2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

Project Pack - PUBLIC

CP.02369
Blackwater Transformer 1 & 2 Replacement

Delivering better value

ID&TS - Reset 2017/18-2021/22 Project Proposal for CP.02369 T032 Blackwater No. 1 & 2 Transformer Replacement

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

Contents

1. Executive Summary

T032 Blackwater Substation was originally established on 1978 as a 132kV injection point into Central Queensland to supply the Ergon Energy distribution network and support local mining development in the Southern Bowen Basin. T032 Blackwater substation has three 132/66/11kV transformers 2 x 80MVA units (Tx1 & Tx2) and transformer 7 which is a 160MVA unit. Tx1 & Tx2 were installed in 1978 with transformer 7 being established in 2006.

The transformer 1 & 2 units are both approaching 40 years of age and are displaying significant condition issues typical of transformers of this age.

The objective of this project is to replace both transformer 1 and transformer 2 with a single new 160MVA transformer unit by June 2022.

2. Project Definition

2.1 Project Scope

Briefly, the project consists of replacing the existing 2 x 80MVA 132/66/11kV transformers at T032 Blackwater with a new single 132/66/11kV 125/160MVA transformer unit.

Decommission, remove and dispose of the recovered transformer 1 and transformer 2 units.

2.1.1 Transmission Line Works

Not applicable.

2.1.2 T032 Blackwater Substation Works

Design, procure erect and commission 1 x 132/66/11kV 125/160MVA transformer, including all necessary civil works:

- Procure, supply and install 1 x 132/66/11kV 125/160MVA transformers, with on load tap changer and cooling facilities;
- Replace Transformer 1 foundations;
- New transformer oil separation tank to allow for increased transformer oil quantity on site if required;
- Replace existing Tx1 80MVA transformer unit with a single new 1 x 132/66/11kV 125/160MVA transformer unit;
- New Transformer 10 - 500kva station services transformer 11kV cable to the new transformer tertiary winding;
- Decommission and recover 132/66/11kV 80MVA Tx2 and associated plant, equipment;
- New surge arrestors;
- Recover and dispose of old T1 and T2 transformer units;

- Modify protection, automation and communication systems as necessary to accommodate the new transformers;

2.2 Major Scope Assumptions

- 132 & 66kV landing spans and strung bus connections are suitable for reuse.
- 132kV TF bay plant equipment is suitable for reuse;
- A high level desktop study determined that the existing oil separation system would be at full capacity with the new transformer. Therefore it has been assumed that a new oil separation tank will be required. With a more detailed study it may be possible to allow the existing oil separation tank to be reused.

2.3 Scope Exclusions

- Any work on Ergon assets;
- TF 132kV bay upgrades. A high level review of the ratings of the primary plant associated with TF1 has determined that the ratings are suitable. The review did not consider the age or condition of the existing assets. More detailed assessment will be required during the design phase.

3. Project Execution

3.1 Project Dependencies & Interactions

Project No.	Project Description	Planned Comm Date	Comment
Pre-requisite Projects			
Co-requisite Projects			
Other Related Projects			

3.2 Site Specific Issues

This is a brownfield site with existing infrastructure in place. No specific issues have been identified.

3.3 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	N/A
	Telecommunication Design	Powerlink
Construction	Earthworks Construction	SPA Contractor
	Civil Construction	SPA Contractor
	Electrical Construction / Installation	SPA Contractor
	Transformer Delivery and Installation	Transformer Manufacturer
Testing	Substation Testing – FAT	SPA Contractor
	Substation Testing – SAT	Ergon Energy
	Substation Testing – Cut-Over	Ergon Energy
	Telecommunication Testing	Ergon Energy

3.4 Proposed Sequence of Works

3.4.1 Project Schedule

To meet the required commissioning date of 30th June 2022 full project approval will be required by 30th June 2020.

