Australian Energy Regulator

Review of TasNetworks' proposed capital expenditure for the 2019-24 regulatory control period

Final draft report

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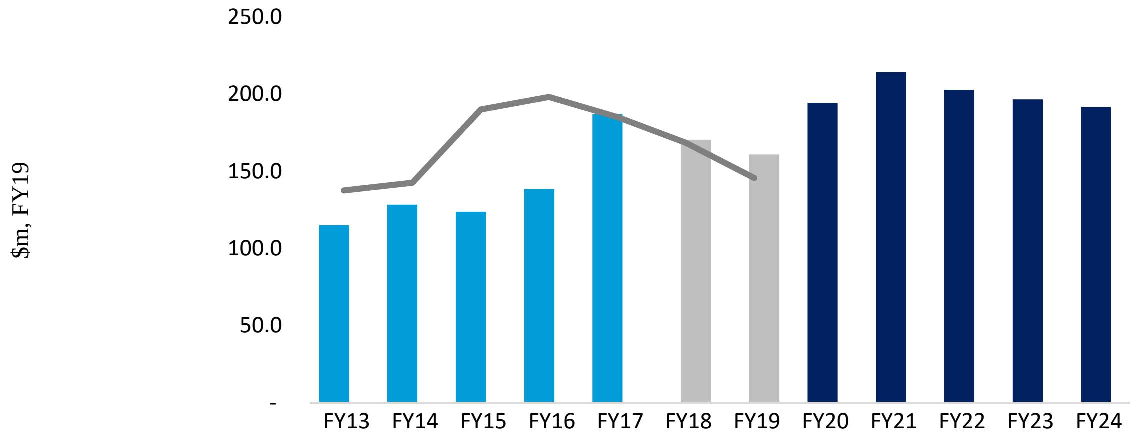
Executive summary

Arup was engaged by the Australian Energy Regulator (AER) to review TasNetworks' transmission and distribution network capital expenditure plans for the 2019-24 regulatory control period (RCP).

TasNetworks has been through a period of significant change with the merger of the TNSP and DNSP functions from 1 July 2014. Throughout this period, TasNetworks has maintained reliability of the network (SAIDI and SAIFI), invested in establishing a comprehensive supporting ICT platform, and has stated that it delivered significant merger efficiencies.

Despite this, TasNetworks are seeking a significant increase in both transmission and distribution capital expenditure over the 2019-24 RCP (see Figure ES 1) while at the same time noting that:

> *"We have heard loud and clear that our customers consider service levels and reliability to be generally acceptable, but affordability is their primary concern."*[1]



	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Combined actual	115.0	128.3	123.8	138.4	187.0	-	-					
Combined proposed	-	-	-	-	-	-	-	194.3	214.2	202.7	196.5	191.6
Combined estimated	-	-	-	-	-	170.5	160.9					
Combined allowance	137.5	142.5	190.1	198.0	185.0	168.4	145.6					

Figure ES 1 Combined actual, proposed, estimated and allowed distribution and transmission capital expenditure for FY13-24

We have reviewed TasNetworks' approach to capital expenditure planning and, while the broad investment framework used by TasNetworks is consistent with industry practice, we have concluded that it is not being applied with sufficient rigour. As such, we do not consider TasNetworks' proposed capital expenditure to be consistent with chapter 6 and 6A of the capital expenditure criteria of the National Electricity Rules (NER).

Based on our review of TasNetworks' documentation, interviews and responses to information requests we have identified the following areas of its capital expenditure planning processes which we believe could be improved:

1. **Lack of a robust quantified approach to investment risk assessment.** TasNetworks adopts a relatively standard likelihood and consequence approach to risk

[1] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 9

assessment to inform investments. However, there is a lack of quantification particularly with respect to estimating the consequence of an event. TasNetworks rely heavily on a 'traffic light' matrix with many investment programs aimed at attempting to effectively eliminate the risk of an event. Without a more objective quantified approach to understanding the consequence of risk, we are unable to confirm that TasNetworks are proposing an efficient level of expenditure.

2. **Shortcomings in the investment evaluation assessment process**. There is a lack of consistency in how TasNetworks develops and assesses capital expenditure investment proposals. This includes differing presentation of results, lack of consistency in application and consideration of sensitivity analysis, lack of detail in developing key assumptions, and limited use of benchmarking and consideration of expert findings. As such, it does not appear TasNetworks are applying a consistent approach to project evaluation and comparison. It is therefore difficult to confirm whether an efficient level of expenditure is proposed across the various investment programs.

3. **Insufficient consideration of alternative capital investment options**. Based on our review it appears TasNetworks generally consider few investment options. Those considered can be limited to 'do nothing', the preferred option and a relatively extreme option. This results in little consideration of alternative feasible options. The approach to the 'do nothing' option is also inconsistently applied across investment evaluations. Consequently, Arup cannot be sure that the preferred option consistently represents the more appropriate option available.

Because of these factors TasNetworks has not been able to demonstrate its full capital expenditure proposal is justified. The impact of these factors is evident across a range of proposed expenditure categories including:

- **Bushfire mitigation expenditure**. TasNetworks are proposing expenditure across 14 individual programs aimed at reducing the risk of bushfire-related events. This suite of programs is a primary driver behind the proposed increase in distribution repex and is not supported by a fully quantified risk assessment.

- **Transmission repex**. The proposed 20% uplift in transmission repex from the current RCP is not fully supported by quantified risk assessments and a number of assumptions driving investment appear overly conservative.

- **ICT**. TasNetworks are seeking a significant investment to replace its existing Meter Data Management System (MDMS) which falls over the next RCP and subsequent RCP. We do not consider the project is sufficiently well progressed at this stage to justify the level of expenditure being proposed.

We consider TasNetworks would benefit from implementing additional detail and consistency to its investment governance processes with a focus on more quantified risk assessment and detailed approach to option consideration.

It is clear TasNetworks has a detailed understanding of its network and a commitment to ensuring the ongoing safe and reliable provision of services to Tasmanians. As TasNetworks continues to mature, we expect it to be able to address the issues we have identified. However, until this is completed we consider a level of capital expenditure consistent with that undertaken during the current RCP to be sufficient for TasNetworks to maintain its existing level of reliability and risk profile.

1 Introduction

This chapter provides the background for this report in describing the scope and context, and the report structure.

This chapter is structured as follows:

1.1 Scope of works

1.2 Assessment approach

1.3 Report structure

1.1 Scope of works

Arup were engaged by the Australian Energy Regulator (AER) in April of 2018 to deliver analysis on TasNetworks' proposed capital expenditure (capex) for the 2019-24 regulatory control period.

The scope of works required Arup to provide technical engineering advice relevant to the AER's assessment under clause 6.5.7 and 6A.6.7 of the National Electricity Rules (NER).

Through consultation, the scope of works was refined to focus on particular areas identified by the AER, which in turn has been reflected throughout this report.

1.2 Assessment approach

The National Electricity Law states the National Electricity Objective to be:

> *"To promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:*
>
> - *price, quality, safety and reliability and security of supply of electricity*
> - *the reliability, safety and security of the national electricity system"*[2]

The current version of the National Electricity Rules also consistently refers throughout chapter 6 and 6A to the necessity of a transmission and distribution network operator to be both prudent and efficient.[3]

With this in mind, and the scope of works, Arup undertook a review of the capex program of TasNetworks.

The first formal step of our review was an inception meeting held between the AER and Arup on Friday 6 April 2018. The AER provided the context and key risks of the project from their perspective, and project management practices, communications and key milestones were agreed upon. The following documents and information sources were also provided:

- TasNetworks' proposal to the AER
- the AER's issues paper

[2] Australian Energy Market Commission, 2018, *National Electricity Rules Version 109*, various
[3] Australian Energy Market Commission, 2018, *National Electricity Rules Version 109*, various

- the AER’s repex model
- the AER’s presentation of TasNetworks’ performance in their forecast capex against the repex model’s findings
- the AER’s summary notes on key issues
- TasNetworks’ strategic asset management plans
- TasNetworks’ various high-level asset management plans, NPVs and Investment Evaluation Summaries (IES)

Preliminary analysis of the documents informed Arup’s Key Issues Paper. The Key Issues Paper flagged issues across TasNetworks’ general process, programs and projects as high, medium, or low in terms of their risk and dollar materiality. The AER and Arup held another meeting in early May following the Key Issues Paper to compare key issues and prioritise areas for analysis, with Arup also clarifying any queries the AER had regarding the Paper.

With the updated key issues list and prioritised areas for analysis, Arup reviewed both documents TasNetworks provided directly to the AER, and those available publicly through the AER’s and TasNetworks’ websites. This informed a list of ~40 questions that Arup developed in preparation for 2 days of interviews that were held in Hobart from 21-22 May.

Representatives from both Arup and the AER attended these interviews with key staff from TasNetworks. Post the interviews, Arup submitted another list of follow up questions to TasNetworks through the AER on May 25.

TasNetworks’ responses to the various questions put to them both at the interviews and in formal information requests, along with the prioritised list of key issues, informed a number of processes, programs and projects that Arup has reviewed in depth.

Arup’s review of these items, and the observations on the capex in reference back to the original scope and the NEO, form the analysis found in this report.

1.3 Report structure

The **Executive summary** is an overview of the engagement and the key observations contained in this report.

Section 1 - Introduction provides the background for this report in describing the scope of works, the assessment approach, and the report structure.

Section 2 - TasNetworks overview describes the context in which TasNetworks operates, in terms of its physical environment, its recent merger and its capex in the most recent regulatory period.

Section 3 - Strategic observations provides an overview and Arup's assessment of TasNetworks' key processes with the most material impact on their current and forecast capex. Processes are assessed in regard to their prudency and efficiency in meeting TasNetworks' obligations while keeping prices in a reasonable range.

Section 4 - Transmission renewal capex observations assesses specific programs and projects in transmission repex that have a material impact on total capex.

Section 5 - Transmission development capex observations contains a brief note on the proposed static VAR compensator at George Town substation, which is to be reviewed by the AER under a RIT-T.

Section 6 - Distribution renewal capex observations includes Arup's observations on key projects within TasNetworks distribution repex program, identifying areas of improvement in how options are developed and assessed.

Section 7 - Distribution development capex observations is structured similarly to the previous three sections, containing Arup's observations on the prudency of key elements of TasNetworks distribution augex profile.

Section 8 - ICT capex observations is once more structured similarly to the sections proceeding it, providing an overview of TasNetworks' capex in ICT considering prudency, efficiency, project evaluations and what alternative approaches may be available.

2 TasNetworks overview

This chapter provides a high level overview of TasNetworks network and performance.

