Investment Evaluation Summary (IES)

Project Details:

Project Name:	BFM - project replace aged/deteriorated copper (Cu) conductor
Project ID:	01509
Business Segment:	Distribution
Thread:	Overhead
CAPEX/OPEX:	CAPEX
Service Classification:	Standard Control
Scope Type:	A
Work Category Code:	REMCU
Work Category Description:	Replace HV copper conductor
Preferred Option Description:	Replace defective copper conductor
Preferred Option Estimate (Dollars $2016/2017):	$7,000,000

	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Unit ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Volume	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Estimate ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total ($)	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000

Governance:

Works Initiator:	Mandy Fish	Date:	12/11/2018
Team Leader Endorsed:	Darryl Munro	Date:	16/11/2018
Leader Endorsed:	Nicole Eastoe	Date:	20/11/2018
General Manager Approved:	Wayne Tucker	Date:	22/11/2018

Related Documents:

Description	URL
TasNetworks Business Plan 2017-18	http://reclink/R779008
TasNetworks Risk Management Framework	http://Reclink/R238142
National Electricity Rules (NER)	http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
Bushfire Risk Mitigation Plan	http://reclink/R303735
Overhead Conductors and Hardware Asset Management Plan	http://reclink/R260427
Conductor Failure Data 2010-2014	http://assetzone.tnad.tasnetworks.com.au/distribution/overhead-system-and-structures/Installation%20%20Maintenance%20Information/Conductor%20Replacement%20Strategy/Conductor_Failure_Update_2010-2014v2.xlsx
Conductor Inventory	http://assetzone.tnad.tasnetworks.com.au/distribution/overhead-system-and-structures/Installation%20%20Maintenance%20Information/DD17%20Data/REMGI_REMCU/Conductor_Inventory.xlsx
Overhead Conductor Replacement Programs Prioritisation Guideline	http://reclink/R603335
Conductor Age Profile Data	http://assetzone.tnad.tasnetworks.com.au/distribution/overhead-system-and-structures/Installation%20%20Maintenance%20Information/HV%20Overhead%20Conductor%20Estimated%20Install%20Date%20Data/Conductor_Age_Profile_Data_DD17_10JUN15.xlsx
TasNetworks Transformation Roadmap 2025	http://Reclink/R0000764285
TasNetworks Corporate Plan - Planning period: 2017-18	http://reclink/R745475
BFM REMCU NPV	http://reclink/R1198464
Distribution Network Planning Manual	http://reclink/R833234
Memorandum of Advice	http://reclink/

1. Overview

1.1 Background

TasNetworks bushfire mitigation programs are aimed to mitigate the top nine high level causes of distribution asset related fires. These programs account for approximately eighty five per cent of all asset related fire causes. Timeframes for each of these programs vary depending upon factors such as risk, volumes and ability to deliver.

Where conductor failures have caused fires, they have been included within fire start data as either conductor failure or connection failure (resulting in conductor failure). As shown within Table 1 below, conductor and connection failure account for a combined total of approximately thirteen per cent of fires caused by distribution assets. Substandard conductors can also be attributed to some cases of fires caused by conductor clashing.

Table 1: Causes of fires started by distribution network assets

Fire Cause	Number of Ground Fire Starts						% of Total
	2012/13	2013/14	2014/15	2015/16	2016/17	TOTAL	
Vegetation outside clearance	5	6	12	10	11	**44**	31.9
Conductor clashing	4	2	2	2	0	**10**	7.2
Conductor failure	4	1	1	3	1	**10**	7.2
EDO fuse element	0	3	4	2	1	**10**	7.2
Vandalism/accidental damage	1	2	4	1	3	**11**	8.0
Insulator broken/damaged	2	1	0	1	6	**10**	7.2
Connector failure	4	1	1	2	0	**8**	5.8
Birds/animals	2	0	1	3	2	**8**	5.8
Tie broken	0	0	1	4	2	**7**	5.1
Vegetation inside clearance	0	1	3	0	0	**4**	2.9
Lightning	0	1	0	1	1	**3**	2.2
Cable termination failure	0	0	0	3	0	**3**	2.2
EDO fuse tube	0	0	1	1	0	**2**	1.4
Turret (cable fault)	0	0	1	1	0	**2**	1.4
U/G cable failure	2	0	0	0	0	**2**	1.4
Switch-gear failure (LV)	1	0	0	0	1	**2**	1.4
Windborne material	0	0	0	0	1	**1**	0.7
Pole failure	0	0	0	0	1	**1**	0.7
TOTALS	**25**	**18**	**31**	**34**	**30**	**138**	**100**

Overhead conductor installed in the past (to the standard of the day) is the cause of a number of mechanical conductor failures, which may result in risks to the community and environment through bushfires and safety risks, as well as interruption of supply. During their life these conductors are exposed to a wide range of events (including electrical, environmental, and mechanical) that cause reduction in tensile strength and scale (reduction in diameter). Conductors that meet pre-determined criteria of deterioration (as detailed within the Conductors and Hardware Distribution Asset Management Plan) are classified as being substandard. Typically, older installations of copper, aluminium and galvanised iron conductor are more likely to be identified as substandard and are the conductor types that are most prone to failure.

