024 dew point measuring indicated that the desiccant is required to be replaced as well. This model of circuit breaker is known as having significant SF6 leaking issues. Analysis of the quantity of SF6 added to all SF6 circuit breakers in the last 25 years as part of leak repairs indicate that ABB HPL300 breakers account for 46% of the SF6 lost, while only making up 19% of the equipment database. The trip time tests indicate that the opening time trip #2 is marginally too fast and the close/trip times are too slow. There are six of this type of CB's in service at Calvale. The recommended strategy for these ABB CBs is to replace those that are already leaking and recover good poles of replaced CBs to increase spare holdings to assist in managing others in the fleet. It is recommended that this circuit breaker is replaced within 5 years.

All other primary plant in this bay is in good condition. The SF6 CTs in this bay were installed in 2015 as a part of twin leg CT replacements.

The associated structures and foundations in this bay have a remaining service life of 40 years, except the CT structure & foundation which have an estimated remaining service life of 50 years.

Recommendation: Based on the above observations, it is recommended that the CB including structures and foundations is replaced within the next 5 years preferably with a deadtank CB. The CT's can be recovered and used as system spares. The rest of the HV plant is in good condition and no replacements are required in the next 10 year outlook.

2.2.11 H024-C06-853- 853 FEEDER BAY

The equipment for this bay is listed in the Table 12, including health index value for each item.

Table 12 - C06-583 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment	Start-up date	HI
H024-C06-853--14VTA	CAPACITOR VOLTAGE TRANSFORMER	TRENCH LIMITED	TCVT300C	20085085	2016	2
H024-C06-853--14VTB	CAPACITOR VOLTAGE TRANSFORMER	TRENCH LIMITED	TCVT300C	20085016	2013	2
H024-C06-853--14VTC	CAPACITOR VOLTAGE TRANSFORMER	TRENCH LIMITED	TCVT300C	20085087	2016	2
H024-C06-853--8530	EARTH SWITCH	ABB ELPAR	TEC	20032104	1999	3
H024-C06-853--8530-1	EARTH SWITCH	NGK STANGER	VSB	20014470	1998	3
H024-C06-853--8530-2	EARTH SWITCH	ABB ELPAR	TEC	20032101	1999	3
H024-C06-853--8532	CIRCUIT BREAKER	ABB SWEDEN	HPL300/25B1 SPAR P	20014790	1998	7
H024-C06-853--8532-CTA	CURRENT TRANSFORMER (SF6)	TRENCH	SAS 300/9G	20082154	2015	2
H024-C06-853--8532-CTB	CURRENT TRANSFORMER (SF6)	TRENCH	SAS 300/9G	20082155	2015	2
H024-C06-853--8532-CTC	CURRENT TRANSFORMER (SF6)	TRENCH	SAS 300/9G	20082156	2015	2
H024-C06-853--8533	ISOLATOR	NGK STANGER	HCB	20014456	1998	3
H024-C06-853--8537	ISOLATOR	ABB ELPAR	SGF300p100+1E	20032097	1999	3

The circuit breaker in this bay was installed in 1998 and is an ABB model HPL 300/25 B1, of which some exhibited issues with SF6 leaks due to an inherent manufacturing defect. Maintenance records show that an SF6 leak was detected on A phase, which has had several top ups of SF6. Leaking was unable to be stopped. This CB has leaked SF6 gas since 2006 and required topping up of gas almost every year and has also recently tested in defect level for dew point. The total quantity of SF6 added to this breaker has totalled 10.33kg. The trip time tests have all tested within specifications, however it is worth noting that the close/trip times have not been recorded recently. This model of circuit breaker is known as having significant SF6 leaking issues. Analysis of the quantity of SF6 added to all SF6 circuit breakers in the last 25 years as part of leak repairs indicate that ABB HPL300 breakers account for 46% of the SF6 lost, while only making up 19% of the equipment database. There are six of this type of CB's in service at Calvale. The recommended strategy for these ABB CBs is to replace those that are already leaking and recover good poles of replaced CBs to increase spare holdings to assist in managing others in the fleet. It is recommended that this CB is replaced within 5 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of 40 years except the CT structure which has a 50 years life.

Recommendation: Based on the above observations, it is recommended that CB including structures and foundations is replaced within the next 5 years preferably with a deadtank CB. The CT's can be recovered and used as system spares. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

2.2.12 H024-C06-8810- 8810 FEEDER BAY

The equipment for this bay is listed in Table 13, including health index value for each item.

Table 13 - C06-8810 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C06-8810-12VTA	Capacitor Voltage Transformer	Trench Limited	TCVT300C	20084991	2013	3
H024-C06-8810-12VTB	Capacitor Voltage Transformer	Trench Limited	TCVT300C	20085000	2013	3
H024-C06-8810-12VTC	Capacitor Voltage Transformer	Trench Limited	TCVT300C	20085010	2013	3
H024-C06-8810-88100	Earth Switch	Ngk Stanger	VSB	20014460	1998	3
H024-C06-8810-88100-1	Earth Switch	Ngk Stanger	VSB	20014461	1998	3
H024-C06-8810-88100-2	Earth Switch	Ngk Stanger	VSB	20014471	1998	3
H024-C06-8810-88100-3	Earth Switch	Ngk Stanger	VSB	20014462	1998	3
H024-C06-8810-88100-4	Earth Switch	Ngk Stanger	VSB	20014463	1998	3
H024-C06-8810-88101	Isolator	Ngk Stanger	HCB	20014448	1998	3
H024-C06-8810-88102	Circuit Breaker	ABB Sweden	HPL300/25B1 SPAR P	20014866	1998	8
H024-C06-8810-88102-1	Circuit Breaker	ABB Transmission &Distribution	HPL300/25B1 SPAR P	20014793	1998	7
H024-C06-8810-88102CTA	Current Transformer (Sf6)	Trench	SAS 300/9G	20084187	2015	2
H024-C06-8810-88102CTB	Current Transformer (Sf6)	Trench	SAS 300/9G	20084188	2015	2
H024-C06-8810-88102CTC	Current Transformer (Sf6)	Trench	SAS 300/9G	20084189	2015	2
H024-C06-8810-88103	Isolator	Ngk Stanger	HCB	20014457	1998	3
H024-C06-8810-88107	Isolator	Ngk Stanger	HCB	20014449	1998	3
H024-C06-8810-88109	Isolator	Ngk Stanger	HCB	20014451	1998	3
H024-C06-8810-8810RSAA	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013151	1998	5

H024-C06-8810-8810RSAB	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013152	1998	5
H024-C06-8810-8810RSAC	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013153	1998	5
H024-C06-8810-8810SAA	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013165	1998	5
H024-C06-8810-8810SAB	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013166	1998	5
H024-C06-8810-8810SAC	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013167	1998	5

This bay was installed in 1998. Most the primary plant in this bay is in relatively good condition and maintenance records show only minor issues with isolator 88109 which is not able to be operated electrically but needs to be opened manually.

The ABB HPL300 CB has been in service for 21 years on both the feeder and reactor and both circuit breakers have developed gas leaks with 88102 A and C phase pole currently experiencing a moderate leak. These breakers have been topped up with gas multiple times which requires a high engagement of maintenance resources. This model of circuit breaker is known as having significant SF6 leaking issues. Analysis of the quantity of SF6 added to all SF6 circuit breakers in the last 25 years as part of leak repairs indicate that ABB HPL300 breakers account for 46% of the SF6 lost, while only making up 19% of the equipment database. There are six of this type of CBs in service at Calvale. The recommended strategy for these ABB CBs is to replace those that are already leaking and recover good poles of replaced CBs to increase spare holdings to assist in managing others in the fleet. The close/trip times on 88102 breaker has also tested outside of specification and 88102-1 is within specification. It is recommended that both are replaced within 5 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of 40 years except CT which has a 50-year life.

Recommendation: Based on the above observations, it is recommended that CB's 88102 & 88102-1 including structures and foundations are replaced within the next 5 years preferably with a deadtank CB if economical. The CT's can be recovered and used as system spares. The rest of the HV plant is in good condition and no replacements are required in the next 10-year outlook.

2.2.13 H024-C07-507- 7 COUPLER BAY

The equipment in this bay is listed in Table 14, including health index value for each item. This bay was originally installed in 1998 with the CTs in this bay being replaced in 2015 as part of the twin leg CTs replacement project OR.01759.

Table 14 - C07-507 Equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C07-507--5070-1	Earth Switch	ABB Elpar	TEC	20032103	1999	3
H024-C07-507--5070-2	Earth Switch	Ngk Stanger	VSB	20014469	1998	3
H024-C07-507—5072	Circuit Breaker	ABB Sweden	HPL300B1 3PAR	20032095	1999	5
H024-C07-507--5072CTA	Current Transformer	Trench	SAS 300/9G	20082148	2015	2
H024-C07-507--5072CTB	Current Transformer	Trench	SAS 300/9G	20082149	2015	2
H024-C07-507--5072CTC	Current Transformer	Trench	SAS 300/9G	20082150	2015	2
H024-C07-507—5078	Isolator	Ngk Stanger	HCB	20014454	1998	3
H024-C07-507—5079	Isolator	ABB Elpar	SGF300p100+2E	20032098	1999	3

The circuit breaker installed in this bay is the HPL300 circuit breaker which as previously discussed has had common defects regarding SF6 leaks on the poles. The HPL300 breaker installed in this bay has not yet had any SF6 leaks develop and all recorded trip test times are within specification, however the most recent test was conducted in 2010. As the breaker is not leaking SF6, it is recommended that this breaker is not replaced and is instead monitored under regular routine maintenance.

The other primary plant installed in this bay is in good condition and no replacements are expected to be required within the next 15 year outlook.

The associated structures and foundations in this bay have a remaining service life of 40 years, except the CT structure & foundation which have an estimated remaining service life of 50 years.

Recommendation: Based on the above observations, all the primary plant in this bay is in good condition and no replacements are recommended in the next 10 year outlook.

2.2.14 H024-C07-854- 854 FEEDER BAY

The equipment for this bay is listed in the Table 15, including health index value for each item.

Table 15 - C07-854 Equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C07-854--15VTA	Capacitor Voltage Transformer	Ge Grid Solutions India	CCV 300	20128570	2019	1
H024-C07-854--15VTB	Capacitor Voltage Transformer	Ge Grid Solutions India	CCV 300	20128571	2019	1
H024-C07-854--15VTC	Capacitor Voltage Transformer	Ge Grid Solutions India	CCV 300	20128572	2019	1
H024-C07-854--8540	Earth Switch	ABB Elpar	TEC	20032102	1999	3
H024-C07-854--8540-1	Earth Switch	Ngk Stanger	VSB	20014472	1998	3
H024-C07-854--8540-2	Earth Switch	ABB Elpar	TEC	20032100	1999	3
H024-C07-854--8542	Circuit Breaker	ABB Sweden	HPL300/25B1 SPAR P	20014789	1998	5
H024-C07-854--8542-CTA	Current Transformer (Sf6)	Trench	SAS 300/9G	20082145	2015	2
H024-C07-854--8542-CTB	Current Transformer (Sf6)	Trench	SAS 300/9G	20082146	2015	2
H024-C07-854--8542-CTC	Current Transformer (Sf6)	Trench	SAS 300/9G	20082147	2015	2
H024-C07-854--8543	Isolator	Ngk Stanger	HCB	20014458	1998	3
H024-C07-854--8547	Isolator	ABB Elpar	SGF300p100+1E	20032096	1999	3

This bay was built in 2000 as part of project CP.0763 with the CVTs and CTs being replaced since.

The circuit breaker installed in this bay is the HPL300 circuit breaker which as previously discussed has had common defects regarding SF6 leaks on the poles. The HPL300 breaker installed in this bay has not yet had any SF6 leaks develop and as such it is recommended that this breaker is not replaced and is instead monitored under regular routine maintenance. The gas has been replaced in 2023 due to defect level dew points along with the desiccant, however this is not expected to contribute to deteriorating the condition of the breaker. The close/trip times are outside of nominal limits, however the opening time trips and closing times are within specified limits.

The other primary plant installed in this bay is in good condition and no replacements are expected to be required within the next 15-year outlook.

The associated structures and foundations are in good condition and are expected to have a remaining life of 40 years.

Recommendation: Based on the above observations, the primary plant in this bay is in good condition and no replacements are required in the next 10 year outlook.

2.2.15 H024-C07-8811- 8811 FEEDER BAY

The equipment for this bay is listed in the Table 16, including health index value for each item.

Table 16 - C07-8811 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-C07-8811-13VTA	Capacitor Voltage Transformer	GE	CCV 300	20137126	2023	1
H024-C07-8811-13VTB	Capacitor Voltage Transformer	GE	CCV 300	20137131	2023	1
H024-C07-8811-13VTC	Capacitor Voltage Transformer	GE	CCV 300	20137134	2023	1
H024-C07-8811-88110	Earth Switch	Ngk Stanger	VSB	20014465	1998	3
H024-C07-8811-88110-1	Earth Switch	Ngk Stanger	VSB	20014466	1998	3
H024-C07-8811-88110-2	Earth Switch	Ngk Stanger	VSB	20014473	1998	3
H024-C07-8811-88110-3	Earth Switch	Ngk Stanger	VSB	20014467	1998	3
H024-C07-8811-88110-4	Earth Switch	Ngk Stanger	VSB	20014468	1998	3
H024-C07-8811-88111	Isolator	Ngk Stanger	HCB	20014452	1998	4
H024-C07-8811-88112	Circuit Breaker	ABB Sweden	HPL300/25B1 SPAR P	20014791	1998	6
H024-C07-8811-88112-1	Circuit Breaker	ABB Transmission &Distribution	HPL300/25B1 SPAR P	20014792	1998	8
H024-C07-8811-88112CTA	Current Transformer (Sf6 - Gas)	ABB	TG300	20130658	2020	1
H024-C07-8811-88112CTB	Current Transformer (Sf6 - Gas)	ABB	TG300	20130659	2020	1
H024-C07-8811-88112CTC	Current Transformer (Sf6 - Gas)	ABB	TG300	20143747	2024	1
H024-C07-8811-88113	Isolator	Ngk Stanger	HCB	20014459	1998	4
H024-C07-8811-88117	Isolator	Ngk Stanger	HCB	20014453	1998	4
H024-C07-8811-88119	Isolator	Ngk Stanger	HCB	20014455	1998	4
H024-C07-8811-8811RSAA	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013154	1998	3
H024-C07-8811-8811RSAB	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013155	1998	3
H024-C07-8811-8811RSAC	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013156	1998	3
H024-C07-8811-8811SAA	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20014970	1998	3
H024-C07-8811-8811SAB	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013168	1998	3
H024-C07-8811-8811SAC	Surge Arrestor (Gapless)	Cooper Power Systems	AZG3025G190240	20013150	1998	3

This bay was originally built in 1998 all the primary plant in this bay is relatively new. The CVTs in this bay were replaced in 2024 due to the defective Trench model being installed and the CTs in this bay were replaced in 2025 due to the defective IMB300 model previously being installed.