This chapter is structured as follows:

2.1 Network description

2.2 Network performance

2.1 Network description

TasNetworks is a wholly government owned utility operating in the National Electricity Market (NEM), and was formed on 1 July 2014 following the merger of Aurora Energy and Transend Networks. TasNetworks operates both the electricity transmission and electricity distribution network throughout Tasmania. The major assets that form each of the networks include:

- transmission assets:
    - 3564 circuit kilometres of transmission lines and underground cables
    - 49 transmission substations
    - 6 switching stations
- distribution assets:
    - 2,400km of distribution overhead lines and underground cables
    - 227,000 power poles
    - 18 large distribution substations
    - 33,000 small distribution substations

TasNetworks face many of the same challenges as their NEM counterparts including:

- reducing capex in response to lower than expected demand and consumer price preferences
- shifting from augex to repex
- requirement to be able to handle two-way networks with the increasing integration of renewables and storage

TasNetworks is a predominately rural network that services relatively few customers compared to other NSPs in the NEM. TasNetworks' customers include industrial, commercial and residential users. Of note is that their transmission network services four customers across 10 sites that together constitute over 50% of consumption in the network. This is summarised in the Consumer Challenge Panel's recent submission on TasNetworks:

> *"Unlike other States, a small number of large industrial consumers account for over half the total electricity consumption. All are price takers in the international markets they sell their products into. This means that electricity costs are key to them retaining their competitive position. The closure of any one could have a large impact*

on electricity costs for all other consumers in the revenue cap regulatory framework."[4]

Arup observation

TasNetworks performs the dual functions of transmission and distribution, which is uncommon in the NEM. However, the challenges they face are not unique. Key considerations in the coming years for TasNetworks include:

- continuing to adapt in delivering a peak demand below what general market expectations were 5-10 years ago
- evolving network planning towards probabilistic rather than deterministic planning
- adapting to renewable integration and exploring demand management and non-network solutions
- empowering customers in decision making where practical

2.2 Network performance

TasNetworks is a reliable network in terms of:

- SAIFI**,** the System Average Interruption Frequency Index measured in number of interruptions per customer
- SAIDI, the System Average Interruption Duration Index measured in minutes of outage per customer

In transmission, TasNetworks have met their current target in four of the past five years, the exception being 2015-16 when Basslink was temporarily disconnected.

Table 1 TasNetworks actual and targeted average outage duration in minutes across transmission[5]

Transmission	2012-13	2013-14	2014-15	2015-16	2016-17	AER target
Lines	142	174	236	437	267	≤ 326
Transformers	277	279	498	1,710	27	≤ 712

Similarly, TasNetworks' distribution services are generally reliable. Though they have not met their internal targets consistently across the current regulatory period, the AER has stated that improved reliability from TasNetworks should not be a driver of investment. TasNetworks' customers equally do not view reliability improvement as an appropriate driver of investment. [6]

[4] Consumer Challenge Panel Sub-Panel 13, 2018, *Response to proposals from TasNetworks for a revenue reset for the 2019-24 regulatory period*
[5] Office of the Tasmanian Economic Regulator, 2017, *Energy in Tasmania Report 2016-17*, various
[6] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 9

Table 2 TasNetworks actual and targeted network performance excluding MEDs across distribution[7] [8]

Distribution	2012-13	2013-14	2014-15	2015-16	2016-17	TasNetworks target
SAIDI (minutes of outage per customer)	191	242	209	221	219	187
SAIFI (interruptions per customer)	1.66	2.05	1.61	1.86	1.77	1.64

Arup observation

TasNetworks is maintaining current reliability standards (SAIDI and SAIFI) to a level that is meeting the required targets. As such, capex with the goal of improving their performance should therefore not be a primary motivation for network investment and was recognised as such by TasNetworks which stated:

> *"We have heard loud and clear that our customers consider service levels and reliability to be generally acceptable, but affordability is their primary concern. Our customers expect us to make a clear case for any expenditure decisions that will increase prices. We have taken this feedback into account in finalising this proposal, by ensuring that our expenditure is aimed at maintaining current overall performance while meeting our safety and compliance obligations."*[9]

[7] Office of the Tasmanian Economic Regulator, 2017, *Energy in Tasmania Report 2016-17*, various
[8] TasNetworks, 2017, *Asset Management Plan: Service Performance*, pg 10
[9] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 9

3 Strategic observations

This chapter provides an overview and assessment of TasNetworks' key processes with the most material impact on their current and forecast capex. Processes are assessed in regard to their prudency and efficiency in meeting TasNetworks' obligations while keeping prices in a reasonable range.

This chapter is structured as follows:

3.1 Strategy and business transformation

3.2 Asset management

3.3 Delivery strategy

3.4 Risk assessment

3.5 Investment evaluation

3.6 Bushfire mitigation

3.1 Strategy and business transformation

TasNetworks' strategy reflects two major factors. The first is the coming together of the Transmission and Distribution businesses as of 1 July 2014 to form TasNetworks. The second factor is TasNetworks' response to the fundamental changes that are occurring in the electricity industry. The elements of this strategy are shown in Figure 1 which shows TasNetworks' current (2017-18) strategy statement.

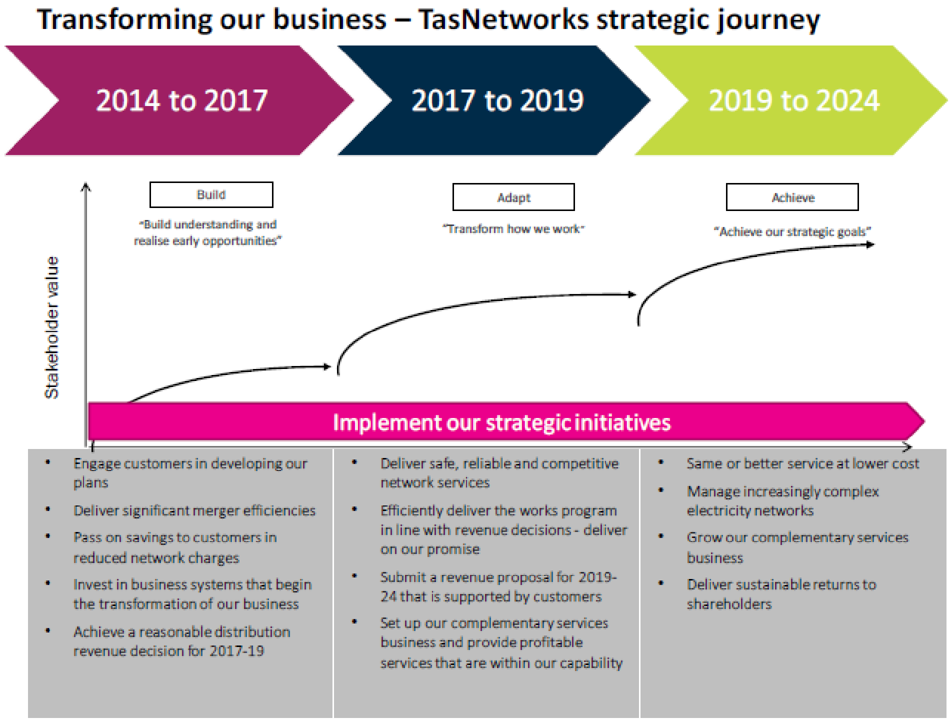


Figure 1 TasNetworks' 2017-18 strategy statement from the 2017-18 Corporate Plan[10]

[10] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 31.

Figure 1 shows the period of integration during 2014 to 2017 where plans are developed and investment in business systems ‘that begin the transformation of our business’, and which deliver ‘significant merger efficiencies’ resulting in ‘savings to customers in reduced network charges’. 2017 to 2019 is now targeted at implementing these changes and ‘transforming how we work’ including a focus on establishing a profitable ‘complementary services business’. 2019 to 2024 then focusses on delivering existing services within a context of increasingly complex electricity networks and growing the complementary business activities of TasNetworks.

With respect to achieving the merger efficiencies and also providing the supporting business architecture for its future operation, TasNetworks noted the following in its 2016 regulatory proposal to the AER for the 1 July 2017 to 30 June 2019 distribution regulatory proposal.

> *“As a recently merged business, we are on a journey of transformation to deliver the lowest sustainable prices to customers and appropriate returns to shareholders. We are already delivering efficiencies as an integrated network business and have commenced a key business initiative to support business transformation. This is a business-critical transformation program that we call Ajilis which will be delivered over the three years to 2018. The project is streamlining business processes and information platforms to improve the way we deliver essential energy services to customers.”*[11]

Figure 2 outlines TasNetworks’ 2017-18 strategy on a page from the Corporate Plan and shows Ajilis as one the strategic initiatives.

Figure 2 TasNetworks’ 2017-18 ‘strategy on a page’[12]

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[11] TasNetworks, 2016, *Tasmanian Distribution Regulatory Proposal. Regulatory Control Period 1 July 2017 to 30 June 2019*, pg 25.

[12] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal, Regulatory Control Period 1 July 2019 to 30 June 2024,* pg 31.

TasNetworks described Ajilis as follows:

> *"The Ajilis Business transformation program delivered an integrated SAP technology platform replacing over 50 disparate systems to deliver TasNetworks' technology platform of the future. The program was delivered in two Releases:*
>
> - *Release one was implemented in February 2017. The scope included procurement, warehousing and supply chain, human capital management and payroll, financial analysis and reporting and governance risk and compliance systems / processes.*
> - *Release Two was implemented in March 2018. The scope included environment, health & safety, enterprise asset management across all asset classes, field work force mobility solution, managing learning, succession planning, recruitment, talent management, compensation, workforce analytics, financial planning including budgeting and forecasting, project financial management, and managing legal claims and litigation.*
>
> *The Enterprise Asset Management solution encompasses the full end-to-end view from strategic planning, determining programs of work, project lifecycle management, developing operations and maintenance work, planning and scheduling work, executing and closing work, managing asset master data, and monitoring performance.*
>
> *The following business processes were targeted for transformation and encompassed in the scope of Ajilis:*
>
> - *Asset Management*
> - *Financial Management*
> - *Human Resource Management and Payroll*
> - *Procurement and Supply Chain Management*
> - *Governance, Risk and Compliance*
> - *Environment, Health and Safety."*[13]

TasNetworks identified benefits from Ajilis to be accrued over the coming 10-year period of around $70M. The majority of these are expected as a result of cost reductions with around $10M contributed from process efficiencies.[14] [15]

In addition, TasNetworks in its submission identified a top-down optimisation that 'will reduce transmission and distribution revenues, in nominal terms, by $29.8 million and $28.4

[13] TasNetworks, 2018, *AER information request, TasNetworks response to questions raised by the AER, Request ID: 019*, pp 9-10.
[14] TasNetworks, 2018, *AER information request, TasNetworks response to questions raised by the AER, Request ID: 019*, pg 10. TasNetworks noted that the benefits were expected to be derived from $55M in cost reduction benefits and $13.4m derived from process efficiencies.
[15] TasNetworks, 2018, *AER information request, TasNetworks response to questions raised by the AER, Request ID: 019*, pg 11. A review following Release One identified slightly higher benefits with actual benefits by the end of 2017-18 of $4.8M largely achieved across Finance, HR and IT applications.

million respectively compared to our provisional plans'.[16] This optimisation was applied on the following basis:

> *"We have heard loud and clear that our customers consider service levels and reliability to be generally acceptable, but affordability is their primary concern. Our customers expect us to make a clear case for any expenditure decisions that will increase prices. We have taken this feedback into account in finalising this proposal, by ensuring that our expenditure is aimed at maintaining current overall performance while meeting our safety and compliance obligations."*[17]

TasNetworks provided further information on the optimisation as follows:

> *"TasNetworks has put forward a package of revenue inputs that include efficiency adjustments to both our operating and capital expenditure forecasts for our transmission and distribution networks. As discussed during the AER/ARUP and TasNetworks meetings on the 21st and 22nd of May, TasNetworks is yet to identify the measures that will result in the achievement of level efficiency improvement."*[18]

To coincide with the completion of the Ajilis implementation, TasNetworks are also proposing to undertake a restructure of the business described as follows:

> *"TasNetworks restructure is setting up our business to deliver on our strategy and to support embedding the outcomes of our recent Ajilis Transformation Program."*[19]

Arup observation

TasNetworks has been through a period of significant change with the merger of the TNSP and DNSP functions and have invested a significant amount in establishing a comprehensive supporting ICT platform. However, there appears to have been a lack of focus on how to maximise the benefits of the investment as evidenced by TasNetworks' inability to:

- identify how the 'optimisation' to its initial expenditure forecasts will be delivered
- provide estimates of the specific benefits to be achieved as a result of its current restructure

We expect TasNetworks should be able to drive additional efficiency improvements in many of its operations as a result of its increasing capability in SAP technology and lessons learned from implementing benefit realisation frameworks.

