

# Investment Evaluation Summary (IES)



## Project Details:

<b>Project Name:</b>	Replacement of HV Ground Mounted Distribution Substations - Oil-filled Switchgear
<b>Project ID:</b>	00702
<b>Thread:</b>	Ground Mounted Substations
<b>CAPEX/OPEX:</b>	CAPEX
<b>Service Classification:</b>	Standard Control
<b>Scope Type:</b>	A
<b>Work Category Code:</b>	REGMS
<b>Work Category Description:</b>	Replace Ground Mtd Sub
<b>Preferred Option Description:</b>	Increased replacement that will reduce the age profile below 50 years of age
<b>Preferred Option Estimate (Nominal Dollars):</b>	\$21,805,000

	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
<b>Unit (\$)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Volume</b>	13	13	13	10	10	9	9	9	9	9
<b>Estimate (\$)</b>										
<b>Total (\$)</b>	\$2,730,000	\$2,730,000	\$2,730,000	\$2,100,000	\$2,100,000	\$1,890,000	\$1,890,000	\$1,890,000	\$1,855,000	\$1,890,000

## Governance:

<b>Project Initiator:</b>	Michael Healy	<b>Date:</b>	27/03/2015
<b>Thread Approved:</b>	David Ellis	<b>Date:</b>	02/11/2015
<b>Project Approver:</b>	David Ellis	<b>Date:</b>	02/11/2015

## Document Details:

<b>Version Number:</b>	1
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## Related Documents:

Description	URL
REGMS and REHSW replacement strategy	<a href="http://projectzone.tnad.tasnetworks.com.au/business-projects/nis-program/DD17SAM/Deliverables/Ground%20Mounted%20Substations/Ground%20MTD%20Subs%20Supporting%20Documents/REGMS_%2B_REHSW_Replacement_Strategy_Spreadsheet.xlsx">http://projectzone.tnad.tasnetworks.com.au/business-projects/nis-program/DD17SAM/Deliverables/Ground%20Mounted%20Substations/Ground%20MTD%20Subs%20Supporting%20Documents/REGMS_%2B_REHSW_Replacement_Strategy_Spreadsheet.xlsx</a>

# Section 1 (Gated Investment Step 1)

## 1. Background

TasNetworks owns and maintains 1892 high voltage ground mounted distribution substations on its network. These substations comprise the following construction types:

- Fence type
- Steel or fibreglass padmount (kiosk)
- Brick kiosk
- Building
- Vault integrated

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

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

### 1.1 Investment Need

Failure of the assets within the substations, particularly the high voltage switchgear can result in significant disruption of supply has the potential to cause harm to both operational personnel and the public.

To manage these risks, the assets at the substations are replaced prior to an asset failure occurring. The asset replacement could be either partial replacement, or complete replacement of the substation.

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 224 of the older ground mounted substations. If 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 operators and the public.

Eight of the last ten high voltage switchgear failures on the network over the last three years were with switchgear that contained oil filled circuit breakers. In each instance the switchgear has been in service for more than 50 years.

To manage this risk an asset replacement program for oil filled switchgear was initiated in 2010. Even though this type of switchgear has been proactively managed, it still presents a significant risk to the business due to the significant amount of it still remaining on the network.

Other non-oil filled switchgear that poses a notable safety and performance risk due to poor design or condition is also being actively replaced.

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 poses a safety risk to the public due to 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, this is due to single phase switching under fault conditions;
- Gas insulated units having insulation failure and subsequent flashovers due to a poorly designed epoxy spout.

Figure 1 shows the consequences of a switchgear termination failure. The cable terminations are made from cast iron and the insulation medium is pitch/tar. The failed components, which was disseminated throughout the chain fence enclosure due to an internal fault.



