Investment Evaluation Summary (IES)

Project Details:

Project Name:	Replacement of high voltage switchgear in ground mounted substations
Project ID:	00704
Business Segment:	Distribution
Thread:	Ground Mounted Substations
CAPEX/OPEX:	CAPEX
Service Classification:	Standard Control
Scope Type:	A
Work Category Code:	REHSW
Work Category Description:	Replace Ground Mtd HV Switchgear
Preferred Option Description:	Planned switchgear replacement, with targeted replacement at 48 years service life.
Preferred Option Estimate (Dollars $2016/2017):	$10,830,000

	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Unit ($)	$190,000	$190,000	$190,000	$190,000	$190,000	$190,000	$190,000	$190,000	$190,000	$190,000
Volume	11.00	11.00	11.00	12.00	12.00	12.00	13.00	13.00	14.00	16.00
Estimate ($)	$2,090,000	$2,090,000	$2,090,000	$2,280,000	$2,280,000	$2,280,000	$2,470,000	$2,470,000	$2,660,000	$3,040,000
Total ($)	$2,090,000	$2,090,000	$2,090,000	$2,280,000	$2,280,000	$2,280,000	$2,470,000	$2,470,000	$2,660,000	$3,040,000

Governance:

Works Initiator:	Greg Hall	Date:	05/11/2018
Team Leader Endorsed:	Darryl Munro	Date:	14/11/2018
Leader Endorsed:	Nicole Eastoe	Date:	20/11/2018
General Manager Approved:	Wayne Tucker	Date:	22/11/2018

Related Documents:

Description	URL
Switchgear replacement analysis	http://reclink/R0001190810
Ground Mounted Substation – Distribution Asset Management Plan	http://reclink/R301623
REHSW HV switchgear replacement NPV	http://reclink/R0001195343
TasNetworks Risk Management Framework	http://reclink/R0000238142
National Electricity Rules (NER)	http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
TasNetworks Transformation Roadmap 2025	http://reclink/R0000764285
TasNetworks Business Plan 2017-18	http://reclink/R0000779008
TasNetworks Corporate Plan - Planning period: 2017-18	http://reclink/R0000745475

Section 1 (Gated Investment Step 1)

1. Overview

1.1 Background

TasNetworks owns and maintains apprioximately 2000 high voltage ground mounted distribution substations on its network. These substations comprise the following construction types:

- Fence type;
- Steel, fibreglass and block wall kiosk;
- Building; and
- Vault integrated.

The substations are supplied at both 11 kV and 22 kV and range in size from 300 kVA to 4500 kVA. These substations contain high voltage switchgear and within these substations there are approximately twenty different makes and models of it.

The substations are actively managed and receive routine inspections and maintenance to maximise their service life, as outlined in the Ground Mounted Substation Asset Mangement Plan.

Many of the older substations were installed in the early 1960s and are at or near the end of their service life.

1.2 Investment Need

Even with routine maintenance, high voltage switchgear does deteriorate over time resulting in a finite operational life for the equipment. As the equipment ages the probability of an in service failure occurring increases. TasNetworks' experience has been that the failure rate of this equipment typically increases after 45 to 50 years of service. TasNetworks experiences approximately eight high voltage switchgear failures in its ground mounted distribution substations per annum, of which the majority are near or over 50 years of age at the time of the failure.

Failure of the high voltage switchgear in substations causes a significant disruption to customer supply and has the potential to cause harm to both operational personnel and the public. The consequences of failure are deemed to present an unacceptable level of risk to the business.

There have been instances of significant switchgear failures that have resulted in components of the switchgear being diseminated both inside the substation and also beyond its extremities. Such events have the potential to cause serious harm to both operational personnel and the public.

To manage this risk an asset replacement program exists to replace the assets prior to an in service failure occurring.

The replacement of the switchgear is undertaken based on the individual risk of the switchgear at each substation on the network. The assessment of risk is done in accordance with TasNetworks' Risk Framework.

The replacement is prioritised based on an assessment against the following criteria:

- Risk to safety i.e. level of exposure e.g. enclosure type, location;
- Criticality of the installation;
- Condition;
- Compliance; and
- Age.

