Investment Evaluation Summary (IES)

Project Details:

Project Name:	Replace Transformers
Project ID:	00699
Thread:	Overhead
CAPEX/OPEX:	CAPEX
Service Classification:	Standard Control
Scope Type:	B
Work Category Code:	RETXL
Work Category Description:	Replace Transformers
Preferred Option Description:	Run to failure strategy: The advantages of this option are that it is low risk, and extracts the maximum life out of the assets so is comparatively low cost. The disadvantages are that there will be an unplanned outage whenever a transformer fails, and the replacement cost will be slightly higher if it is done under fault rather than as planned work.
Preferred Option Estimate (Nominal Dollars):	$73,800,000

	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
Unit ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Volume	102	102	105	130	171	153	194	201	218	286
Estimate ($)										
Total ($)	$2,040,000	$2,040,000	$2,100,000	$2,600,000	$3,420,000	$3,060,000	$3,880,000	$4,020,000	$4,360,000	$5,720,000

Governance:

Project Initiator:	Gary Carleton	**Date:**	26/03/2015
Thread Approved:	David Eccles	**Date:**	20/10/2015
Project Approver:	David Eccles	**Date:**	20/10/2015

Document Details:

Version Number:	1

Related Documents:

Description	URL
TasNetworks NPV RETXL Replace Transformers	http://teamzone.tnad.tasnetworks.com.au/asset-strategy/Shared%20Documents/DD17/Overhead%20Thread/Transformer%20pole%20mounted/TasNetworks%20NPV%20RETXL%20Replace%20Transformers.XLSM
Investment Evaluation Summary - RETXL	http://teamzone.tnad.tasnetworks.com.au/asset-strategy/Shared%20Documents/DD17/Overhead%20Thread/Transformer%20pole%20mounted/Investment%20Evaluation%20Summary%20RETXL.docx
RIN DATA - 5 Transformers	http://teamzone.tnad.tasnetworks.com.au/asset-strategy/Shared%20Documents/DD17/Overhead%20Thread

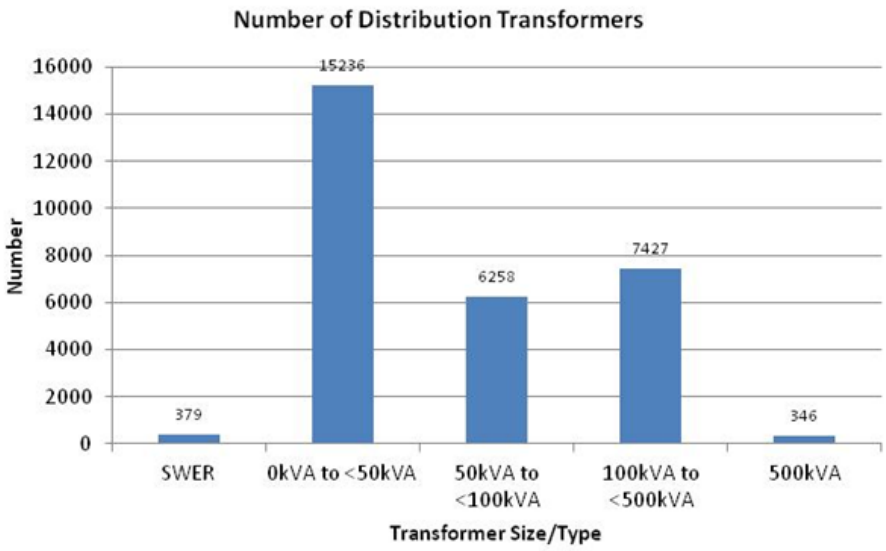
	/Transformer%20pole%20mounted /RIN%20DATA%20-%205%20Transformers.xlsx
transformer failure data	http://teamzone.tnad.tasnetworks.com.au/asset-strategy /Shared%20Documents/DD17/Overhead%20Thread /Transformer%20pole%20mounted /transformer%20failure%20data.xls

Section 1 (Gated Investment Step 1)

1. Background

TasNetworks owns and manages 30,000 pole mounted transformers. Over half of the pole mounted transformers are less than 50kVA in size. The physical size and weight of the units limits pole mounted transformers to 500kVA in size. TasNetworks also manages a number of Single Wire Earth Return (SWER) systems in relatively remote rural locations where there is light load. There are 379 SWER transformers in the system.

