Investment Evaluation Summary (IES)

Project Details:

Project Name:	Replace 110 kV ASEA HLD live tank breakers
Project ID:	01670
Business Segment:	Transmission
Thread:	Transmission Substations
CAPEX/OPEX:	CAPEX
Service Classification:	Prescribed
Scope Type:	A
Work Category Code:	RENSB
Work Category Description:	Substations
Preferred Option Description:	Replace 110 kV ASEA HLD circuit breakers in the 2019-24 regulatory period
Preferred Option Estimate (Dollars $2016/2017):	$5,479,632

	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Unit ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Volume	0.00	0.13	0.60	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Estimate ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total ($)	$0	$712,352	$3,287,779	$1,479,501	$0	$0	$0	$0	$0	$0

Governance:

Works Initiator:	Michael Verrier	Date:	04/11/2018
Team Leader Endorsed:	Darryl Munro	Date:	15/11/2018
Leader Endorsed:	Nicole Eastoe	Date:	20/11/2018
General Manager Approved:	Wayne Tucker	Date:	22/11/2018

Related Documents:

Description	URL
ASEA HLD 110 kV NPV analysis	http://reclink /R0001198184#NPV_V3_ASEA_HLD_110_kV_breakers.xlsm
EHV Circuit Breaker AMP	http://reclink/R0000040413
Estimate L1	http://reclink/R0000681178
EHV Circuit Breaker risk analysis tool	http://reclink/R0000743375
EHV circuit breaker replacement program-D11 6850	http://reclink/R0000743337
Norwood B152 defect report	http://reclink/R0000743338
National Electricity Rules (NER)	http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
TasNetworks Business Plan 2017-18	http://reclink/R0000779008
TasNetworks Risk Management Framework	http://Reclink/R0000238142
TasNetworks Transformation Roadmap 2025	http://Reclink/R0000764285
TasNetworks Corporate Plan - Planning period: 2017-18	http://reclink/R0000745475

Section 1 (Gated Investment Step 1)

1. Overview

1.1 Background

There are 14 Asea HLD 110 kV live tank circuit breakers (CBs) currently installed at TasNetworks transmission Substations. These CBs are installed on critical transmission circuits.

The CBs are outside oil-insulated, coupled, 110 kV units manufactured by ASEA in 1978.

These units have not been refurbished, predominately due to lack of manufacture spare parts, or relocated since their original installation.

It was detailed and supported in a circuit breaker replacement program document present to the Transend board of management in 2011 that the Asea HLD units would be scheduled for replacement in 2023.(Note that Transend subsequently merged with Aurora Energy in 2014 to form TasNetworks.)

As detailed in TasNetworks EHV Circuit Breaker Asset Management Plan (AMP) a extra high voltage (EHV) circuit breaker replacement program commenced in 1993, with its primary objective being to address compliance (safety, environmental and technical capability), performance and life-cycle management issues. The program has generally been implemented on a prioritised basis with bulk oil and air blast circuit breaker designs attributed the highest priority. The detailed sequence of the circuit breaker replacements has largely been determined by the criticality of the asset to sustaining the security and reliability of the transmission network, with consideration of the efficiencies that could be realised through coordinating the circuit breaker replacements with other planned works where appropriate. The 220 kV component of the original identified EHV circuit breaker replacement program was completed in 2004 and the replacement of the original identified 110 kV air blast and bulk oil circuit breaker components of the program was completed in 2003 and 2004 respectively. The AMP highlights that the Asea HLD CBs be replaced due in part to their intensive maintenance requirements and resultant high operational expenditure (OPEX) costs.

1.2 Investment Need

Asea HLD 110 kV live tank circuit breakers have been experiencing some failures, all which are complicated by the lack of manufacturer support and spares availability. The circuit breakers also utilise oil as an insulating and arc extinguishing medium, which requires more frequent maintenance intervals compared to modern equivalent assets.

Asea circuit breakers are costly to maintain when compared with units of dead tank design.

Replacement of these circuit breakers aligns with TasNetworks EHV Circuit Breaker asset management plan which details that EHV circuit breakers have an average service life of 45 years, which aligns with the Sinclair Knight Mertz “Asset Valuation for Financial Reporting Purposes” report prepared in May 2012 (D12/36181).

