2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

Project Pack - PUBLIC

CP.02356
Lilyvale Transformer Replacement

Delivering better value

ID&TS - Reset 2017/18-2021/2 Project Proposal for CP.02356 Lilyvale Transformer Replacement

Document Approval		
	Name	Position
Prepared by		Project Manager
Reviewed by		Manager Projects
Approved by		Group Manager Infrastructure Delivery

Contents

1. Executive Summary

Lilyvale Substation was initially developed in 1980 to supply the developing coal mining areas around the Emerald district. The original two 132/66kV transformers, T3 and T4 were installed at that time. A third transformer T7, originally installed at Rockhampton in 1974, was later relocated to Lilyvale in 1999. All have been subjected to high cyclic and continuous loads for many years.

Recent analysis of the insulation has revealed that their insulation age is above the physical name plate age of the units. The name plate age for T3 and T4 is 32 years however the insulation age is estimated at 38 and 39 years.

Consequently there is an increased risk of failure for each transformer due to the condition of the insulation, especially when subjected to repeated 66kV system faults due to increased storm and lightning activity.

The installed 132/66kV capacity at Lilyvale is 3 x 80 MVA transformers, which represents a firm substation capacity of 240MVA based on name plate rating.

The objective of this project is to replace the two original 132/66kV transformers at Lilyvale with new 160MVA units by October 2020.

2. Project Definition

2.1 Project Scope

The project consists of replacing T3 and T4 transformers at Lilyvale with new 160MVA transformers and decommissioning the remaining T7 transformer. This will return Lilyvale to a 2 x 160MVA transformer site with a 2 x 132kV and 2 x 66kV bus bar configuration, rather than the non conventional arrangement currently in place.

2.1.1 Transmission Line Works

Not applicable.

2.1.2 H015 Lilyvale Substation works

Design, procure, erect and commission 2 x 132/66kV transformers, including all necessary civil works:

- Procure, supply and install two 160MVA 132/66kV transformers, each with tertiary windings for connection to station service transformer, on load tap changer and cooling facilities;
- Replace existing T3 132/66kV transformer with a new 160MVA transformer;
- Reconnect local supply to new T3 transformer and commission;
- Replace existing T4 132/66kV transformer with a new 160MVA transformer;
- Reconnect local supply to new T4 transformer and commission;
- Upgrade the 132kV and 66kV strung bus connections;

- Decommission old T7 transformer bay and recover associated primary and secondary plant;
- Retain T7 in-situ on site as a system spare for possible reuse;
- Modify protection, automation and communication systems as necessary to accommodate the new transformers and decommissioning of T7 transformer;
- Decommission and dispose the old T3 and T4 transformers from site.

2.2 Major Scope Assumptions

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

- It is assumed that extended outages will be available for the in-situ replacement of transformers T3 and T4.
- The existing protection and control panels for T3 and T4 at Lilyvale were designed to the current SDM8 standard and installed between 2010 and 2012. It has therefore been assumed that there is no need to replace these panels and relays to accommodate the new T3 and T4 transformers.
- Any modifications will be designed to meet the current standard on site(SDM8).
- Detailed outage plans are not required to be submitted as part of this reset proposal.
- Based on the high level advice received from network operations it has been assumed that long duration outages will be available for in-situ replacement of the transformers.
- It has been assumed that the transformer pads/foundations and associated bays can be replaced in-situ.
- Any required modifications to Ergon assets will be performed within the required timeframes to avoid delaying Powerlink work.

2.3 Scope Exclusions

- Demolition of old T7 transformer foundation or removal of T7 from site. T7 is to be retained as a system spare.
- No allowance has been made in this estimate for the replacement of the existing station services transformers.
- Replacement or upgrading of the 132kV transformer bay primary plant. Preliminary investigations have shown that the 132kV bay ratings are sufficient.
- Uprating of 66kV primary plant. Preliminary investigations indicate that the 66kV transformer bay primary plant will need to be uprated to accommodate the new transformers. As these are Ergon assets this work is considered to be outside the scope of work and has not been included in this estimate.

- Oil separation tank replacement. Preliminary investigations have shown the size is sufficient to satisfy the new transformers. Only costs for minor modifications have been included.