Figure 1: Number of Distribution Transformers



1.1 Investment Need

TasNetworks aims to care for its assets, delivering safe, reliable and affordable networks services while transforming its business.

Transformer failures occur due to condition, overloading, internal or external failure, breakdown of insulation, and extreme weather events. The aim of this program is to replace failed transformers so as to:

- minimise risks to public safety
- minimise outage frequencies and durations
- deliver the most cost effective solution

The age profile of TasNetworks' distribution transformers is shown in Figure 2 and Figure 3. Over 90% of the transformers with a known age are less than 35 years old. Less than 4.5% of transformers with a known age are over 40 years old. There are an additional 1441 transformers where the age is not known.

Figure 2: Transformer Age Profile

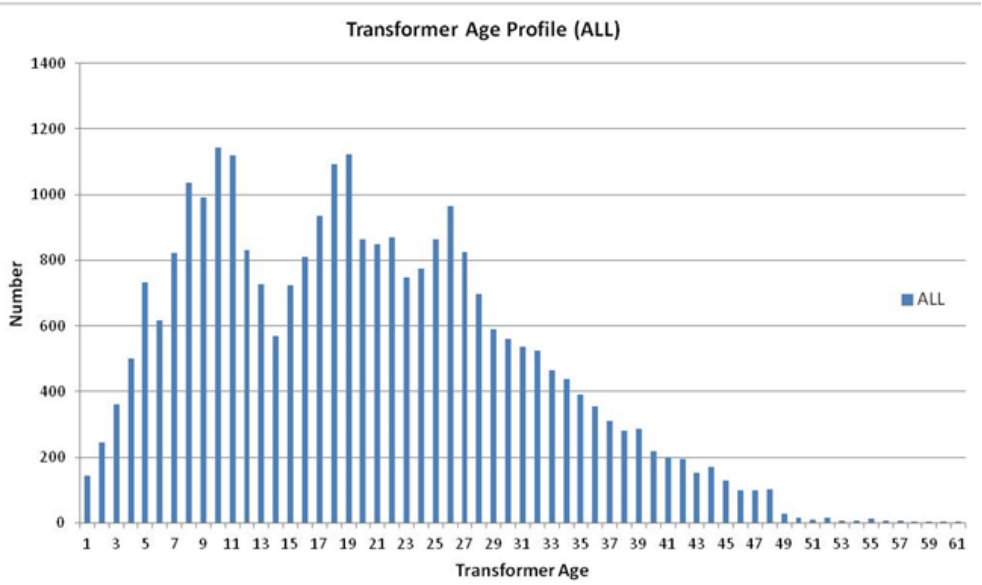
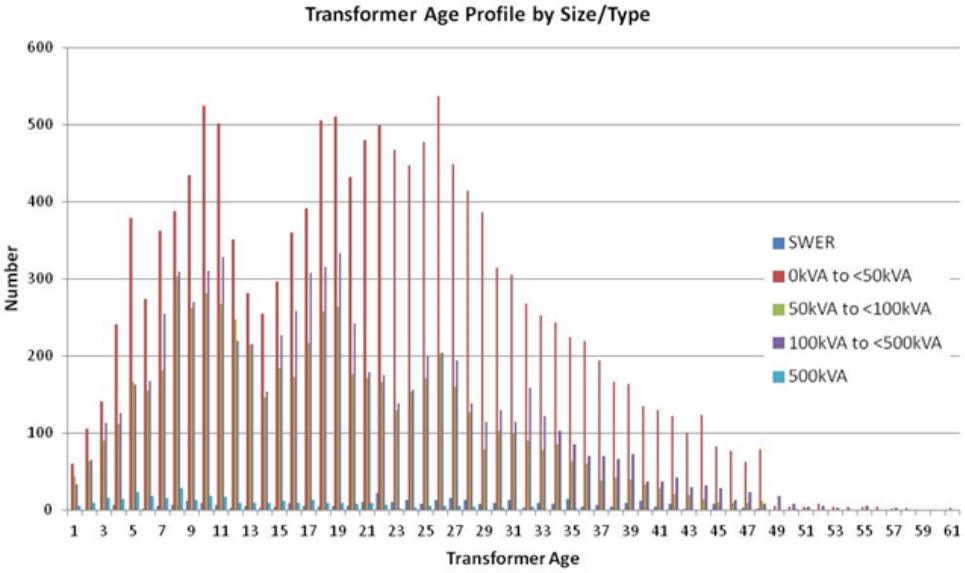


Figure 3: Transformer Age Profile by Size/Type



Transformer failures account for around 7% of outages by outage duration or around 550 hours of outages per year on average. An outage caused by a transformer failure lasts for an average of 9.3 hours.