Both ABB HPL300 CB 88112-1 are 27 years old and developed gas leaks in 2008 which have required top ups with gas multiple times. Both CB’s have been topped up with SF6 gas several times since 2007 which has required a high engagement of maintenance resources. 88112 circuit breaker has been confirmed to no longer be leaking, while the 8812-1 circuit breaker still has a slow leak on the A phase pole. 88112-1 has been particularly troublesome with ~20kg of SF6 added throughout its lifetime which is ~70% of its entire contents. Repairs have consistently been unsuccessful. Both circuit breakers have

recently had their gas replaced along with their desiccants. 88112 and 88112-1 trip times are both within specification. It is recommended that the 8812-1 is replaced within 3 years. It is not expected that 8812 circuit breaker will require replacement within the next 10 years.
All the other primary plant in this bay is not expected to require replacement within the next 10 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of 40 years.

Recommendation: Based on the above observations, it is recommended that CB 88112 -1 including structures and foundations are replaced within the next 3 years. The rest of the HV plant is in good condition and no replacements are required in the next 10 year outlook.

2.2.16 H024-D04-442- 132kV 2 TRANSFORMER BAY

The equipment for this bay is listed in the Table 17, including health index value for each item.

All the primary plant in this bay was installed in 1987. All the primary plant in this bay is in relatively good condition.

Table 17 - D04-442 equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-D04-442--2SAA	Surge Arrestor (Gapless)	Hitachi	ZLA-X15S	20005109	1986	7
H024-D04-442--2SAB	Surge Arrestor (Gapless)	Hitachi	ZLA-X15S	20005111	1986	7
H024-D04-442--2SAC	Surge Arrestor (Gapless)	Hitachi	ZLA-X15S	20005110	1986	7
H024-D04-442--4420	Earth Switch	Siemens	SSB111-145	20011035	1976	5
H024-D04-442--4421	Isolator	Siemens	SSBIII-145	20005103	1987	5
H024-D04-442--9VTC	Capacitor Voltage Transformer	Haefely	CVE145/650	20005122	1986	7

The disconnectors installed in this bay are the Hapam type SSBIII-145's which have experienced significant reliability issues associated with the deterioration of the contacts within the moving contact arm assembly. Poor contact design has been responsible for the development of high contact resistances which have exceed the maximum allowable values in significant portion (over 30%) of the in-service population. Excessive contact resistance has the risk of escalating into an arcing fault situation and failure in service. This issue was fixed in 2020 when the isolator arms were replaced.

The CVT installed in this bay was manufactured by Haefely and is currently 39 years old. No condition based defects have been raised against this CVT, however given the CVT is oil filled with porcelain bushings (producing a safety risk for personnel on site) and the expected lifetime of these designs are only 40 years, it is recommended that it is replaced within the next 3 years.

The surge arrestors installed in this bay are manufactured by Hitachi and are 39 years old. No condition based defects have been raised against them, however these surge arrestors have only been designed for a technical design life of 40 years. When exceeding this age, no guarantee can be made that they will function correctly. As such it is considered prudent to replace them within the next 3 years.

Recommendation: Based on the above observations, the CVTs and surge arrestors should be replaced within the next 3 years. The other primary plant in this bay is in good condition and no replacements are required in the next 10-15 year outlook.

2.2.17 1311 – 33kV Underground Cable TX2

The underground cable is listed in the table below, including a health index.

Table 18 - 33KV UGC

Functional Loc.	Description	Manufacturer	Model number	Start up date	HI
1311	Underground Cable			01/07/1987	6

The underground cable was commissioned in 1987 and is a 33kV, consisted of three single core 185mm^2 cables with copper conductor and max continuous current of 345A in each core. The sheath insulation resistance tests for all cores are within acceptable limits. It has been reported that the cable has rusting on the washer of the cable termination, deteriorating coating on the associated insulators, leaking oil from the C phase cable termination/pothead. It is estimated that the cable has 10-15 years of service life remaining based on its condition. The fault level of this cable however is underrated for the site and as such this should be replaced as soon as possibly.

Figure 16 - Deteriorated coating on associated insulator

Recommendation: Based on the above observations, the underground cable is in good condition for its age however given its fault level is below the calculated fault level at this site, this underground cable should be replaced as soon as possible.

2.3 Bus Diameters

2.3.1 275kV & 132kV Bus Diameters

The equipment associated with both 275kV & 132kV buses are listed in Table 18, including a health index value for each item.

Table 19 - 132kV and 275kV bus equipment

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-KC--KC1--1BUSSAA	Surge Arrestor (Gapless)	Hitachi	ZLA-X25C	20005115	1986	7
H024-KC--KC1--1BUSSAB	Surge Arrestor (Gapless)	Hitachi	ZLA-X25C	20005116	1986	7
H024-KC--KC1--1BUSSAC	Surge Arrestor (Gapless)	Hitachi	ZLA-X25C	20005120	1986	7
H024-KC--KC1--1VTB	Capacitor Voltage Transformer	Trench Limited	TCVT300C	20085021	2013	1

H024-KC--KC1--5910	Earth Switch	Merlin Gerin	DR	20011050	1976	6
H024-KC--KC2--2BUSSAA	Surge Arrestor (Gapless)	Hitachi	ZLA-X25C	20005119	1986	7
H024-KC--KC2--2BUSSAB	Surge Arrestor (Gapless)	Hitachi	ZLA-X25C	20005118	1986	7
H024-KC--KC2--2BUSSAC	Surge Arrestor (Gapless)	Hitachi	ZLA-X25C	20005117	1986	7
H024-KC--KC2--2VTB	Capacitor Voltage Transformer	Trench Limited	TCVT300C	20085086	2014	1
H024-KC--KC2--5920	Earth Switch	Merlin Gerin	DR	20011051	1976	6

The equipment in the bus diameters are all original with exception of the CVTs where 2VTB was replaced in 2020 and 1VTB was replaced in 2023.

The capacitor voltage transformers are like new and in good condition.

The surge arrestors installed for the bus diameters are 39 years old and are manufactured by Hitachi. No condition-based defects have been raised against them, however these surge arrestors have only been designed for a technical design life of 40 years. When exceeding this age, no guarantee can be made that they will function correctly. As such it is considered prudent to replace them within the next 3 years.

The earth switches installed have been identified to be the model that have a long operation rod which is easily bent when operated. An engineering design is available and has been implemented on both earth switches in this bay.

In both 275kV & 132kV yards bus support structures have been built as lattice type structures and tubular poles. The bus support post insulators are in very good condition when inspected in 2020 and the associated structures and foundations in these buses are in good condition. However, a number of the structures were identified to have advanced corrosion of the bolts as shown in Figure 24. It is recommended to replace all corroded bolts.

The lattice structures and foundations installed in late 1990s and 2000s were tubular structures which have an estimated remaining service life of 20 years. The rest of the tubular structures and foundations have an estimated remaining service life of 40 years.

Lattice structures were used as bus supports in the initial construction while in the late 1990s and 2000s tubular structures were used. All structures are in good condition when inspected in 2020 and no significant issues were found. Examples of the lattice and tubular structures are shown in the figures below.

Figure 15: 275kV Lattice Bus Support Structure

Figure 16: 275kV Tubular Bus Support Structure

The 132kV bus support structures were established in 2019 and are in as new condition. The structures support all three phases as shown in the figures below.

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Figure 17: 132kV Bus Support Structure

Figure 18: 275kV Tubular Bus Support Structure

Recommendation: The corroded bolts on all structures are recommended to be replaced immediately. The surge arrestors should also be replaced within 3 years. Apart from this, based on the above observations, the rest of the primary equipment in these bays is in good condition and no replacements are required in the next 10-15 year outlook.

2.4 Strung Bus and Structures

From ground level both 275kV & 132kV strung bus conductors and connectors over the bays appear to be in good condition when inspected in 2020.

The overhead earth wire appears to be in good condition. The connections of the earth wire to their strain towers vary in configuration but these are also in good condition when inspected in 2020.

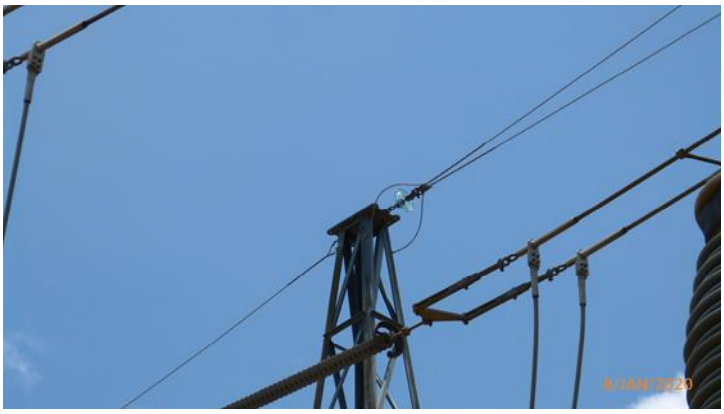

Figure 19: Earth wire

Figure 20: strung bus conductors

The 275kV strain structures were established between 1984 and 2013. All 275 kV strain structures are the same lattice type as shown in the figures below. No issues related to the structures were found in 2020.

Figure 21: 275kV Strain Structure

Figure 22: 275kV Structure Main Leg

2.5 Site Infrastructure

2.5.1 AC supply transformers

There are two AC supplies, one is via 19.1/0.433 kV auxiliary transformer connected to the tertiary of power transformer T2 and other connected to H030 Callide B 6.6kV board via a 6.6/0.433 kV auxiliary transformer. These provide adequate and reliable local supply for this substation.

These two station transformers are in good condition. However, the 4 station transformer is 50 year old and has approached the end of it's service life.

Figure 23: 3 Stn Transformer

Figure 24: 4 Stn Transformer

Figure 25: Diesel generator

Table 20- AC supply Transformers

Functional Loc.	Description	Manufacturer	Model number	Equipment Number	Construction year	HI
H024-SIN-ACSU-3STN	LOCAL SUPPLY TRF	TYREE	MODEL396	20005104	1998	5
H024-SIN-ACSU-4STN	LOCAL SUPPLY TRF	WILSON	6.6KV 300KVA	20011325	1975	7
H024-SIN-ACSU-1DIESEL	DIESEL ALTERNATOR 150kVA	GENELITE	-	20094170	2019	1

Recommendation: Based on the above observations, the station transformer 4 is recommended for replacement within next 3 years along with associated cables.

2.5.2 AC Changeover board

The AC changeover board was installed under project CP.01151 and is in good condition. The arc flash studies completed under OR.02429 found that the ACCO board is category 3 and that the incomer MCCBs F1 & F2 Isd should be changed to 1512A (though noting this will still result in a PPE category 3 for the board).

Figure 26: AC changeover board

Recommendation: Based on the above observations and records, the only action required is for the MCCBs Isd to be changed, apart from normal maintenance.

2.5.3 Security Fence

The substation security fence was upgraded to an electric fence in 2017.

The substation security fence consists of a standard chain wire fence and an electrical fence mounted on the inside of the chain wire fence. The chain wire fence is approximately 3m tall, has a bottom rail and barbed wires at the top. At the base of the fence is a concrete strip in line with Powerlink's standard requirements. The fence is in good condition and its civil aspects should provide about 20 year life before significant repairs are required. A section of the fence is shown in Figure 27.

Figure 27: Security Fence

2.5.4 Substation Access and Internal Roads

The Calvale Substation is accessed from Biloela Callide Rd, Biloela. This is a suburban road with good visibility of the entrance shown in Figure 28.

Figure 28: Substation access from Biloela Callide Rd

The access road through Powerlink's property between the road gate and the substation security gate is sealed and in good condition. The security gate and fence were not inspected due to the planned security fence upgrade project.

The substation internal roads are in a reasonable condition although broken in some areas. In particular the road surface is broken in the vicinity of the entry gate as shown in Figure 29.

Figure 29: Broken road surface

Recommendation: Based on the above observations and records, there is no action required in the next 10-15 year outlook, apart from normal maintenance.

2.5.5 Substation Yard, Platform and Site Drainage System

The substation platform is covered in gravel and is generally well maintained. Some evidence of minor surface water pooling was observed on the platform, however identifying any drainage issues was unlikely as the inspection occurred in dry weather.

2.5.6 Cable Trenches

There is no indication in the maintenance records of any issues related to the cable trench covers. They are generally in good condition with occasional gaps between covers and some bent covers that were obviously driven over. These should be rectified through condition based maintenance.

2.5.7 Yard Lights

The switchyard lights are weatherproof low level floodlights.

2.5.8 *Substation earthing*

2.5.8.1.1 Structure and equipment earthing

The lowest rated earth tail is suitable to conduct fault current of 27 kA for 250 ms, which is only just suitable for current fault level for this site.

Figure 30: no tail to fence

The fence post should be connect to the main earth grid at the grid crossings, it was noticed on site that this was not the case.