3.2 Asset management

TasNetworks' approach to asset management practices, including its hierarchy of strategies and policies is shown in Figure 3. The figure shows the relationship between the overall corporate strategy and how this is executed via the strategic asset management plan and then

[16] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal, Regulatory Control Period 1 July 2019 to 30 June 2024*, pg 10.
[17] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal, Regulatory Control Period 1 July 2019 to 30 June 2024*, pg 9.
[18] TasNetworks, 2018, *AER information request, TasNetworks response to questions raised by the AER, Request ID: 019*, pg 5
[19] TasNetworks, 2018, *AER information request, TasNetworks response to questions raised by the AER, Request ID: 019*, pg 5

specific asset management plans based on asset categories which are supported by area plans and annual planning reports.

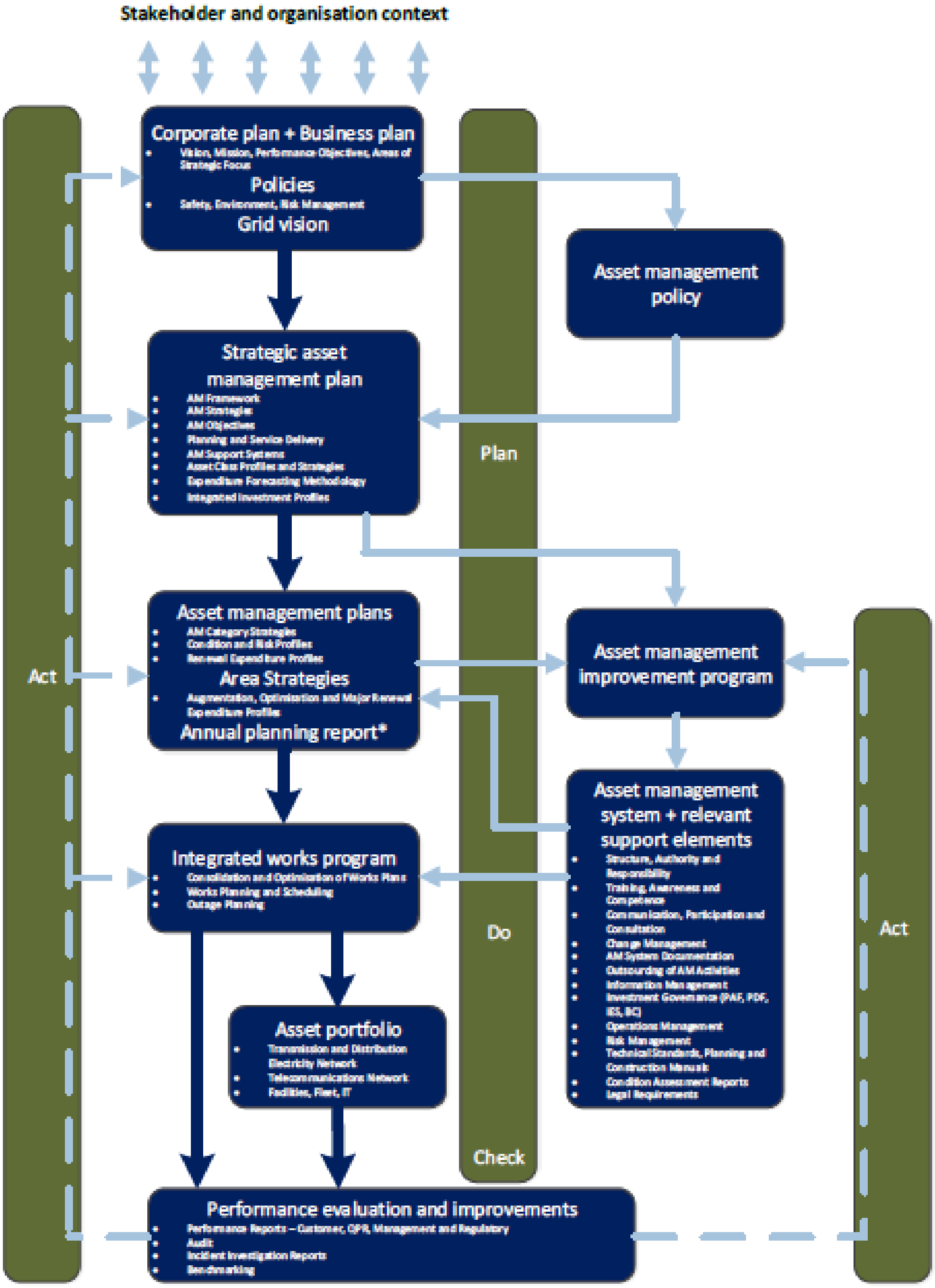

Figure 3 TasNetworks' organisational structure[20]

Arup observation

TasNetworks has adopted an overall approach to asset management that is consistent with other industry members. The effectiveness of how this approach is implemented is discussed further in the following sections.

[20] TasNetworks, 2017, *Strategic Asset Management Plan 2017*, pg 5.

3.3 Delivery model

3.3.1 Program size

TasNetworks proposed capital expenditure program is summarised in Table 3.

Table 3 TasNetworks capex in the current and proposed regulatory periods ($m, FY19)[21] [22]

	Total 2015-19	2020	2021	2022	2023	2024	Total 2020-24
Transmission	211.3	39.5	64.4	65.7	47.8	43.2	260.2
Distribution	569.3	154.8	149.8	137.0	148.7	148.4	738.7
Total	780.6	194.3	214.2	202.7	196.5	191.6	999.3

TasNetworks' capex against the AER allowance is summarised in Table 4.

Table 4 TasNetworks capex against AER allowance in FY15-19 ($m, FY19)[23] [24] [25]

		Total 2015-19
Transmission	Actual and estimated	211.3
	Allowance	269.1
	Difference	57.8
Distribution	Actual and estimated	569.3
	Allowance	618.0
	Difference	48.7
Total	Actual and estimated	780.6
	Allowance	887.1
	Difference	106.5

[21] FY15-17 are actuals, FY18-19 are estimated, FY20-24 are proposed capex figures
[22] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, various
[23] AER, 2014, *Draft decision: TasNetworks transmission determination 2015-16 to 2018-19*, pg 9
[24] Aurora Energy, 2012, *Final Distribution Determination*, pg 25
[25] AER, 2017, *Final Decision: TasNetworks distribution determination 2017-18 to 2018-19*, pg 20

Arup observation

The capex program proposed by TasNetworks represents a total increase compared to the current regulatory period of 218.7m. The increase is comprised of 49.3m in transmission (a 23% increase) and 169.4m in distribution (30% increase).

The proposed capex represents a significant increase compared to what has been – and what is estimated to be – spent over the current regulatory period.

Also of note is that TasNetworks' capex in FY15-19 is approximately $100m below what the AER allowance was during that time. There is an incentive for NSPs to propose high capex levels then spend below and benefit from capex efficiency schemes. Given this, TasNetworks need to demonstrate that they have the capacity to deliver the larger program in the upcoming period.

3.3.2 Insource and outsource strategy

TasNetworks has developed a Works Delivery Plan covering 2019-24[26]. The delivery plan describes a strategy with a mix of insourcing and outsourcing, with insourced labour deployed from four major resourcing centres and eight response centres across the state.

Figure 4 Location of TasNetworks' operations[27]

TasNetworks has an internal field based workforce of 358 FTEs across:

- asset inspectors, distribution operators
- dual-trade electricians/lineworkers
- distribution lineworkers
- live line workers

[26] TasNetworks, 2018, *2019-2024 TasNetworks Works Delivery Plan*
[27] TasNetworks, 2018, *2019-2024 TasNetworks Works Delivery Plan*, pg 5

- meter readers
- electricians

There are no current set plans to increase the size of the internal workforce to deliver the proposed capex program.[28]

Insourced labour typically addresses fault, emergency and reactive works. Outside of that, TasNetworks turn to external labour for high volume and low complexity works, with large capital projects tendered to the national market. Transmission projects tend to be outsourced as well as a legacy of Transend's delivery model and TasNetworks view that building the internal capacity to deliver transmission projects would be unsustainable[29].

On the general strategy of outsourcing, TasNetworks state:

> *"Outsourced resources are engaged to manage the peaks in the program of work. Work that cannot be abandoned and works that are outside internal resources capability and capacity will also be outsourced. Large portions of work that require a sustained effort and present a risk to continuous supply also fit within TasNetworks outsource strategy."* [30]

Arup observation

TasNetworks' delivery model that allows for flexibility in insourcing versus outsourcing depending on the project type, size and complexity represents a prudent approach to delivery. Through not relying purely on internal labour, TasNetworks should better be able to manage 'lumpy' workloads and complex projects that would otherwise lead to an underutilised workforce when complex and expensive projects are completed.

3.3.3 Strategy

TasNetworks' existing planning tools and works management system was superseded by SAP in February 2018. TasNetworks' Works and Service Delivery Group undertake planning on a rolling 1-3 year basis, and will use SAP in order to deliver an efficient program of works in relation to:

- work priority
- resource availability
- location and travel
- skill set requirements
- outages
- customer requirements

Five planners look after discrete areas of Tasmania, and sit in the same room at head office to share knowledge, centralise planning, and ensure SAP is being applied consistently across the delivery plan.