There is an average of 65 outages per year due to transformer failure.

1.2 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) • 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, restoration of faults/emergencies and supply reliability • affordability, green, communicative, innovative, efficient and reliable services 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.

1.3 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 (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) to 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

TasNetworks proposes that the management of transformers continues the same practices as existing with no real change. That is, no preventative maintenance is done on transformers. Transformers are replaced at failure, or when they are identified during other routine inspections as in sufficiently poor condition (e.g dripping oil).

3. Strategic Alignment

3.1 Business Objectives

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 understand our customers by making them central to all we do. • We enable our people to deliver value. • We care for our assets, delivering safe and reliable networks services while transforming our business.

3.2 Business Initiatives

The business initiatives that relate to this project are as follows: • Safety of our people and the community, while reliably providing network services, is fundamental to the TasNetworks business and remains our immediate priority • We care for our assets to ensure they deliver safe and reliable network services • We will transform our business with a focus on: - the customer, and a strong commitment to delivering services they value - an engaged workplace with strong cultural qualities and people who will be great ambassadors for TasNetworks - a high performing culture with clear accountabilities for deliverables - an appropriate approach to the management and allocation of risk - a well run, efficient business, that delivers sustainable returns to the Tasmanian community and is resilient to future challenges. The strategic key performance indicators that will be impacted through undertaking this project are as follows: • Customer engagement and service – customer net promoter score • Price for customers – lowest sustainable prices • Culture and people engagement – Culture score • Zero harm – significant and reportable incidents • Network service performance – meet network planning standards • Network service performance – outcomes under service target performance incentive schemes • Sustainable cost reduction – efficient operating and capital expenditure

4. Current Risk Evaluation

The risk assessment below is indicative of the existing risks within the pole mounted transformer asset population throughout the TasNetworks distribution network.

The safety risk to the public or risk of environmental damage is managed through the latest design policy whereby the location of new transformers takes the surrounding environment into consideration before undertaking installation.

Additionally, given that transformers with visible cracks, leaks or significant rust are replaced during routine pole inspections, the likelihood of an internal failure resulting in a rupture of the transformer tank is very low and there are no reports of such incidents occurring.

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
Customer	Disruption to customers resulting from transformer failures in service	Almost Certain	Negligible	Medium
Environment and Community	Transformer failure causes localised damage to surrounding environment (e.g oil spill into adjacent waterways, etc)	Possible	Minor	Low
Financial	Excessive payouts from reliability incentive schemes (NCEF, GSL, STPIS) resulting from transformer failures in service	Likely	Negligible	Low
Network Performance	Localised interruption to supply	Almost Certain	Minor	Medium

Safety and People	Transformer failure causes risk to members of the public (e.g through leaking oil or pole top fire)	Rare	Major	Medium

Section 1 Approvals (Gated Investment Step 1)

Project Initiator:	Gary Carleton	**Date:**	26/03/2015
Line Manager:		**Date:**	
Manager (Network Projects) or Group/Business Manager (Non-network projects):		**Date:**	
[Send this signed and endorsed summary to the Capital Works Program Coordinator.]			

Actions			
CWP Project Manager commenced initiation:		**Assigned CW Project Manager:**	
PI notified project initiation commenced:		**Actioned by:**	

Section 2 (Gated Investment Step 2)

5. Preferred Option:

The preferred option is the 'Do Nothing' option, i.e to run transformers to failure. This represents the lowest sustainable cost to customers, with negligible increase in risk and minor increases in unplanned outages, and fewer planned outages compared to a proactive aged based approach.

5.1 Scope

Transformers are replaced when they fail on a like for like basis. Failure may occur due to the condition of the transformer, overloading, internal or external failure, breakdown of insulation, and extreme weather events such as storms or bushfires. Transformers may also be replaced prior to total failure when they are found to be dripping oil. Old transformers in poor condition may also be replaced opportunistically during other maintenance work on the pole. This program does not include the replacement of functional transformers that are upgraded or removed for capacity reasons.

5.2 Expected outcomes and benefits

The expected outcomes of this program are continued safe and reliable running of the network. This solution presents the lowest life cycle cost. It removes the need for ongoing operational costs through routine transformer testing and monitoring, which would add little value or extension of life for transformers of this size.