Renewal drivers

1.2.1 Design

The CBs are outside oil-insulated, live tank units manufactured by ASEA in 1978.

These units have not been refurbished, due to lack of manufacture spares, nor have they been relocated since their original installation.

The CBs will be 45 years old at time of recommended replacement having reached the end of their economic life based on Sinclair Knight Mertz report, which specifies that the economic life of a circuit breaker is 45 years.

1.2.2. Condition

A condition assessment report has been prepared for these Asea HLD 110 kV live tank circuit breakers. It is understood that they:

- Are approaching 45 years of age;
- Have inherent design deficiencies compared to modern units;
- Are maintenance intensive and costly to maintain when compared with modern equivalent unit;
- Require skilled personnel to maintain - the availability of skilled resources is declining due to an increased staff age profile and staff turnover;
- Have oil leaks;
- Are in declining physical condition; and
- Lack manufacturer support and spares availability.

The condition assessment report noted that the following units have required repairs for:

1. Bridgewater Substation (BW-H152) suffered a failure of the spring-wind motor.
2. Chapel Street Substation (CS-A552) suffered seizing of the outer operating arm. Repair of outer interlock arm.
3. Norwood Substation (NW-A752) had moisture in the red phase interrupter chamber.
4. Norwood Substation (NW-A752) required replacement of the blue phase pole due to ongoing oil leaks.
5. Lindisfarne Substation (LF-G152) required replacement of the blue phase pole due to ongoing oil leaks.
6. Kingston Substation (KI-A752) was replaced in 2011 and put into store requiring a new close damper and a trip damper to make fit for purpose.

It is noted in the CIGRE technical bulletin "Final report of the 2004-2007 International enquiry on reliability of High Voltage Equipment, Part 2 - reliability of High Voltge circuit breakers" the most frequent cause for minor or major failure is due to wear and ageing.

1.2.3. Defects records

With reference to TasNetworks defects register, there have been 19 recorded defects for ASEA HLD 110 kV circuit breakers between 2001-2017.

Majority of defects related to corrosion and leaking gaskets. Typical repairs involve:

- replacing motors and interlock arm mechanism;
- replacing oil seals on poles to stop leaks and prevent water ingress;
- repairing oil leaks on dash pots and refilling oil; and
- renewal works due to overall unit age including to free up rusted linkages.

1.2.4. Condition based risk management (CBRM)

Risk analysis for EHV circuit breakers was conducted in 2015 with the in-house development of a EHV Circuit Breaker risk analysis tool. This analysis resulted in the ASEA HLD 110 kV circuit breakers being grouped in the "medium" health index network risk category (only three ratings applicable Low, Medium or High).

1.3 Customer Needs or Impact

TasNetworks continues to undertake consumer engagement as part of business as usual and through the voice of the customer program. This engagement seeks in depth feedback on specific issues relating to:

- How it prices impact on its services;
- Current and future consumer energy use;
- Outage experiences (frequency and duration) and expectations;
- Communication expectations;
- STPIS expectations (reliability standards and incentive payments); and
- Increasing understanding of the electricity industry and TasNetworks.

Consumers have identified safety, restoration of faults/emergencies and supply reliability as the highest performing services offered by TasNetworks.

Consumers also identified that into the future they believe that affordability, green, communicative, innovative, efficient and reliable services must be provided by TasNetworks.

This project specifically addresses the requirements of consumers in the area of supply reliability.

1.4 Regulatory Considerations

This project is required to achieve the following capital expenditure objectives in alignment with NER 6A.6.7 (Transmission) as outlined in table 1.

Table 1 Capital expenditure objectives relevant to this project.

This project is required to achieve the following capital expenditure objectives:	Yes/No
• Meet or manage the expected demand for prescribed services.	Yes
• Comply with all applicable regulatory obligations associated with the provision of prescribed services.	Yes
• Maintain the quality, reliability and security of supply of prescribed services.	Yes
• Maintain the reliability and security of the system through the supply of prescribed services.	Yes
• Maintain the safety of the system through the supply of prescribed services.	Yes

2. Project Objectives

The objective of this project is to replace the remaining fleet of ASEA HLD 110 kV live tank circuit breakers is to:

- Contribute to the achievement of the capital expenditure objectives identified in the NER;
- Provide a safe, secure and reliable electricity supply to customers connected through transmission substations by replacing obsolete assets;
- Achieve life-cycle cost savings due to reduced operations and maintenance requirements;

- Align with TasNetworks circuit breaker standard; and
- Align with strategic asset management plans.