2.5.8.1.2 Earth grid

A grid injection test was performed in August 2018 and the results were satisfactory. However the earth grid design report (objective ID A2984746) recommended that gravel surfacing be completed inside the northeastern fence and the southwestern gate and an asphalt strip placed outside these areas as a minimum and ideally gravel throughout and the asphalt around the entire yard. It appears that this recommendation was not implemented. The current gravel layer installed inside the substation appears to be of smaller thickness usually used to reduce requirements for vegetation maintenance inside substations.

The earth grid is rated for fault currents up to 38 kA for 250 ms.

Figure 31: Gravel in the yard

Figure 32: Asphalt along part of the outside

3. EQUIPMENT REPLACEMENT RECOMMENDATION - OVERVIEW

In addition to the above mentioned recommended maintenance actions, it is recommended to replace below listed equipment in the next 5 year outlook. It is necessary to confirm the enduring need for this equipment prior to initiation of a replacement project.

Table 21- Equipment Replacement Recommendation Summary

Asset	Action Req. (Y/N)	Asset Replc. Recom. (Y/N)	Refurb. Recom. (Y/N)	Corr. Maint. Rec. (Y/N)	Comments
H024-C03-503	Y	Y (3 yrs)	N	N	Replace CB and CTs in 3 years.
H024-C03-541	Y	Y (3 yrs)	N	N	Replace CB, CTs & CVT in 3 years
H024-C03-8874	Y	Y (3 yrs)	N	N	Replace CB, CVTs & CTs in 3 years
H024-C04-504	Y	Y (3 yrs)	N	N	Replace CB and CTs in 3 years
H024-C04-542	Y	Y (3 yrs)	N	N	Replace CB and SAs in 3 years
H024-C04-851	Y	Y (3 yrs)	N	N	Replace CB & CTs in 3 years
H024-C05-505	Y	Y (3 yrs)	N	N	Replace CB & B/C phase CTs in 3 years. If economical replace A phase as well to allow dead tank CB
H024-C05-852	Y	Y (3 yrs)	N	N	Replace CB & CTs in 3 years
H024-C05-871	Y	Y (3 yrs)	N	N	Replace CB, A/B phase CTs & CVT in 3 years
H024-C06-506	Y	Y (5 yrs)	N	N	Replace CB in 5 years. If economical replace CTs to allow dead tank CB
H024-C06-853	Y	Y (5 yrs)	N	N	Replace CB in 5 years. If economical replace CTs to allow dead tank CB
H024-C06-8810	Y	Y (5 yrs)	N	N	Replace CB in 5 years. If economical replace CTs to allow dead tank CB
H024-C07-507	N	N	N	N	-
H024-C07-854	N	N	N	N	-
H024-C07-8811	Y	Y (3 yrs)	N	N	Replace CB & CVTs in 3 years. If economical replace CTs to allow dead tank CB
H024-D04-442	N	N	N	N	Replace CVT & Sas in 3 yrs
1 BUS DIAMETER	N	N	N	Y	Replace SAs in 3 yrs
2 BUS DIAMETER	N	N	N	Y	Replace SAs in 3 yrs
BUILDINGS	N	N	N	N	-
AC SUPPLY	Y	Y (3 yrs)	N	N	Replace Station 4 Transformer and assoc. cables
DC SUPPLY	N	N	N	N	-
EARTHING	Y	N	Y	N	Gravel surfacing to be completed inside the north eastern fence and asphalt coating throughout whole yard. Fence post earthing to connect to main earth grid at grid crossings.

3.1 Conclusions

The strategy for H024 Calvale Substation in the next 5 years outlook includes a mix of maintenance activities and replacement of nominated high voltage equipment and infrastructure as per the above Table. Revealed issues are related to the plant condition, unavailability of spares and therefore the inability to maintain the existing equipment. A high number of damaged porcelain insulators were also found on site. All of these represent risks to the provision of reliable supply and to safety of both personnel and public. Each risk is different and has a difference consequence. To manage the worst of these risks, replacement of some plant should be undertaken within next 3 years at the latest. Appropriate maintenance activities will be required to manage the remaining risks.

4. APPENDIX

- *Civil condition assessment report (Objective Id A3296102).*

- *Equipment list (SAP)*
- *Notifications, work orders and measurement documents (SAP)*
- *275kV & 132kV operating diagram*
- *Switchyard earth grid layouts*
- *Equipment, bay and feeder ratings*
- *Discussions with Powerlink technical staff*
- *Discussions with the maintenance service provider*
- *Relevant Powerlink drawings*
- *Electrical condition assessment report (Objective Id A3320203)*

4.1 Health Index Methodology

Health index for substation equipment is based on the condition of the equipment in the bay, condition of structures and foundations (all being assigned health index as condition indicator), It provides an indication of the remaining life based on its condition and criticality, rather than based on nameplate age.

Table 22- HI Methodology Overview

RI	Estimated Remaining Life(yrs)	Action	Comment	Comment
10	1 -2	condition assessment (CA) required on annual basis (or special maintenance regime)	project scoped and approved, included in the current Reset period	**Poor condition needs urgent action.**
9	2-3	CA required on annual basis (or special maintenance regime)	project scoped and in final approval stages, included in the current Reset period	Poor condition, needs prompt, planned action.
8	3 - 5	CA required on annual basis (or special maintenance regime)	project scoping, options analysis	
7	5 - 10	high level project scoped	high level project scoped for regulator, CA done	
6	10 - 20	CA trigger	CA to be done within 1 year and ready for next Reset, scope project before next Reset	Deteriorating condition, future replacement required, but in a planned fashion.
5	20 - 25	plan CA in 5 yrs		Aged satisfactory condition.
4	25 - 30	mid life CA (desktop)	Desktop assessment of notified issues	Needs some replacements, typically only few, minor components
3	30 - 35	annual review of HI and RI begins	aging - good condition	
2	35-40	good condition, annual review of notifications, dealing with infant mortality issues		
1	≥40	New		

Planning Report		**3/08/2020**
Title	CP.02922 – Calvale Substation Selective Replacement of Primary Plant	
Zone	Central West	
Need Driver	Emerging network, compliance and safety risks arising from the condition of ageing primary plant	
Network Limitation	Calvale Substation is required to maintain power transfer capabilities out of Central West Queensland to load centres in Gladstone and southern and northern Queensland and to meet Powerlink Queensland's N-1-50MW/600MWh Transmission Authority reliability standard.	
Pre-requisites	None	

Executive Summary

Calvale Substation is a bulk supply point for Moura and Biloela substations and is an essential switching substation for the transfer of power between Central-West Queensland and load centres in Gladstone, southern Queensland (SQ) and north Queensland (NQ) zones. Calvale substation also connects the local Callide generators to the network.

The Central scenario load forecasts show an enduring need for the supply of electricity to Biloela and Moura substations.

Emerging primary-plant condition risks at H024 Calvale Substation require Powerlink to take action in order to continue to meet its Transmission Authority reliability obligations for Moura and Biloela and avoid constraining the transfer of energy to load centres in SQ, NQ and Gladstone zones.

The preferred network solution for Powerlink to continue to meet its statutory obligations is the replacement of the at-risk primary plant.

Table of Contents

1. Introduction

The Calvale Substation provides an essential switching service for the transfer of energy between the Central-West, Southern Queensland, Gladstone and North Queensland grid sections. It also serves as the bulk supply point for Biloela and Moura and the point of connection for Callide B Power Station and Callide C Power Plant.

The substation was established in the mid-1980s with two 275kV generator connections for the Callide B Power Station and connecting feeders to Cedavale Tee and Stanwell Substation at 275kV and Callide A Substation at 132kV.

The Calvale Substation was subsequently extended in 1998 for the connection of Callide C Power Plant and the double circuit 275kV line to Tarong. Further extension was undertaken in 2013 to include additional bays for the Stanwell 275kV double circuit line.

Under the proposed Gladstone Project Priority Transmission Investment (PTI), Calvale Substation will be further expanded to connect a high capacity 275kV double circuit transmission line between Calvale and Calliope River substations. Furthermore, the proposed Callide Dedicated Network Asset (DNA) will also connect to the Calvale Substation. The Callide DNA is being designed to host up to 4,500MW of renewable generation.

Figure 1 shows the geographic location of the Calvale Substation.

Figure 1. Calvale Substation location in the Central Queensland region

This report assesses the impact that removal of the at-risk plant 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 the Calvale Substation.

2. H024 Calvale Substation configuration

Figures 2 and 3 show the operational configuration of the Calvale Substation and the primary plant identified in the condition report. The impacted primary plant is also listed in Appendix A.

[redacted]

Figure 2. Calvale 275kV Line Diagram

[redacted]

Primary Plant to be replaced under CP.02922

Figure 3. Calvale 132kV Line Diagram

The condition assessment [1] identified selected equipment in the original three diameters (C03, C04 & C05) with emerging condition and safety risks. In addition, the circuit breakers in diameters C06 and C07 have significant, irreparable SF6 leakage.

Future network augmentations associated with the Gladstone Project Priority Transmission Investment (PTI) also require the 275kV busbars at Calvale to be uprated.

3. Calvale Transformers Demand Forecast

The Calvale Substation has two 275/132kV transformers supplying power to Biloela and Moura substations. An outage of both transformers will result in their loss of supply.

The historic and forecast maximum demand of Moura and Biloela load is shown in Figure 4. Over the next 10 years, the maximum demand is forecasted to remain steady.

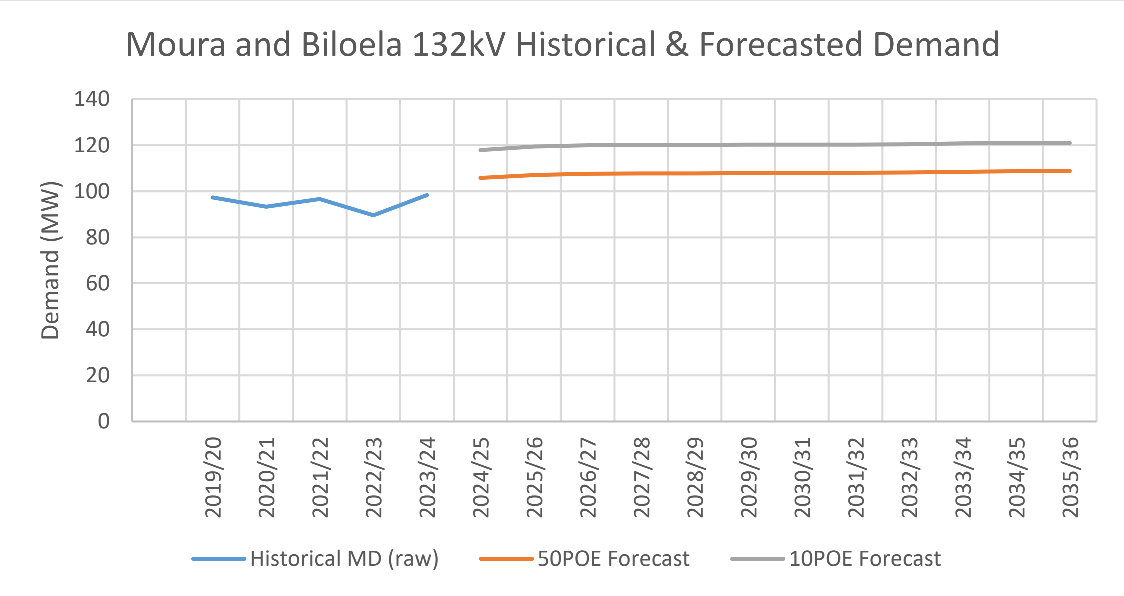

Figure 4. Calvale 132kV Maximum Demand

Figure 5 shows the duration curve for the loads connected to Calvale's 132kV network.

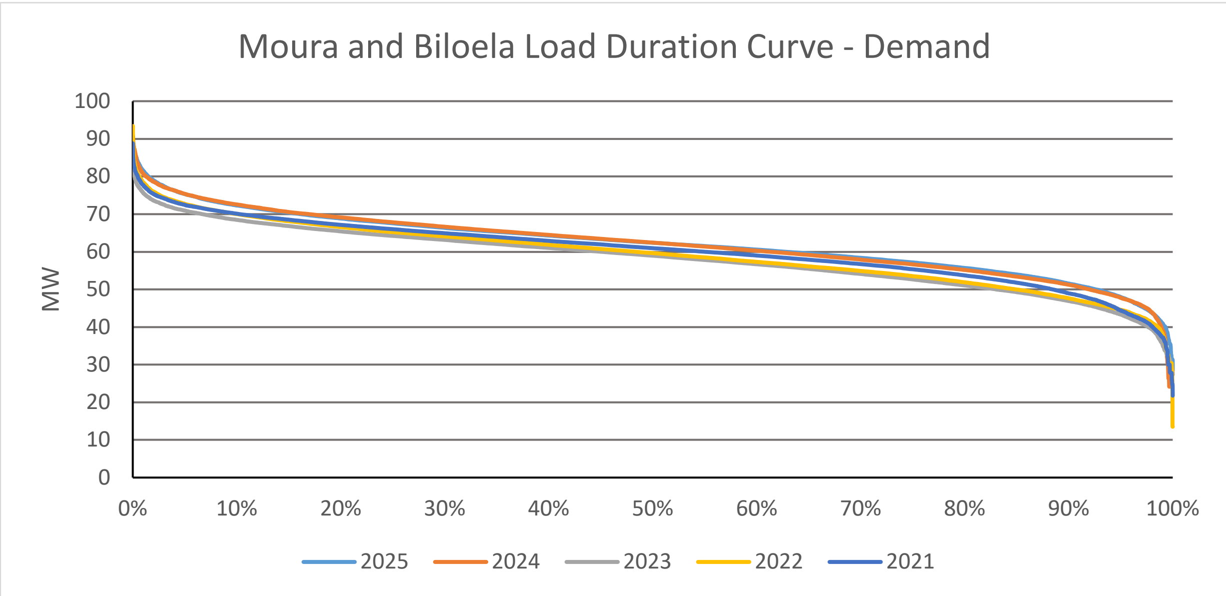

Figure 5. Calvale 132kV Load Duration Curve

The 132kV network supplied from Calvale Substation also connects the 82MW Moura Solar Farm (connects to Moura Substation at 132kV).