Given the large volumes of work associated with the state-wide conductor replacement programs and TasNetworks' ability to deliver such volumes, works have now been prioritised to ensure that the highest ranking risks are addressed first. Highest ranking risks include sites where aged conductor exists, is confirmed as being substandard, and is within the high bushfire loss consequence area (HBLCA). The HBLCA has been identified as an area where the losses associated with starting a major bushfire have the potential to cause greatest impact on communities and the environment in terms of loss of life and damage to infrastructure. The HBLCA aligns with contemporary best practice principles, and utilises the Phoenix Model. This Model enables the application of the 80 per cent fire loss consequence model as detailed within the 2009 Powerline Bushfire Safety Taskforce Final Report. Details on the HBLCA are detailed in the Buhfire risk mitigation plan as referenced (http://reclink/R303735). Also detailed in the management plan are the statutory and regulatory responsibilities that apply to TasNetworks.

It must also be noted that with the future forecasts of escalating risks assoicated with bushfire due to climate change, and given the long life conductors that TasNetworks installs and operates, that the assets must ensure safe ad reliable operation into the future.

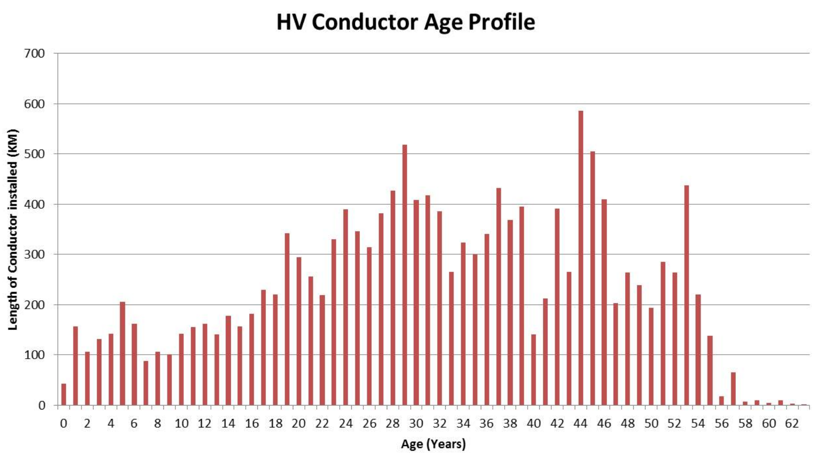
This investment evaluation summary (IES) has been developed to address the risk associated with potential fire starts due to copper conductor failures within the HBLCA.

The makeup of all high voltage (HV) conductors in the distribution network and the number of bare wire overhead conductor breakages (from WASP outage data) is shown in Table 2, and Figure 1 shows the current estimated age profile of HV overhead conductor within the network. Table 2 is ordered in terms of most failures per 100 km for each conductor type with copper showing the highest failure rate.

Table 2: Failure Statistics for bare wire conductor failures

Bare HV conductors			Failures per year										Average	
Type	Total Length	Percentage of Network	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Per year	Per 100 km of conductor
Cu	1,111	6.7	1	5	7	7	8	4	5	1	11	13	6.2	5.58
ACSR	732	4.4	2	0	4	6	2	1	4	3	4	1	2.7	3.69
AAA	2,783	16.8	4	1	6	10	9	8	3	5	10	13	6.9	2.48
GI	5,775	34.9	11	7	20	13	15	4	14	9	17	28	13.8	2.39
AA	6,147	37.1	8	10	13	11	9	3	12	9	12	8	9.5	1.55
ABC	19	0.1	0	0	0	0	0	0	0	0	0	0	0.0	0.00
Total	16,567	100	26	23	50	47	43	20	38	27	54	63	39.1	2.36

Figure 1: Estimated age profile for all HV conductor in the network



The majority of copper conductor in the low voltage (LV) and HV system was installed prior to 1964 and is now in excess of 50 years in age.

During their life these conductors are exposed to significant fault currents that could cause the copper to anneal (reduction in tensile strength) and scale (reduction in diameter). This deterioration, which is easily identified by its orange and scaling appearance, affects the tensile strength.

Smaller stranded conductor (7/.044 and 7/.048) does not comply with C (b) 1 (AS/NZS 7000), which requires conductors to have an ultimate breaking strength of at least 5 kN.

Small size copper conductor is particularly susceptible to corrosion and failure in marine type environments.

The replacement programs for copper, aluminium and galvanised iron conductor have, prior to 2012, been replaced as part of Replace HV Feeders for Safety program (REHSA). To better manage and monitor business risks, costs and field works associated with these replacement programs, three new work categories were created at the beginning of the 2012-2017 Determination Period, namely REMCU (HV copper conductor replacement), REMAC (HV aluminium conductor replacement) and REMGI (HV galvanised steel conductor replacement) respectively. These programs continue in parallel to this IES in order to address the risks identifed outside of the HBLCA.