[28] Interviews between Arup and TasNetworks, May 21-22 2018
[29] TasNetworks, 2018, *TasNetworks response to questions raised by the AER 019*, pg 23
[30] TasNetworks, 2018, *TasNetworks response to questions raised by the AER 019*, pg 24

TasNetworks acknowledge that there will not always be the same level of competitive tension in their operations as in the equivalent mainland NSPs, though for major projects and where practical otherwise TasNetworks do tender out to national providers.[31] The delivery teams attempt to combat the lack of competitive tension through benchmarking, both internally in regard to similar projects and externally between similar organisations.

TasNetworks provided the following as evidence of where benchmarking has been implemented to improve efficiency.

> *"TasNetworks implemented a Contractor Performance Management Framework that defines how TasNetworks will measure and report of key contractor's performance. These outcome are benchmarked against TasNetworks performance targets and other like external service provider performance results. TasNetworks has created competitive tension between contractors to improve efficiency/performance/cost and to understand the value derived from our contractors. In recent substation projects - two suppliers were awarded separable portions of a tender. These substation projects had detailed cost estimates that enable TasNetworks to benchmark anticipated internal performance against two external contractors. These projects are on-going and will be used to keep benchmarking of efficiency and pricing for these activities."*[32]

Arup observation

TasNetworks are taking what appears to be a practical and prudent approach to implementing SAP into their resourcing decision making, and ensuring outsourced projects are cost-competitive in instances where there is not the level of competitive tension in the local market to otherwise guarantee competitive prices.

However, maintaining this competitive tension, or benchmarking approximating it, will be more challenging for TasNetworks should they deliver the capital program they are proposing. The program represents an increase in demand for labour, and basic economics suggests that unless there is an equal increase in labour supply, then there will be upwards pressure on prices and unit costs.

3.4 Risk assessment

3.4.1 Network risk

Electricity networks are by nature infrastructure that carries significant risks, both through how integral their continual operation is to the economy, and the dangers they pose to human life.

The risk of failure to deliver electricity is measured in the value of unserved energy. In the NEM, where networks are generally reliable by global standards, consumers are often unprepared for outages. Of the businesses affected by the South Australian blackout in 2016, only 12% had back up generation and almost two thirds didn't have business interruption insurance.[33] The blackouts cost businesses $367m through loss of production, trading and

[31] Interviews between Arup and TasNetworks, May 21-22 2018
[32] TasNetworks, 2018, *TasNetworks response to questions raised by the AER 019*, pg 24
[33] Business South Australia survey, 2016

wages paid. Industry often bears these costs, with a third of the cost of the South Australian blackouts born by four major industrial users.

The value of unserved energy is determined across the NEM by AEMO's power system models, and is an approximation under varying scenarios of customer demand in MWh that can't be served due to a deficiency in generation or network delivery.

The risk of network assets causing serious injury or death can occur through a number of ways, including:

- contact with assets, through accidental collisions or from a fallen pole or line
- electrocution from a faulty asset, not necessarily through direct contact
- injury or death from fires originated by a network asset

Unlike the value of unserved energy, there is currently no uniformly agreed approach across the NEM on how to measure this aspect of risk.

3.4.2 Risk management framework

TasNetworks' approach to risk management is to "*achieve an appropriate balance between realising opportunities for gains while minimising adverse impacts*."[34] Though broad, this does represent the trade-off between minimising the risk of running an electricity network while keeping expenditure, and therefore ultimately customer charges, at a reasonable rate.

TasNetworks' corporate plan outlines the official Risk Management Policy, to:

- prepare and deliver a plan for managing risk in accordance with our risk appetite, the expectations of our stakeholders and the law
- integrate effective and appropriate risk management into all business and management activities and policies
- make available the necessary resources for effectively managing risk
- provide regular reports to the Board detailing material business risks and the effectiveness of associated risk management strategies
- report key risks and associated management strategies to key stakeholders
- review key risks at regular intervals to ensure they remain relevant and additional risks are escalated to align with changing business circumstances

TasNetworks' Risk Management Framework outlines the structured processes by which their policy objectives can be achieved in accordance with *AS/NZS ISO31000:2009 Risk Management – Principles and Guidelines*.

[34] *TasNetworks Framework: Risk Management Framework*, TasNetworks 2017

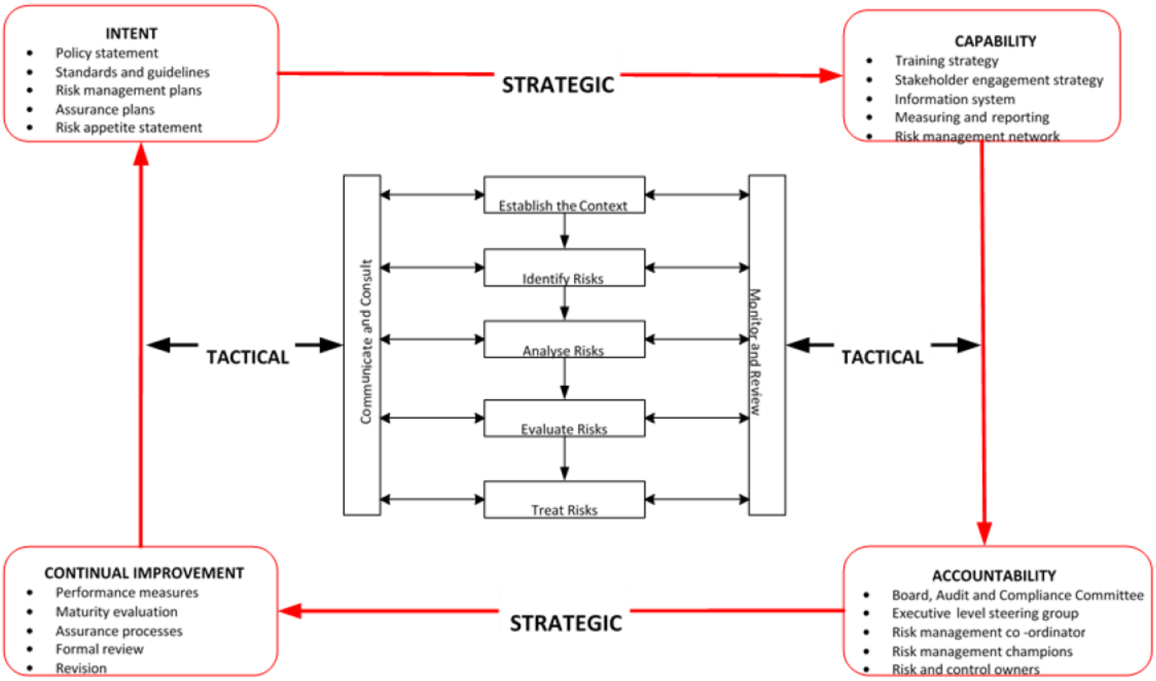

Figure 5 TasNetworks' risk management framework[35]

The framework is designed to:

- demonstrate the commitment and approach to the management of risk – how it is integrated with existing business practices and processes and ensure risk management is not viewed or practiced as an isolated activity
- set a consistent and structured approach for the management of all types of risk
- provide an overview on how to apply the risk management process

The risk management process itself is the core aspect of the framework, and is made up of three steps highlighted in the following figure.

[35] *Transmission and Distribution Regulatory Proposal 2019-2024*, TasNetworks

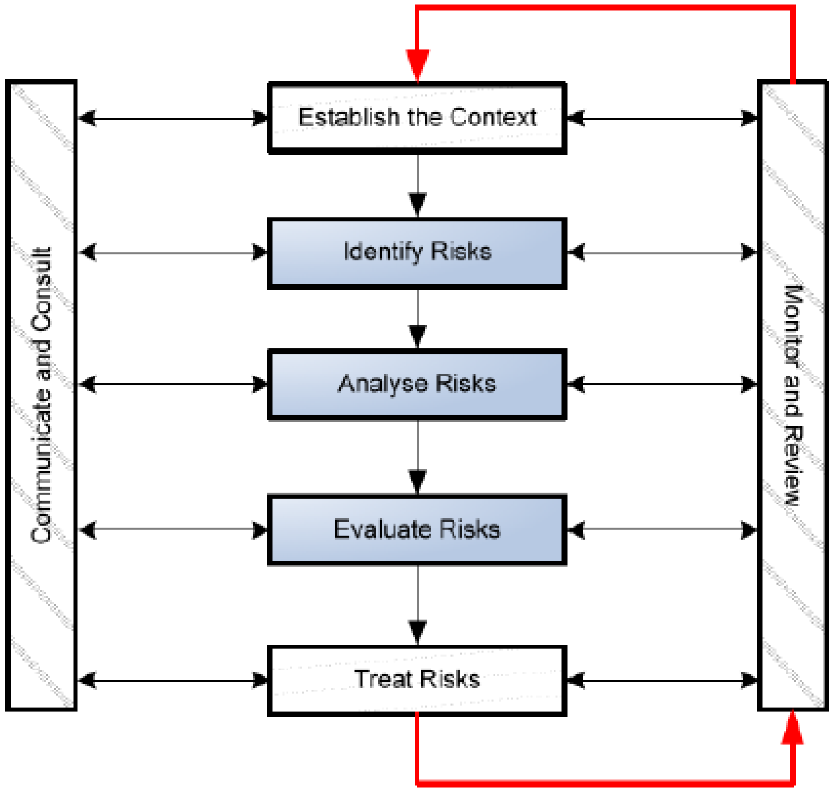

Figure 6 TasNetworks' three step risk assessment process (coloured blue)[36]

The risk assessment process consists of three steps, and is guided by *ISO 31010 – Risk Management – Risk Assessment Techniques*. The guidelines state that the following steps should be adhered to in risk identification:

- identifying the risk and the reason for its occurrence
- identifying the consequences if the risk occurs
- identifying the probability of the risk occurring once more
- identifying factors that reduce the consequences or probability of the risk

3.4.2.1 Identify risks

TasNetworks uses a variety of methods to identify risks, including three formal approaches:

- hazard and operational studies (HAZOP)
- failure modes and effects and criticality analysis (FMECA)
- reliability centred maintenance (RCM)

These, combined with general brainstorming and checklists, are used to identify the what, why, where, when and how events could either harm or enhance TasNetworks. Risks are stated in regard to how they could impact on TasNetworks' objectives.

[36] TasNetworks, 2017, *TasNetworks Framework: Risk Management Framework*, pg 14

3.4.2.2 Analyse risks

TasNetworks employs qualitative risk assessment in its analysis. Risks are first assessed regarding whether there are any existing controls in place to mitigate them, and what the effectiveness of these controls are.

Risks are specifically measured in terms of:

- The most likely consequence on TasNetworks and/or their stakeholders
- The likelihood that TasNetworks and/or its stakeholders will be impacted at the measured level of consequence

The risks are mapped to a risk matrix in provided by TasNetworks.