2.4 Project Dependencies & Interactions

Project No.	Project Description	Planned Comm Date	Comment
Pre-requisite Projects			
NA			
Co-requisite Projects			
CP.02340	Lilyvale Selected Primary Plant Replacement	Oct 2020	
Other Related Projects			
NA			

2.5 Site Specific Issues

2.6 Project Delivery Strategy

It is expected that the project will be delivered using a Substation Panel Contractor under a Construct Only contract. Powerlink is expected to perform the design with the Maintenance Service Provider performing the testing and commissioning.

Project Delivery Strategy Matrix		
Design	Earthworks Design	Powerlink
	Civil Design	Powerlink
	Electrical Design (Primary)	Powerlink
	Electrical Design (Secondary) – Protection	Powerlink
	Electrical Design (Secondary) – Automation	Powerlink
	Transmission Line Design	NA
	Telecommunication Design	Powerlink
Procurement	Transformer Procurement	Powerlink

Construction	Earthworks Construction	SPA Contractor
	Civil Construction	SPA Contractor
	Electrical Construction / Installation	SPA Contractor
	Transmission Line Construction	NA
Testing	Substation Testing – FAT	Ergon Energy
	Substation Testing – SAT	Ergon Energy
	Substation Testing – Cut-Over	Ergon Energy
	Telecommunication Testing	Ergon Energy

2.7 Proposed Sequence of Works

2.7.1 Project Schedule

To meet the required commissioning date of October 2020 full project approval will be required by 1st August 2018.

High Level Schedule

- Ergon Notification : Oct 2017
- Project Approval : 1st August 2018
- Transformer Procurement : August 2018
- Design Complete : March 2019
- SPA Construct contract awarded : May 2019
- Staged bay construction : June 2019 – August 2020
- Staged bay test/commissioning : August 2019 – Sept 2020
- Final decommissioning/Tidy up : October 2020
- Project Completion : 31st October 2020

2.7.2 Project Staging

Major project stages of the project are considered to be:

Stage	Description/Tasks
1	Non outage prep work
2	Remove old TF4 and transformer foundations.

	Construct new foundations and install new Transformer 4 ready for commissioning.
3	Test and Commission new Transformer 4 including bus mods.
4	Remove old TF3 and transformer foundations. Construct new foundations and install new Transformer 3 ready for commissioning.
5	Test and Commission new Transformer in new location including bus mods..
6	Decommission TF7 and remove redundant plant

2.7.3 Network Impacts and Outage Planning

Preliminary outage advice from Network Operations has indicated that extended transformer outages will be difficult to get but available where a good contingency plan can be put in place. The estimate has assumed that single transformer outages will be available for full in situ replacement.

There are potential impacts on customer and Ergon load/security and more detailed analysis will be required. Outage availability is considered medium/high risk.

2.8 Project Health & Safety

The implications of relevant workplace health & safety legislation in delivering the proposed solution have been considered in preparing this estimate. In particular, this estimate includes an allowance for typical safety related activities required in the delivery phase of the project.

2.9 Project Environmental Management

As this is a brownfield site no specific environmental management implications for the delivery of this project have been identified.

3. Project Risk Management

Please see the estimate detail for the Risks that have been included in this estimate.
Please refer to the assumptions and exclusion as these items have implications for the overall project risk.

Outage availability or constraints could pose a significant risk to this project. It has been assumed that extended outages are available for in situ replacement of the transformer however these outages are considered medium/high risk. Detailed outage plans should be submitted and outages agreed as early as practical. Some risk cost have been allowed in the estimate to cover contingency requirements for in-situ outages. No risk costs have been included to cover the risk that the extended outages will not be granted. If extended outages are not available it is expected that there would be a significant change to the scope and associated costs.

The replacement of the two transformers is expected to trigger upgrades of Ergon 66kV assets. These upgrades would need to be agreed with Ergon and they would need to be performed in parallel with the Powerlink work. Any delays to the Ergon work are likely to have a significant impact on the Powerlink work. No allowance has been made for this risk.