1.2 Investment Need

The majority of copper conductor was installed prior to 1964. Copper conductors range in size from 7/.044 to 19/.104.

When conductors are subjected to fault currents, they are rapidly heated, which may result in annealing if the fault is not adequately cleared. Copper conductor is typically not fault rated, so the exposure of conductor to fault currents for extended duration results in annealing, which reduces the tensile strength of the conductor. This may be identified by the conductor taking on an orange and scaling appearance. The condition of the conductor can also be determined by the number of joints installed in a span (generally installed following conductor failure) from a visual inspection. The smaller 7 stranded conductor is particularly susceptible to this failure mode.

Substandard overhead conductor is resulting in broken wires throughout the distribution network, increasing the risks accociated with the community and environment, safety and interruption to supply. The key drivers for this program are therefore to protect community and the environment (particularly in the form of bushfire mitigation), maintain safety, network performance associated with failure of copper conductors and compliance with regulatory responsibilities.

Given the potential failure modes mentioned above, copper conductor also creates unsafe working enviornment for field staff and restrictions currently apply for specific work methods when working on some copper conductors due to its tendency to fail whist being manouvered. For example, HV live line techniques cannot be used when working on small gauge copper conductors (such as 7/.044 and 7/.064) due to the safety risks posed by potential conductor failure. As such, operational costs and supply reliability are negativey impacted when works are required on copper conductors.

Table 3 shows that there have been a significant number of copper conductor failures over the past few years (from WASP outage data where the cause is 'Conductor Failure – Bare Wire – Broken'). The total number of failures per year is shown in Table 3 and illustrates the growing trend in conductor failures. This trend, if left unmitigated, also increases the risk of fires starts from the increased occurrances of conductor failure, which is a concern to TasNetworks given our risk appetite towards fire starts.

Table 3: Number of copper conductor failures by year

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of failures	5	7	7	8	4	5	1	11	13

An analysis of copper conductor age and condition indicates that 99.96 per cent of all installed copper conductor is greater than forty years old with the majority being in poor condition and will require replacement in the near future. Approximately seventeen per cent of installed copper conductor is installed within the HBLCA.

Following submission of TasNetworks draft determination to the Australian Energy Regulator (AER), the AER and its consultants have indicated in their review of TasNetworks' proposed capital expenditure for the 2019-24 regulatory control period, the as low as reasonably practicable approach (ALARP) process "is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate expenses".

Since TasNetworks draft determination submission, we have undertaken quantitative risk cost assessment, to ensure that the risk cost is commensurate with the capital expenditure outlined. Details of the quantitative risk cost methodology that TasNetworks has applied is outlined in secion 6.

TasNetworks assesses that availability and suitability of ways to eliminate or minimise the risk from Copper Conductor. After assessing the extent of the risk and the available ways of eliminating or minimising the risk TasNetworks uses the quantitative risk methodology as outlined in Section 6. This methodology enables

TasNetworks to establish the cost associated with available ways of eliminating or minimising the risk, against the risk cost. This enables TasNetworks to determine if the response is proportionate with the risk. TasNetworks, specifically in relation to the bushfire risks associated with the copper condcutors, also assesses whether other precautions are reasonable. This ensures that TasNetworks identifies all practicable precautions, especially as it relates to industry practices. TasNetworks must also consider the specific environmental conditions relevant to TasNetworks. Given the findings and recommendations made public in various interstate reports relating to major electricity caused bushfires, TasNetworks has been made aware of the risks and the ways of minimising the risks. Tasmania has a history of catastrophic bushfires, and is assessed as having areas of very high to extreme bushfire risk. There are also multiple climate change research papers which outline that the bushfire risk into the future continues to increase. Expert information relating to the risk of bushfire within Tasmania, climate change projects, and practices of other industry participants are provided within the referenced Bushfire Risk Mitigation Plan (http://reclink/R303735) and expert findings within this Investment Evaluation Summary.

TasNetworks is legally bound to mitigate the risk of bushfire to ensure it meets industry benchmark or best practice. The AER have expressed an opinion that TasNetworks is not legally mandated to undertake mitigation of bushfire. However, TasNetworks has sought independent legal advice from John T (Jack) Rush Q.C. (http://reclink/) to the draft decision of the AER as it outlines concerns against the proposed capital expenditure forecast of TasNetworks for the period 2019 to 2024 relating to bushfire mitigation and the need to undertake work even though we are not mandated through legislation. The independent advice has advised that even though TasNetworks is not mandated by legislation to undertake this mitigation work, it would not relieve TasNetworks of our obligations to undertake this work for copper conductors. This is because we are legally bound to mitigate the risk of bushfire to ensure it meets industry benchmark or best practice.