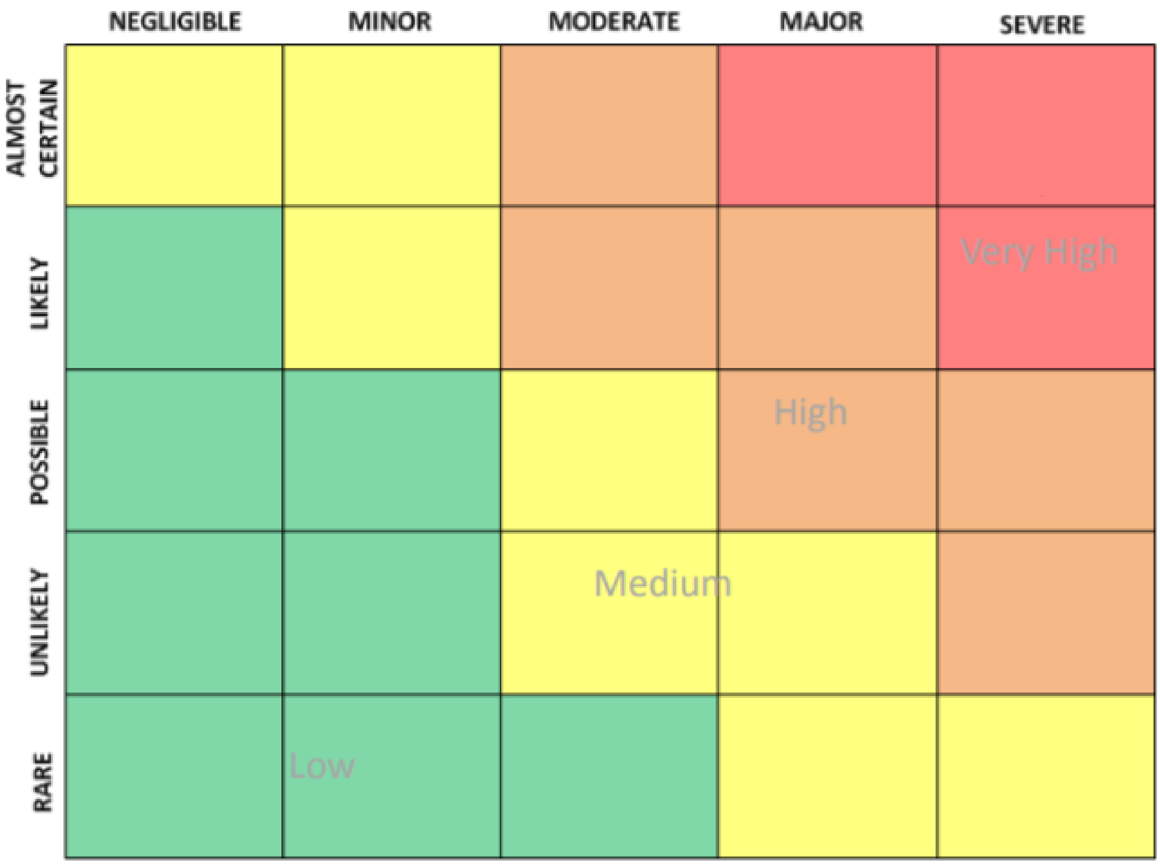

Figure 7 TasNetworks risk matrix

In their most recent Risk Management Framework, TasNetworks has made efforts to quantify the consequence and likelihoods that describe each 'bucket' in the risk matrix. As example, 'Possible' likelihoods may be between 20-39% probability, and moderate consequence may be a loss or gain of between 5 and 30 million dollars[37].

Arup observation

Risk consequence is measured in a range between negligible and severe, while likelihood is measured between rare and almost certain. TasNetworks has updated their approach to the

[37]TasNetworks, 2017, *TasNetworks Framework: Risk Management Framework*, pg 19-20

risk matrix by quantifying what each of the buckets in likelihood and consequence represent. However, it is not clear whether each risk analysis is being quantified in order to be allocated to the correct 'bucket' in the risk matrix.

Management has indicated that the network's approach to risk is under review with an intent to quantify risks in the future. This is in accordance with the AER's communication to the NSPs in general that risk quantification is a key step to robust network planning.[38]

3.4.2.3 Evaluate risks

The aim of TasNetworks' risk evaluation is to determine which risks need addressing, and in what order they should be prioritised.

Risks are ranked in accordance to the risk matrix results from the previous step. TasNetworks also factor in their corporate guidance on risk appetite, as well as the willingness to tolerate risks that exceed the stated appetite in a given aspect of operations (i.e. environmental risk versus financial risk).

TasNetworks state that the primary consideration in risk evaluation is whether the risk can be treated further in a cost-effective manner.

TasNetworks notes that "the level of risk alone does not necessarily indicate a need for further risk treatment."[39] As such, risks that are outside of TasNetworks' risk appetite that can be treated cost-effectively are prioritised for mitigation. Otherwise, risks that continue to be tolerated are subject to further assessment.

Generally, this is measured through a cost benefit test on whether the benefits from risk treatment exceed the costs, both in financial and non-financial terms. Otherwise, an ALARP[40] approach can be adopted, particularly in instances regarding health and safety such as in bushfire risk mitigation. The Health and Safety Executive provides a good summary on ALARP in this context:

> *"The 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]"*[41]

Arup observation

Effective risk evaluation is predicated on effective risk identification and analysis. TasNetworks' risk identification appears to be a prudent approach, but the lack of quantifying risk consequences means that TasNetworks' approach to risk analysis is inadequate in fully understanding the impact of risks to the network.

TasNetworks does not apply a robust quantified approach to its considerations of risk. The current approach based on a 'traffic light' matrix with minimal quantification lacks the level of sophistication required to support the volume of expenditure sought. TasNetworks' approach to risk analysis is inadequate to fully understand the impact of risks to the network,

[38] Conversations that took place during interviews between Arup and TasNetworks, May 21-22 2018
[39] TasNetworks, 2017, *TasNetworks Framework: Risk Management Framework*, pg 23
[40] As Low As Reasonably Practical
[41] HSE, 2018, http://www.hse.gov.uk/risk/theory/alarpglance.htm

and as a result, TasNetworks cannot be sure whether its proposed expenditure program is decreasing, maintaining or increasing its overall risk profile.

TasNetworks should increase the extent to which its considerations of risk are quantified, especially with respect to its assessment of consequences. In instances where a traditional cost benefit approach may not be appropriate, such as in bushfire mitigation or other areas where health and safety is the primary concern, TasNetworks has flagged ALARP as an example framework but do not appear to have implemented it to any significant extent.

3.5 Investment governance

3.5.1 Overview and framework

Investment governance is framed by TasNetworks as an investment lifecycle as per the following figure.

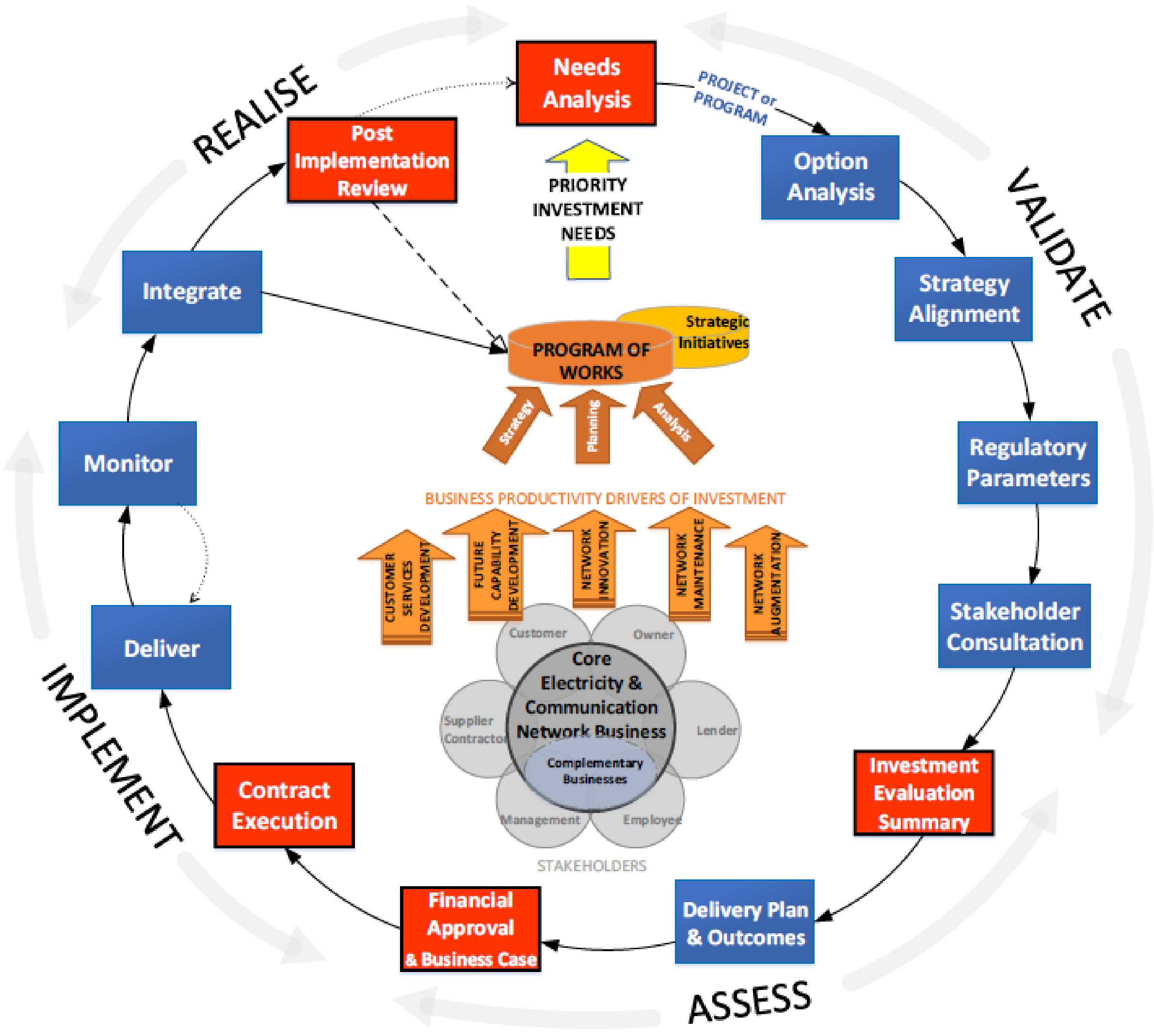

Figure 8 The investment lifecycle[42]

[42] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 61

TasNetworks employ a lifecycle approach to investment decisions, incorporating five key decision points represented as gates in the figure below. A proposed investment must make it through the first four gates before it is implemented, and then undergo a review regarding benefits realisation and lessons learned in gate 5.

Figure 9 TasNetworks decision gates in the investment lifecycle

Gate 1, Needs Analysis, is designed to determine the rationale for investment by linking it to a core business need. If a proposed investment is ancillary to the business needs, then it will not proceed to gate 2.