4. Statement of Investment Need

The Calvale Substation provides connection to the Callide generators, supplies the loads of Biloela and Moura, and performs a vital switching function for critical grid sections between Central West and Gladstone zones and to southern and northern Queensland.

The failure to replace the at-risk primary plant at the Calvale Substation would breach the N-1-50MW/600MWh Transmission Authority reliability standard to Moura and Biloela substations and Boyne Island Smelter.

Removal of a 275kV feeder, due to a primary plant failure, would also reduce the power transfer capability out of the Central West zone and consequently have a market impact.

A new 275kV double circuit is to be constructed between Calvale and Calliope River substations under the Gladstone Project Priority Transmission Investment (PTI). This double circuit line is being constructed with High Temperature Conductor (HTC). The thermal rating per circuit is approximately 2200MVA. The requires the 275kV busbars at Calvale to be uprated.

5. Network Risk

Table 1 summarises the load and energy at risk due to failure of primary plant at Calvale Substation.

Table 1. Calvale 132kV Load at Risk

At Risk	Contingency	Metric	2025	2031
Moura & Biloela Loads (without Blackwater loads)	Outage of 2T (CVT) followed by outage of 1T (trip)	Max (MW)	93	105
		Average (MW)	63	69
		24h Energy Unserved Max (MWh)	1970	2047
		24h Energy Unserved Average (MWh)	1523	1657
Boyne Potline No. 3	Outage of 871 [1] (CVT) followed by outage of 818 (trip)	Max (MW)	425	425
		Average (MW)	417	417
		24h Energy Unserved Max (MWh)	10200	10200
		24h Energy Unserved Average (MWh)	10003	10003
Boyne Potline No. 1	Outage of 871 (1) (CVT) followed by outage of 7146 (trip)	Max (MW)	135	225
		Average (MW)	132	221
		24h Energy Unserved Max (MWh)	3240	5400
		24h Energy Unserved Average (MWh)	3177	5295
Boyne Potline No. 2	Outage of 871 (1) (CVT) followed by outage of 7145 (trip)	Max (MW)	290	290
		Average (MW)	284	284
		24h Energy Unserved Max (MWh)	6960	6960
		24h Energy Unserved Average (MWh)	6825	6825

Note 1:

(1) In the event of an outage of feeder 871, Boyne Island 132kV bus is split. Potline 3 is connected to the 275kV and Potlines 1 and 2 are connected to separate 132kV feeders (7145 and 7146). As a result, each potline is at risk for the next (2^{nd}) credible contingency.

6. Market impact risk

Table 4 summarises the market impact of removing each of these circuits in-turn. The table defines the maximum and average difference in total system costs (including emission reduction benefits) per 24-hour period with and without the at-risk circuit in-service. The analysis also takes account of any impact on the operation the VRE plant due to system strength impacts.

The analysis assumes that there is not impact on the generation investment pathway as a result of this outage.

The methodology used to assess these market impacts is outlined in Appendix C.

Table 1 – Calvale multiple 275kV Feeders outage Market Impact

At Risk	Contingency	Metric	$M
Constraint on Central West generation	Outage of 8874	Max 24h incremental system operational cost ($m)	0.116
		Average 24h incremental system operational cost ($m)	0.00003
Constraint on Central West and North Queensland generation	Outage of 871	Max 24h incremental system operational cost ($m)	1.351
		Average 24h incremental system operational cost ($m)	0.056
Constraint on Central West and North Queensland generation	Outage of 8810	Max 24h incremental system operational cost ($m)	0.557
		Average 24h incremental system operational cost ($m)	0.007

7. Non-Network Options

Potential non-network solutions for the 132kV network would need to provide supply to the 66kV Biloela and Moura loads. To non-network solution must be capable to delivering up to 110MW and 2000MWh per day. The non-network solution would be required to be capable of operating during a contingency or outage on a continuous basis until normal supply is restored.

Powerlink is not aware of any Demand Side Solutions (DSM) in the area supplied by Calvale Substation. However, Powerlink will consider any proposed solution that can contribute significantly to the requirements of ensuring that Powerlink continues to meet its required reliability of supply obligations as part of the formal RIT-T consultation process.

8. Network Options

8.1 Preferred network option to meet the identified need

The recommended network solution is the replacement of all 275kV and 132kV primary equipment reaching end of life at H024 Calvale Substation. This option ensures that all reliability of supply and asset condition criteria is met as well as maintaining the power transfer capability between Central West and Gladstone and North and South Queensland zones.

In addition to the condition-based replacement of selected primary plant, the recommended option also increases the rating of the 275kV buses to 9900A.

The rating of the existing 275kV bus is 3490 Amps (~1700MVA).

Figure 2 shows the layout of the existing circuits at Calvale Substation. Historically, power flows have been predominately south on the Calvale to Halys double circuit line and the Callide Power Plant (C units) are in the same diameters. This configuration helps manage bus currents.

However, network augmentations are planned to connect to the Calvale Substation. These projects include:

- Double circuit high capacity 275kV line, utilising high temperature conductor (HTC) between Calvale and Calliope River substation, with an emergency rating of approximately 2250MVA/circuit. The final approval of this project is with the Queensland Government[1]. Early works funding has been approved to preserve a March 2029 commissioning date.

- Double circuit high capacity 275kV line, utilising high temperature conductor (HTC) between the Callide Regional Energy Hub (REH) and Calvale Substation. This REH is being designed to have a transmission network capacity of up to 2650MVA on this double circuit line.

- Powerlink's current strategy (refer to Network Investment Outlook) emphasizes a shift toward a more western Central to Southern Queensland (CQ-SQ) upgrade to better capture the high-quality wind resources in the Darling Downs and Surat Regional Energy Hubs (REHs). The development can be staged, leveraging existing inland corridors until generation and load growth justifies further augmentation. Importantly, the Calvale Substation serves as a critical switching hub, allowing staged connections that postpone the need for full-scale reinforcement.

Due to substation expansion constraints and entry and exist constraints, these new high capacity 275kV double circuit lines are required to connect to diameters at opposite ends of the substation (refer to Figure 6). The existing bus rating (3490A) is less than the rating of these individual circuits.

As a result, this configuration can result in high bus currents and significant exceedance of the bus rating when one bus is out of service. To avoid far more expensive relocation of circuit alignment across diameters the project proposes to uprate the two 275kV buses to at least 9900A.

[1] As a network augmentation proposed under the Gladstone Project Priority Transmission Investment (PTI)

[redacted]

Figure 6. Calvale 275kV Substation layout

8.2 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.

8.2.1 Do Nothing

"Do Nothing" would not be an acceptable option as the primary drivers (primary system condition) and associated safety, reliability and compliance risks would not be resolved. 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.

8.2.2 Central West Supply from Blackwater Substation

Under the current configuration, Blackwater Substation is unable to supply the loads of Biloela and Moura. Feeder 7113 (Blackwater to Baralaba) has been removed from service due to condition. Therefore, investment in a second circuit would be required to deliver the required reliability of supply to Moura and Biloela. Furthermore, reinvestment in the Baralaba Substation primary and secondary systems and dynamic reactive power control at Moura to address voltage stability and system strength limitations[2] would be required.

This option is not economically feasible.

9. Recommendations

Emerging primary-plant condition risks at H024 Calvale Substation require Powerlink to take action in order to continue to meet its Transmission Authority reliability obligations for Moura

[2] Compliance of Moura Solar Farm with Generator Performance Standards

and Biloela and avoid constraining the transfer of energy to load centres in SQ, NQ and Gladstone zones.

The preferred network solution for Powerlink to continue to meet its statutory obligations is the replacement of the at-risk primary plant.

10. References

1. H024 Calvale Substation Electrical Condition Assessment Report 2020, A3320203
2. H024 Calvale Replace Selective Primary Plant CP.02922 project scope, A5798005
3. 2025 Transmission Annual Planning Report (A6049612)
4. Asset Planning Criteria - Framework (ASM-FRA-A2352970)
5. Powerlink Queensland's Transmission Authority T01/98

11. Appendix A - Primary Plant to be Replaced under CP.02922

Func Location	Equipment	Network impact
H024-C03-503--5032	Coupler CB 1T and 8874	N-3 required before impact
H024-C03-503--5032CTA	Coupler CT	N-3 required before impact
H024-C03-503--5032CTB	Coupler CT	N-3 required before impact
H024-C03-503--5032CTC	Coupler CT	N-3 required before impact
H024-C03-541--5412	2 Bus CB 1T	N-3 required before impact
H024-C03-541--5412CTA	CT	N-3 required before impact
H024-C03-541--5412CTB	CT	N-3 required before impact
H024-C03-541--5412CTC	CT	N-3 required before impact
H024-C03-541--7VTB	CVT 1T 275/132kV Tx	N-2 (1T & 2T trip) results in LOL
H024-C03-8874-88742	Bus CB (feeder 8874)	N-3 required before impact
H024-C03-8874-8874CTA	Bus CT	N-3 required before impact
H024-C03-8874-8874CTB	Bus CT	N-3 required before impact
H024-C03-8874-8874CTC	Bus CT	N-3 required before impact
H024-C03-8874-8874VTA	CVT 8874	N-1 (8874 OOS) market impact
H024-C03-8874-8874VTB	CVT 8874	N-1 (8874 OOS) market impact
H024-C03-8874-8874VTC	CVT 8874	N-1 (8874 OOS) market impact
H024-C04-504--5042	Coupler CB 2T and Call B 1G	N-2 (5042 & 8512 CB/CT Call B 1G OOS) market impact
H024-C04-504--5042CTA	CT	N-3 required before impact
H024-C04-504--5042CTB	CT	N-3 required before impact
H024-C04-504--5042CTC	CT	N-3 required before impact
H024-C04-542--5422	2 Bus CB 2T	N-3 required before impact
H024-C04-851--8512	1 Bus CB Call 1G	N-2 (8512 & 5042 CB/CT Call B 1G OOS) market impact
H024-C04-851--8512CTA	CT	N-2 (8512 & 5042 CB/CT Call B 1G OOS) market impact
H024-C04-851--8512CTB	CT	N-2 (8512 & 5042 CB/CT Call B 1G OOS) market impact
H024-C04-851--8512CTC	CT	N-2 (8512 & 5042 CB/CT Call B 1G OOS) market impact
H024-C05-505--5052	Coupler CB 871 and Call B 2G	N-2 (5052 & 8522 CB/CT Call B 1G OOS) market impact N-2 (5052 & 8712 CB/CT feeder 871 OOS) market impact N-3 (871 & 881) BSL #3 N-3 (871 & 7145) BSL #1

		N-3 (871 & 7146) BSL #2
H024-C05-505--5052CTA	CT	N-2 (5052 & 8522 CB/CT Call B 1G OOS) market impact N-2 (5052 & 8712 CB/CT feeder 871 OOS) market impact N-3 (871 & 881) BSL #3 N-3 (871 & 7145) BSL #1 N-3 (871 & 7146) BSL #2
H024-C05-505--5052CTB	CT	N-2 (5052 & 8522 CB/CT Call B 1G OOS) market impact N-2 (5052 & 8712 CB/CT feeder 871 OOS) market impact N-3 (871 & 881) BSL #3 N-3 (871 & 7145) BSL #1 N-3 (871 & 7146) BSL #2
H024-C05-505--5052CTC	CT	N-2 (5052 & 8522 CB/CT Call B 1G OOS) market impact N-2 (5052 & 8712 CB/CT feeder 871 OOS) market impact N-3 (871 & 881) BSL #3 N-3 (871 & 7145) BSL #1 N-3 (871 & 7146) BSL #2
H024-C05-852--8522	2 Bus CB feeder Call 2G	N-2 (8522 & 5052 CB/CT Call 2G OOS) market impact
H024-C05-852--8522CTA	CT	N-2 (8522 & 5052 CB/CT Call 2G OOS) market impact
H024-C05-852--8522CTB	Ct	N-2 (8522 & 5052 CB/CT Call 2G OOS) market impact
H024-C05-852--8522CTC	CT	N-2 (8522 & 5052 CB/CT Call 2G OOS) market impact
H024-C05-871--4VTB	CVT	N-1 (871) market impact N-2 (871 & 881) BSL #3 LOL N-2 (871 & 7145) BSL #1 LOL N-2 (871 & 7146) BSL #2 LOL
H024-C05-871--4VTSB	CVT	N-1 (871) market impact N-2 (871 & 881) BSL #3 LOL N-2 (871 & 7145) BSL #1 LOL N-2 (871 & 7146) BSL #2 LOL
H024-C05-871--4VTSC	CVT	N-1 (871) market impact N-2 (871 & 881) BSL #3 LOL N-2 (871 & 7145) BSL #1 LOL N-2 (871 & 7146) BSL #2 LOL
H024-C05-871--8712	2 Bus Feeder 871	N-2 (8712 & 5052 CB/CT 871 OOS) market impact
H024-C05-871--8712CTA	CT	N-2 (8712 & 5052 CB/CT 871 OOS) market impact