The majority of the substations installed on the network prior to 1990 use oil as the insulating medium in the high voltage switchgear. This type of switchgear is used at 189 of the older ground mounted substations. If a failure occurs in this type of switchgear it presents a greater risk than other types of switchgear because the oil can become a fuel source making failures more dangerous for both operational personnel and the public, with a catastrophic failure being potentially life threatening. The replacement of this type of switchgear has been given the highest priority.

Asset replacement of other types of switchgear is also undertaken when an assessment against the previously defined assessment criteria provides sufficient justification.

The installation types of greatest concern are the following:

- Oil-filled switchgear in fence and kiosk type substations;
- Oil-filled switchgear in substations where a failure could lead to a fire with a high consequence e.g. building fire;
- Gas insulated switchgear that have operating restrictions placed on them; and
- Gas insulated switchgear with known design deficiences leading to premature failure e.g. moisture ingress in ABB RGB24 switchgear.

The switchgear types being replaced as part of this program usually consist of:

- Reyrolle JK and JKSS;
- Reyrolle LMT;
- English Electric OLX;
- Statter;
- Hazemeyer MD4; and
- Asea Brown Boveri RGB24.

Figure 1 is an example of the type of switchgear being replaced under this program.

Figure 1 – English Electric oil filled switchgear.

This program is predominantly targeting high voltage switchgear installed in building type substations as the replacement of individual assets in this type of substation is usually the most appropriate solution.

Where high voltage switchgear requires replacement and it is installed in a kiosk substation complete substation replacement is usually the most appropriate solution. This is because the other assets within the substation are usually also near end of life. Where complete kiosk replacement is the most appropriate solution the work is usually undertaken under the ground mounted substation replacement program (REGMS).

The rate of replacement has been developed with a target of removing the high voltage switchgear from service prior to it reaching 48 years of age. This is based on TasNetworks' experience that the risk of failure greatly increases above this age.

This program of work is considered one of TasNetworks' most critical programs with its Board of Directors endorsing the management strategy for these assets in July 2015.

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 its 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 areas of safety and supply reliability.

1.4 Regulatory Considerations

This project is required to achieve the following capital expenditure objectives as described by the National Electricity Rules section 6.5.7(a) in order to:

(1) meet or manage the expected demand for standard control services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;

(3) the extent that there is no applicable regulatory obligation or requirement in relation to:

(i) the quality, reliability or security of supply of standard control services; or

(ii) the reliability or security of the distribution system through the supply of standard control services,

to the relevant extent:

(iii) maintain the quality, reliability and security of supply of standard control services; and

(iv) maintain the reliability and security of the distribution system through the supply of standard control services; and

(4) maintain the safety of the distribution system through the supply of standard control services.

2. Project Objectives

The objective is to replace the high voltage switchgear at end of life to minimise the safety risk to operational personnel and the public, and to ensure the current network performance levels are maintained.

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 care for our assets, delivering safe and reliable network 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:

- Voice of the customer: We anticipate and respond to your changing needs and market conditions;
- 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.

The risks associated with these assets were evaluated using TasNetworks' Risk Framework. Due to the potential consequences of an asset failure the risk was assessed as being 'High'. The 'High' classification was due to the fact that asset failures have the potiential to cause harm to operational personnel and the public.

The elevated level of risk was such that a treatment plan was required to reduce the risk down to a manageable level.

A 'Do nothing' approach, with the assets left to run to failure does not address the safety risks concerning this type of switchgear. Over time as the rate of failure increases further the risk would increase to 'Very High'. As the rate of failure increased the network performance would also reduce.

If the current rate of replacement was continued it would lead to an increase in asset failures as the age profile of the switchgear would increase. This is due to the fact that in the 1960s and 1970s ground mounted substations were installed at a much higher rate than in earlier years and these substations are either at or near end of life. An increase in the failure rate would result in the risk further increasing over time.

To reduce the risk down to 'Medium' level, a requirement of TasNetworks' risk framework, a minor increase in the rate of replacement is required, with a target to have the HV switchgear replaced by 48 years of age. The preferred option, Option 2 has been developed to achieve this outcome.