High Level Schedule

- Project Approval : 30th June 2020
- Order Transformer : July 2020
- Design Complete : March 2021
- SPA Construct contract awarded : May 2021
- Construction : July 21 - April 2022
- Test/commissioning : March/April 2022
- Final decommissioning/Tidy up : May/June 2022
- Project Completion : 30th June 2022

3.4.2 Project Staging

Major project stages of the project are considered to be:

Stage	Description/Tasks
1	Non outage prep work including replace oil separation tank and connect to Transformer 1 drainage systems.
2	Decommission, remove and dispose of old transformer 1 including transformer and foundations. Construct new foundations and install new transformer followed by noise wall including all associated bay electrical works.
3	Test and commission new transformer 1 and associated bay electrical works.
4	Decommission, remove and dispose of old transformer 2 including foundations.

3.4.3 Network Impacts and Outage Planning

Preliminary outage advice from Network Operations has indicated that outages will be available for in situ replacement of the Transformer 1. The remaining two 132/66kV transformers will need to remain in service, at T32 Blackwater, during the replacement. The 66kV load will need to be managed below 91MVA E/C rating of 2T. When T32, 1T is out of service Blackwater will only have one station supply via 7T hence a local genset connected to the local AC supply board is required for the duration of this work (no AC supply means 2T have no fans, therefore, operating on ONAN rating (40MVA) and greater load shed required).

3.5 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.

3.6 Project Environmental Management

No specific environmental management implications for the delivery of this project have been identified.

4. Project Risk Management

Some allowances have been allowed in the estimate. Please see estimate for details.
Please refer to the assumptions and exclusion as these items have implications for the overall project risk.

5. Project Estimate

5.1 Estimate Summary

Quote Summary

The quotation at current base level and escalated for completion by 30/06/2022 at 2.5% per yearplus labour rate revisions, for CP.02369 T032 Blackwater No.1 & 2

CP.02369 Quotation in $ AUD	Base Levels	Escalated to Compln.	Comment (Costs @ Base Levels)
T032 Blackwater Substation	[redacted]	[redacted]	Replace the existing 2x 80MVA 132/66/11kV transformers at T032 Blackwater with a new single 132/66/11kV 125/160MVA transformer unit. Decommission, remove and dispose of the recovered transformer 1 and transformer 2 units. Replace existing transformer foundation. Modify transformer oil separation tank. New 132kV surge arrestors and 66kV surge arrestors. New 11kV underground cables connect between the Transformer 10-500kVA station services transformer and the new T1 & T2 Transformers tertiary winding. Modify protection and automation systems.
Project Management	[redacted]	[redacted]	
Qleave			
Other Costs			
TOTAL QUOTE (EXCL RISKS AND OFFSETS)	**4,430,410**	**5,140,737**	
Offsets Estimate	**0**	**0**	
TOTAL QUOTE (INCL OFFSETS)	**4,430,410**	**5,140,737**	
Climate	[redacted]		
Construction			
Design			
Risk Estimate	**266,000**	**266,000**	
TOTAL QUOTE (INCL RISKS AND OFFSETS)	**4,696,410**	**5,406,737**	

5.2 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.02369 Asset Disposal. Values current at 30th June 2016

Functional Loc.	Description	Asset	Subnumbe	Book val.	% Disposal	Disposal Value	Currency
T032-D06-442-	132kV 2 TRANSF BAY	105771	0	3,763.44	0%	0.00	AUD
T032-D08-441-	132kV 1 TRANSF BAY	105775	0	3,763.44	0%	0.00	AUD
T032-T01-1TRF	1 TRANSFORMER	105798	0	147,840.87	100%	147,840.87	AUD
T032-T02-2TRF	2 TRANSFORMER	105799	0	147,840.87	100%	147,840.87	AUD
					Total	295,681.74	AUD

6. References

Document name and hyperlink (as entered into Objective)	Version	Date
Project Scope Report	1.0	June 2015
Estimate Detail	2.0	Jan 2016