3. Strategic Alignment

3.1 Business Objectives

Strategic and operational performance objectives relevant to this project are derived from TasNetworks 2017-18 Corporate Plan, approved by the Board in 2017.

This project is relevant to the following areas of the corporate plan:

- We understand our customers by making them central to all we do;
- We enable our people to deliver value; and
- We manage our assets to deliver safe and reliable services while transforming our business.

3.2 Business Initiatives

The business initiatives reflected in TasNetworks Transformation Roadmap 2025 publication (June 2017) for transition to the future that have synergy with this project are as follows:

- Network and operations productivity: We'll improve how we deliver the field works program, continue to seek cost savings and use productivity targets to drive our business;
- Electricity and telecoms network capability: To meet your energy needs and ensure power system security, we'll invest in the network to make sure it stays in good condition, even while the system grows more complex;
- Predictable and sustainable pricing: To deliver the lowest sustainable prices, we'll transition our pricing to better reflect the way you produce and use electricity; and
- Enabling and harnessing new technologies and services: By investing in technology and customer service, we'll be better able to host the technologies you're embracing.

4. Current Risk Evaluation

The qualitative risk evaluation summarised in section 4.1 below shows the untreated risk associated with a do nothing option. It equates to a worst case scenario of inherent risk associated with a particular asset. A lower level of likelihood and / or consequence may be applied as part of the sensitivity analysis when calculating the total risk cost as part of the quantitative options analysis.

4.1 5x5 Risk Matrix

TasNetworks' business risks are analysed utilising the 5x5 corporate risk matrix, as outlined in TasNetworks Risk Management Framework.

Relevant strategic business risk factors that apply are as follows:

Risk Category	Risk	Likelihood	Consequence	Risk Rating
Customer	Material supply interuption to many	Unlikely	Moderate	Medium

	customers.			
Environment and Community	Environmental remediation work. No impact beyond Tasnetworks area.	Unlikely	Negligible	Low
Financial	Moderate financial impact. Assets has been identified in deteriorating condition and if fail in service will result in un-intended costs to the business in excess of what would be expected for a controlled CAPEX spend	Unlikely	Moderate	Medium
Network Performance	Localised supply interuption.	Unlikely	Minor	Low
Regulatory Compliance	No potential to damage relationship with regulator and any breach managed internally.	Unlikely	Minor	Low
Reputation	Some local media attention.	Unlikely	Minor	Low
Safety and People	Risk of injury dependant on asset failure mode and potential industrial action for not adequately maintaining asset. Existing aged assets exhibiting external signs of degradation which introduces risk of failure.	Rare	Severe	Medium

Section 2 (Gated Investment Step 2)

5. Preferred Option:

The preferred option is to replace the existing aged and poor condition Asea HLD 110 kV live tank circuit breakers in the R19 regulatory period.

5.1 Scope

Replace remaining fleet of 110 kV ASEA HLD live tank circuit breakers (LTCB) with dead tanks circuit breakers (DTCB) at Lindisfarne (LF), Bridgewater (BW), Chapel St (CS), Kingston (KI) and Norwood (NW) substations:

- LF-F152, LF-G152;
- BW-A752, BW-G152, BW-H152;
- CS-A552, CS-F152, CS-G152;
- KI-A152, KI-B152; and
- NW-A152, NW-A752, NW-B152.

Addition scope of work to be considered for inclusion:

- Replacement of LTCB with standard DTCB and removal of current transformers (CTs) at LF, BW, CS, KI and NW;
- CS A5 bay to be rearranged to be opposite J1 bay (CS-CR3). Additional structure required at CS A5 bay to cross transformer track to new DTCB location. Post insulators to be removed from bay; and
- Relocation of existing line disconnector switch/earth switch (DS/ES) at KI on both A1 and B1 bays to allow room for DTCB. Bays to remain in-situ at present.

