Investment Evaluation Summary (IES)

Project Details:

Project Name:	Replacement of ground mounted substations
Project ID:	00703
Business Segment:	Distribution
Thread:	Ground Mounted Substations
CAPEX/OPEX:	CAPEX
Service Classification:	Standard Control
Scope Type:	A
Work Category Code:	REGMS
Work Category Description:	Replace Ground Mtd Sub
Preferred Option Description:	Planned substation replacement, with targeted replacement at 48 years service life.
Preferred Option Estimate (Dollars $2016/2017):	$23,220,000

	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Unit ($)	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000
Volume	25.00	25.00	26.00	26.00	27.00	27.00	28.00	28.00	29.00	29.00
Estimate ($)	$4,500,000	$4,500,000	$4,680,000	$4,680,000	$4,860,000	$4,860,000	$5,040,000	$5,040,000	$5,220,000	$5,220,000
Total ($)	$4,500,000	$4,500,000	$4,680,000	$4,680,000	$4,860,000	$4,860,000	$5,040,000	$5,040,000	$5,220,000	$5,220,000

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
Substation replacement analysis	http://reclink/R0001190810
REGMS Substation replacement NPV	http://reclink/R0001120672
Ground Mounted Substation – Distribution Asset Management Plan	http://reclink/R301623
National Electricity Rules (NER)	http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
TasNetworks Risk Management Framework	http://reclink/R0000238142
TasNetworks Transformation Roadmap 2025	http://Reclink/R0000764285
TasNetworks Business Plan 2017-18	http://reclink/R0000779008
TasNetworks Corporate Plan - Planning period: 2017-18	http://reclink/R0000779008

Section 1 (Gated Investment Step 1)

1. Overview

1.1 Background

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

- fence type;
- steel, fibreglass and block wall kiosks;
- 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. Within these substations there is a variety of configurations and equipment, with approximately twenty different makes and models of high voltage switchgear.

The substations are actively managed and receive routine inspections and maintenance to maximise their service life. Many of the older substations were installed in the early 1960's and are at or near the end of their service life.

1.2 Investment Need

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

Failure of the assets within the substations, particularly the high voltage switchgear has the potential to cause harm to both operational personnel and the public and can cause significant disruption to customer supply. The consequences of failure have been assessed as 'High' and present an unacceptable level of risk to the business.

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

The replacement of the ground mounted kiosk substations is undertaken based on the individual risk of each substation. The assessment of risk is done in accordance with TasNetworks' Risk Framework.

The replacement of a substation is usually driven by the risks associated with the increased probability of an asset failure occurring, particularly the high voltage switchgear and the consequences of the failure e.g. safety risk to operational personnel and the public, network disruption and environmental impact.

Each substation identified for 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 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 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 and the public. The replacement of this type of switchgear has been given the highest priority.

The risks attributed to the concerning failure modes of the switchgear types are briefly detailed below:

- Oil-filled switchgear in fence and padmount type substations due to catastrophic failure presenting a potential safety risk to the public due to the increased exposure;
- Oil-filled switchgear in enclosures having a high risk of catastrophic failure and oil fuelling a substation fire;
- Gas insulated units having operating restrictions due to operational safety issues associated with single phase switching under fault conditions; and
- Gas insulated units having insulation failure and subsequent flashovers due to poor design.

The substations being replaced as part of this program usually contain the following switchgear types as they are the ones that present the highest risk:

- Reyrolle JK and JKSS;
- Statter;
- Hazemeyer MD; and
- Asea Brown Boveri RGB24.

While the risks associated with the HV switchgear within the substations is often the main driver for the replacement of the substation, the condition

and associated risk of the other major components also contribute to the assessment. In some instances these components may in themselves be the driver for the replacement of the substation.

Where the replacement of the substation is the most appropriate solution to address the risk or deficiency, it is replaced under this program. Where the replacement of only the switchgear is a viable option the work is done under the REHSW high voltage switchgear replacement program.

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

The planned rate of replacement is initially 25 substations for the 2019/20 financial year, increasing to 27 substations for the 2023/24 financial year. The increase in the rate of replacement over the period is due to the increasing number of ground mounted substations that were installed on the distribution network through the 1960s and 1970s.

1.3 Customer Needs or Impact

This project specifically addresses the requirements of consumers in the areas of safety, affordability and reliability by providing well maintained assets to ensure they operate as required for their service life. Consumers have identified safety, restoration of faults/emergencies and supply reliability as the highest performing services offered by TasNetworks. TasNetworks continues to undertake a 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 also identified that into the future they believe that affordability, green, communicative, innovative, efficient and reliable services must be provided by TasNetworks.

Customers will continue to be consulted through routine TasNetworks processes, including the Voice of the customer program, the Annual Planning Review and ongoing regular customer liaison meetings.

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 ground mounted substations at end of life to minimise safety risks 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.

Due to the potential conseqeunces 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 associated with these substations. Over time as the rate of failure increases further the risk would increase to 'Very High'.

If the current rate of replacement was continued, it would lead to an increase in asset failures as the age profile of the substations 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.