**Figure 1 - Recent Reyrolle JKSS switchgear with cast iron pitch filled cable terminations failure - 2014**

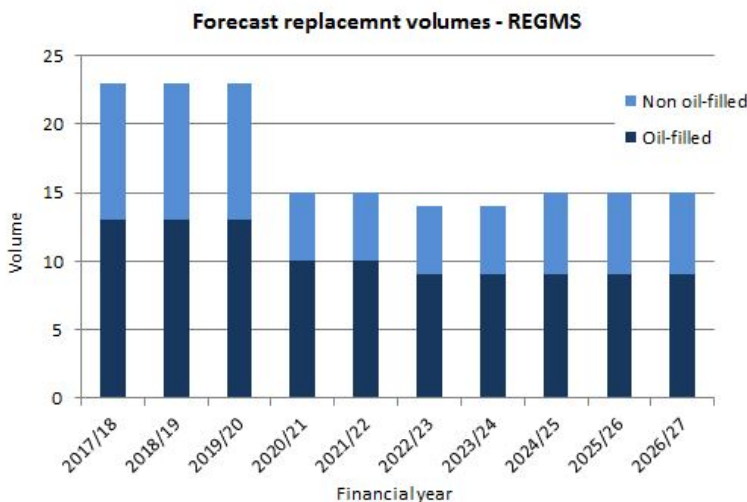
In early 2015 a high voltage switchgear failure in a substation in Perth, Western Australia resulted in two fatalities. TasNetworks has similar equipment to that which failed on its network. As an interim measure to manage the safety risk it has imposed a live switching ban on similar types of switchgear. This unfortunate example shows that these types of switchgear have potential for serious injury or death under fault and that asset replacement must be a priority.

As the oil-filled switchgear in the network presents a safety risk for operators and the public due to catastrophic failure being potentially life threatening. The high safety risk makes the replacement program of oil-filled switchgear a high priority for TasNetworks.

Asset replacement of other types of switchgear has also been necessary due to the switchgear being deemed to be at end of life due (poor condition) or due to operational deficiencies e.g. single phase switching under fault conditions. To address the risk complete replacement of the substation would occur.

Where the replacement of the substation is the most appropriate solution to address the risk of deficiency it is undertaken under the REGMS program.

The rate of replacement has been developed with target of removing high voltage switchgear from service prior to it reaching 50 years of age because the risk of failures greatly increase above this age..



**Figure 3 - Forecasted replacement volumes for REGMS split between oil and non-oil filled switchgear**

Figure 3 shows the recommended REGMS replacement volumes for the 10 year period starting in 2017/18.

The replacement strategy is related to the REHSW replacement program as they are both targeting high risk switchgear.

## 1.2 Customer Needs or Impact

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 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)
- increase 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, restoration of faults/emergencies and supply reliability.

### **1.3 Regulatory Considerations**

This project is required to achieve the following capital and operational expenditure objectives as described by the National Electricity Rules section 6.5.7(a) and 6.5.6(a).

6.5.7 (a) Forecast capital expenditure

- (2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;
- (4) Maintain the safety of the distribution system through the supply of standard control services.

## **2. Project Objectives**

The objective is to replace/renew ground mounted substations containing oil-filled switchgear 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**

The Asset Management Strategic Objectives are:

- Minimise the cost of asset management to a sustainable level
- No significant safety or environmental incidents.
- Maintain risk such that the residual risk level for all assets risks is “as low as reasonable practical” taking into consideration any expressed or implied duty of care.
- Achieve compliance with relevant legislative, regulative statutory requirements.

### **3.2 Business Initiatives**

Strategic and operational performance objectives relevant to this project are derived from TasNetworks 2014 Corporate Plan, approved by the board in 2014. This project is relevant to the following areas of the corporate plan:

- We care for our assets, delivering safe and reliable networks services while transforming our business.
- Safety of our people and the community, while reliably providing network services, is fundamental to the TasNetworks business and remains our immediate priority

The strategic key performance indicators that will be impacted through undertaking this project are as follows:

- Prices for customers – lowest sustainable prices
- Zero harm – significant and reportable incidents
- Sustainable cost reduction – efficient operating and capital expenditure

## **4. Current Risk Evaluation**

The following section details the business risks specific to this project, as identified in TasNetworks Risk Management Framework. High voltage switchgear can fail catastrophically resulting in a significant safety risk to operators and the public is at risk. Due to multiple types of switchgear there are several drivers for this program.