4. Project Estimate

4.1 Estimate Summary

Quote Summary

The quotation at current base level and escalated for completion by 31/10/2020 at 2.5% per year plus labour rate revision, for CP.02356 Lilyvale Transformer Replacement is as follows:

CP.02356 Quotation in $ AUD	Base Levels	Escalated to Compln.	Comment (Costs @ Base Levels)
H015 Lilyvale Substation	[redacted]	[redacted]	Replace T3 and T4 transformers at Lilyvale with new 160MVA transformers and decommission T7 transformer at H015 Lilyvale substation. Modify existing oil separation tank and construct 2x transformer foundations. Keep existing T7 transformer as system spare. Upgarde strung bus, 132kV and 66kV surge arrestors.
Project Management	[redacted]	[redacted]	
Qleave			
Other Costs			
TOTAL QUOTE (EXCL RISKS AND OFFSETS)	**8,449,406**	**9,360,850**	
Offsets Estimate	**0**	**0**	
TOTAL QUOTE (INCL OFFSETS)	**8,449,406**	**9,360,850**	
Climate	[redacted]	[redacted]	
Construction			
Design			
Risk Estimate	**570,000**	**570,000**	
TOTAL QUOTE (INCL RISKS AND OFFSETS)	**9,019,406**	**9,930,850**	

4.2 Asset Disposal Table

The current net book value of assets to be disposed of as a result of this project are set out in the table below.

CP.02356 Asset Disposal Table. Values current at 30th June 2016

Functional Loc.	Description	Asset	Subnumber	Book val.	% Disposal	Disposal Value	Currency
H015-D03-443-	132kV 3 TRANSF BAY	104999	0	113,087.11	100%	113,087.11	AUD
H015-D05-444-	132kV 4 TRANSF BAY	105003	0	113,087.11	100%	113,087.11	AUD
H015-D09-447-	132kV 7 TRANSF BAY	105011	0	318,127.80	100%	318,127.80	AUD
H015-SSS-447-	132kV 7 TRANSF BAY	123210	0	324,070.30	100%	324,070.30	AUD
H015-T03-3TRF	3 TRANSFORMER	105030	0	244,437.07	100%	244,437.07	AUD
H015-T04-4TRF	4 TRANSFORMER	105031	0	244,437.07	100%	244,437.07	AUD
					Total	1,357,246.46	AUD

5. References

Document name and hyperlink (as entered into Objective)	Version	Date
Project Scope Report	1.0	July 2015
Estimate Detail	4.0	Jan 2016

Transformers Condition Assesment
H015 Lilyvale Substation

Report requested by:	[redacted]	**Requested Completion Date:**	30/09/2014
Report Prepared by:	[redacted]	**Date of site visit:**	02/07/2014
AUTHOR/S:	[redacted]		
Report Approved by:	[redacted]	**Report Approval Date:**	16/09/2014
Report Reviewed by:	[redacted]	**Review Date:**	07/01/2016
Issue Approved by:	[redacted]	**Issue Date:**	

Date	Version	Objective ID	Nature of Change	Author	Authorisation
18/08/2014	1.0	A2050093		[redacted]	
07/01/2014	2.0	vA3359638	Small modifications	[redacted]	

IMPORTANT: - This condition assessment report provides an overview of the condition of power transformers (excluding internal transformer inspections) and high level indications of their residual reliable service life. As it is a snapshot in time and subject to the accuracy of the assessment methodology and ongoing in-service operating environment, the comments in this report are valid for 3 years from the date of the site visit stated above.

Table of Contents

[redacted]

1. SUMMARY

A thorough condition assessment was performed on all three (3) 80MVA 132/69/11kV bulk supply transformers installed at H015 Lilyvale Substation to determine their residual service life and any immediate issues that may need to be considered. No internal inspections were performed on the in-service transformers.

Although power transformer condition is monitored closely, the exact point of power transformer failure cannot be accurately predicted. As the consequences associated with catastrophic power transformer failure in electricity transmission are very high in terms of the financial costs, and potential loss of supply, impact on safety of personnel and public and on the environment (fire, gasses, oil disposal, etc.), the asset management strategy employed is to plan and execute replacement before the actual failure occurs.