The AER has outlined expenditure concerns for asset replacement plans proposed to mitigate bushfire risk caused by the failure of electrical infrastructure initially in an area determined, after significant consultation, as the HBLCA. The AER brings into question TasNetworks assessment concerning extreme bushfire events is based on the Phoenix Rapid – Fire Model (Phoenix). The Phoenix model is used elsewhere in Australia to assess bushfire risk and is broadly considered a contemporary model and recognised as the most suitable tool to assess fire loss consequence. The independent legal advice outlines that "...It is in my opinion incumbent on TasNetworks to adopt a prudent bushfire mitigation strategy that at the least meets the standards of electricity providers in other high impact zones – zones identified by Phoenix as very high to extreme risk of bushfire". And "In the circumstances I can only say it seems close to incomprehensible that AER would not consider TasNetworks capex program for bushfire mitigation as essential".

TasNetworks firmly believes that proposed bushfire mitigation programs to replace the copper conductor is reasonable and will reduce the risk of bushfires starting from the network to a level that is ALARP for an investment that is not grossly disproportionate to the risk. And also meets our obligations to ensure that the approach takes reasonably practicable precautions.

This program is a continuation of an existing project approved and commenced in 2017/2018 as part of TasNetworks' Bushfire Mitigation Strategy. The program has been scheduled to replace all copper conductor (that meets the criteria mentioned within 5.1 *Scope*) within the HBLCA within the next two regulatory periods, after which the focus will then move to non-HBLCA areas with the intention to reduce risk in the HBLCA as quick as possible, taking into account finite TasNetworks' resources before addressing the fire start risk across the remainder of the state. The approach being undertaken by TasNetworks is consistent with other distribution networks in response to significant bushfires in other states.

There is another replacement program (REMCU) run parallel to this program where the primary focus is safety and reliability of supply rather than bushfire risk reduction.

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;
- restoration of faults/emergencies; and
- supply reliability.

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).

6.5.7 (a) Forecast capital expenditure:

(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

To replace HV copper conductor with new standard conductor, to address the safety, community and environmental risks presented by the potential failure of these conductors with focus on conductors located within the HBLCA. The replacement conductors shall be selected from TasNetworks' standard conductors as defined in the Distribution Network Planning Manual.

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 networks 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

If TasNetworks does not continue to monitor and replace the condition of overhead conductors there is a risk that a conductor failure could result in a severe bushfire or a serious injury sustained by a member of the public or staff.

The relevant key risk criteria and underlying assumptions that result in the current assigned rating of 'high' under our risk management framework are the:

- risk likelihood rating is considered to be 'unlikely'. This assumes a risk probability of 1 to 19 per cent, or 'may occur but not anticipated' or 'could occur in years to decades'; and

- consequence rating is considered to be 'severe'. The worst case consequence of a bushfire caused by TasNetworks would cause permanent impairment or fatality, severe impairment to critical habitat and ecosystems and/or greater than $75 million financial cost.

TasNetworks' risk assessment relating to bushfires

AON's risk assessment

TasNetworks' corporate insurance broker (AON) has provided an assessment of TasNetworks' risks in relation to a bushfire resulting from distribution overhead assets within the HBLCA.

This assessment has been completed taking into account TasNetworks' current level of risk and controls in place.

It is noted that AON's risk assessment aligns with TasNetworks' assessment.

Further information relating to AON's risk assessment and quantification is detailed within Section 6 Options Analysis and Section 6.5.1 *Quantitative risk analysis.*

4.1 5x5 Risk Matrix

TasNetworks' business risks are analysed utilising the 5x5 corporate risk matrix, as outlined in TasNetworks Risk Management Framework.

Relevant strategic business risk factors that apply are as follows:

Risk Category	Risk	Likelihood	Consequence	Risk Rating
Customer	A failed distribution overhead conductor would cause network outages affecting local customers. Cost of consequence: Calculated unserved energy costs.	Rare	Negligible	Low
Environment and Community	Conductor failure could initiate a severe bushfire, causing substantial damage to the environment and community. Description of consequence: Extensive impairment to critical habitat and ecosystems or species.	Unlikely	Major	Medium
Financial	Potential to start a severe bushfire. Description of consequence: Property loss >$75M	Unlikely	Severe	High
Network Performance	Potential to start severe bushfire. Description of consequence: Widespread seperation of network.	Unlikely	Major	Medium
Regulatory Compliance	This project is required to achieve compliance with regulatory obligations in regards to maintaining the safety of the distribution network. Potential to start severe bushfire. Description of consequence: Sustained regulator intervention.	Unlikely	Moderate	Medium
Reputation	The organisations reputation would be harmed if a conductor failure caused a severe bushfire. Description of consequence: Non sustained state press coverage.	Unlikely	Moderate	Medium
Safety and People	A conductor failure could lead to electrical shock, injury or fatality to the public or staff. Potential to start a severe bushfire. Description of consequence: Fatality or total impairment.	Unlikely	Severe	High

Section 2 (Gated Investment Step 2)

5. Preferred Option:

The preferred option is to replace a targeted selection of substandard conductor which has been identified as the highest risk within the HBLCA before moving to other parts of the state.

5.1 Scope

Replace HV copper conductor based on condition assessment to reduce the risk associated with substandard assets starting a bushfire with associated safety risk to public, environment and community. This program has focus on HBLCA followed by other locations across the state, with a primary focus on reduction of the risk of fire start. Volumes for HV copper conductor replacement driven by this program for Bushfire Mitigation (BFM) and parallel program for safety/network reliability (Non-BFM) are shown in Table 4 below.