5.3 Regulatory Test

6. Options Analysis

The table below shows the feasible options considered for the pole mounted transformer management program.

Option description	
Option 0 **Run-to-fail strategy**	The advantages of this option are that it is low risk, and extracts the maximum life out of the assets so is comparatively low cost. The disadvantages are that there will be an unplanned outage whenever a transformer fails, and the replacement cost will be slightly higher if it is done under fault rather than as planned work.
Option 1 **Age based replacement strategy**	Proactively replace all transformers at 45 years of age. The advantages of this option are that it is low risk and reduces the number of unplanned outages due to transformer failure. The disadvantages are that some assets will be replaced while they still have some functional life remaining, and will not be able to identify all transformers before they fail, so some will still fail in service.
Option 2 **Condition monitoring strategy**	This strategy isolates those transformers that supply a large customer base or critical customers (generally transformers of 500kVA) and develops a predictive and condition based methodology for their management as opposed to a run-to-failure management strategy. The advantage of this strategy is that an optimal balance between replacement on failure and implementing condition based practices. The disadvantage of this option is that 500kVA transformers account for only 1% of the total pole mounted transformer population and most of these transformers are sealed units that do not allow for oil samples to be replenished. Additionally, resourcing, training and access to the pole mounted transformers would make the cost of condition monitoring an expensive exercise for only a small gain in performance.

6.1 Option Summary

Option description	
Option 0 (preferred)	Run to failure strategy: The advantages of this option are that it is low risk, and extracts the maximum life out of the assets so is comparatively low cost. The disadvantages are that there will be an unplanned outage whenever a transformer fails, and the replacement cost will be slightly higher if it is done under fault rather than as planned work.
Option 1	Age based replacement strategy: Proactively replace all transformers at 45 years of age. The advantages of this option are that it is low risk and reduces the number of unplanned outages due to transformer failure. The disadvantages are that some assets will be replaced while they still have some functional life remaining, and will not be able to identify all transformers before they fail, so some will still fail in service.
Option 2	Condition Monitoring Strategy: This strategy isolates those transformers that supply a large customer base or critical customers (generally transformers of 500kVA) and develops a predictive and condition based methodology for their management as opposed to a run-to-failure management strategy. The advantage of

	this strategy is that an optimal balance between replacement on failure and implementing condition based practices. The disadvantage of this option is that 500kVA transformers account for only 1% of the total pole mounted transformer population and most of these transformers are sealed units that do not allow for oil samples to be replenished. Additionally, resourcing, training and access to the pole mounted transformers would make the cost of condition monitoring an expensive exercise for only a small gain in performance.

6.2 Summary of Drivers

Option	
Option 0 (preferred)	Minimise risks to public safety The risks to public safety from unplanned transformer failure are low. Minimise outage frequency and duration There will be a higher incident of unplanned outages due to transformer failure (compared with Option 1), however an overall lower number of total outages. Deliver the most cost effective solution This option replaces the minimum number of transformers possible each year. Additional costs to the Business are incurred in the form of NECF and STPIS payments.
Option 1	Minimise risks to public safety The risks to public safety from unplanned transformer failure are low, but proactively replacing transformers would not remove it entirely. Premature failure of transformers happens sporadically and frequently enough to have minimal impact on any risk to public safety. Minimise outage frequency and duration There will be a lower incident of unplanned outages due to transformer failure, but a higher incident of planned outages, as the number of planned replacements must logically exceed the number of unplanned replacements. Deliver the most cost effective solution This option necessitates the premature replacement of some assets. Additional costs to the Business in the form of NCEF and STPIS payments are lower than for Option 0 but cannot be completely avoided as some transformers will always fail before their expected asset life.
Option 2	Minimise risks to public safety The risk to public safety from unplanned transformer failure is slightly lower although the 500kVA transformers only account for 1% of the entire transformer fleet. Minimise outage frequency and duration There will be a slightly lower incident of unplanned outages due to transformer failure, but a higher incident of planned outages, as the number of planned replacements must logically exceed the number of unplanned replacements. However, this strategy only covers 500kVA transformers which only make up 1% of the transformer fleet. Deliver the most cost effective solution Costs to the Business in the form of NCEF and STPIS payments will be lower than for Option 0. However there will be an increase in cost by replacing transformers that still have some residual service life. There will be an increase in cost to implement a condition monitoring program with both internal and external resources.