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	Failure of critical equipment results in loss of HV feeder and notable disruption to customer supply.	Likely	Minor	Medium
Safety and People	Failure of HV switchgear in substation results in injury or death to member of the public or TasNetworks employee.	Unlikely	Severe	High

5. Preferred Option:

Substations comprise several major components including the substation enclosure, HV switchgear, power transfomer and LV switchboard.

Although asset replacement is often driven by only one of these major substation components, as all the assets in the substation have a similar service life and are usually also at or close to the end of their life complete substation replacement is usually the most appropriate solution.

An increase in the rate of replacement is required to reduce the risk down to 'Medium', with a target to have the substations replaced by 48 years of age.

5.1 Scope

Replacement of ground mounted substations with new substations.

The scope includes:

- determination of substation requirements;
- detailed design;
- procurement of equipment;
- installation of new substation and commissioning; and
- decommissioning and removal of existing substation.

5.2 Expected outcomes and benefits

The benefits of this replacement program are:

- a reduction in the safety risks associated with the ground mounted substations being reduced from a 'High' level of risk to a 'Medium' risk;
- a reduction in the number of substations on the network with operational restrictions;
- maintaining the current rate of high voltage switchgear on the network;
- maintaining network performance at its current level; and
- a 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. Refurbishment of individual components of the substation was not a viable option as the design of the older substations does not comply with legislative requirements and current Australian Standards.

Option 0 - Do nothing - Maintain assets only and replace following failure (Business As Usual base case)

Maintaining the assets, with no planned replacements is the least expensive option from a capital expenditure perspective, but it is not seen as a viable option because 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 - Substation replacement with a targeted service life of 45 years

Asset replacement with a targeted replacement age of 45 years provides the best outcome from a risk perspective, but requires a notable increase in capital expenditure and business capability to deliver the strategy. Although this option aims to replace the substations when they reach 45 years of service the actual time of replacement is based on asset condition and risk. 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 -Substation replacement with a targeted service life of 48 years (Preferred)

Continuation of the existing replacement strategy, with substation replacement at a target age 48 years service is the preferred option because it is the lowest cost option to maintain the risk at a manageable level. This option also provides the greatest positive return from an economic perpsective.

A minor increase in the rate of replacement over the period from 2019/20 to 2023/24 and subsequent years is required to reduce the risk down to 'Medium'.

Option 3 - Switchgear replacement with a targeted service life of 55 years

Extending the service life of the assets to 55 years would initially 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 failure 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 - Repair/replace substation following failure.
Option 1	Planned substation replacement, with targeted replacement at 45 years service life.
Option 2 (preferred)	Planned substation replacement, with targeted replacement at 48 years service life.
Option 3	Planned substation replacement, with targeted replacement at 55 years service life.

6.2 Summary of Drivers

Option	
Option 0	Do nothing - Replace substations 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 substation replacement, with targeted replacement of 45 years service life. Implement a substation 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 postive 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.
Option 2 (preferred)	Planned substation replacement, with targeted replacement of 48 years service life. Implement a substation 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 capability to deliver program; and • Provides the most positive return from an economic perspective. Disadvantages • Does not fully address the business risks previously identified. This option does not fully address the risks previously identified in Section 4, but is the most cost effective option to reduce the level of risk down to a manageable level.
Option 3	Planned substation replacement, with targeted replacement of 55 years service life. Implement a substation 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', further increasing over time; • Does not fully address the business risks previously identified; • 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 economic return for the investment.

6.3 Summary of Costs

Option	Total Cost ($)
Option 0	$2,025,000
Option 1	$28,980,000
Option 2 (preferred)	$23,220,000
Option 3	$9,900,000

6.4 Summary of Risk

Option 0 - Do nothing - Repair/replace substation following failure.

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

Option 1 - Planned substation 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 substation replacement with a targeted service life of 48 years (Preferred).

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

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

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

The quantiifcation of risk was made using TasNetworks' Risk Management Framework.

6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing - Repair/replace substation following failure.	-$53,112,709
Option 1	Planned substation replacement, with targeted replacement at 45 years service life.	$874,933
Option 2 (preferred)	Planned substation replacement, with targeted replacement at 48 years service life.	$3,763,665
Option 3	Planned substation replacement, with targeted replacement at 55 years service life.	-$5,643,459

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

This replacement program is consistent with other distribution network service providers who 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 substation failures per annum for the period from 2019/20 to 2023/24 would steadily increase at a rate of 7 per cent over the period;
- If the preferred replacement strategy was adopted the average number of asset failures per annum would remain constant at ten;
- If a strategy was adopted to replace substations at a slower rate at 55 years' service life the average number of asset failures per annum for the period would increase at a rate of 2 per cent over the period;
- For the economic analysis a value of $28 580 was used for the cost of unserved energy and 3.59 per cent was used as the discount rate;
- The average time until customer supply would be restored to all customers following an asset failure would be 4 hours; and
- That the new substations would have the same rating and function capability as the substations being replaced.