5.2 Expected outcomes and benefits

The expected outcomes and benefits of the preferred option are as follows:

- Security, availabilty and reliability of supply maintained in various supply areas;
- Reduction of safety risk;
- Alignment with strategic asset management plans; and
- Remove fleet of aged assets.

5.3 Regulatory Test

As this project has a capital value which is nearing but not exceeding the threshold for triggering a regulatory investment test, TasNetworks deems that a regulatory investment test is not required.

6. Options Analysis

Completion of options analysis has been undertaken using a modified Net Present Value (NPV) tool, to include Risk Cost. Risk Cost represents the expected annual cost of risk events ($ million) associated with the failure of asset. The business as usual case (BAU) base case definition applied in the options analysis is aligned to

Australian Energy Regulator (AER) repex planning guideline. The NPV outcomes for all options considered, is relative to the BAU base case. The NPV tool has also been modified to include a Basis of Preparation. This enables increased transparency of the methodology and analysis undertaken, outlining methodology, key inputs, key assumptions. The Risk Cost methodology is represented as below:

Annual asset risk cost= Probability of Asset Failure (PoF) * Asset units (No) * Likelihood of Consequence of Failure (LoC) * Cost of Consequence (CoC).

The analysis of all options is aligned with the Australian Energy Regulators application note for asset replacement planning, to ensure alignment of our approach. The risk cost categories, likelihood and consequence ratings are aligned with TasNetworks Corporate Risk Framework. The categories can also be mapped to the AER's repex planning guideline

AON, TasNetworks corporate insurer provided Cost of Consequence (CoC) and Likelihood of Consequence (LoC) data. We have also analysed our assets and sought additional benchmarked data to develop Likelihood of Failure, Likelihood of Consequence and Cost of Consequence when it can be obtained.

The replacement of the remaining fleet of ASEA HLD 110 kV CBs (14 in total) in revenue reset period 2019-2024, option 1, is the preferred option. This is the most cost-effective solution to address the project requirements and aligns with the TasNetworks Zero Harm policy by removing a safety risk in a more timely manner than option 2 and is the most positive NPV economically.

It is noted that the AER/ARUP preliminary proposal has highlighted that a partial replacement may be justified with some work in 2019-24 regulatory period and remainder in the 2024-29 period. It is noted that the fleet only comprises 14 units and a better supply price will be provided with a single project to replace all instead of staggering over different regulatory periods. The NPV analysis shows that completion of the proposed works in the 2019-24 regulatory period is the preferred option.

The holding of removed units as spares is not the preferred asset management practice with these old, poor condition units as the spares themselves will not provide reliable service. The cost penalty for reactive replacement works with the inherent risk of supply security and increased cost would negatively impact TasNetworks and their customers as opposed to a planned capital replacement in a controlled proactive manner.

The AER has commented that no unserved energy costs have been included with the NPV analysis. This is the case with transmission circuits impacted by this proposed project. These transmission circuits provide a redundant system where firm supply is provided for, ie. N-1 configuration. To allow for this there is a parallel supply path associated with each of the identified circuit breakers and as such failure of any one would not have any unserved energy costs associated. Any second failure (N-2) would result in unserved energy but N-2 analysis is not considered as credible.

The preferred option is to undertake the proposed works as one project in the 2019-24 regulatory period.

Note that the NPV analysis undertaken for this project is based on capital and operational costs including risk based costs. The project has been deemed to be justified on the grounds that it is:

1. a safety related replacement project based on a need to satisfy a zero harm business requirement;
2. a safety related replacement project based on a strategy; and
3. a replacement project for assets that have a finite life or condition based identified during inspection or condition test reports and failure can be assured or predicted. Replacement in a controlled manner is strongly recommended over an unplanned response which also aligns with good asset management practice.

6.1 Option Summary

Option description	
Option 0	Do nothing and replace on failure
Option 1 (preferred)	Replace 110 kV ASEA HLD circuit breakers in the 2019-24 regulatory period
Option 2	Defer replacement of 110 kV ASEA HLD circuit breakers until the following 2025-29 regulatory period
Option 3	Staggered replacement of 110KV ASEA HLD circuit breakers in the 2019-24 and 2024-29 regulatory periods.