The switchgear is installed in a variety of enclosures types and they are: chain wire fence, building, kiosk, padmount and vault types. The greatest risk to the public is from the switchgear installed in the chain wire fence type substations as they do not provide protection from fire and limited protection from projectiles.

The switchgear types replaced under this program consist of:

**Reyrolle JK/JKSS switchgear**

The replacement of Reyrolle JK and JKSS switchgear has become a priority due to an increase in their failure rate, with instances of catastrophic failure occurring. The increased failure rate is indicative of the deteriorating condition of this type of switchgear. This switchgear was installed in the 1960’s. There are 91 substations on the network that contain Reyrolle JKJKSS switchgear and 61 of these are installed in fence type enclosures.

**English Electric OLX and Reyrolle LMT switchgear**

The English Electric OLX and Reyrolle LMT switchgear was installed in building type substations from the early 1960’s. The lengthy in service life has resulted in a recent increase in the failure rate of this type of switchgear due to a deterioration in the condition of this equipment. These failures have a variety fo cause form faulty operating mechanisms, burnt out trip coils and failure of protective devices.

Although the high voltage switchgear on the network is unlikely to fail, the numbers of incidents with oil filled switchgear has increased recently. Due to the consequence of failure having the potential to result in personal harm or even a fatality, the safety risk is rated as ‘high’.

The failure of other types of switchgear would result in the same level of customer supply disruption, but the consequence are lower resulting in a ‘medium’ risk to network performance.

The business risk associated with these assets has been evaluated by using the TasNetworks Risk Framework.

Asset Name	Risk Category	Risk	Likelihood	Consequence	Risk Rating
English Electric OLX & OLX2	Safety	Injury or illness that results in multiple fatalities	Unlikely	Severe	High
Reyrolle LMT	Safety	Injury or illness that results in multiple fatalities	Unlikely	Severe	High
Reyrolle JK & JKSS	Safety	Injury or illness that results in multiple fatalities	Unlikely	Severe	High

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

**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 follows:

Risk Category	Risk	Likelihood	Consequence	Risk Rating
Network Performance	Disruption to network and loss of customer supply from a switchgear failure.	Unlikely	Minor	Low
Safety and People	<p>Failure from high voltage oil filled switchgear that results in injury or fatalities to operational personnel or the public.</p> <p>This risk may occur from the following switchgear types:</p> <ul style="list-style-type: none"> <li>English Electric OLX &amp; OLX2</li> <li>Reyrolle LMT</li> <li>Reyrolle JK &amp; JKSS</li> </ul>	Unlikely	Severe	High

## Section 1 Approvals (Gated Investment Step 1)

<b>Project Initiator:</b>	Michael Healy	<b>Date:</b>	27/03/2015
<b>Line Manager:</b>		<b>Date:</b>	
<b>Manager (Network Projects) or Group/Business Manager (Non-network projects):</b>		<b>Date:</b>	

[Send this signed and endorsed summary to the Capital Works Program Coordinator.]

### Actions

<b>CWP Project Manager commenced initiation:</b>		<b>Assigned CW Project Manager:</b>	
<b>PI notified project initiation commenced:</b>		<b>Actioned by:</b>	

## Section 2 (Gated Investment Step 2)

### 5. Preferred Option:

The preferred option is to replace the ground mounted substations containing oil filled high voltage switchgear that presents a high risks, with a new padmount substation containing modern vacuum switchgear. As the other substation components would also be near end of life at the same time as the high voltage switchgear e.g. low voltage switchgear, transformer and enclosure complete substation replacement is a more cost effective solution as it would eliminate the need for future investment for forty to fifty years.

Replacement would occur when the switchgear presents a significant business risk or has reached end of life. Based on historical experience the switchgear would reach end of life at approximately 50 years of age.

Where the condition of the substation makes the replacement of only the switchgear a viable option, the work will be done under the REHSW switchgear replacemnt program. program

#### 5.1 Scope

The scope is to replace ground mounted substations containing oil-filled switchgear with new substations containing vacuum circuit breakers

A prioritised replacement of ground mounted substations will be 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 risk 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
- Age

The rate of replacement is as follows:

Financial year	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
Volume	13	13	13	10	10	9	9	9	9	9

#### 5.2 Expected outcomes and benefits

The benefits of this option are:

- A reduction in safety risk associated with switching from “high” to a manageable level of “low” in a timely manner.
- It maintains the reliability of the network as poor condition assets are replaced.
- Reduce the environmental risk from an oil-filled asset.
- Reduce OPEX expenditure.
- Align with TasNetworks risk framework.