Transformer T1 & T2 Condition Assesment
T032 Blackwater Substation

Report requested by:	[redacted]	**Requested Completion Date:**	30/10/2015
Report Prepared by:	[redacted]	**Date of site visit:**	10/06/2015
AUTHOR/S:	[redacted]		
Report Approved by:	[redacted]	**Report Approval Date:**	29/07/2015
Report Reviewed by:	[redacted]	**Review Date:**	08/01/2015
Issue Approved by:	[redacted]	**Issue Date:**	

Date	Version	Objective ID	Nature of Change	Author	Authorisation
29/07/2015	1.0	A2289888	Original		
08/01/2015	2.0	A2371191	Review	[redacted]	

IMPORTANT: - This condition assessment report provides an overview of the condition of power transformer/s (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

1. SUMMARY

Transformer T1 and T2 are a 36 year old General Electric design and in line with the requirements of AM-POL-0056, a condition assessment has been performed towards “end of life” including an on-site visual assessment combined with a desktop analysis of historical oil and insulation test data, maintenance history and through fault data history where available.

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 the 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.

No attempt has been made in this report to cover any detailed economic analysis of the viability of rectifying any highlighted issues associated with this transformer but it provides a condition assessment of the “key” parameters for the transformer and what may need to be actioned by Powerlink if in-service operation is to continue for a further 5 years and beyond.

A summary of the findings is shown in Table 1. This suggests that both transformers have an estimated reliable “as is” residual service life of about three (3) to five (5) years even though the cellulose insulation in T1 appears to be marginally less aged by a couple of years. This is because of other expensive corrective actions that could be necessary on T1, no different to T2. To keep the transformers much beyond this would likely require significant expenditure on repairs which may not be economic due to the poor reliability of the internal active parts (the heart) of the transformers.

As a minimum and recommended approach, some routine maintenance would be required over the next few years to try and slow down existing oil leaks and fix localised corrosion in order to keep the transformers operational. This may include addressing additional radiator panel oil leaks which may develop where the oval radiator panel tubes enter the bottom radiator header and through the oval oil tube walls and header welds.

These transformers should be classified as having a low level of in-service reliability due to a range of factors, especially due to the condition of the winding insulation and the on-going mechanical stability of the active part.

TABLE 1

Summary of Estimated Residual Life of T1 and T2
"Key" Transformer Components

Parameter	Estimated Residual Life		Further Comments
	Transformer T1	Transformer T2	
Anti-corrosion system	10 years	10 years	Existing paint system for both T1 & T2 is in good condition. It is hiding corrosion problems in some locations.
Winding paper life	5 to 7 years	3 to 5 years	T1 calc average DP_V =325. Lowest DP_V = 225. T2 calc average DP_V =290. Lowest DP_V = 190.
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.	Clamping structure considered to be weak. Old clamping structure design, lowering of DPv & repeated moisture exchange
External HV OIP 132kV bushings	3 to 5 years with increased risk	3 to 5 years with increased risk	Presently at / exceeded OEM limit of reliability.
Insulating Oil	5 years	5 years	Oil processed when transformers were refurbished.
Radiators	3 to 5 years	3 to 5 years	Oval tubes / bottom header joints failing. Pin-hole oil leaks in shoulder welds of bottom header.
Repairs to leaking gaskets.	3 to 5 years	3 to 5 years	Significant oil leaks visible now.
OVERALL RESIDUAL LIFE	**5 to 7 years**	**3 to 5 years**	

2. INVESTIGATION:

Planning Statement – Blackwater Transformer Assessment

Recommendation: *It is recommended that transformers 1T and 2T be replaced with a single transformer, with a minimum name plate rating of 160MVA rating, at end of life.*

Purpose: The purpose of this paper is to determine the 132/66kV transformation capacity forecast for the Blackwater substation.