Table 4: Replacement forecasts of HV copper conductors

REMCU Replacement of aged/deteriorated HV Copper Conductors												
Year	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Volumes (km)												
BFM (this program)	20	20	20	20	20	20	20	20	20	20	20	20
Non-BFM program	8.4	0	33	33	33	33	33	33	33	33	33	33
Total	28.4	20	53	53	53	53	53	53	53	53	53	53

5.2 Expected outcomes and benefits

The expected outcome of this program is a reduction in the risk to public safety, community and environment from fire starts resulting from failing HV copper conductors. This program will start with a focus on the HBLCA before moving to other parts of the state.

5.3 Regulatory Test

A Regulatory Investment Test will not be required for this program.

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.

6.1 Option Summary

Option description	
Option 0	Do nothing
Option 1 (preferred)	Replace defective copper conductor
Option 2	Defer replacement of defective copper conductor for 5 years

6.2 Summary of Drivers

Option	
Option 0	The main driver for Option 0 is to avoid capital expenditure during the 2019-24 period.
Option 1 (preferred)	The main driver for Option 1 is to mitigate the risks (particularly bushfire risks) presented by conductor failure on the distribution network through a program that is targeted and prioritised according to the risk presented. This option adequately addresses TasNetworks' risks as identified within Section 4.1 (5x5 Risk Matrix) in this IES and is the preferred

	option from an economic perspective with the most positive economic outcome.
Option 2	Similar to Option 0, the main driver for Option 2 is to avoid capital expenditure during the 2019-24 period by deferring expenditure until post 2024.

6.3 Summary of Costs

Option	Total Cost ($)
Option 0	$0
Option 1 (preferred)	$7,000,000
Option 2	$0

6.4 Summary of Risk

Option 0 - Do Nothing:

Option 0 involves no programmed replacement of copper conductor as a bushfire mitigation measure.

Emergency repair/replacement will only be carried out when required and will involve increased operating and maintenance costs.

This option does not address the fire start risks presented in locations where copper conductor fails, nor does it mitigate the risks in relation to:

- Customer;
- Environment & Community;
- Financial;
- Network Performance;
- Compliance;
- Reputation; and
- Safety.

This option is not aligned with the objectives and risk mitigation requirements identified in this IES.

This option does have the benefit of capital expenditure deferral but is not aligned with the strategies within TasNetworks' Bushfire Risk Mitigation Plan or the relevant distribution Asset Management Plans, developed to enable TasNetworks to maintain a safe and reliable network in a prudent and efficient manner.

Option 1 - Replace defective copper conductor. (Preferred Option):

Option 1 is the preferred option that aims to mitigate the risks presented by copper conductor failure on the distribution network through a program that is targeted and prioritised according to the risk presented.

This option adequately addresses TasNetworks' risks as identified within Section 4.1 (5x5 Risk Matrix) in this IES and is the most positive NPV option economically including risk cost.

Option 1 is aligned with the Bushfire Risk Mitigation Plan, the relevant distribution Asset Management Plans, and strategic performance objectives set by the business.

Option 2 - Defer replacement of defective copper conductor for 5 years:

Similar to Option 0, Option 2 involves no programmed replacement of copper conductor as a bushfire mitigation measure during the 2019-24 period.

Emergency repair/replacement will only be carried out when required and will involve increased operating and maintenance costs.

This option does not address the fire start risks presented in locations where copper conductor fails, nor does it mitigate the risks in relation to:

- Customer;
- Environment & Community;
- Financial;
- Network Performance;
- Compliance;
- Reputation; and
- Safety.

This option is not aligned with the objectives and risk mitigation requirements identified in this IES.

This option does have the benefit of capital expenditure deferral but is not aligned with the strategies within TasNetworks' Bushfire Risk Mitigation Plan or the relevant distribution Asset Management Plans, developed to enable TasNetworks to maintain a safe and reliable network in a prudent and efficient manner.

6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing	-$43,281,727
Option 1 (preferred)	Replace defective copper conductor	$28,301,127
Option 2	Defer replacement of defective copper conductor for 5 years	$18,819,997

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.

TasNetworks' corporate insurance broker (AON) has provided quantification of TasNetworks' risks in relation to a bushfire resulting from distribution overhead assets within the HBLCA.

This assessment has been completed taking into account TasNetworks' current level of risk and controls in place with the most positive option selected as the preferred option.

As outlined in section 6 above, TasNetworks has utilised this information to calcualte the risk cost that exist for EDO fuses. This assessment has been completed for various options, including a Business as Usual base case option. Which isthe point of comparison for all other options. The values used for the quantitative risk costs assessment are included in the Net Present Value relevant to this investment need, as refeerenced in the related documents section. Quantification of the risk has been completed, using the Cost of Consequence (CoC) and Likelihood of Consequence (LoC) data as

provided by TasNetworks corporate insurer for the relevant risk categories.