This is done by assessing condition of the major transformer components and estimating their end of life as well as that of the overall transformer. As the transformer systems and components deteriorate their probabilities of failure increase leading to an increased risk cost and decreased transformer availability. While component repair or replacement may be possible, in many cases they would provide very little or no benefit with regards to the transformer probability of failure. Typically repairs would have to be performed on a number of power transformer components, whilst the major internal components (insulation, core and mechanical enforcement of internal components) cannot be repaired.

This report does not attempt to cover any detailed economic analysis of the viability of rectifying the highlighted issues associated with each transformer but provides a condition assessment of the “key” parameters for each of the three transformers and recommendations for maintenance going forwards.

Transformers T3 and T4:

Apart from having a range of oil leaks with some very significant, poor paintwork and aged oil, both transformers T3 and T4 after 34 years of service appear to have mechanically weak winding paper insulation based on the calculated average cellulose insulation DPv of 250 and 270 respectively. The DPv at the winding hot spots would be even lower by 50 points or more, effectively indicating end of reliable winding paper life. Due to the low DPv value, only minimal maintenance expenditure should be considered for these transformers going forwards in order to extract the last few years of service life, in case of insulation failure on through fault. It may be statistically possible to achieve a further 5 years of service from these transformers with only minimal oil leak attention and no oil change.

It should also be noted that the mechanical stability of the windings can’t be confirmed due to not performing transformer internal inspections but if the DPv is used as an indicator of loss of cellulose mass, there is a loose correlation

with residual axial winding clamping pressure. So the calculated DPv values indicate the windings of these transformers to be mechanically weak.

At this stage, replacement of the high voltage terminal bushings is not considered necessary based on DLA/ capacitance test data. It is worthwhile noting that field DLA / capacitance field testing does not detect partial discharge activity which can be well advanced before being detectable.

Transformer T7:

Transformer T7 with 40 years of service has a more reliable average cellulose insulation DPv value of 400, a couple of oil leaks of interest, two potential holes forming towards the bottom of the main tank conservator and a tap changer which has completed close to 300,000 operations. Its paint work is however the worst with cracks appearing in the outer layer on the cooler bank 'A' frame structural supports.

If no action is taken to rectify the failure of the paint system in particular, including the conservator issue, the aging rate of the transformer will accelerate and it already appears in poor physical condition. Moisture can reside under the cracked paint surface on the cooler bank 'A' frame support structures. It would be difficult to see this transformer remaining serviceable for more than 5 years.

It is easier to justify the expense of performing more maintenance on T7 to address the poor paintwork and the oil leaks due to the calculated average cellulose insulation age of 60 percent nameplate age (less than unity aging). Theoretically this transformer's insulation system has 13 years of untapped service life but we must be mindful of other factors such as some ancillary items and fittings that will be coming up for replacement soon which will add to the cost of ownership.

If the oil leaks and paintwork were addressed and the serviceability of the tap changer ensured, it should be possible to achieve more than 5 - 10 additional years of service life from this transformer provided the additional cost of the replacement of ancillary items and fittings that will be necessary over that time are considered economical. This expectation needs to be tempered with the residual mechanical stability of the windings.

Hence it should be noted that the mechanical stability of the windings can't be confirmed due to not having performed transformer internal inspections but if the DPv is used as an indicator of loss of cellulose mass, there is a loose correlation with residual axial winding clamping pressure. So, using the calculated DPv value, the windings of this transformer would have to be considered mechanically stronger than T3 and T4.

At this stage, replacement of the high voltage terminal bushings is not considered necessary but field DLA / capacitance field testing does not detect partial discharge activity which can be well advanced before being detectable via the average insulation quality reading DLA test data.