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	Asset failure resulting in loss of customer supply.	Unlikely	Moderate	Medium
Network Performance	Asset failure resulting in impact to network performance.	Unlikely	Moderate	Medium
Safety and People	Failure of high voltage switchgear that results in injury or loss of life.	Possible	Severe	High

Section 2 (Gated Investment Step 2)

5. Preferred Option:

The preferred solution is to replace the high voltage switchgear with new switchgear that provides equivalent functionality. The rate of replacement is one that reduces the maximum service life down to 48 years over the long term.

5.1 Scope

Replacement of high voltage switchgear that has reached end of life with new switchgear.

The new switchgear will have the equivalent functionality, with the functionality only expanded where there is either a network or customer benefit in doing so.

The scope includes:

- Determination of substation requirements;
- Detailed design;
- Procurement of equipment;
- Decommissioning and removal of existing switchgear; and
- Installation of new switchgear and commissioning.

5.2 Expected outcomes and benefits

The benefits of this option are:

- Reduction in safety risk associated with switching from 'High' to a manageable level of 'Medium';
- Network reliability maintained at its current level; and
- Reduction in operational expenditure.

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.

Several options were considered to manage these assets, from a run to failure approach through to varying planned replacement options. Switchgear refurbishment was not a viable option as the switchgear is no longer supported by the original equipment manufacturer and the lack of product support means that the new replacement parts required to undertake refurbishment are no longer available.

Option 0 - Do nothing - Replace switchgear following failure (Business As Usual base case)

To do nothing is the least expensive option from a capital expenditure perspective, but it is not seen as a viable option because if the strategy was adopted the rate of asset failure would increase over time creating an increased safety risk. As the rate of failure increased there would also be a reduction in network reliability of supply and greater disruption to customer supply. Operational expenditure would need to increase to cover the increased level of fault response.

Option 1 - Planned switchgear replacement, with a targeted service life of 45 years

Asset replacement at 45 years of service provides the best outcome from a risk perspective, but it would requires a notable increase in capital expenditure and business capability to deliver the strategy. This option aims to replace the switchgear prior to it reaching 45 years of service life with the actual replacement age being dependant on condition and risk. Although there is a preference to reduce the service life of these assets, due to the increased level of investment required to deliver this strategy it is not seen as providing sufficient return for the investment.

Option 2 - Planned switchgear replacement, with a targeted service life of 48 years (Preferred)

Continuation of existing replacement strategy with replacement at 48 years of service, with a minor increase in the rate of replacement over the period from 2019/20 to 2023/24 and subsequent years. This option is the lowest cost option to maintain the safety risk at a manageable level. This option also provides the greatest return from an economic perspective making it the preferred strategy. The option also provides an acceptable network performance outcome.

At the commencement of the 2019/20 financial year there would be 16 substations on the network where the switchgear would have already reached or exceeded the targeted 48 years service life. The delivery of an additional 16 switchgear replacement jobs in the 2019/20 financial year was not seen as being achieveable due to resource constraints and so these 16 replacement jobs were spread over the four financial years from 2019/20 to 2022/23.

Option 3 - Planned switchgear replacement, with a targeted service life of 55 years

This option would extend the service life to 55 years which would initally result in a reduced level of capital expenditure due to the reduced rate of asset replacement, but with the service life increasing, over time the rate of asset failures would increase resulting in an elevated safety risk. Network performance would also decrease over time. For this reason this option was not the preferred option.

6.1 Option Summary

Option description	
Option 0	Do nothing - Replace switchgear following failure.
Option 1	Planned switchgear replacement, with targeted replacement at 45 years service life.
Option 2 (preferred)	Planned switchgear replacement, with targeted replacement at 48 years service life.
Option 3	Planned switchgear replacement, with targeted replacement at 55 years service life.

6.2 Summary of Drivers

Option	
Option 0	Do nothing - Replace switchgear following failure. To do nothing will not address the safety risks concerning this type of switchgear. A do nothing approach would see assets run to failure, which would result in an increased safety risk. Advantages • Low planned capital expenditure. Disadvantages • Safety risk would increase from 'High' to 'Very high'; • Greatly increased likelihood of significant asset failure with potential for loss of life; • Reduction in network reliability and greater disruption of customer supply; • Increased operational expenditure; and • Increased unplanned asset replacement under fault conditions. This option does not fully address the risks previously identified in Section 4.
Option 1	Planned switchgear replacement, with targeted replacement of 45 years service life. Implement a switchgear replacement plan with a targeted replacement age of 45 years. Advantages • Reduces safety risk from 'High' to 'Medium'; • Reduction in asset failures and unplanned outages; • Shift from reactive to planned replacement; and • Provides a positive return from an economic perspective.