Gate 2 is an Investment Evaluation Summary (IES). According to TasNetworks in their recent proposal:

> *"The purpose of this gate is to evaluate different options in order to identify the preferred investment solution. An approved evaluation is required for all investment projects and programs that are to be included into the Works Program.* [43] *"*

The level of approval will depend on the proposed expenditure in the IES; larger or strategic projects will require CEO or Board approval. Approval of an IES signals to the organisation as a whole that the investment is required, meets the needs of the business and is to be incorporated into the rolling works program.

TasNetworks note that the IES is a "*living document*",[44] to be updated over the lifecycle of the investment as new or updated information comes to hand.

3.5.2 IES template

TasNetworks provided the IES template *E2E Stage 2 Project Initiation Step 2 of 3 – Investment Evaluation Summary* that is used to guide employees. The template outlines the following assumptions for an NPV analysis. It is not clear whether these are assumptions to be followed, or just for an example project:

- NPV analysis is carried out for a 25-year period (2015-39)
- Weighted average cost of capital (WACC) of 3.80% is used
- Value of Customer Reliability (VCR) of $14,960 per MWh of electricity is used for calculating cost of involuntary load shedding45
- No voluntary load shedding has been assumed
- Reduction in system losses has been ignored

[43] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 61
[44] TasNetworks, 2018, *TasNetworks response to questions raised by the AER 019*, pg 7
[45] AEMO, 2014, *Value of Customer Reliability Review*, - this is the value of customer reliability for mining customers

- 0.5% of proposed capital cost is assumed as incremental operations and maintenance cost (opex)

The appendix also describes assumptions to be used for the economic analysis in an IES:

- Project timing (tested for advancing by 2 years and delaying by 4 years)
- WACC (tested for the range from 3% to 8% real WACC)
- VCR (tested for $10,000 per MWh to $80,000 per MWh)
- Capital cost (tested for 10% lower than the base cost to 30% higher than the base cost)
- Operation and maintenance cost (tested for 20% lower than base cost to 100% higher than base cost)

The template *E2E Stage 2 Project Initiation Step 2 of 3 – Investment Evaluation Summary* is reasonably prescriptive in terms of how the IES should be set out, what should generally be discussed in each section (though many of the sections are not deemed mandatory), and how the sections relate back to a gateway or other aspect of TasNetworks' various frameworks.

While this is consistent with good practice, the lack of a detailed methodology by which various options should be identified and analysed is concerning. As a result, it is likely that potential investments are not being considered on a like-for-like basis. While some flexibility is obviously necessary to develop options that accurately reflect the situation, TasNetworks would benefit from a more prescribed methodology on how many, the form of options and how these are assessed. In addition, there appears to be a lack of consistency with how 'do nothing' outcomes are assessed. This is linked to the lack of a quantitative approach to risk assessment.

As an example, a methodology could provide more structure in the timeframes various options are considered (for example, whether an option to be considered would be to undertake the project in 5 or 15 years), and also give more specific guidance on what the 'do nothing' approach should consider and how this is estimated.

Ultimately more guidance on the options to consider would lead to more consistent application of the IES across the business, increasing familiarity with the process organisation-wide, and ultimately lead to more robust decision making.

Section 6.5 of the template is headed as 'Quantitative risk analysis'. The guidance included here is minimal, and the section is not mandatory for an IES. This reflects TasNetworks general approach to quantitative risk assessment, and likely manifests in projects designed to mitigate risks that aren't thoroughly understood.

It is not clear whether the assumptions being used for the NPV are just for the example project. If this is the case, then there appears to be inadequate guidance for NPV assumptions generally. There should be a range of assumptions presented, reflecting the differing requirements for projects undertaken across various areas of the business.

In the IES template, the VCR is set at $14,960 per MWh, reflecting AEMO's estimate for the VCR of mining customers in 2014. This is the highest VCR for directly connected customers by some margin:

Table 5 Value Customer Reliability – industrial users[46]

Sector	Sector-wide weighted average	Metals	Wood, pulp, and paper	Mining
Weighted average VCR ($/kWh)	6.05	5.29	1.44	14.96

The AEMO also estimates VCR for other customer types:

Table 6 Aggregate VCR values for the NEM and Tasmania[47]

Location	NEM	Tasmania
VCR excluding direct connects ($/kWh)	39.00	39.43
VCR including direct connects ($/kWh)	33.46	25.62
Residential VCR ($/kWh)	25.95	28.58

Given the values estimated by the AEMO, TasNetworks' use of $14,960 in the template guidelines appears simplistic were it meant to apply across all projects. As does the use of $39,430 in the projects sampled throughout this report.

A more prudent approach may be to use values more representative of the customers impacted by a particular project or program:

- for general investment in the transmission network, a weighted average of the 'Sector-wide weighted average' of industrial users and the 'VCR excluding direct connects', reflecting the relative percentages of direct industrial consumption and electricity passing through the distribution network
- for general investment in the distribution network, a VCR excluding direct connects
- for investments isolated to parts of the network servicing residential or industrial customers exclusively, use the appropriate specific VCR as per the AEMO tables above
- carry out sensitivity analysis on this proposed approach as per the current IES template assumptions

3.5.3 Application

To assess both the appropriateness of the framework in delivering prudent and efficient projects, as well as how strictly the framework and template are followed, Arup has sampled a number of project IES supplied by TasNetworks as part of their proposal for the upcoming regulatory period. For the purpose of this analysis specifically, projects and programs contained in the IES's have not been judged in regard to their prudency and efficiency, but

[46] AEMO, 2015, *Fact Sheet: Value of Customer Reliability*, pg 2
[47] AEMO, 2014, *Value of Customer Reliability – Application Guide*, pg 5

rather whether the IES is in line with best practice, TasNetworks own template, and is therefore likely to result in a good outcome for customers.

Below are extracts from three sampled IES's.

Transmission Line Conductor Assembly Refurbishment Program[48]

The objective of the proposed investment is to mitigate the risk of conductor assembly failure. Failure could potentially result in:

- safety incidents due to fallen conductors
- decreased circuit reliability
- increased lifecycle cost of conductor assemblies

The preferred option has a cost estimate of $6,656,793. The options considered for the IES are outlined in Table 7.

Table 7 Transmission Line Conductor Assembly Refurbishment Program – IES option summary

Option description		**NPV**	**Reason for selection/rejection**
Option 0	No planned capital replacement	-$17,083,498	Rejected – This option is rejected as it exposes TasNetworks to unacceptably high levels of risk. This option does not improve circuit reliability.
Option 1 (preferred)	Maintain all conductors in conjunction with a targeted replacement program	-$6,295,403	Preferred – This option mitigates the risk of conductor assembly failure, improves circuit reliability, reduces the lifecycle costs of conductor assemblies and is the most favourable option economically.
Option 2	Maintain all conductors in conjunction with a deferred targeted replacement program	-$7,342,427	Rejected – This option is rejected as it exposes TasNetworks to unacceptable levels of risk relating to conductor failure.
Option 3	Maintain all conductor assemblies in conjunction with the replacement of all conductor assemblies that have exceeded their economic life	-$80,000,000	Rejected – This option is rejected as it does not comply with TasNetworks' preferred asset management strategy to only replace assets identified as being in poor condition.

[48] TasNetworks, undated, *Investment Evaluation Summary (IES) Project Name: Transmission Line Conductor Assembly Refurbishment Program*.

There was no quantitative risk assessment, sensitivity analysis or expert findings included as part of this IES.

The key assumptions used in the economic analysis as stated in the IES were:

- NPV analysis carried out for a 25-year period (2019 to 2044)
- a discount rate of 3.59%
- a Value of Customer Reliability (VCR) of $39,430 per megawatt-hour of electricity (used to calculate the cost of involuntary load shedding)
- an average transmission line load of 50MW as a risk to loss of supply across the network (either through network constraint or disconnection of radial generation or loads)
- a conductor assembly condition based failure rate of 0.05 per annum extrapolated exponentially over 20 years (to represent the increasing likelihood of failure due to asset condition deterioration), assuming one failure per year after that point in time
- the time to repair a conductor assembly failure of 24 hours

Market Systems – MDMS Replacement[49]

The objective of this project is to replace the current Meter Data Management System (MDMS) as it reaches end of life. The MDMS is responsible for:

- maintaining Installation Details for all distribution connection points including unmetered supplies
- generation and storage of consumption data for unmetered supplies
- metering configuration details for all distribution connection points
- reading rounds and interface to Meter Reading System
- validation, substitution and storage of meter reading / consumption data for all basic meters

The preferred option has a cost estimate of $62,698,480[50]. The options considered for the IES are outlined in Table 8.

[49] TasNetworks, 31/07/2017, *Investment Evaluation Summary (IES) Project Name: Market Systems – MDMS Replacement*.
[50] Flagged as confidential by TasNetworks

Table 8 Market Systems – MDMS Replacement – IES option summary

Option description		NPV[51]	Reason for selection/rejection
Option 0	No planned capital replacement	-$42.845m	Highest risk.
Option 1 (preferred)	Deploy a new ERP module and transfer functionality into the ERP. Build interfaces to Market systems and the Meter Reading System. (preferred option)	-$51.705m	Best alignment with the corporate strategy.
Option 2	Upgrade to new version with current vendor. Build interfaces to Market systems and the Meter Reading System.	-$49.034m	Less aligned with the corporate strategy.
Option 3	Go to market & source new vendor/product. Build interfaces to Market systems and the Meter Reading System.	-$70.400m	Less aligned with the corporate strategy. Higher business impact on implementation.

There was no quantitative risk assessment, benchmarking, sensitivity analysis or expert findings included as part of this IES.

The key assumptions used in the economic analysis were not stated in the IES.

Bushfire management – project replace aged / deteriorated Cu conductor[52]

The project's objective is to address safety, community, and environmental risks in the High Bushfire Loss Consequence Area (HBLCA) through replacing HV copper conductors with new standard conductors.

The preferred option has a cost estimate of $12,772,000. The options considered for the IES are outlined in Table 9.

[51] Flagged as confidential by TasNetworks
[52] TasNetworks, undated, *Investment Evaluation Summary (IES) Project Name: BFM – project replace aged/deteriorated Cu conductor*.

Table 9 BFM – project replace aged / deteriorated Cu conductor – IES option summary

Option description		NPV	Reason for selection/rejection
Option 0	Do nothing	$0	Not provided in table format in the IES
Option 1 (preferred)	Review and replace HV copper conductor based on condition and risk of fire start.	-$16,327,319	
Option 2	Replace HV copper conductors after 50 years.	-$48,887,709	

There was no quantitative risk assessment, sensitivity analysis or expert findings included as part of this IES.

The key assumptions used in the economic analysis were not stated in the IES.

3.5.3.1 NPV application summary

In general, the application of the IES template appears to differ from IES to IES. This makes comparison between projects challenging, as the IES's include sections and present findings in a manner that isn't consistent across the project summaries. Similarly, some of the IES' were dated with version control and others undated.

None of the three sampled IES' included a quantitative risk assessment or expert findings of note. This is of concern particularly in regard to the risk assessment. A quantitative risk assessment is necessary so as to be aware of the risk being addressed by the project. As a high-level example, the risk of not proceeding with a project could be $30m to TasNetworks, and the project could have a cost of $50m. Therefore, the project may not be worth pursuing, but this would not be clear without performing a quantitative risk assessment.