6.2 Summary of Drivers

Option	
Option 0	Do nothing and replace on failure Retain exisiting fleet of ASEA HLD 110 kV CBs (14 in total). Scope The proposed scope for this option includes: • Maintaining fleet of ASEA HLD 110 kV CBs (14 in total) and run to failure. Benefits The benefits for this option are: • No capital expenditure. Drawbacks The drawbacks for this option are: • Higher operational costs; • Increased likelihood of CB failure; • Increased maintenance cost; and • Reactive replacement at higher cost.
Option 1 (preferred)	Replace 110 kV ASEA HLD circuit breakers in the 2019-24 regulatory period Replace exisiting fleet of ASEA HLD 110 kV CBs (14 in total). Scope The proposed scope for this option includes: • Replace fleet of ASEA HLD 110 kV CBs (14 in total). Benefits

<table>
<tr><td></td><td>The benefits for this option are:

Most positive economical outcome from NPV analysis including monetised risk;
Maintain current level of supply reliability;
Controlled replacement of assets; and
Appropriate spend of capital expenditure.

Drawbacks

The drawbacks for this option are:

Higher capital expenditure.
</td></tr>
<tr><td>Option 2</td><td>Defer replacement of 110 kV ASEA HLD circuit breakers until the following 2025-29 regulatory period

Replace exisiting fleet of ASEA HLD 110 kV CBs (14 in total).

Scope

The proposed scope for this option includes:

Replace fleet of ASEA HLD 110 kV CBs (14 in total).

Benefits

The benefits for this option are:

Controlled replacement of assets; and
Appropriate spend of capital expenditure.

Drawbacks

The drawbacks for this option are:

Level of supply reliability decreases;
higher capital expenditure; and
Deferment for another 5 years introducing risk of adverse supply reliability and safety consequences due to increased likelihood for asset failure.
</td></tr>
<tr><td>Option 3</td><td>Staggered replacement of 110KV Asea HLD circuit breakers in the 2019-24 and 2024-29 regulatory periods.

This option includes the replacement of the existing Asea HLD circuit breakers. This option addresses all the condition issues associated with this type of circuit breaker.

Scope

The proposed scope for this option includes:

Replacement of EHV breakers at Bridgewater, Kingston and Lindisfarne Substations in 2019-2024 revenue reset period
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	• Replacement of EHV breakers at Chapel St and Norwood Substations in 2024-2029 revenue reset period Benefits The benefits for this option are: • Deferred some capital expenditure on replacement of EHV circuit breakers in declining condition. Drawbacks The drawbacks for this option are: • Higher capital cost; • Inefficient use of project resources; • Increased maintenance cost for remaining units; and • Continue with higher risk of failure as opposed to replacing out all units.

6.3 Summary of Costs

Option	Total Cost ($)
Option 0	$0
Option 1 (preferred)	$5,479,632
Option 2	$5,479,632
Option 3	$5,979,632

6.4 Summary of Risk

Option 0: Do nothing and replace on failure

Identified risks predominately to customers, financial, network performance, regulatory compliance, reputation and safety increase further over time as the asset condition deteriorates further.

Option 1: Replace 110KV Asea HLD circuit breakers in the 2019-24 regulatory period

Reliability of supply maintained for the long term. Risks to customers, network performance, regulatory compliance and reputation reduced with safety consequence reduced substantially.

Option 2: Defer replacement of 110KV Asea HLD circuit breakers until the following 2025-29 regulatory period

The deferment of the replacement would result in an increased exposure to a failure.

With the asset failure likelihood increasing due to condition degradation, the risks to customers, financial, network performance, regulatory compliance, reputation and safety continue as per do nothing option for greater period of time.

Option 3: Staggered replacement of 110KV Asea HLD circuit breakers in the 2019-24 and 2024-29 regulatory periods.

The deferment of replacement of half the fleet would result in continued increased exposure to a failure on remaining units.

With the asset failure likelihood increasing due to condition degradation, the risks to customers, financial, network performance, regulatory compliance, reputation and safety continue as per do nothing option for greater period of time.