6.3 Summary of Costs

Option	Total Cost ($)
Option 0 (preferred)	$73,800,000
Option 1	$100,800,000
Option 2	$76,800,000

6.4 Summary of Risk

The preferred option is the run to failure strategy, which is essentially the “do nothing” option. The residual risk therefore of this option can be taken as the uncontrolled risk as documented in Section 4. This is within TasNetworks’ risk appetite which states:

Financial: We have a low appetite for volatility in returns to shareholders.

Customer: We have a low appetite for risking the trust our customers place in us by not delivering on our commitments to our customers. (Noting that the risk identified to customers is considered not likely to damage the trust of customers as failures are spread throughout the network and unlikely to affect any single group of customers multiple times.)

Network Performance: We have a moderate appetite to accept a reduction in the reliability of our network and the quality of our services provided that these remain within acceptable norms for Tasmania.

Environment & Community: Accordingly, we have a low appetite for the potential to cause widespread environmental harm as a result of our network or operations.

Safety & People: We have a low appetite for the potential of injury of members of the public in conducting our business.

The preferred option is the run to failure strategy, which is essentially the “do nothing” option. The residual risk therefore of this option can be taken as the uncontrolled risk as documented in Section 4. This is within TasNetworks’ risk appetite which states:

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Network Performance: We have a moderate appetite to accept a reduction in the reliability of our network and the quality of our services provided that these remain within acceptable norms for Tasmania.

Environment & Community: Accordingly, we have a low appetite for the potential to cause widespread environmental harm as a result of our network or operations.

Safety & People: We have a low appetite for the potential of injury of members of the public in conducting our business.

6.5 Economic analysis

Option	Description	NPV
Option 0 (preferred)	Run to failure strategy: The advantages of this option are that it is low risk, and extracts the maximum life out of the assets so is comparatively low cost. The disadvantages are that there will be an unplanned outage whenever a transformer fails, and the replacement cost will be slightly higher if it is done under fault rather than as planned work.	-$25,586,292
Option 1	Age based replacement strategy: Proactively replace all transformers at 45 years of age. The advantages of this option are that it is low risk and reduces the number of unplanned outages due to transformer failure. The disadvantages are that some assets will be replaced while they still have some functional life remaining, and will not be able to identify all transformers before they fail, so some will still fail in service.	-$36,413,227
Option 2	Condition Monitoring Strategy: This strategy isolates those transformers that supply a large customer base or critical customers (generally transformers of 500kVA) and develops a predictive and condition based methodology for their management as opposed to a run-to-failure management strategy. The advantage of this strategy is that an optimal balance between replacement on failure and implementing condition based practices. The disadvantage of this option is that 500kVA transformers account for only 1% of the total pole mounted transformer population and most of these transformers are sealed units that do not allow for oil samples to be replenished. Additionally, resourcing, training and access to the pole mounted transformers would make the cost of condition monitoring an expensive exercise for only a small gain in performance.	-$28,533,839

6.5.1 Quantitative Risk Analysis

TBC

6.5.2 Benchmarking

TBC

6.5.3 Expert findings

TBC

6.5.4 Assumptions

There is inadequate failure age data of transformers, as existing attribute data is overwritten with the installation of its replacement asset. It is assumed from the age profile that most transformers fail between the age of 45 and 55 years old. An unquantified number will last longer than this, and an unquantified number will fail earlier than this for a range of reasons. It is assumed for Option 1 that any existing transformers that are already older than the modelled age for replacement, will be funded from within existing 2012-2017 budgets and will not extend into DD17. It is assumed for Option 0 that any existing transformers that are already older than the modelled age for replacement, will all fail within the next two years (2015-2016). This gives figures consistent with current spend. It is assumed that if run to failure, transformers have an average life of 50 years. Unit costs to replace

transformers are calculated based on the actual dollars for transformer fault capitalisation per month divided by the number of outages due to transformer failure per month. It is assumed that to replace a transformer under planned maintenance will be 80% of the total cost of doing it under fault. There are 1441, or 5% of the total population of transformers with no age data. It is assumed that these follow the same age profile of the rest of the population. An additional 5% has been added to the cost of each option to cover this unknown.

Section 2 Approvals (Gated Investment Step 2)

Project Initiator:	Gary Carleton	**Date:**	26/03/2015
Project Manager:		**Date:**	

Actions			
Submitted for CIRT review:		**Actioned by:**	
CIRT outcome:			