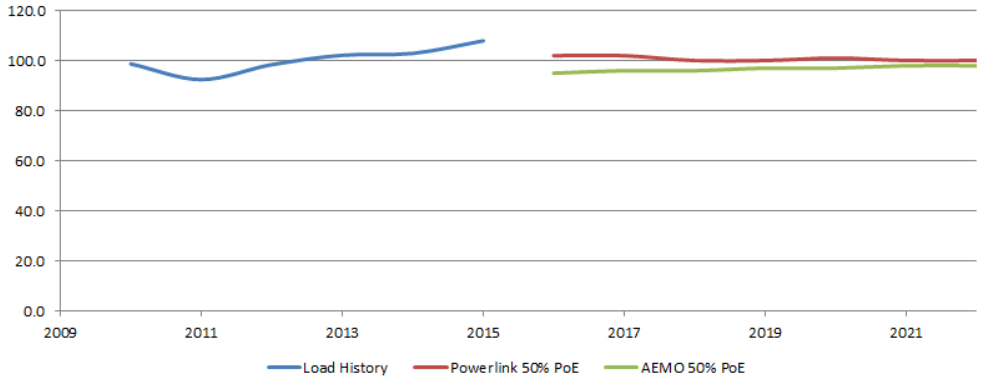
Background: Blackwater substation was established in 1969 in conjunction with the establishment of the coal mines around Blackwater. The 132 kV yard has three 132/66 kV transformers (2 X 80 MVA [1T and 2T], 1 X 160 MVA [7T]).

The ratings of the transformers installed at the substation are shown in Table 1 below.

Table 1: Transformer Ratings

Transformer Ratings (MVA)	1T	2T	7T
Normal Cyclic	85.7	85.9	160
Emergency Cyclic	93.2	93.4	176
2h Short Term	107.7	107	223

The historic and forecast loadings on the T032 Blackwater 132/66kV transformers are shown in Figure 1.



Load History						50% PoE Forecast							
2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
98.8	92.6	98.6	102.3	103.0	108.0	102.1	102.1	100.2	100.2	101.1	100.2	100.2	Powerlink MVA
						95.1	96.1	96.1	97.1	97.1	98.1	98.1	AEMO MVA

Figure 1: Historic and Forecast loads for T032 Blackwater

Latest condition information indicates that 1T and 2T are approaching their end of life, and it is expected that they will be removed from service within the next 10 years.

Due to the nature of the loads at T032 Blackwater, being predominantly mining load, significant fluctuations in load occur and the instantaneous load can be up to 30% higher than the 30 minute average, as shown in Figure 2. This should be taken into account when selecting appropriately rated transformers.