#### 5.3 Regulatory Test

Not applicable

## 6. Options Analysis

Option 0 is the most cost effective in terms of capital expenditure although there are much larger OPEX costs involved due to the reactive nature of the replacement plan compared to options 1 and 2.

The do nothing option takes into account the capital investment needed which is determined from industry switchgear failure data. Options 1 and 2 average 1.62m and 2.06m annually respectively, option 1 fluctuates heavily and involves a large initial investment.

Option 2 which is preferred and has a consistent CAPEX profile that when combined with the non-oil filled switchgear program found in section 8 & 9 and REHSW program produce a consistent delivery rate.

#### 6.1 Option Summary

Option description	
Option 0	Do nothing
Option 1	Continue with the current replacement
Option 2 (preferred)	Increased replacement that will reduce the age profile below 50 years of age

## 6.2 Summary of Drivers

Option	
Option 0	<p>Run switchgear to failure and replace reactively.</p> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• Lowest cost solution</li> <li>• Deferral of CAPEX</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• Increased likelihood of catastrophic failure</li> <li>• Increased OPEX</li> <li>• Does not address safety risks resulting in significant risk or harm to operational personnel and public</li> <li>• Does not address performance risks</li> </ul> <p>This option does not address the risks previously identified in Section 4.</p>
Option 1	<p>Replace ground mounted substations with modern padmounts at the current level of replacement.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>• Deferral of CAPEX</li> <li>• Consistent replacement volumes</li> <li>• Partially addresses safety risk</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• CAPEX required</li> <li>• Age profile will become unmanageable.</li> </ul> <p>This option does not fully address the risks previously identified in Section 4.</p>
Option 2 (preferred)	<p>Implement an increased replacement plan that aligns with the REHSW program for a consistent decrease in the age profile of oil-filled switchgear, to reduce the safety risks to operators and the public.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>• Reduces safety risk to a manageable level</li> <li>• Shift from unplanned to planned outages</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• Largest capital expenditure needed</li> </ul> <p>This is the lowest cost option to reduce the business risks to manageable.</p>

## 6.3 Summary of Costs

Option	Total Cost (\$)
Option 0	\$2,100,000
Option 1	\$16,200,000
Option 2 (preferred)	\$21,805,000

## 6.4 Summary of Risk

If a replacement program did not occur the safety risk for this type of switchgear, with the asset left to run to failure. Letting the assets run to failure could result in catastrophic failures resulting a significant risk to operational personnel and the public.

Continuation of the current rate of replacement plan would led to a network with an unmanageable age profile; this is due to sites being erected at a much higher rate in the 1960's. The lower rate of removal of oil-filled switchgear substations within fence type enclosures would result in this higher risk switchgear remaining on the network for an extended period, resulting in operational



personnel and the public being exposed to the risk of failure for a longer time.

The preferred program of initially increasing the rate of replacement for 5 years from the 2017/18 financial year before reverting back to the current rate of replacement would reduce the risk to a manageable level and result in a rate of replacement that is achievable for the long term. This plan aligns with the high voltage switchgear replacement program (REHSW).

## 6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing	\$0
Option 1	Continue with the current replacement	\$0
Option 2 (preferred)	Increased replacement that will reduce the age profile below 50 years of age	\$0

### 6.5.1 Quantitative Risk Analysis

Not applicable

### 6.5.2 Benchmarking

Other DNSP's 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

Nil

## Section 2 Approvals (Gated Investment Step 2)

<b>Project Initiator:</b>	Michael Healy	<b>Date:</b>	27/03/2015
<b>Project Manager:</b>		<b>Date:</b>	

### Actions

<b>Submitted for CIRT review:</b>		<b>Actioned by:</b>	
<b>CIRT outcome:</b>			