Investment Evaluation Summary (IES)

Project Details:

Project Name:	Chapel St 11kV HV switchgear
Project ID:	01689
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:	New 11 kV Circuit breaker switchgear housed in existing switch room in the 2019-24 regulatory period
Preferred Option Estimate (Dollars $2016/2017):	$3,646,530

	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Unit ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Volume	0.00	0.00	0.00	0.13	0.61	0.26	0.00	0.00	0.00	0.00
Estimate ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total ($)	$0	$0	$0	$474,049	$2,224,383	$948,098	$0	$0	$0	$0

Governance:

Works Initiator:	Michael Verrier	Date:	04/11/2018
Team Leader Endorsed:	Darryl Munro	Date:	16/11/2018
Leader Endorsed:	Nicole Eastoe	Date:	20/11/2018
General Manager Approved:	Wayne Tucker	Date:	22/11/2018

Related Documents:

Description	URL
Estimate L1	http://reclink/R0000681145
Substation High Voltage Switchgear Arc Flash Hazard Risk Management Assessment	http://reclink/R0000152836
HV switchgear AMP	http://reclink/R0000032659
Chapel St 11 kV replacement NPV analysis	http://reclink/R0001191367#NPV_V3-_Chapel_St_11_KV_switchgear.xlsm
TasNetworks Risk management Framework	http://Reclink/R0000238142
TasNetworks Transformation Roadmap 2025	http://Reclink/R0000764285
TasNetworks Corporate Plan - Planning period: 2017-18	http://reclink/R0000745475
National Electricity Rules (NER)	http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
TasNetworks Business Plan 2017-18	http://reclink/R0000779008
Chapel St Whipp and Bourne CV 11kV Switchgear Condition Assessment Report	http://reclink /R0000837781#Chapel_St_Whipp_and_Bourne_CV_11kV_Switchgear_Condition_Assessment_Report.docx

Section 1 (Gated Investment Step 1)

1. Overview

1.1 Background

TasNetworks has a fleet of HV metal-clad type switchgear which have been identified as not being arc fault contained and being high risk of failure due to;

1. not meeting current acceptable standards of arc fault containment and minimum insulation protection level; and
2. exhibiting Partial Discharge levels indicative of insulation breakdown.

Replacement of HV metal-clad type switchgear installed on the transmission network is the continuation of a replacement program initiated during the 2014-19 regulatory period. Future failures can be expected and some of them could be of a more serious nature with potential to result in large unserved energy. Modern switchgear using vacuum medium for arc interruption are very reliable, safe to operate and require substantially reduced maintenance compared to oil type switchgear. Modern switchgear also provides arc fault containment which provides personnel safety as well as minimising any physical damage to site in the unlikely event of a circuit breaker failure. The current switchgear does not have the Internal Arc Containment (IAC) features to withstand 25 kA, for 1s as per Australian Standard (AS) 62271.200, including racking circuit breakers behind arc proof doors for safety of operators.

1.2 Investment Need

Failure of the high voltage switchgear has the potential to cause severe harm to personnel in the vicinity of the switchgear with the arc flash energy level at Chapel St substation exceeding 40 cal per square cm, which exceeds the rating for category 4 personal protective equipment. TasNetworks has obligation under WHS legislation to provide a safe workplace for its employees. Failure can also cause significant disruption to customer supply. The consequences of failure are therefore deemed to present an unacceptable level of risk to TasNetworks.

Increasing the routine maintenance activities, which is a lower level of engineering risk control, is not considered to mitigate the duty of care risks, due to the inherent design issues associated with this type of switchgear. A risk assessment on HV switchgear arc flash hazards was completed in 2016 (Substation High Voltage Switchgear Arc Flash Hazard Risk Management Assessment) and recommended replacement of switchgear that is not arc flash contained.

Defects records

With reference to TasNetworks defects register, there have been 15 defects recorded for HV switchgear at Chapel St Substation between 2003 and 2017.

Majority of defects related to aging assets. Typical repairs involve:

- lubrication of motor rewind mechanism;
- alignment of limit switch; and
- Freed tight close/trip operaing switches and busbar/earth selector buttons.