H024-C05-871--8712CTB	CT	N-2 (8712 & 5052 CB/CT 871 OOS) market impact
H024-C06-506--5062	Coupler CB (8810 & Call 3G)	N-2 (5062 & 8532 CB/CT Call 3G OOS) market impact N-2 (5062 & 88102 CB/CT 8810 OOS) market impact
H024-C06-853--8532	1 Bus Call 3G CB	N-2 (8532 & 5062 CB/CT Call 3G OOS) market impact
H024-C06-8810-88102	2 Bus 8810 CB	N-2 (88102 & 5062 CB/CT 8810 OOS) market impact N-2 (88102 & (853 CB/CT or 853 trip)) Call 3G OOS) market impact
H024-C06-8810-88102-1	2 Bus 8810 CB	N-2 (88102 & 5062 CB/CT 8810 OOS) market impact N-2 (88102 & (853 CB/CT or 853 trip)) Call 3G OOS) market impact
H024-C06-853--8532CTA	CT	N-2 (8532 & 5062 CB/CT Call 3G OOS) market impact N-2 (8532 & 8810 trip 8810 OOS) market impact
H024-C06-853--8532CTB	CT	N-2 (8532 & 5062 CB/CT Call 3G OOS) market impact N-2 (8532 & 8810 trip 8810 OOS) market impact
H024-C06-853--8532CTC	CT	N-2 (8532 & 5062 CB/CT Call 3G OOS) market impact N-2 (8532 & 8810 trip 8810 OOS) market impact
H024-C06-8810-88102CTA	CT	N-2 (88102 & (5062 CB/CT or 853 trip) 8810 OOS) market impact
H024-C06-8810-88102CTB	CT	N-2 (88102 & (5062 CB/CT or 853 trip) 8810 OOS) market impact
H024-C06-8810-88102CTC	CT	N-2 (88102 & (5062 CB/CT or 853 trip) 8810 OOS) market impact
H024-C07-854--8542CTA	CT	N-2 (8542 & 5072 CB/CT Call 3G OOS) market impact N-2 (8542 & 8811 trip 8811 OOS) market impact
H024-C07-854--8542CTB	CT	N-2 (8542 & 5072 CB/CT Call 3G OOS) market impact N-2 (8542 & 8811 trip 8811 OOS) market impact
H024-C07-854--8542CTC	CT	N-2 (8542 & 5072 CB/CT Call 3G OOS) market impact N-2 (8542 & 8811 trip 8811 OOS) market impact
H024-C07-8811-88112CTA	CT	N-2 (88112 & (5072 CB/CT or 854 trip) 8810 OOS) market impact

H024-C07-8811-88112CTB	CT	N-2 (88112 & (5072 CB/CT or 854 trip) 8810 OOS) market impact
H024-C07-8811-88112CTC	CT	N-2 (88112 & (5072 CB/CT or 854 trip) 8810 OOS) market impact
H024-C07-8811-88112	2 Bus 8811 CB	N-2 (88112 & (5072 CB/CT or 854 trip) 8811 OOS) market impact
H024-C07-854--8542	1 Bus Call 4G CB	N-2 (8542 & (5072 CB/CT or 8811 trip) 8811 OOS) market impact
H024-C07-507--5072	Coupler CB 8811 & Call 4G	N-2 (5072 & (88112 CB/CT or 8811 trip) 8811 OOS) market impact N-2 (5072 & (8542 CB/CT or 854 trip) Call 4G OOS) market impact
H024-C07-8811-88112-1	2 Bus 8811 CB	N-2 (88112 & (5072 CB/CT or 854 trip) 8811 OOS) market impact
H024-D04-442-9VTC	CVT 2T 275/132kV Tx	N-2 (2T & 1T trip) results in LOL

12. Appendix B – Market Impact Assessment

Market modelling was used to assess the operational market impact of network limitations as a result from outages of primary system equipment at the Calvale Substation.

The market modelling approach is consistent with the regulatory investment test for transmission requirements that a market benefit "must be a benefit to those who consume, produce and/or transport electricity in the market, that is, the change in producer plus consumer surplus." Critically, a market benefit must not "include the transfer of surplus between consumers and producers".[3]

As such, the market impact is assessed by comparing the changes in costs for market participants due to the differences in the operational and maintenance costs (including fuel costs), changes in involuntary load shedding (at the value of customer reliability [VCR] [4]), and changes in greenhouse gas emissions (at the value of emissions reduction [VER] [5])

The market modelling simulations considered committed and anticipated generators were commissioned on time, coal units closed according to their announced dates (as of December 2025), and modelled generation and storage projects consistent with the Queensland Energy Roadmap 2025.[6] The profiles of demand and energy available for variable energy resources followed the 2015 weather reference year as published by AEMO, as being a year found to result in 'median' outcomes.

A schedule of generator planned outages was modelled. However, generator forced outages were not considered. Instead, a reserve requirement is maintained via a reserve constraint equation, and therefore unserved energy may be underestimated in some circumstances.

Appropriate network detail (in the form of network constraints or sub-regional transfer limits) was added to adequately represent the network capability across major grid sections.

The outage (transmission lines as a result of the failure of primary system equipment at Calvale Substation) was modelled as occurring in perpetuity to approximately capture the effect of this occurring at any time.

The market impact was then quantified as the differential total system cost (as above) for each hour between a base case with all transmission equipment in-service against the state of the world with an outage of impacted plant. Both the hourly and a moving 24-hour differential cost were determined.

The values in the report tables capture the maximum differential total system cost for any 24-hour period (averaged over the 5-year analysis period) and the average differential total system cost for a 24-hour period (over the 5-year analysis period).

[3] AER, November 2024, "Regulatory investment test for transmission", p4

[4] AER, December 2024, "Values of customer reliability: Final report on VCR values" available at

[5] AER, May 2024, "Valuing emissions reduction: AER guidance and explanatory statement"

[6] The State of Queensland (Queensland Treasury), October 2025, "Energy Roadmap"

Project Scope Report

CP.02922

H024 Calvale Replace Selective Primary Plant

Concept – Version 2

Document Control

Change Record

Issue Date	Revision	Prepared by	Reviewed by	Approved by	Background
8/4/25	1	[redacted]	[redacted]	[redacted]	
14/5/25	2	[redacted]		[redacted]	Inclusion of D04 CVT in Attachment 1 and maximum bay current rating added

Related Documents

Issue Date	Responsible Person	Objective Document Name
24/02/2020	[redacted]	H024 Calvale Substation Electrical Condition Assessment Report_2020 (A3320203)
31/01/2020	[redacted]	Calvale Civil Condition Assessment 2020 (A3296102)
22/02/2018	[redacted]	PIF_H024 Calvale Selective Primary Plant Replacement (A2886504)

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, MP 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

H024 Calvale Substation was established in the mid-1980s. It is located in Central Queensland area and has 275/132kV operating voltages in one yard. The 275/132kV systems at Calvale substation were originally built in 1988 to connect two generator units at H030 Callide B Power Station, Wurdong feeder 871 and T022 Callide A feeder 7161 (Bay C03 and C05).

The substation was extended in 1998 to connect H050 Callide C Power Station and Tarong substation (Bay C06 and C07) including two feeder reactor bays. In 2013, two new bays (C01 and C02) were established to reinforce the network between Calvale and Stanwell due to thermal constraints arising from increased demand on the Central Queensland Network.

As a result of substation extensions with load growth and system augmentation, a mixture of primary plant is currently established at Calvale, ranging in age from 1988 through to 2013. A condition assessment was carried out in 2020 that identified selected equipment in the original three diameters (C03, C04 & C05) requires replacement. In addition to this, the circuit breakers in diameters C06 and C07 have significant, irreparable SF6 leaks and replacement of these breakers is also recommended.

In addition to the condition risks, it is expected that future network augmentations will drive a requirement to uprate the 275kV busbars at Calvale.

The objective of this project is to replace selected primary plant and undertake uprating works at Calvale substation by September 2033 for Option 1 and October 2040 for Option 2.

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

2. Project Drawing

[redacted]

Figure 1: Calvale 275kV Line Diagram (A0-H-104155-001)

[redacted]

Figure 2: Calvale 132kV Line Diagram (A1-H-155983-001)

[redacted]

Figure 3: Calvale Ultimate Development

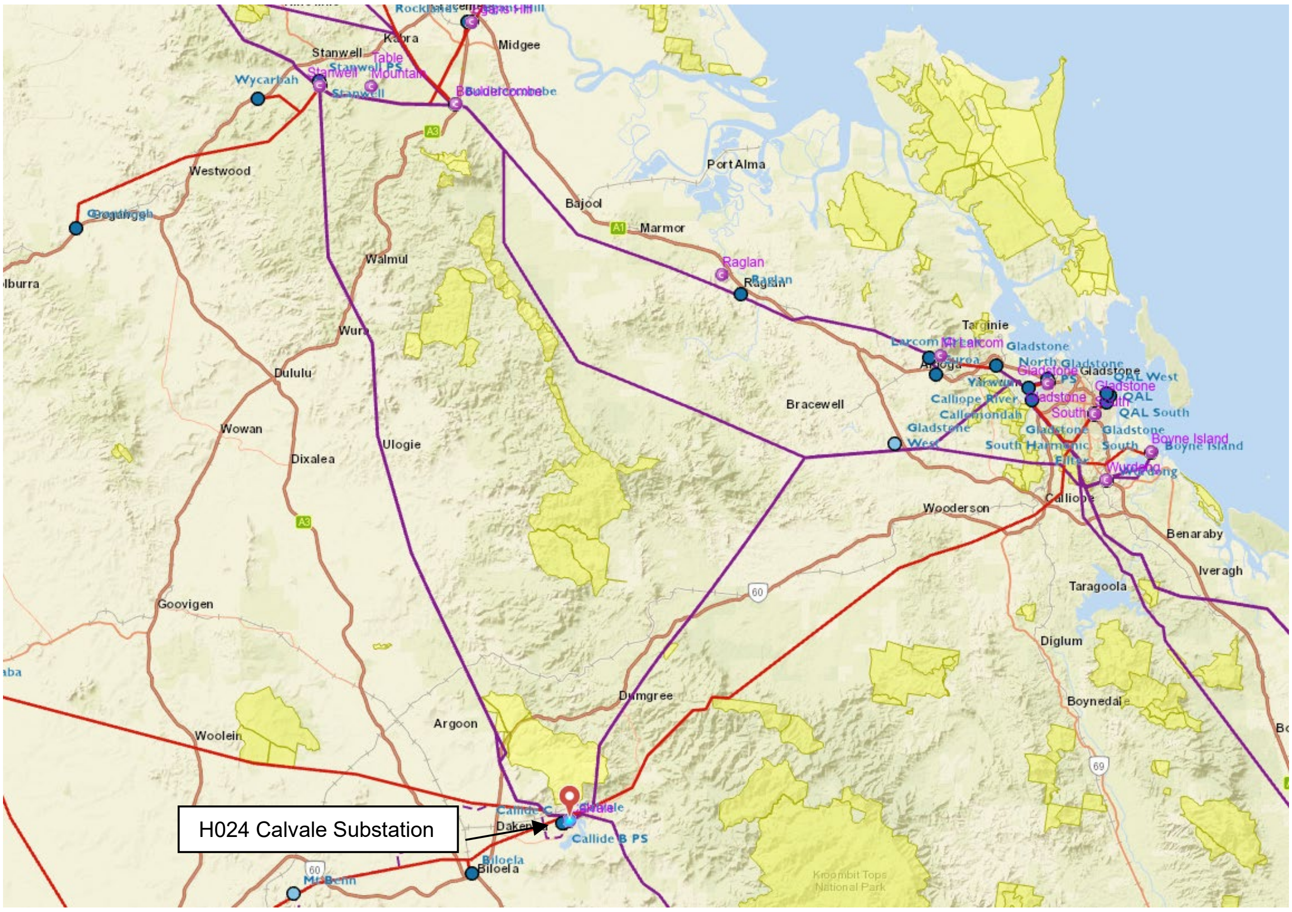

Figure 4: Location of H024 Calvale Substation

3. Deliverables

The following deliverables are to be provided in response to this Project Scope Report. The requirement dates for these deliverables will be communicated separately.

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 with consideration of the following:

    - Enduring need for the Callide B Power Station is uncertain. Works at Calvale to replace equipment in the associated bays are to be estimated as a separable portion.

    - Enduring need for the Callide C Power Station is uncertain. Works at Calvale to replace equipment in the associated bays are to be estimated as a separable portion.

    - Works associated with uprating the 275kV busbars is to be estimated as a separable portion.

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. Provide a high level project schedule for each option and identify any requirements for early funding to meet the commissioning date (e.g. procurement of long lead time equipment).

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 replacement of selected primary plant and uprating works at Calvale substation.

Two credible options have been identified to replace selected equipment at Calvale substation, as presented in Table 1 below. These options will be presented in the RIT-T public consultation. Concept estimates are required for each option to inform feasibility and cost assessments.

Table 1 - Options summary

Option	Stage	Works	Comm. Date
1	1	Undertake all condition driven replacements of selected primary plant and undertake works to uprate 275kV busbars and remove bus zone CT feeder rating limitations	September 2033
2	1	Uprate 275kV busbars and undertake all condition driven replacements of selected primary plant excluding plant in diameters C06 and C07	September 2033
	2	Undertake condition driven replacements of selected primary plant and replacement of bus zone CTs to uprate feeders in diameters C06 and C07	Oct 2040

4.1.1. Transmission Line Works

Not applicable

4.1.2. Option 1 – Single Stage Replacement - H024 Calvale Substation Works

Design, procure, construct and commission the replacement of the selected primary plant listed in Attachment 1, with consideration of the following:

- For bays requiring both CB and CT replacement, consideration should be given to utilising dead tank circuit breakers;
- Current transformers used for bus zone protection must be sufficiently rated to avoid limiting power flows on any feeders. Planning have advised the CT ratio must be sufficient to support a maximum emergency bay current rating of 5,500A (maximum rating driven by Mt Benn feeders); and
- Existing structures and foundations are to be reused where possible, ensuring they are fit for purpose for a minimum of 40 years.

Uprating of 275kV 1 and 2 busbars to 11,000 Amps (min at 40°C).

Decommission and recover all redundant equipment, and update drawing records, SAP records, config files, etc. accordingly.

4.1.3. Option 2 – Two Stage Replacement - H024 Calvale Substation Works

As per scope of Option 1 with the following exceptions:

- Replacement works for the C06 and C07 diameter are to be commissioned by October 2040.