6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing and replace on failure	-$8,350,861
Option 1 (preferred)	Replace 110 kV ASEA HLD circuit breakers in the 2019-24 regulatory period	$1,710,308
Option 2	Defer replacement of 110 kV ASEA HLD circuit breakers until the following 2025-29 regulatory period	-$681,888
Option 3	Staggered replacement of 110KV ASEA HLD circuit breakers in the 2019-24 and 2024-29 regulatory periods.	-$72,300

6.5.1 Quantitative Risk Analysis

A quantitative risk analysis has been completed including the cost of risk as described in section 6 above. The most positive option has been selected as the preferred option.

A CBRM assessment has been completed, which indicates these assets are in the high risk category and require works to manage this risk.

6.5.2 Benchmarking

TasNetworks participates in various formal benchmarking forums with the aim to benchmark asset management practices against international and national transmission companies. Key benchmarking forums include:

- International Transmission Operations and Maintenance Study (ITOMS); and
- Transmission survey, which provides information to the Electricity Supply Association of Australia (ESAA) for its annual Electricity Gas Australia report.

In addition, TasNetworks works closely with transmission companies in other key industry forums, such as CIGRE (International Council on Large Electric Systems), to compare asset management practices and performance.

ITOMS provides a means to benchmark asset class averages (maintenance cost and service levels) between related utilities from around the world. There is a strong need to ensure capital expenditure, maintenance processes and procedures are continually reviewed to ensure optimum financial and service benefits and minimal fault outages.

The completion of this project is expected to ensure TasNetworks continues to meet it benchmarking obligations and any improvement initiatives related to those benchmarking results.

6.5.3 Expert findings

Not Applicable.

6.5.4 Assumptions

Assets require replacement due to two main issues:

1. Aged assets past financial life; and
2. Aged assets approaching end of technical life (replace before failures / defects eventuate).

Addition scope of work to be considered for inclusion:

- Replacement of Live Tank Circuit Breaker with standard Dead Tank Circuit Breaker and removal of CTs at LF, BW, CS, KI and NW.
- CS A5 bay to be rearranged to be opposite J1 bay (CS-CR3). Additional structure required at CS A5 bay to cross transformer track to new DTCB location. Post insulators to be removed from bay.
- Relocation of existing line DS/ES at Kingston on both A1 and B1 bays to allow room for DTCB. Bays to remain in-situ at present.

Unserved energy and/or network penalties used in NPV:

1. Operating costs based on either continued maintenance regime of aged assets, or new maintenance practice due to replaced assets. Maintenance schedules based on details listed in EHV circuit breaker asset management plan.
2. Use energy through line or transformer.
3. Apply failure rate, typically for EHV assets assume to be a certain per cent for aged (eg. 0.48 per cent) and a tenth of that (eg. 0.048 per cent) for new. An example of figures to use for penalty applied for impact on generation:
    a. Historical total MWh generated in a year which for example for Wilmot, 137GWh
    b. Use probability of CB fail, disconnector, CT or VT failure
    c. Use generation rescheduling cost of $20-30/MWh
    d. Loss generation cost Annual MWh x probability x $20 = 137,000 x 2 per cent x $20 = $54,800.
4. Noted that no <0.1 or >1.0 system minute loss for last few years and that for each project, EHV CB's, CT's and CVT's that failure of asset will typically not result in unserved energy due to N-1 arrangement. Only if breaker fail occurs and then bus trip will unserved energy be possible. If system minutes loss would result in ~$300K for each >0.1 and >1.0 loss of supply events; and
5. Market Impact Congestion - Transmission (MICT) is an important consideration, Transmission congestion occurs when the transmission network has insufficient capacity to support the optimal generator dispatch based upon a bidding generator in the National Electricity Market (NEM). As current year performance impacts two years future target and next year performance, a value of $10,000 per hour (12 Dispatch Intervals) can be used as lost opportunity cost for the use in NPV analysis. An example from 30 May 2017 when 97 dispatch intervals were binding during a forced outage on the HA–GT No 1 220 kV required due to an oil leak on current transformer HA-Q196. The HA–GT No 1 transmission circuit was out of service for 36 hours (or 432 DI). Penalty cost $360,000.