The percentage value shown as LoC relate to an annual event (e.g.: 0.010 = 1 in a 100 year event).

The annual CoC is determined by CoC multiplied by the LoC (e.g.: for property damage, the annual CoC = $75,000,000 X 0.010 = $750,000).

The expected number of asset failures has been calculated based on historical failure rates. This has been used to quantify TasNetworks' bushfire risk for conductor failures.

The LoC has been applied to determine the relative percentage of CoC for each risk category. (e.g.: for property damage, the annual CoC in relation to copper conductor failures = ($75,000,000 X 0.010) = $750,000 per annum).

6.5.2 Benchmarking

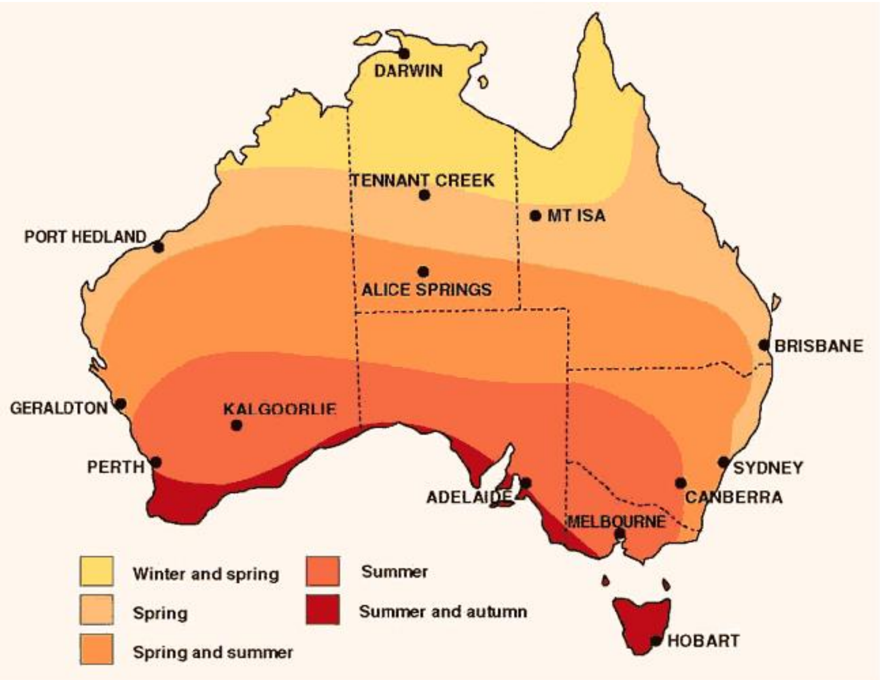
HV copper conductor replacement programs are consistent with strategies implemented by other Australian Distribution Network Service Providers to effectively manage the risk of fire starts associated with these assets.

6.5.3 Expert findings

This project is one of TasNetworks' targeted bushfire mitigation programs of work. All of TasNetworks' bushfire mitigation projects are aimed at addressing the increasing risks as detailed within recent research and modelling (relevant to Tasmania) published by a range of climate and bushfire experts.

South-eastern Australia has the reputation of being one of the three most fire-prone areas in the world, along with southern California and southern France[1].

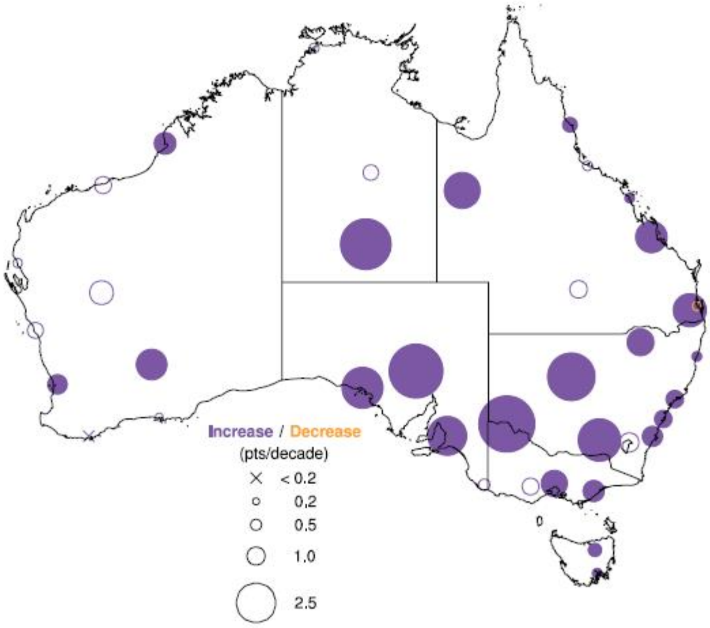
Figure 3: Seasonal pattern of fire danger. http://www.bom.gov.au/climate/c20thc/fire.shtml



Fire danger has increased in recent decades[2]. Observed fire weather in Australia from 1973–2010 is analysed for trends using the McArthur Forest Fire Danger Index (FFDI). Annual cumulative FFDI, which integrates daily fire weather across the year, increased significantly at 16 of 38 stations. Annual 90th percentile FFDI increased significantly at 24 stations over the same period. None of the stations examined recorded a significant decrease in FFDI.