TABLE 1

Summary of Estimated Residual Life of Transformer T3, T4 & T7 "Key" Components

Parameter	Estimated Residual Life			Further Comments
	T3	T4	T7	
Anti-corrosion system	5 years for main tank. 5-10 years for cooler bank	10 years for main tank and cooler bank.	10 years for main tank and cooler bank.	Considered as not economic to address.
Winding paper life	3 to 5 years	5 to 7 years	10 to 13 years	Calculated Av age = 38 /36/ 27 years for T3, T4 & T7 respectively.
Winding mechanical stability	Cannot be assessed accurately, but is questionable due to design and exposure.	Cannot be assessed accurately, but is questionable due to design and exposure.	Cannot be assessed accurately, but is questionable due to design and exposure.	Old clamping structures design, lowering of DPv & moisture exchange.
External HV & LV bushings	May need replacement if and when test indicates the need. Expected to be within 5 years.	May need replacement if and when test indicates the need. Expected to be within 5 years.	May need replacement if and when test indicates the need. Expected to be within 5 years.	Bushings exceeded their expected design life.
Insulating Oil	5 to 7 years	5 to 7 years	7 to 10 years.	Assuming no big changes to in-service operating conditions.
Radiators	5 to 10 years	10+ years	10+ years	
Repairs to leaking gaskets.	Required now.	Required now.	Required now, but less oil leaks than on T3 and T4.	Many gasket leaks mean air ingress and therefore moisture exchange between air, oil and paper insulation.
Overall residual life.	**3 to 5 years**	**5 to 7 years. May need to replace bushings.**	**7 to 10 years. May need to replace bushings. Mechanical stability is compromised.**	**Assuming on-going maintenance as usual.**

Planning Statement – Lilyvale Transformer Assessment

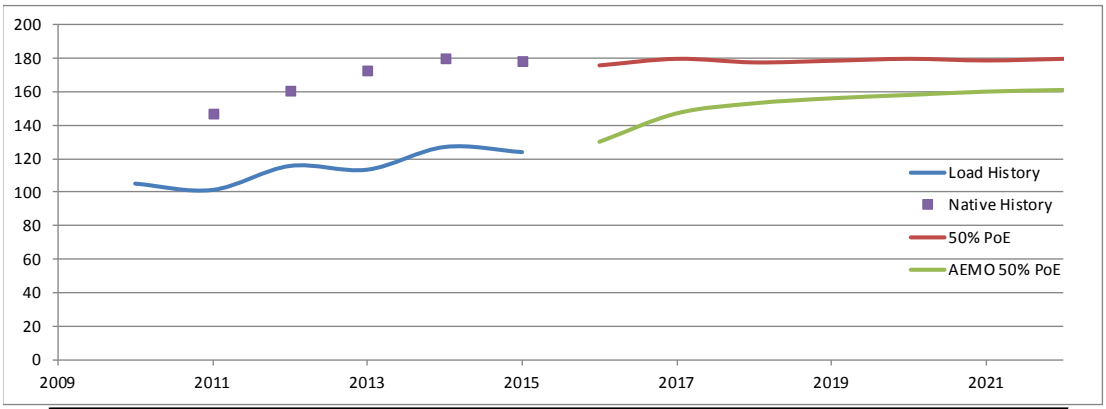
Recommendation: *It is recommended that transformers 3T, 4T and 7T be replaced with two transformers at end of life.*

Purpose: The purpose of this paper is to determine the transformation capacity forecast for the Lilyvale substation.

Background: Lilyvale Substation was established in the 1980's to support the load growth associated with the expansion of coal mining in the Northern Bowen Basin. At establishment, 2 x 70MVA 132/66kV transformers were installed, with a third 70MVA transformer added in 1999 (relocated from Rockhampton). The ratings of the transformers are shown below

Transformer Ratings (MVA)	**3T**	**4T**	**7T**
Normal Cyclic	88	88	93
Emergency Cyclic	92	92	100
2hr Short Term	105	105	106

The historic and forecast loadings for H015 Lilyvale are shown in Figure 1.



	Load History						50% PoE Forecast						
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
MVA	105	101	116	113	127	124	176	180	178	179	180	179	180
Native History	147	161	173	180	178								
AEMO MVA							130	147	153	156	158	160	161

Figure 1: Historic and Forecast loads for H015 Lilyvale

Latest condition information indicates that all three transformers are approaching their end of life, and it is proposed that they be removed from service within the next 10 years.

There are two large non-scheduled embedded generators on the 66kV network out of Lilyvale at Oaky Creek (21MW) and German Creek (45MW). These generators have been operating in recent years and have reduced the peak demand at these sites historically, as shown in Figure 1.

Due to the nature of the loads at H015 Lilyvale, being predominantly mining load, significant fluctuations in load occur and the instantaneous load can be up to 50% higher than the 30 minute average, as shown in Figure 2. This should be taken into account when choosing appropriate rated transformers.