	Disadvantages • Notable increase in the rate of replacement; • Business capability would need to be notably improved to deliver strategy; and • Notable increase in capital expenditure. This is the lowest cost option to fully address the risks previously identified in Section 4.
Option 2 (preferred)	Planned switchgear replacement, with targeted replacement of 48 years service life. Implement a switchgear replacement plan with a targeted replacement age of 48 years. This option would require a minor increase in the rate of replacement over the current program. Advantages • Reduces safety risk from 'High' to 'Medium'; • Reduction in capital expenditure over Option 1; • Business has the capability to deliver strategy; and • Provides the greatest positive return from an economic perspective. Disadvantages • Does not initially fully address the business risks previously identified due to the time frame to reduce the risk down to an acceptable level. The maximum targeted service life of 48 years would not be achieved until the end of the 2022/23 financial year. Until this time any elevated risk would be managed though operational controls. This option does initially fully address the risks previously identified in Section 4, but is the most cost effective option that reduces the level of risk down to a manageable level.
Option 3	Planned switchgear replacement, with targeted replacement of 55 years service life. Implement a switchgear replacement plan with a targeted replacement age of 55 years. This approach would see an increase in the number of asset failures, resulting in an increased safety risk. There would also be a reduction in network performance. Advantages • Deferral of capital expenditure. Disadvantages • Safety risk would be maintained at 'High', with it further increasing over time; • The number of asset failures would increase over time as the maximum service life of the assets increases from 48 to 55 years; • Reduction in network reliability and greater disruption of customer supply; • Increased unplanned asset replacement under fault conditions; • Increased operational expenditure over options 1 and 2; and • Does not provide a positive return from an economic perspective.

6.3 Summary of Costs

Option	Total Cost ($)
Option 0	$1,920,000
Option 1	$13,300,000
Option 2 (preferred)	$10,830,000
Option 3	$3,420,000

6.4 Summary of Risk

Option 0 - Do nothing - Replace switchgear following failure.

Increase in rate of failure would result in risk increasing from 'High' to 'Very high'.

Option 1 - Planned switchgear replacement with a targeted service life of 45 years.

Would result in risk decreasing from 'High' to 'Medium' at a faster rate than the preferred option.

Provides the best outcome from a risk perspective, but requires a notable increase in expenditure and effort.

Option 2 - Planned switchgear replacement with a targeted service life of 48 years (Preferred).

Would result in risk decreasing from 'High' to 'Medium'.

Option 3 - Planned switchgear replacement with a targeted service life of 55 years.

Increase in rate of failure would result in risk increasing from 'High' to 'Very high'.

6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing - Replace switchgear following failure.	-$35,505,272
Option 1	Planned switchgear replacement, with targeted replacement at 45 years service life.	$3,518,520
Option 2 (preferred)	Planned switchgear replacement, with targeted replacement at 48 years service life.	$4,311,785
Option 3	Planned switchgear replacement, with targeted replacement at 55 years service life.	-$4,235,187

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 sensitivity analysis was also undertaken using differing probabilities for the likelihood of asset failures occurring, value of customer reliability ($/MWh) and WACC.

6.5.2 Benchmarking

Other distribution network service providers also have asset replacement programs for their high voltage switchgear to minimise the safety risk this type of equipment presents to the public and to also maintain network reliability.

6.5.3 Expert findings

Nil.

6.5.4 Assumptions

The assumptions made in the analysis were as follows:

- That there was a direct correlation between asset age and condition, with the number of asset failures being proportional to the average age of the assets;
- If there was no planned asset replacement strategy the average number of switchgear failures per annum would steadily increase at a rate of 7 per cent over the period from 2019/20 to 2023/24;
- If the preferred replacement strategy was adopted the average number of switchgear failures per annum would be maintained constant at eight;
- If a strategy was adopted to replace switchgear at 55 years service life the average number of switchgear failures per annum would increase at a rate of 2 per cent over the period; and
- The average time until customer supply would be restored to all customers following an asset failure would be 4 hours;