The largest increases in seasonal FFDI occurred during spring and autumn, although with different spatial patterns, while summer recorded the fewest significant trends. These trends suggest increased fire weather conditions at many locations across Australia, due to both increased magnitude of FFDI and a lengthened fire season.

Figure 4: Map of trend in annual 90th percentile FFDI. Marker size is proportional to the magnitude of trend. Reference sizes are shown in the legend. Filled markers represent trends that are statistically significant.



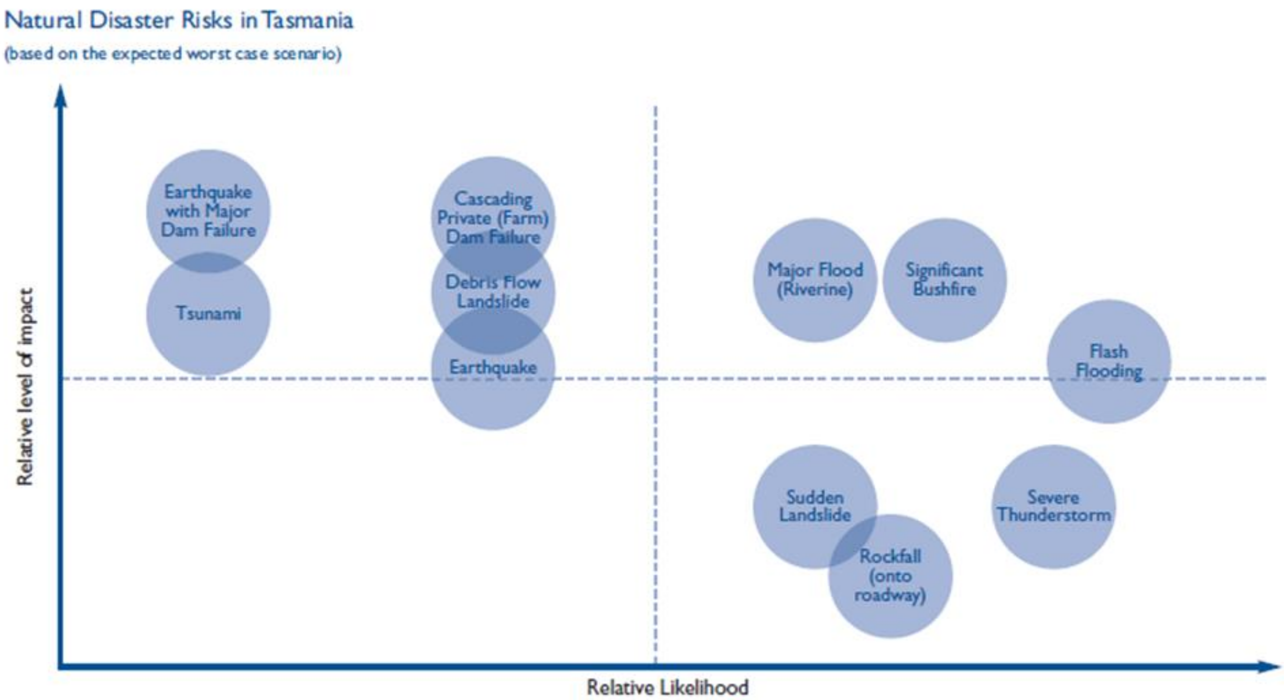
Fire danger is projected to increase further with greenhouse warming[3]. *The impact of climate change on the risk of forest and grassland fires in Australia* concludes that Australia will be significantly more exposed to forest and grassland fire risk in the future.

Bushfires already cause extensive damage and concern, and any increase in fire danger or shifts in the frequency, intensity or timing of fires, will have widespread consequences for human communities and natural systems[4]. Multi-model mean fire dangers indicate an accelerated increase if fire danger later this century via:

- a continuation of the trend of increasing springtime fire danger, a gradual increase in summer fire danger, but little change in autumn;
- an overall broadening of the fire season; and
- an increase in the number of days at the highest range of fire danger at several representative locations around Tasmania, associated with synoptic patterns conducive to dangerous fire weather.

The 2012 Tasmanian State Natural Disaster Risk Assessment (TSNDRA)[5] highlighted fire driven by changing weather and climate as one of the natural hazards most likely to cause significant damage and cost to Tasmania.

Figure 5: Relative impact and likelihood of natural disasters in Tasmania



Relative Impact and Likelihood of Natural Disasters in Tasmania

The TSNDRA identifies that Bushfire and Flood remain Tasmania's most significant hazard risk types. The assessment found that Bushfires are generally more severe in the southeast part of the State.