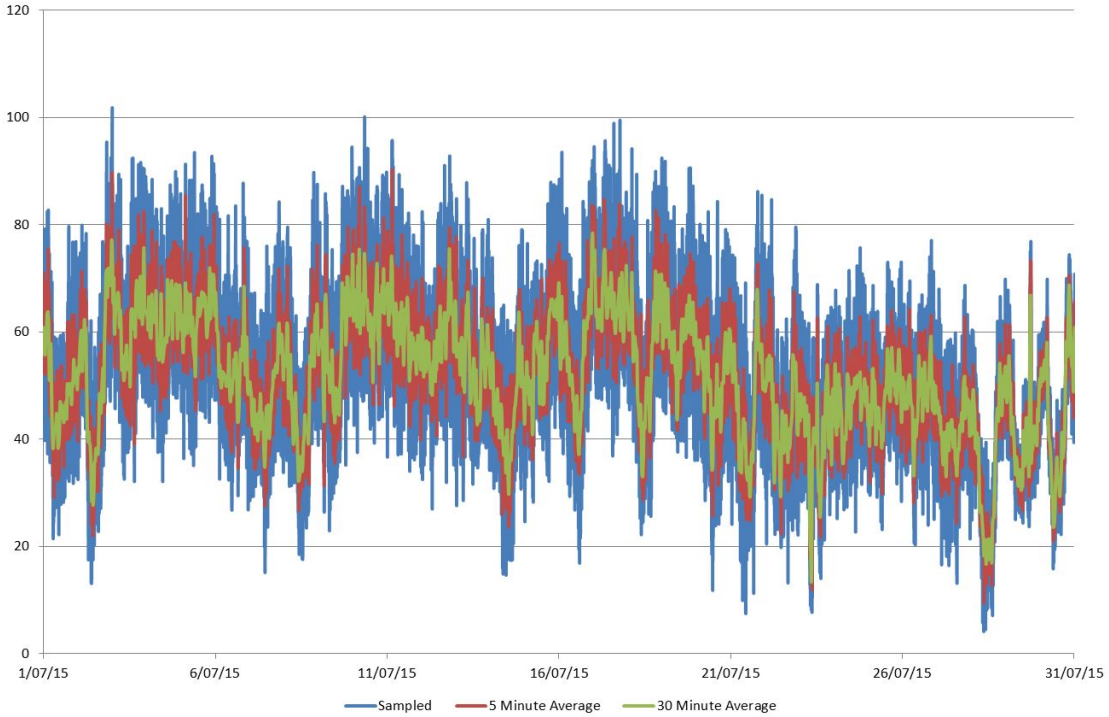


Figure 2: Load variance at H015 Lilyvale

The following Options were considered to address the EOL of transformers 3T, 4T and 7T at Lilyvale.

Option: Replace T3, T4 and T7 with two transformers

Under this option the 2 x 70MVA transformers would be replaced with 2 new (nominally 100MVA) 132/66kV transformers.

With no changes to the operation of embedded generation, this option can provide adequate N-1 capacity and ensures that Powerlink's reliability obligations under its Transmission Authority are met.

The use of 100MVA (or lower) rated transformers and network support could be considered if it were to be cost effective.

***Recommendation**: This option would meet Powerlink's reliability criteria, however the continued operation of the embedded generation cannot be guaranteed and closure may result in not satisfying Powerlink's reliability criteria.*

Option: Replace T3, T4 and T7 with three transformers

Under this option it would be proposed to replace the 2 x 70MVA transformers with a three (minimum 80MVA) transformers.

This option provides adequate N-1 capacity and ensures that Powerlink's reliability obligations under its Transmission Authority are met.

***Recommendation**: This option should not be considered further on the basis that it is not likely to represent prudent investment to meet Powerlink's reliability obligations.*

Option: Replace T3, T4 and T7 with two larger transformers

Under this option the 2 x 70MVA transformers would be replaced with 2 new (minimum 160MVA) 132/66kV transformers.

Independent of the operation of embedded generation, this option provides adequate N-1 capacity and ensures that Powerlink's reliability obligations under its Transmission Authority are met.

***Recommendation**: This option is recommended on the basis that it meets reliability obligations and represents the most economic and efficient investment decision.*