The IES' also did not include a sensitivity analysis to measure the impact of changing key variables in the project that cannot be known for certain before investment. In actual fact, some of the NPV calculations that were not included in the IES did appear to undertake sensitivity analyses, but there is no evidence that the results impacted decision making.

The NPV calculations for the sampled projects used a value of customer reliability of $39,430 per MWh of interruption. This reflects the cost identified by the AEMO as the VCR excluding direct connections, and does not appear uniformly appropriate for the projects sampled. In addition, it's not clear that the VCR is feeding through the various NPV calculations in the spreadsheet supplied to Arup.

There also does not appear to be consistency in terms of the number and type of options considered across the IES's. The 'do nothing' option doesn't seem to have been consistently applied in the same manner: in one IES it has a $0 NPV, while in others the NPV has been calculated in some detail.

Across other IES's, the 'do nothing' option appears to represent both BAU as well as a literal do nothing approach, where capex on the asset is stopped entirely. As such, it is not clear whether the 'do nothing' option consistently represents a BAU approach where there are still costs of failures and maintenance in the program or asset being considered.

The number of years used to evaluate NPVs also differs across the IES's. For example, the copper conductor replacement program performs an NPV over 50 years, while the transmission line conductor assembly refurbishment program uses 25 years. No clear reason appears to have been given for these differences.

Overall, the framework and template for the IES's does not appear to be prescriptive enough so as to allow for consistent application across various projects and programs. This gives too much discretion to each project manager, resulting in inconsistent approaches to NPV and option assessment.

The manner in which TasNetworks quantifies (or doesn't quantify) risk also needs to be addressed. Currently, the selection of the preferred option in an IES is an opaque process. The option with the highest NPV may not be selected, in preference of another option that better addresses risk. However, without quantifying that risk there can't be full confidence that the right decision has been made. To make the process more robust, risks should be quantified where practical and incorporated into the NPV analysis.

Arup observation

There are significant shortcomings in TasNetworks' investment evaluation assessment process. There is a lack of consistency in how TasNetworks develops and assesses investment proposals including:

- differing presentation of results
- lack of supporting assumptions
- little consistency in use of benchmarking or consideration of expert findings[53]

Where sensitivity analysis is applied, it does not appear to have been applied to all the necessary key variables in order to get a robust understanding of project performance under different scenarios.

In addition, TasNetworks give insufficient consideration and apply a lack of rigour in the assessment of alternative options. TasNetworks' generally consider few options – with those considered generally limited to 'do nothing', the preferred option and a relatively extreme option – resulting in what appears to be an incomplete consideration of alternative feasible options.

3.6 Bushfire mitigation

3.6.1 Objectives

TasNetworks view bushfire mitigation as a central aspect of their risk management: the risk of "Major bushfire start is attributed to TasNetworks assets and/or work practices, leading to fatality or permanent impairment of a member of the public" is included in the network's Key Risk Profile.[54]

[53] Noting that the Phoenix and HBLCA modelling could be considered an expert finding for BFM projects.
[54] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 8

TasNetworks' Bushfire Risk Mitigation Plan, updated in 2017, sets out to address four key strategic objectives:[55]

- safety, principally in the form of bushfires started by:
  - live assets coming into contact with vegetation
  - asset failure resulting in bushfire ignition
  - errors or mismanagement by TasNetworks staff when constructing, operating or maintaining assets
  - deliberate or accidental third-party actions
- compliance with legislative or statutory requirements
- performance through mitigating supply interruptions from bushfires started by TasNetworks assets
- business risk appetite through managing risks in a manner consistent with TasNetworks Risk Management Framework

3.6.2 Tasmanian risk

One of the key reasons TasNetworks view bushfire mitigation as an area of such importance is that they consider Tasmania to be one of the "*most bushfire prone areas of Australia with the potential for extreme bushfire events*",[56] even "*among the highest bushfire prone areas of the world, alongside areas such as California, Canada and the South of France and Spain*".

TasNetworks are basing their assessment at least in part on the Phoenix Rapid-Fire model, a model used elsewhere by NSPs in Australia to measure bushfire risk.

[55] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 8-9
[56] TasNetworks, 2018, *TasNetworks response to questions raised by the AER: 019*, pg 26-27

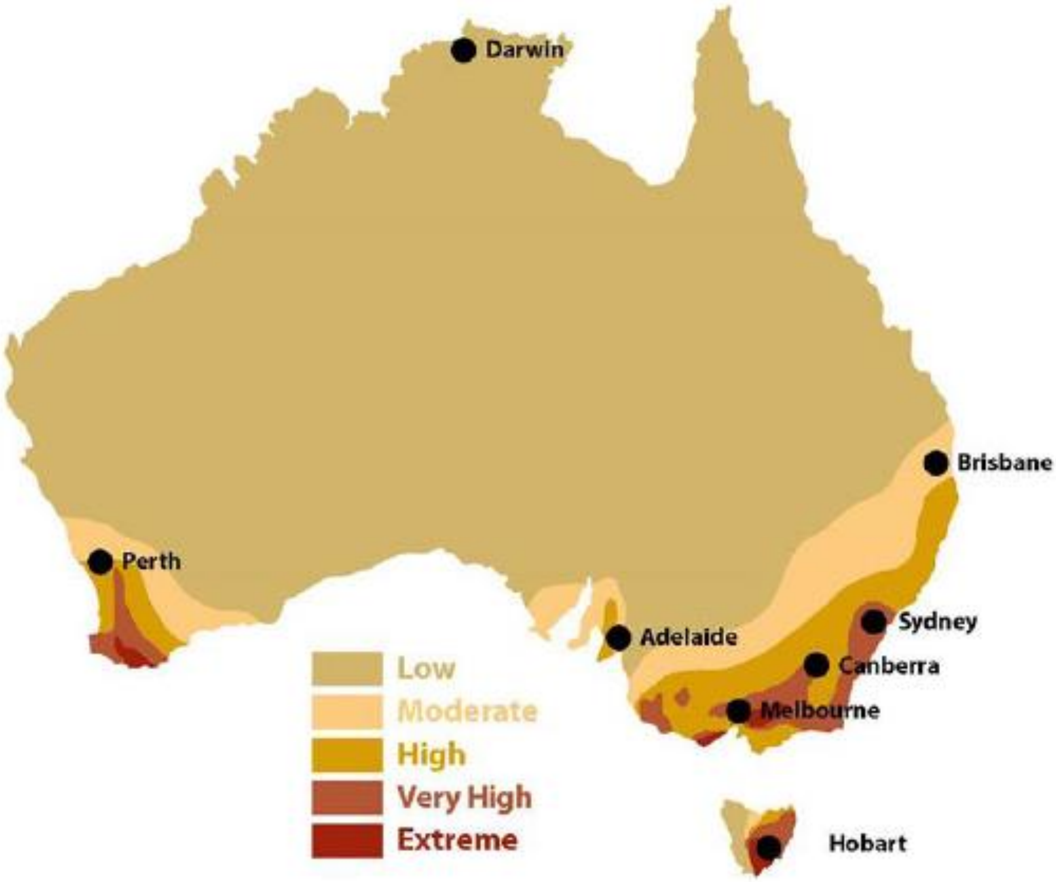

Figure 10 Bushfire prone areas of Australia according to the Phoenix Rapid-Fire model

While TasNetworks acknowledge that high impact bushfires are more common in mainland Australia, it considers the severity of the 1967 bushfire in which 62 people were killed, along with two more recent bushfires in 2007 and 2013, to be evidence that bushfires were and remain a genuine risk to people and property in Tasmania.

TasNetworks appear to be following industry standard in adopting Phoenix modelling to map their bushfire risk. However, consideration is required regarding the conclusion drawn by TasNetworks that Tasmania is one of the highest risk areas in the world.

TasNetworks' Bushfire Risk Mitigation Plan includes a section on Tasmania Fire Danger Ratings, which is summarised in Figure 11.

FDI	FDR	Description
100+	Catastrophic	• Most fires breaking out a 'catastrophic' day will spread rapidly and be uncontrollable. • There is a high likelihood that people in the path of a fire will be killed or seriously injured. • Many homes are very likely to be destroyed. • Even the best-prepared homes will not be safe.
75-99	Extreme	• Some fires breaking out today will spread rapidly and be uncontrollable. • People in the path of a fire may be killed or seriously injured. • Many homes are very likely to be destroyed.
50-74	Severe	• Some fires breaking out today will spread rapidly and be uncontrollable. • People in the path of a fire may be killed or seriously injured. • Some homes are likely to be destroyed.
25-49	Very High	• Some fires breaking out today will spread rapidly and be difficult to control. • There is a possibility that people in the path of a fire will be killed or seriously injured. • Some homes may be destroyed.
12-24	High	• Fires breaking out today can be controlled. • People in the path of a fire are unlikely to be killed or seriously injured if they take shelter.
0-11	Low-Moderate	• Fires breaking out today can be controlled easily. • There is little risk to people and property.

Figure 11 Relationship between Fire Danger Index and Fire Danger Rating[57]

TasNetworks note that Tasmania has only experienced six days in the last 90 years where there has been a Fire Danger Index (FDI) over 75, and has on average three days per year of total fire bans where the FDI is greater than 38.

Measuring bushfire risk in the context of the FDI appears to show Tasmania as having considerably less risk than Victoria, as shown in the following table included in TasNetworks' Bushfire Risk Mitigation Plan.

Arup observation

While recognising that Tasmania is a bushfire prone area, evidenced by the major bushfire in 1967 and the less severe but still damaging bushfire in 2013, TasNetworks has not demonstrated how it has accounted for the state's relatively milder climate compared to mainland Australia. TasNetworks state that Tasmania is one of the highest bushfire risk areas in the world. This conclusion, which is a driver of TasNetworks' bushfire mitigation expenditure, requires further substantiation.

57 TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 16

Table 10 Historical analysis of fire danger occurrence (1974-2003)[58]

Location		**Number of days per year with FDI between 25 and 49**	**Number of days per year with FDI greater than 50**
Tasmania	Hobart	3.4	0.3
	Launceston	1.5	0.0
Victoria	Melbourne	9	0.6
	Bendigo	17.8	1.6
	Mildura	79.5	10.4

TasNetworks' findings presented in Table 10, along with the number of major bushfire events on the Australian mainland compared to Tasmania, indicate that TasNetworks has further work to do to substantiate the conclusion that Tasmania is one of the highest bushfire risk regions in the world.

3.6.3 Mitigation plan

3.6.3.1 Bushfire loss areas

TasNetworks engaged a consultant to work in conjunction with the Tasmania Fire Service (TFS) and Parks and Wildlife Service (PWS) to determine areas in Tasmania particularly vulnerable to bushfires. The result of the engagement was development of the high bushfire loss consequence area (HBLCA).