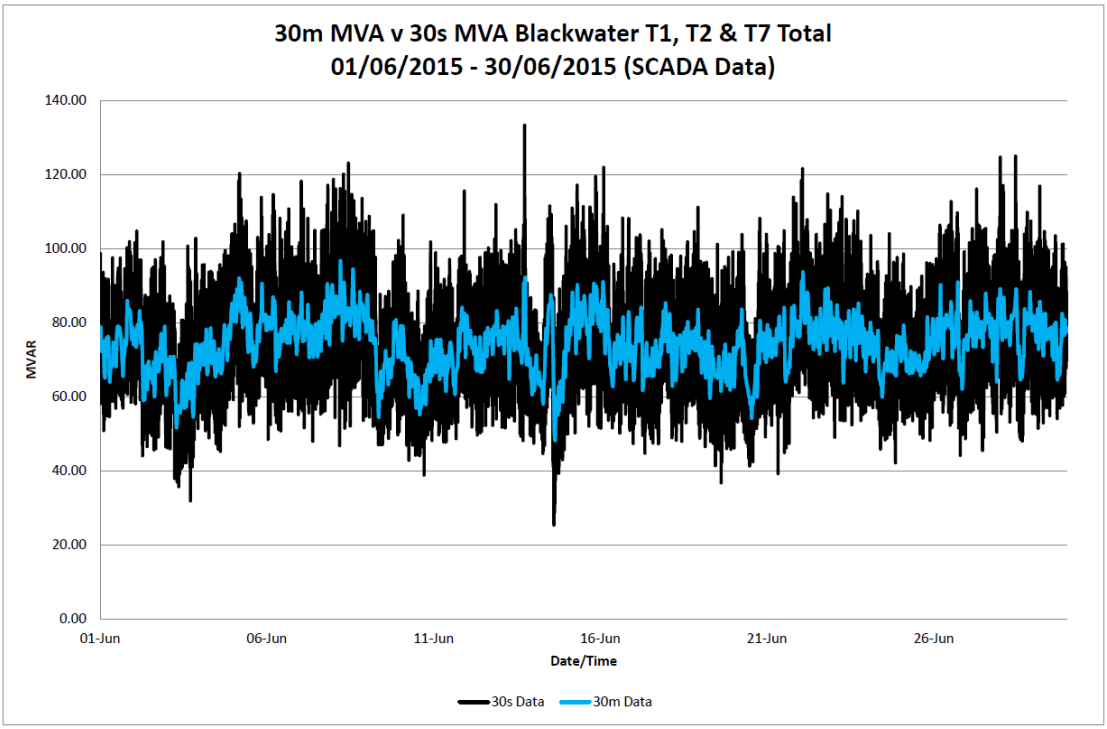


Figure 2: Load variance at T032 Blackwater

The following options were considered to address the EOL of transformers 1T and 2T at Blackwater.

Option: Remove 1T and 2T from service

Under this option the 2 x 80MVA transformers would be removed from service and their capacity not replaced.

This option would not meet Powerlink's obligations under its Transmission Authority, as more than 50MW would be at risk for the loss of the remaining single transformer.

Minimal 66kV transfers available between T032 Blackwater and H015 Lilyvale, however these are not sufficient to reduce the load at risk to less than 50MW.

***Recommendation**: This option should not be considered further on the basis that it does not meet reliability obligations.*

Option: Replace 1T and 2T with one transformer

Under this option the 2 x 80MVA transformers would be replaced with one new 132/66kV (minimum 160MVA) transformer.

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.*

Option: Replace 1T and 2T with two transformers

Under this option the 2 x 80MVA transformers would be replaced with two new 132/66kV (minimum 80MVA) transformers.

In the context of Powerlink's reliability obligations, installing one 132/66kV transformer (minimum rating 100MVA) provides sufficient N-1 capacity to ensure that Powerlink's reliability obligations under its Transmission Authority are met.

Recommendation*: This option should not be considered further. Ergon Energy has advised that Blackwater is to remain the supply point for the Emerald zone substation, however this has not yet been included in any forecast update.*

22kV local supply

Ergon currently take 11kV tertiary supply from 1T (and 7T) and step it up to 22kV for local distribution, however it has been agreed that where Powerlink was replacing transformers, Ergon would provide an alternate supply where economic to do so.

Powerlink's current 132/66kV transformer specification has an 11kV tertiary supply, however Blackwater has a local 22kV supply. There are a number of options detailed below that can be considered for the replacement of the tertiary.

Option: 132/66/11kV transformer with 11/22kV transformers

Procure and install a 132/66/11kV transformer (current specification) with the existing 11/22kV transformation replaced at the end of its life.

Recommendation: *This option does not comply with Powerlink policy, however would minimise switchgear requirements.*

Option: 132/66/22kV transformer with 11/22kV transformers

Specify, procure and install 132/66/22kV transformation (contrary to current specifications), with one of the existing 11/22kV transformers recovered.

Recommendation: *This option does not comply with Powerlink policy and would likely require a new spare to be procured, adding to the overall cost.*

Option: Install one 132/66kV transformer and one 66/22kV transformer

Install a 132/66kV transformer, as well as a 66/22kV transformer and 66kV bay. One of the 11/22kV transformers would be recovered.

Recommendation: *This option would likely have a high upfront cost due to the additional transformer and switchgear requirements, however may present a lower NPV.*