4.1.4. Telecoms Works

Not applicable

4.1.5. Easement/Land Acquisition & Permits Works

Not applicable

4.2. Key Scope Assumptions

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

- Under [redacted]) will be built. (Only the Q20 and Q30 bays will be populated under CP.02942).

4.3. Variations to Scope (post project approval)

Not applicable

5. Key Asset Risks

From an asset risk perspective, priority is to be given to replacement of porcelain instrument transformers in diameters C03, C04 and C05 due to increased probability of catastrophic failure presenting a high safety risk.

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

6. Project Timing

6.1. Stage 1 Approval Date

The anticipated date by which the project will be Stage 1 approved is March 2026.

6.2. Site Access Date

This is an operational substation, therefore, site access is 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, is 30th September 2033 and October 2040 for Option 2.

The project team is to assess the earliest possible delivery date for these works as part of the Concept Estimate and provide a schedule of key milestones and funding requirements to meet this date. The project team are to advise the Sponsor as soon as possible if preapproval funding is required to procure long lead time equipment before completion of the estimate to meet the proposed commissioning date.

7. Special Considerations

- For feeders 8810 and 8811 reactor breaker outages need to be kept as short as practically possible due to potential charging voltage issues with the feeders during energisation. If possible, short recall times on these would also assist with facilitating the outages.

- Feeders 8810 and 8811 are crucial CQ-SQ feeders so any unnecessary delays when/if required to put these back into service under urgency should be avoided.
- Bus outages may be onerous from an operations perspective due to the critical role that Calvale station plays in supporting central generation, Boyne Island smelter and CQ-SQ power transfer. Although not a credible contingency, operations would need to assess the implications if a critical central 275kV connection is lost. Therefore, it is critical to keep bus outages to a minimum duration and recall times are to be minimised as much as possible
- Operations have a preference to have the reactor outages run separate to both the '2 Bus' outages and CB 88102/88112 outages due to potential charging voltage issues with the feeders during energisation.
- Outages on Calvale bus and feeders 855, 871, 8873 and 8874 will have system strength implications and operations will need to consider outages in relation to other programmes of work/outages in north Queensland, as well as the market impact they can potentially have.
- Outages on feeder 871will require Boyne Island to be radialised, placing substantial Load at Risk (LAR). Therefore, short outages and short recall times (<2Hrs) will be essential to meet customer requirements.
- Outages on Transformers 1 and 2 will also potentially place LAR, so minimising outage durations and recall times would be beneficial.
- Due to these complexities, it is important that outages are programmed with as much notice as possible (i.e. ideally 13 months out, but not less than 6 months) to have a greater chance of success from a works programme perspective.

8. Asset Management Requirements

Equipment shall be in accordance with Powerlink equipment strategies.

Unless otherwise advised Pat Tighe will be the Project Sponsor for this project. The Project Sponsor must be included in any discussions with any other areas of Network and Business Development including Asset Strategies & Planning.

Reza Matouri will provide the primary customer interface with Callide Power Station. The Project Sponsor should be kept informed of any discussions with the customer.

9. Asset Ownership

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

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

Not applicable

12. Division of Responsibilities

Not applicable

13. Related Projects

Project No.	Project Description	Planned Comm Date	Comment
Pre-requisite Projects			
Co-requisite Projects			
Other Related Projects			
CP.02942 (Combined with CP.03087)	Banana Range Wind Farm Connection	April 2028	Calvale site works may require co-ordination
CP.02928 (Combined with CP.03095)	Calvale to Calliope River 275kV DCST Transmission Line	October 2028	Calvale site works may require co-ordination

Attachment 1: Primary Plant to be Replaced under CP.02922

Func Location	Equipment	Manufacturer	Start up date
H024-C03-503--5032	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C03-503--5032CTA	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-503--5032CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-503--5032CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-541--5412	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C03-541--5412CTA	CURRENT TRANSFORMER	HAEFELY	16.02.1996
H024-C03-541--5412CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-541--5412CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-541--7VTB	CAPACITOR VOLTAGE TRANSFORMER	HAEFELY	01.07.1984
H024-C03-8874-88742	CIRCUIT BREAKER (SF6 SPRING MultiVol)	MITSUBISHI	02.08.1988
H024-C03-8874-8874CTA	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-8874-8874CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-8874-8874CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C03-8874-8874VTA	CAPACITOR VOLTAGE TRANSFORMER	TRENCH	
H024-C03-8874-8874VTB	CAPACITOR VOLTAGE TRANSFORMER	TRENCH	
H024-C03-8874-8874VTC	CAPACITOR VOLTAGE TRANSFORMER	TRENCH	
H024-C04-504--5042	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C04-504--5042CTA	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C04-504--5042CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C04-504--5042CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C04-542--5422	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C04-851--8512	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C04-851--8512CTA	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C04-851--8512CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C04-851--8512CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C05-505--5052	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C05-505--5052CTA	CURRENT TRANSFORMER	GEC ALSTHOM - T&D BALTEAU	29.10.1997
H024-C05-505--5052CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C05-505--5052CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1987
H024-C05-852--8522	CIRCUIT BREAKER	MITSUBISHI	02.08.1988
H024-C05-852--8522CTA	CURRENT TRANSFORMER	HAEFELY	20.12.1995
H024-C05-852--8522CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C05-852--8522CTC	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C05-871--4VTB	CAPACITOR VOLTAGE TRANSFORMER	HAEFELY	01.07.1987
H024-C05-871--4VTSB	CAPACITOR VOLTAGE TRANSFORMER	HAEFELY	01.01.1985
H024-C05-871--4VTSC	CAPACITOR VOLTAGE TRANSFORMER	HAEFELY	01.01.1985
H024-C05-871--8712	CIRCUIT BREAKER	MITSUBISHI	02.08.1988

H024-C05-871--8712CTA	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C05-871--8712CTB	CURRENT TRANSFORMER	HAEFELY	01.01.1986
H024-C06-506--5062	CIRCUIT BREAKER	ABB SWEDEN	01.07.1998
H024-C06-853--8532	CIRCUIT BREAKER	ABB SWEDEN	04.12.1998
H024-C06-8810-88102	CIRCUIT BREAKER	ABB SWEDEN	04.12.1998
H024-C06-8810-88102-1	CIRCUIT BREAKER	ABB TRANSMISSION &DISTRIBUTION	04.12.1998
H024-C06-853--8532CTA	CURRENT TRANSFORMER (SF6)	TRENCH	1/10/2015
H024-C06-853--8532CTB	CURRENT TRANSFORMER (SF6)	TRENCH	1/10/2015
H024-C06-853--8532CTC	CURRENT TRANSFORMER (SF6)	TRENCH	1/10/2015
H024-C06-8810-88102CTA	CURRENT TRANSFORMER (SF6)	TRENCH	22/10/2015
H024-C06-8810-88102CTB	CURRENT TRANSFORMER (SF6)	TRENCH	22/10/2015
H024-C06-8810-88102CTC	CURRENT TRANSFORMER (SF6)	TRENCH	22/10/2015
H024-C07-854--8542CTA	CURRENT TRANSFORMER (SF6)	TRENCH	15/04/2015
H024-C07-854--8542CTB	CURRENT TRANSFORMER (SF6)	TRENCH	15/04/2015
H024-C07-854--8542CTC	CURRENT TRANSFORMER (SF6)	TRENCH	15/04/2015
H024-C07-8811-88112CTA	CURRENT TRANSFORMER (SF6)	TRENCH	21/02/2025
H024-C07-8811-88112CTB	CURRENT TRANSFORMER (SF6)	TRENCH	21/02/2025
H024-C07-8811-88112CTC	CURRENT TRANSFORMER (SF6)	TRENCH	21/02/2025
H024-C07-8811-88112	CIRCUIT BREAKER	ABB SWEDEN	4/12/1998
H024-C07-854--8542	CIRCUIT BREAKER	ABB SWEDEN	4/12/1998
H024-C07-507--5072	CIRCUIT BREAKER	ABB SWEDEN	19/11/1998
H024-C07-8811-88112-1	CIRCUIT BREAKER	ABB TRANSMISSION &DISTRIBUTION	04.12.1998
H024-D04-442-9VTC	CAPACITIVE VOLTAGE TRANSFORMER	HAEFELY	01.07.1987
H024-SIN-ACSU-4TRF	LOCAL SUPPLY TRF	WILSON	01.07.1976
H024-KC1-1BUS	275kV 1 BUS		05/07/1999
H024-KC2-2BUS	275kV 2 BUS		05/07/1999

CP.02922 H024 Calvale Replace Selective Primary Plant

Concept Estimate

Table of Contents

1. Executive Summary

H024 Calvale Substation was established in the mid-1980s. It is located in Central Queensland area and has 275/132kV operating voltages in one yard. The 275/132kV systems at Calvale substation were originally built in 1988 to connect two generator units at H030 Callide B Power Station, Wurdong feeder 871 and T022 Callide A feeder 7161 (Bay C03 and C05).

The substation was extended in 1998 to connect H050 Callide C Power Station and Tarong substation (Bay C06 and C07) including two feeder reactor bays. In 2013, two new bays (C01 and C02) were established to reinforce the network between Calvale and Stanwell due to thermal constraints arising from increased demand on the Central Queensland Network.

As a result of substation extensions with load growth and system augmentation, a mixture of primary plant is currently established at Calvale, ranging in age from 1988 through to 2013. A condition assessment was carried out in 2020 that identified selected equipment in the original three diameters (C03, C04 & C05) requires replacement. In addition to this, the circuit breakers in diameters C06 and C07 have significant, irreparable SF6 leaks, and replacement of these breakers is also recommended.

In addition to the condition risks, it is expected that future network augmentations will drive a requirement to uprate the 275kV busbars at Calvale.

The assessment behind this proposal has established that the project can only be delivered by September 2033.

The project will follow the two (2) stage approval process and is subject to a RIT-T.

1.1 Project Estimate

No escalation costs have been considered in this estimate.

		Total ($)
Estimate Class	5	
Base Estimate – Un-Escalated (2025/2026)		39,165,651
TOTAL		**39,165,651**

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 2027	2,908,715
To June 2028	1,940,068
To June 2029	11,346,949
To June 2030	6,820,065
To June 2031	6,820,065
To June 2032	6,820,065
To June 2033	1,745,518
To June 2034	764,206
TOTAL	**39,165,651**

2. Project and Site-Specific Information

2.1 Project Dependencies & Interactions

Project No.	Project Description	Planned Commissioning Date	Comment
Interactions			
CP.02942	Banana Range Wind Farm Connection	Mar 2028	Calvale site works require co-ordination
CP.02928	Calvale to Calliope	Oct 2028	Calvale site works require co-ordination

2.2 Site Specific Issues

- From an asset risk perspective, priority is to be given to replacement of porcelain instrument transformers in diameters C03, C04 and C05 due to increased probability of catastrophic failure presenting a high safety risk.
- Asbestos register has no current findings, risk is Low, presumed asbestos on site
    - Presumed asbestos - Live electrical equipment to Powerlink yard - internals not accessed - The presence of asbestos containing materials cannot be ruled out.
    - Presumed asbestos - 9 x Mitsubishi circuit breakers throughout central sub yard. This particular model is presumed to feature asbestos containing components. Each breaker has 3 cabinets.
- The Calvale area is subject to the following average number of days of rain. Consideration was given to this when developing the project schedule

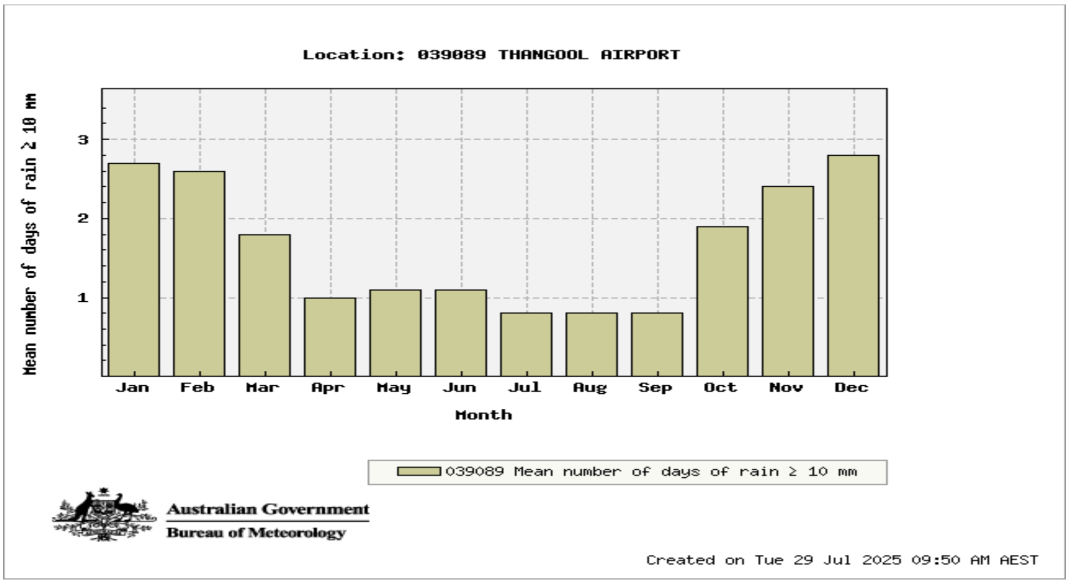

Figure 1 - Number of Days of Rain >10mm Brisbane (Source: Bureau of Meteorology 28th June 2025)

3. Project Scope

H020 Calvale Substation is a 275kV transmission substation located in Central Queensland on Biloela Callide Road Mount Murchison, 125km Southwest of Gladstone.