Key finding of the TSNDRA includes the necessity to maintain focus on prevention in awareness and education programs:

> *This was a common issue expressed across hazard – that work was needed to further embed prevention and mitigation into hazard and risk education and communication programs. It was felt that there remained a focus on 'what to do in the event of a disaster' in current programs, when it was likely that community resilience could be improved better by focusing on preventative actions.*

Climate Futures for Tasmania modelling[6] projections indicate the following changes by the end of the century:

- The type of strong weather system that brings the majority of the worst fire weather days to south–east Tasmania is projected to become more frequent.
- The total number of days per year categorised as 'Very High Fire Danger' is projected to increase by at least 120%. In the future, this is about a 10% per decade increase to 2100.
- Projected changes show strong regional and seasonal variations. Regions currently with the greatest risk of fire are projected to get worse most rapidly.
- The area of Tasmania under 'Total Fire Ban' conditions during summer due to fire weather is projected to increase by at least 75%. This is a 6% increase per decade.
- The average area of Tasmania in spring categorised as 'Very High Fire Danger' is projected to increase by at least 250%. This is a 20% increase per decade.
- There is no major change to the fire danger risk in autumn.
- The analysis suggests that all projections could be conservative estimates of future changes.

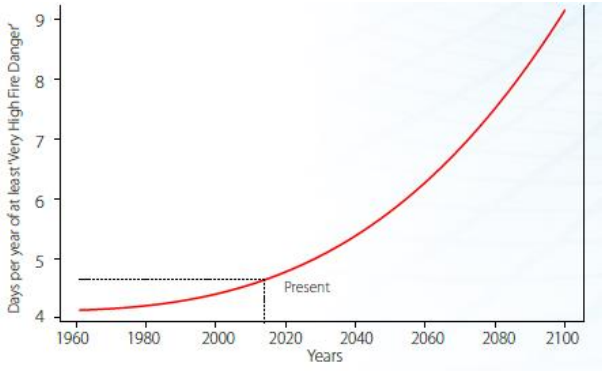
The Climate Futures for Tasmania study provides supporting evidence for stakeholders to prioritise and develop future bushfire strategies.

There is an increase in both average and extreme (99th percentile) Forest Fire Danger Index projected through the century. The rates of change vary across Tasmania and are different in each season. Most notably there is an increase in high fire danger days projected to occur in spring. There is also a projected increase in the frequency of the weather systems associated with many of the most severe fire weather events, and increases to other large–scale drivers of fire risk, as well as projected increases in soil dryness.

Taken together, all these factors provide a consistent story of increasing ire weather risks through the 21st century. This increase in risk factors will underlie the ongoing year–to–year and decade–to–decade variability of fire weather events in Tasmania.

Given the expected shorter return periods of bushfire events, emergency services may need to plan for more rapid repair of vital infrastructure and recovery of personnel to meet these increased risks.

Figure 6: Projected frequency of 'Very High Fire Danger' days from 1961 to 2100



Smoothed projection of the number of days per year categorised as at least 'Very High Fire Danger' from 1961 to 2100. Forest Fire Danger Index values will increase into the future, with the majority of the increase after 2050.

---

[1] K. Hennessy, C. Lucas, N. Nicholls, J. Bathols, R. Suppiah and J. Ricketts. Climate change impacts on fire-weather in south-east Australia. CSIRO Marine and Atmospheric Research, Bushfire CRC and Australian Bureau of Meteorology. 2005.

[2] Clarke H, Lucas C, Smith P. Changes in Australian fire weather between 1973 and 2010. International Journal of Climatology. 2013.

[3] Pitman A, Narisma G, McAneney J. The impact of climate change on the risk of forest and grassland fires in Australia. 2007.

[4] Paul Fox-Hughes, Rebecca Harris, Greg Lee, Michael Grose and Nathan Bindoff. Future fire danger climatology for Tasmania, Australia, using a dynamically downscaled regional climate model.2015.

[5] Department of Police and Emergency Management. 2012 Tasmanian State Natural Disaster Risk Assessment. 2012.

[6] Fox–Hughes P, Harris RMB, Lee G, Jabour J, Grose MR, Remenyi TA & Bindoff NL. Climate futures for Tasmania – Future fire danger. 2015.

6.5.4 Assumptions

- The unit rate would be $58,203 to replace 1 km of conductor (assumed to be 1km of 3 x 19/3.25AAC HV Replacement - 9 x 120m Spans).

Related Projects

Conductor replacement programs for copper, galvanised steel and aluminium are similar projects aimed at prevention of conductor failure for their specific design/construction characterisitics. Parallel conductor replacement programs (where the main driver is safety and reliability of supply) also exist focusing outside of the HBLCA (REMCU = line item 591, REMAC = line item 1719, REMGI = line item 594). These are not duplicate programs.

Material Specifications

Whilst new conductor technology is being investigated, the current strategy for HV copper conductor is to replace with aluminium 19/3.25AAC conductor.

Program Development

The HBLCA unit volumes have been derived from condition assessment of total length of HV copper conductor installed in the network within the HBCLA to determine project volumes.

Annual volumes are a derivative of total program volumes divided by program timeframes.

Unit values have been determined using historical unit costs.

Unit costs are applied to annual program volumes to determine annual costs.