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).
- 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 and safety.

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

Address the safety and operational constraints presented by the continued operation of indoor metal-clad 11 kV switchgear that has no internal arc containment, is presenting high partial discharge (PD), has limited spares availability, is aging asset with potential for catastrophic failure.

The objective of this project is to replace the 11 kV switchgear at Chapel St Substation. This will address the safety and operational constraints presented by the continued operation of indoor metal-clad 11 kV switchgear that has no internal arc containment, has limited original equipment manufacturer (OEM) spares availability and is aging asset with potential for catastrophic failure leading to a reduced ability or inability 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 customers	Unlikely	Moderate	Medium
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 capital expenditure spend.	Unlikely	Moderate	Medium

Network Performance	Localised supply interuption Assets has been identified as exceeded expected life and in deteriorating condition and if fail in service will result in unserved energy until replacements installed.	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 insulation degradation (pd testing) 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 non arc fault contained HV switchboards in the 2019-24 regulatory period.

5.1 Scope

Replace 11 kV switchgear at Chapel St Substation with internal arc contained rated units.

5.2 Expected outcomes and benefits

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

- replace aging assets, which have been identified as in a deteriorating condition;
- replace aging assets, which do not meet current technical specifications in providing safety and operational requirements;
- reduce the risk of asset failure and the safety aspects associated with high energy failure of high voltage indoor switchgear and control gear consistent with good electricity industry practice;
- reducing risk of asset failure, resulting in improvement of power supply reliability, safety and availability to connected customers;
- reduces overall business risk as a result of targeting both likelihood and consequence measures;
- reduced need to undertake extended outage duration to perform costly repairs or replacement of assets in poor condition;
- reducing duty of care risk (safety) within the stated risk tolerances of TasNetworks Risk Management Framework;
- removing risk of loss of the whole switch house if an internal arc fault was to occur in any of the switchbays;
- removing obsolete and maintenance intensive technology; and
- removing the risk of failure of obsolete assets which could result in large unserved energy.

5.3 Regulatory Test

Not applicable.

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 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 Chapel St Substation HV switchgear with new Internal Arc Containment (IAC) 11 kV Vacuum Circuit breaker switchgear 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 is the most positive NPV economically.

This outcome will align with recommendations contained in the HV switchgear arc flash hazard risk management analysis and with industry best practice by removing a hazard in accordance with good risk management hierarchy of control.

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.

VCR is determined based on the customer base at the particular substation. The assumption by ARUP to use $21,400 is simplistic and may be considered for a program of work. In this case of a single project actual customer details have been used to select the most appropriate VCR.

Failure rate has been based on industry accepted values. The defect rate that TasNetworks has observed, whilst not reflective of catastrophic failures, is higher that the accepted industry rate. For uniformity TasNetworks has adopted the industry accepted rate.

Unserved energy has been based on the winter period which covers three months. The station average value has been used with consideration given to load transfer to restore supply following failure. Sensitivity conducted for other seasonal periods average load with no impact on preferred option. Unserved energy re-evaluated on the context of using average station load and that would not lose entire substation but possible to lose one bus, noting that scenario focusses on loss of bus coupler and bus arrangement, which would initially "blacken" out station. Have assume that would take 4 hours from failure for personnel to access site, evaluate situation, isolate bus coupler and one bus. Then after 4 hours one bus would be re-energised picking up half station load. Thereafter it is assumed that after each 4 hour period, field switching would occur transferring remaining load onto other feeders until all load restored.

No of units not considered as it is assumed that the failure rate is applicable to each unit and the likelihood of a bus couple failure is the same as for any other. The resulting impact if any of the breakers had a catastrophic failure that without arc fault containment similar resultant damage will occur. Worse case would be that the entire substation is damaged, but scenario has been restricted to only an impact on one bus. If loss of entire station was considered then NPV expected to be even greater.