Briefly, the project consists of replacement of selected primary plant and uprating works at Calvale substation:

- Undertake all condition driven replacements of selected primary plant and undertake replacement works to uprate 275kV busbars and remove bus zone CT feeder rating limitations

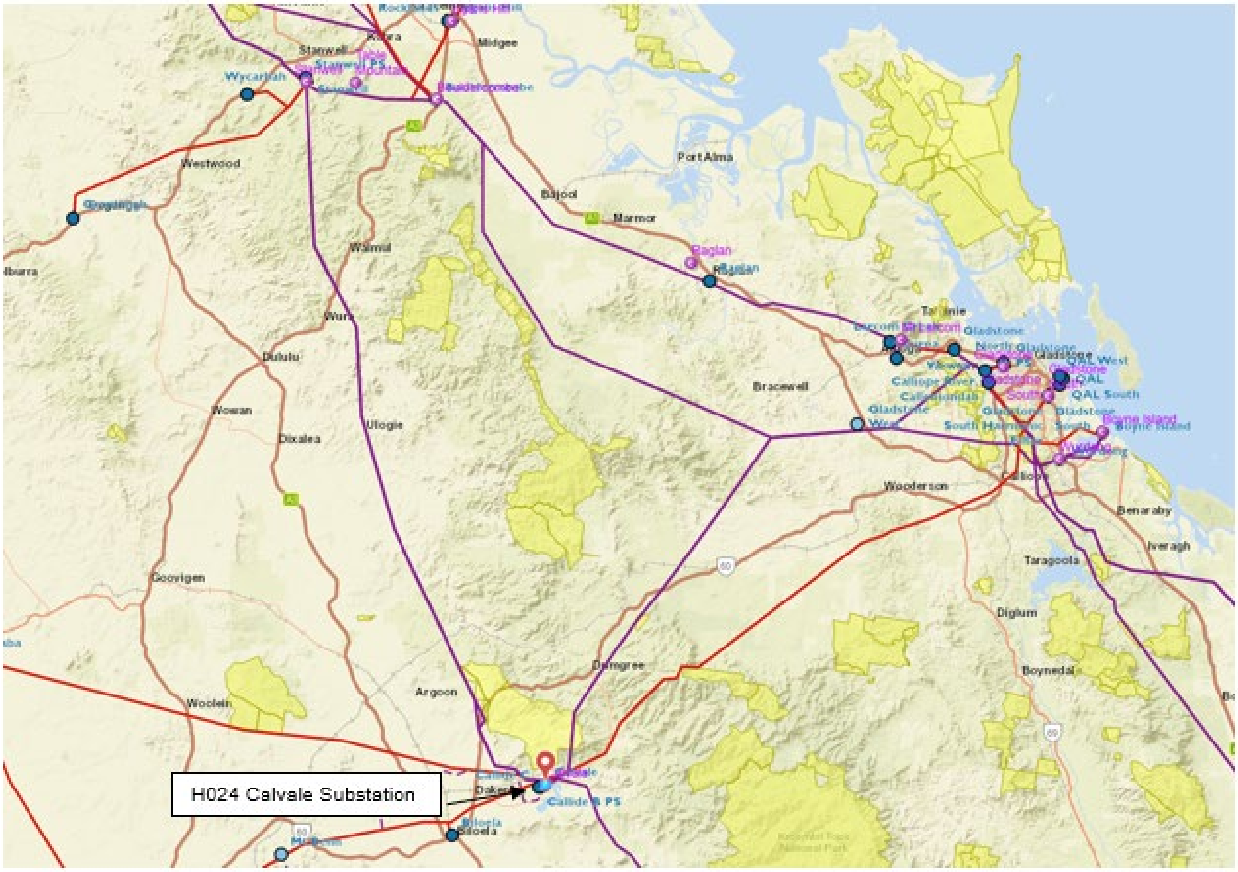

Figure 2 – H024 Calvale Location Diagram

[redacted]

Figure 3 - Calvale 275kV Line Diagram (A0-H-104155-001)

[redacted]

3.1 Substations Works

The project involves replacement of selected 275kV primary plant and uprating works at Calvale substation

- Design, procure, construct and commission the replacement of the selected primary plant listed in Attachment 1 with consideration of the following:
  - For bays requiring both CB and CT replacement, consideration should be given to utilising dead tank circuit breakers, on existing foundations.
  - Current transformers used for bus zone protection must have at least a 3000/1A ratio to avoid limiting power flows on the Calliope and Mt Benn feeders.
  - Existing structures and foundations are to be reused where possible, ensuring they are fit for purpose for a minimum of 40 years.
- Uprating of 275kV 1 and 2 busbars to 11,000 Amps (min at 40°C).
- Decommission and recover all redundant equipment, and update drawing records, SAP records, config files, etc. accordingly

3.2 Major Scope Assumptions

The following key assumptions were made for this Project Estimate:

- The 12 live tank circuit breakers being replaced with dead tank CBs and CVTs being replaced will be erected on new foundations.
- The 5 live-tank CBs (including 2 reactor CBs) will be replaced utilising the existing foundations.
- The local supply transformer will be replaced on new foundation and structure.
- The other primary plant being replaced including 5 live tank CB, and 7 CVTs will be replaced in-situ on new structures or adaptor plates.
- The existing busbars will be uprated and replaced under live subs due to feeder outage constraints.
- All existing primary plant will be decommissioned and disposed.
- The existing primary plant will be replaced under minor outage and live subs where specified.
- New bay kiosks are included for the 12 dead tank circuit breakers replacing live tank CBs and CTs.
- It is assumed that outages will be available as required.
- It is assumed that no Restricted Access Zone will be deployed on this site during construction.

3.3 Scope Exclusions

The following items are excluded from the Project Estimate:

- No new foundations are required for the in-situ replacement of 3 live tank CBs.
- Removal of rock or unsuitable material, including asbestos and other contaminants.
- No replacement of secondary systems cabling from the marshalling kiosk to the Control building.
- Extreme weather conditions.
- Additional time and cost for Design, Planning and Implementation of any restoration plans required for outages is not included in this estimate.
- Replacement of secondary systems cabling from the marshalling kiosk to the control building.
- No modification and upgrading of the internal roads, lights, fences and gates.

4. Project Execution

4.1 Project Schedule

Milestones	High-Level Timing
Request for Class 5 Estimate	September 2025
Class 5 Project Proposal Submission	December 2025
Request for Class 3 Estimate	February 2026
Class 3 Project Proposal Submission	August 2026
Stage 1 Approval (PAN1) includes funds for design & procurement, & ITT preparation	October 2026
RIT-T (assumed 26 weeks)	November 2026 – May 2027
Project Development Phase 1 & Phase 2	November 2026 – April 2028
ITT Submission (8 Weeks)	January 2028 – March 2028
Evaluate Tender, Reconcile Estimate and Submit PMP for Stage 2 Approval	April 2028
Stage 2 Approval (PAN2)	Jun 2028
Execute Delivery (including award of SPA contract)	July 2028
SPA Site Establishment	February 2029
SPA Civil Works and Construction	February 2029 – September 2033
MSP Site Establishment	April 2029
Staged Bay Construction and Commissioning	April 2029 – September 2033
Project Commissioning	September 2033

4.2 Network Impacts

- For feeders 8810 and 8811 reactor breaker outages need to be kept as short as practically possible due to potential charging voltage issues with the feeders during energisation. If possible, short recall times on these would also assist with facilitating the outages.
- Feeders 8810 and 8811 are crucial CQ-SQ feeders so any unnecessary delays when/if required to put these back into service under urgency should be avoided.
- Bus outages may be onerous from an operations perspective due to the critical role that Calvale station plays in supporting central generation, Boyne Island smelter and CQ-SQ power transfer. Although not a credible contingency, operations would need to assess the implications if a critical central 275kV connection is lost. Therefore, it is critical to keep bus outages to a minimum duration and recall times are to be minimised as much as possible.
- Operations have a preference to have the reactor outages run separate to both the '2 Bus' outages and CB 88102/88112 outages due to potential charging voltage issues with the feeders during energisation.
- Outages on Calvale bus and feeders 855, 871, 8873 and 8874 will have system strength implications and operations will need to consider outages in relation to other programmes of work/outages in north Queensland, as well as the market impact they can potentially have.
- Outages on feeder 871will require Boyne Island to be radialised, placing substantial Load at Risk (LAR). Therefore, short outages and short recall times (<2Hrs) will be essential to meet customer requirements.
- Outages on Transformers 1 and 2 will also potentially place LAR, so minimising outage durations and recall times would be beneficial.
- Due to these complexities, it is important that outages are programmed with as much notice as possible (i.e. ideally 13 months out, but not less than 6 months) to have a greater chance of success from a works programme perspective.
- To reduce the Return To Service time, the planned future outages of 8 weeks on Callide feeders will be utilized to deliver portions of construction.

4.3 Resourcing

- Civil works and new cable installation to be carried out by SPA contractor.
- Primary equipment replacement to be carried out by MSP.

5. Project Asset Classification

Asset Class	Base ($)	Base (%)
Substation Primary Plant	36,806,977	94%
Substation Secondary Systems	2,358,674	6%
Telecommunications	-	0%
Overhead Transmission Line	-	0%
TOTAL	**39,165,651**	**100**

6. References

Document name and hyperlink (as entered into Objective)	Version	Date
Project Scope Report	2.0	14/05/2025

Risk Cost Summary Report

CP. 02922

Calvale Selective Primary Plant Replacement

Document Control

Change Record

Issue Date	Revision	Prepared by
19/12/2025	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 and option risk cost profiles for the equipment at the Calvale Substation which are proposed for reinvestment under CP.02922. These risk cost profiles are then included as part of an overall cost-benefit analysis (CBA) to understand the economic benefit of the proposed 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 equipment at the Calvale Substation, the following modelling assumptions have been made:

- The functionality of the equipment is assumed to decay according to decay curves calculated by Powerlink, and associated probability of failure (PoF).
- Where equipment in scope is replaced, its associated Health Index (HI) score is reverted to one.
- The likelihood of personnel within the substation in the event of explosive failure of equipment (used to calculate safety risk) is assumed to be 25% (based upon historic site entry averages), with the likelihood of resulting injury or death depending on the explosive radius of the equipment, its housing, and the total substation land area. The modelling also assumes that personnel are equally likely to be anywhere within the substation land area. No escalation to the likelihood has been made during construction as it is assumed appropriate risk assessments and risk mitigation measures are completed by the project team.
- In the event of an SF6 gas leak, it is assumed that the entire quantum of SF6 gas is leaked.
- For the purposes of the cost-benefit analysis, the total useful asset life of 40 years has been applied.
- A site-specific value of customer reliability (VCR) of $25,750 has been applied when calculating network risks.

Base Case Risk Analysis

Risk Categories

Four main categories of risk are assessed as part of this project as consistent with Powerlink's Asset Risk Management Framework:

- Financial Risk
- Safety Risk

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

Table 1: Risk categories

Risk Category	Failure Types	Equipment in scope
Safety Risk	Explosive failure	All equipment with the potential to fail explosively
Financial Risk	Peaceful failure	All equipment
	Explosive failure	All equipment with the potential to fail explosively
Network Risk	Peaceful failure	All equipment related to network elements identified in the planning statement
Environmental Risk	Peaceful failure	Circuit breakers and current transformers containing SF6

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 $2.61 million in 2026 to $6.39 million in 2036 and $12.08 million by 2046. Key highlights of the analysis include:

- Financial risk forms approximately 79% of the base case risk in 2030. Of this, the majority is a result of peaceful failures modes with the risk dollars spread evenly across the bays included for re-investment.
- Network risk and safety risk accounts for approximately 15% and 5% of the total risk. A lower proportion of network risk is reflective of the circuit breaker and a half substation arrangement while low safety risks reflect a conservative assumption that personnel are unlikely to be in proximity of equipment during an explosive failure event
- Environmental risk has been calculated and totals 1% of the base case risk.