6.1 Option Summary

Option description	
Option 0	Do nothing. No planned capital investment - Continue current maintenance practices
Option 1 (preferred)	New 11 kV Circuit breaker switchgear housed in existing switch room in the 2019-24 regulatory period
Option 2	Defer new 11 kV Circuit breaker switchgear housed in existing switch room until the following 2025-29 regulatory period

6.2 Summary of Drivers

Option	
Option 0	Benefits The benefits for this option are: • Defers capital cost. Drawbacks

	The drawbacks for this option are: • It does not mitigate the issues associated with the limitations of the existing switchgear; • It does not mitigate the safety issues presented by lack of internal arc containment; • It maintains present levels of operational expenditure; and • It doesn't address the obsolescence of the aging circuit breaker switchgear that have limited spare parts availability.
Option 1 (preferred)	Benefits The benefits for this option are: • Most positive economical outcome from NPV analysis including monetised risk; • It addresses all the condition and design issues associated with the existing switchgear; • Ongoing operational expenditure will be reduced; • Built in Internal Arc Containment (IAC) features to withstand 25 kA, for 1s as per AS 62271.200, including racking circuit breakers behind arc proof doors for safety of operators; • Contingency plans remain unaltered; and • The switchgear lifetime will be at least 45 years. Drawbacks The drawbacks for this option are: • High capital cost; • The existing 11 kV incomer and feeder cables are to be reconnected to the new switchboards. Some cable extensions may be required (to be determined at detailed design stage); and • Prolonged outages will be required to facilitate installation and electrical connection modifications associated with the new unit, placing restrictions on the connected customer.
Option 2	Benefits The benefits for this option are: • It addresses all the condition and design issues associated with the existing switchgear; • Ongoing operational expenditure will be reduced; • Built in Internal Arc Containment (IAC) features to withstand 25 kA, for 1s as per AS 62271.200, including racking circuit breakers behind arc proof doors for safety of operators; • Contingency plans remain unaltered; and • The switchgear lifetime will be at least 45 years. Drawbacks The drawbacks for this option are: • System and safety risks remain present for several more years and likelihood of failure could escalate; • High capital cost; • The existing 11 kV incomer and feeder cables are to be reconnected to the new switchboards. Some cable extensions may be required (to be determined at detailed design stage); and • Prolonged outages will be required to facilitate installation and electrical connection modifications associated with the new unit, placing restrictions on the connected customer.

6.3 Summary of Costs

Option	Total Cost ($)

Option 0	$0
Option 1 (preferred)	$3,646,530
Option 2	$3,646,530

6.4 Summary of Risk

Option 0: Do nothing and replace on failure

Identified risks predominately to customers, financial and safety increase further over time as the asset condition deteriorates further.

Option 1: Replace 11 kV circuit breakers in the 2019-24 regulatory period

Reliability of supply maintained for the long term. Risks to customers and financial reduced with safety consequence reduced substantially.

Option 2: Defer replacement of 11 kV circuit breakers until the 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 and safety continue as per do nothing option for greater period of time.

6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing. No planned capital investment - Continue current maintenance practices	-$7,628,477
Option 1 (preferred)	New 11 kV Circuit breaker switchgear housed in existing switch room in the 2019-24 regulatory period	$2,574,390
Option 2	Defer new 11 kV Circuit breaker switchgear housed in existing switch room until the following 2025-29 regulatory period	$534,840

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 risk assessment has been completed, which indicates these assets are in the high risk category due to lack of arc fault containment and aging assets and require work 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 & 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 commitments 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 main issues of:

1. Assets do not meet current TasNetworks or Australian Standards;
2. Assets do not have arc-fault containment and at risk of catastrophic failure leading to total loss of supply, physical building damage and/or personnel safety;
3. Assets approaching end of technical life (replace before failures / defects eventuate); and
4. Retrofit Internal Arc Containment (IAC) features into the existing switchgear not practically available.

Operating costs, 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 HV circuit breaker asset management plan.
2. Use average energy through transformer per annual planning report and consider available load transfers upon failure.
3. Failure rate derived from defect data and if not available the failure rate for HV assets is assumed to be 2 per cent for aged (as per industry date) and 0.2 per cent for new (assumed one tenth of new).
4. WACC (pre-tax real) assumed to be 3.59 per cent.
5. VCR assumed to be $14,960 $/MWh.