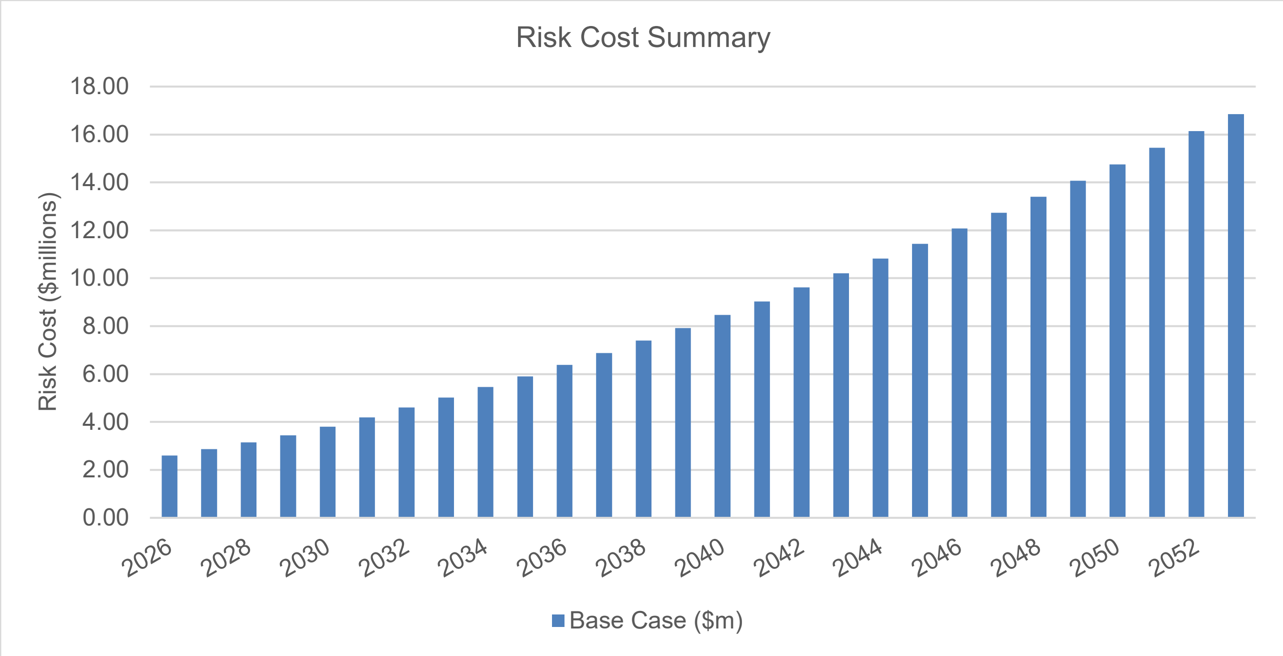

Figure 1: Total risk cost

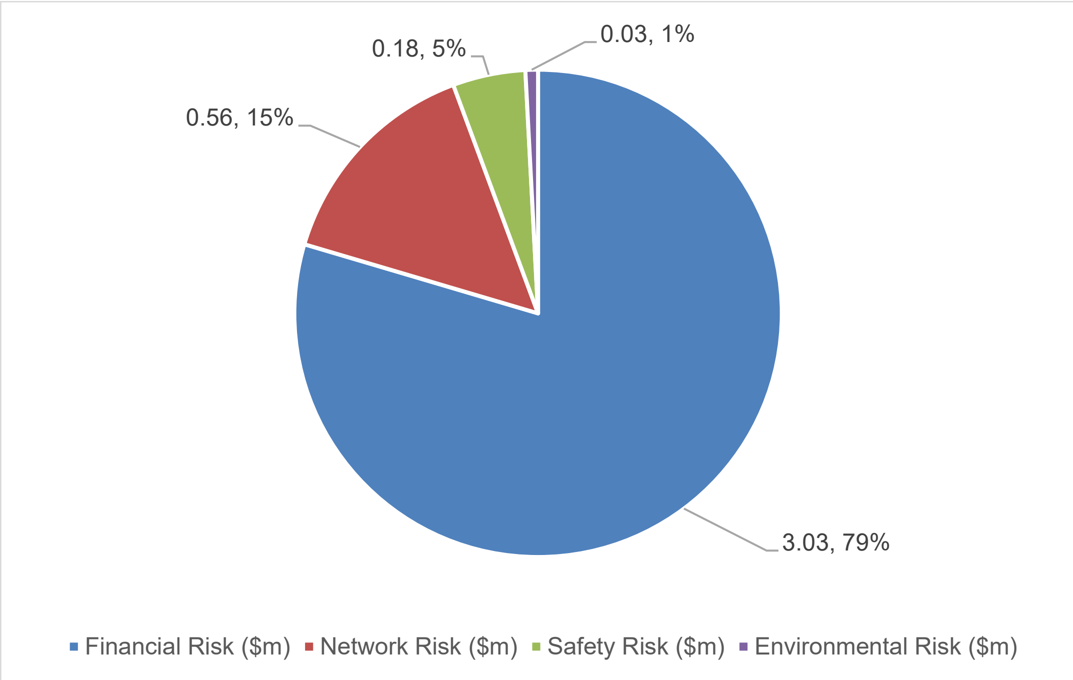

Figure 2: Base case risk cost by contributions (2030)

Option Risk Cost

For modelling purposes, the replacement of equipment at the Calvale substation reduces effective HI scores to one, significantly lowering its probability of failure and therefore risk cost.

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

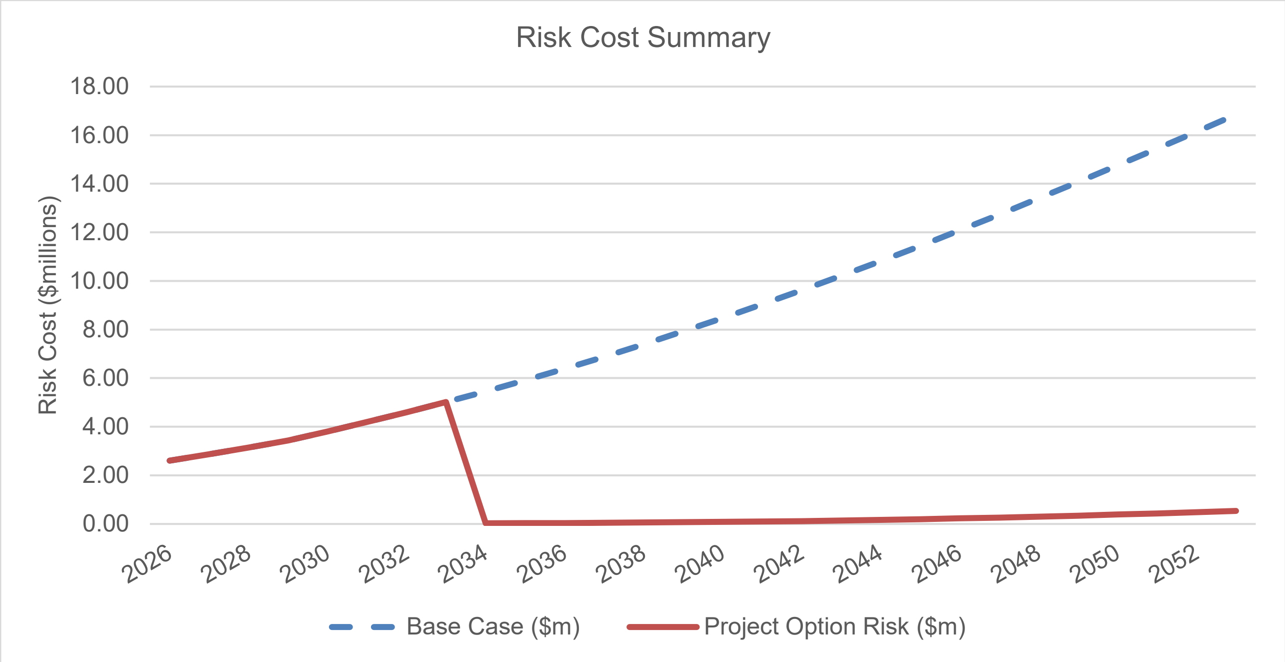

Figure 3: Project Option Risk Cost (compared to base case)

Following the year of investment (2033) the risk cost associated with the equipment in scope effectively reduces to approximately $0.03m. By 2046, the risk cost of the project option is approximately $0.23 million, compared with the base case risk cost of $12.08 million.

Cost Benefit Analysis

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

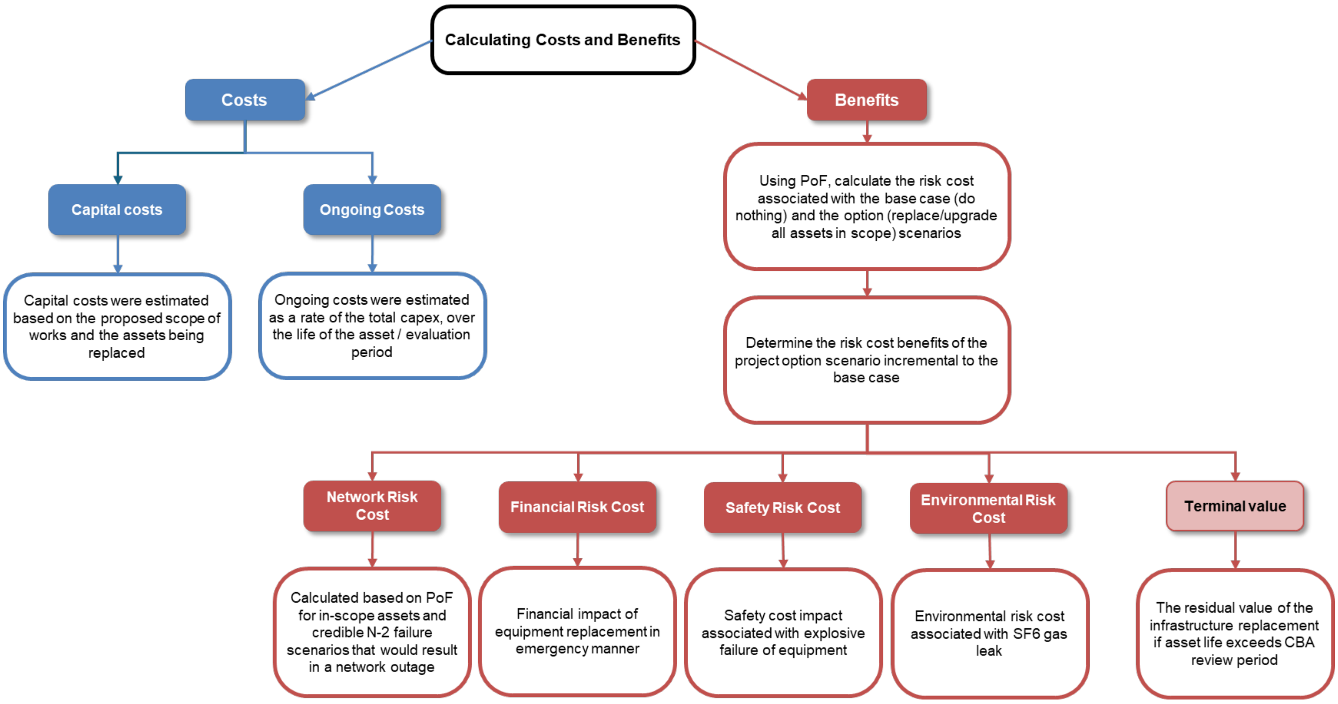

Figure 4: CBA methodology

The project is estimated to cost approximately $39.2 million. This represents a significant cost saving over the estimated financial risk cost of replacing assets individually in an emergency manner, due to the efficiencies associated with planned upgrades.

Based on a baseline discount factor of 7%, the project has a net present value (NPV) of $50.9 million over a 35-year period, and a benefit-cost ratio (BCR) of 3.23.

The project also has a positive NPV and BCR when a discount factor of 10% is applied.

Given this, replacement of the nominated assets within this project is considered appropriate.

Table 2: Net Present Value and Benefit-Cost Ratio

		Present Value Table ($m)		
Discount rate	%	**3%**	**7%**	**10%**
NPV of Net Gain/Loss	$m	$142.2	$50.9	$23.6
Benefit-Cost Ratio	ratio	5.6	3.23	2.29

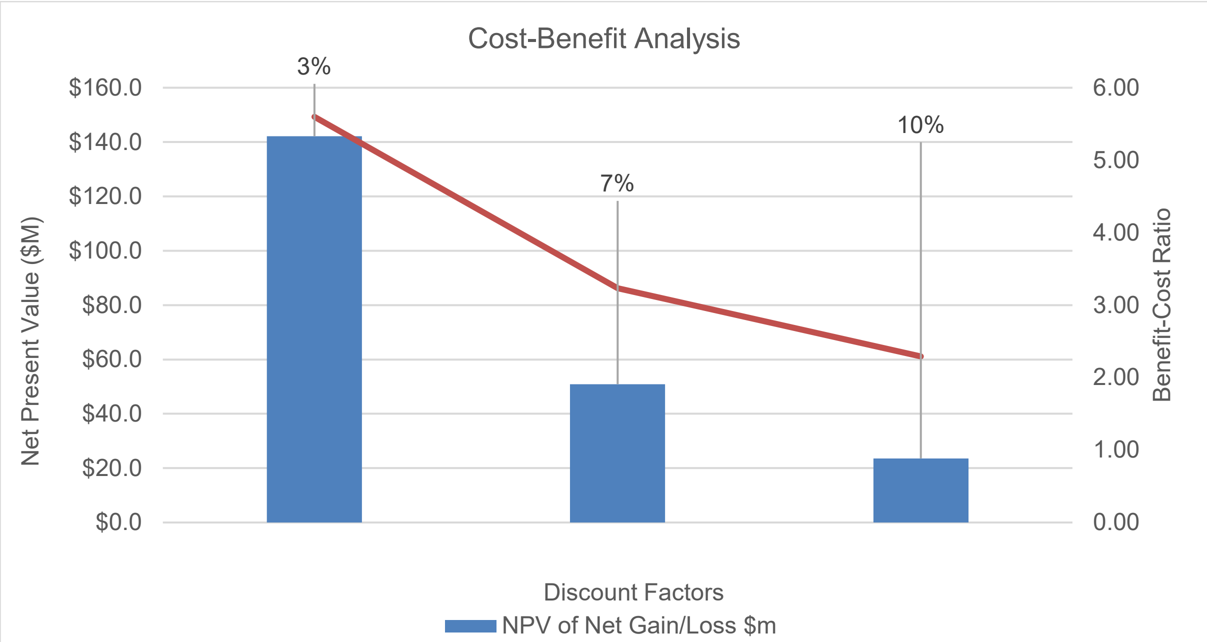

Figure 5: Cost benefit summary

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). Applying a 50% reduction in key inputs still resulted in a cost benefit ratio greater than 2.9.

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 value of customer reliability** results in a decrease in risk cost of $0.28 million, or approximately 7.38% of the original base risk.
- **Changes in emergency premium (peaceful failure)** – results in a decrease of $0.23 million or approximately 5.96%.
- **changes in the restoration time** in the event of a network outage (halving the return to service time) represents decrease in risk cost of $0.22 million, or approximately 5.79% of the original base case risk.

Table 3: Participation Factors

Input	Baseline value	Sensitivity value (-50%)	Change in risk cost at 2030 ($m)	CBA	Participation (%)
Safety					
Likelihood of personnel within substation	25%	12.5%	-0.09	3.14	-2.41%
Cost consequence of multiple fatality	$11,400,000	$5,700,000	-0.03	3.21	-0.75%
Cost consequence of single fatality	$5,700,000	$2,850,000	-0.06	3.17	-1.67%
Cost consequence of multiple serious injury	$4,206,600	$2,103,300	-0.02	3.21	-0.53%
Financial					
Emergency premium (peaceful failure)	20%	10%	-0.23	3.06	-5.96%
Emergency premium (explosive failure)	300%	150%	-0.12	3.12	-3.03%
Network					
VCR ($/MWh)	25,750	12,875	-0.28	2.92	-7.38%
Restoration Time (hrs)	72-720	36-360	-0.22	2.91	-5.79%