[58] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 17

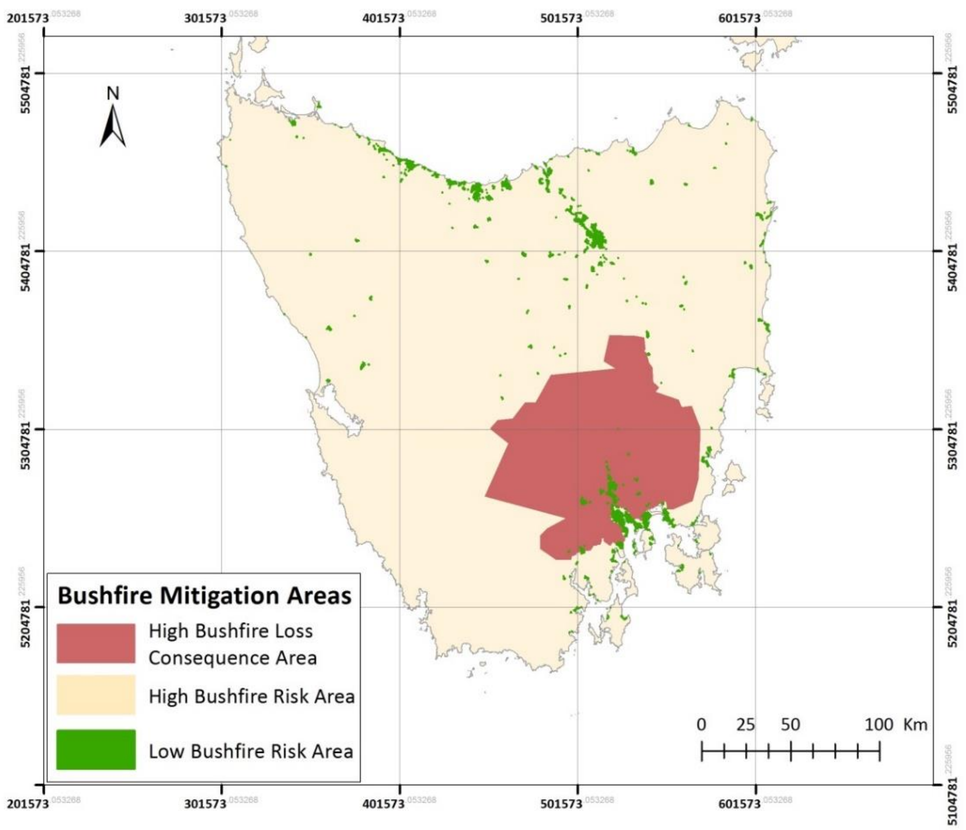

Figure 12 TasNetworks' bushfire mitigation areas[59]

The HBLCA allows TasNetworks to prioritise their bushfire management practices. Assets within the HBLCA are the first to be targeted for remediation.

Once these bushfire mitigation programs in the HBLCA have been exhausted, TasNetworks intend move onto mitigating bushfire risk in the remaining high bushfire risk area.

As an approximation of total assets that fall within each classification:

- 30,000 poles in the HBLCA, approximately 13% of the total network
- 118,000 poles in the HBRA, approximately 52% of the total network
- 80,000 poles in the LBRA, approximately 35% of the total network

3.6.3.2 Targeted assets

TasNetworks monitor the number of ground fire starts originated by their distribution assets, summarised in the table below for ground fire starts from 2012 to 2017[60]. Ground fires are defined by TasNetworks in the Bushfire Risk Mitigation Plan as:

> *"fires that occur at ground level (in grass or vegetation). Pole fires are fires that are contained to the top of the pole and are not generally included within ground fire*

[59] TasNetworks, *TN-Response IR019 – Meeting with Consultant Arup – PUBLIC*, slide 28
[60] TasNetworks has access to pre 2012 data but it is not considered reliable

statistics due to specific conditions resulting in lower risk rankings. In the event that pole fires do cause ground fires, occurrences are recorded as ground fires." [61]

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**

Figure 13 Causes of fires initiated by distribution network assets[62]

TasNetworks has analysed the ground fire starts in regard to their own distribution assets, and defined six main causes of potential asset failure related to bushfire risk:[63]

- electrical joints – causing 31% of potential ground fires causing sparks, burns, flames etc. between 2012 and 2016
- conductor clashing – 16%
- conductor failure – 16%
- EDO fuses – 16%
- HV insulators – 10%
- birds / animals – 9%

These six main causes of potential asset failure result in 80% of all potential asset related fires. TasNetworks' risk mitigation programs have been developed to mitigate these risks classified internally as high and very high.

Figure 14 and Figure 15 from TasNetworks' Bushfire Mitigation Plan highlight that >98% of outages that have the potential to cause ground fires do not result in a fire, and ~1.5% of fires attended by the TFS were caused by electrical assets.

[61] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 22
[62] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 22
[63] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 26-27

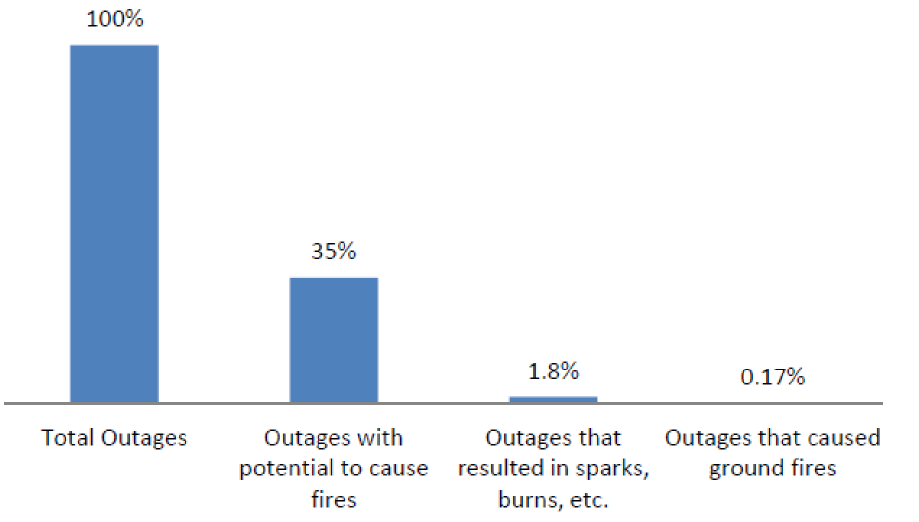

Figure 14 Percentage of outages versus percentage of fires (July 2012 to June 2015)[64]

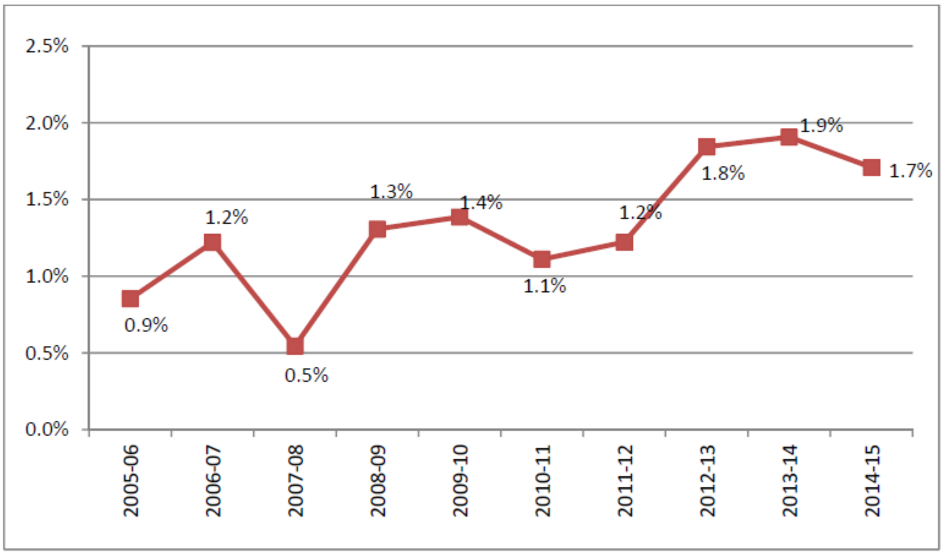

Figure 15 Fires caused by electrical assets as % of total vegetation fires attended by Tasmania Fire Services[65]

While both the outages that result in ground fires and the proportion of fires started by electrical assets appears minimal, TasNetworks consider they have an obligation to develop a program to address these risks on the basis of the severity of consequence that bushfires pose.

The programs and their volume of works are described across 14 prioritised asset groups within the HBLCA, summarised in Figure 16.

[64] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 28
[65] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 34

Bushfire mitigation works programs	Unit measure	2017-18 Units	2018-19 Units	2019-20 Units	2020-21 Units	2021-22 Units	2022-23 Units	2023-24 Units
Live Line Clamp Program	pole	1,510	1,510	1,311	1,311	1,311	1,311	1,311
Install single phase reclosers for SWER	site	11	11	6	6	6	6	6
Replace/relocate open wire HV with insulated alternative	km	5	5	20	20	20	20	20
Replace HV connectors within 2km of zone substations	pole	75	25	25	25	25	-	-
Conductor Clashing (LV spreader retrofit) Program	span	1,000	1,000	877	877	877	877	877
Conductor Clashing (LV cross arms) Program	crossarm	305	305	83	83	83	83	83
Install Vibration Damper Program	pole	500	500	75	75	75	75	75
Copper (CU) Conductor Replacement Program	km	27	27	48	48	48	19	19
Galvanised Iron (GI) Conductor Replacement Program	km	11	11	36	36	36	14	14
Aluminium (Al) Conductor Replacement Program	km	9	9	12	12	12	5	5
Replace HV ABC	span	20	20	20	20	20	20	20
HV fuse replacement program	sites	667	1,000	1,667	1,667	1,667	333	333
Bird/Animal Mitigation Program	span	125	125	50	50	50	50	50
Install LV Fuse Links Program	pole	163	50	50	50	50	50	50

Figure 16 TasNetworks overhead system capex unit volumes[66]

The majority of the program focused on the HBLCA is to be completed over a seven year period, noting that TasNetworks has stated that the program will also continue to other areas of the State:

> *"The bushfire mitigation program (14 separate line items) is not a seven year program. Each program is a multi-year program with specific timeframes determined by balancing volumes, costs and risk. Programs timeframes range between 1, 2, 5 and 10 years. In some cases (such as HV Fuse replacement where risks, volumes, and costs are high), once priority sites are completed (such as those within the HBLCA), future year programs will change focus to the next highest areas of priority. Programs such as this will extend beyond 10 years."* [67]

Given TasNetworks' intention to extend the bushfire mitigation programs beyond the HBLCA to the HBRA, the programs are likely to continue for many years.

The volumes across the bushfire mitigation works programs represented as capex is summarised in the following graph from TasNetworks.

[66] TasNetworks, 2017, *Bushfire Risk Mitigation Plan*, pg 39
[67] TasNetworks, 2018, TasNetworks response to questions raised by the AER: 019, pg 26

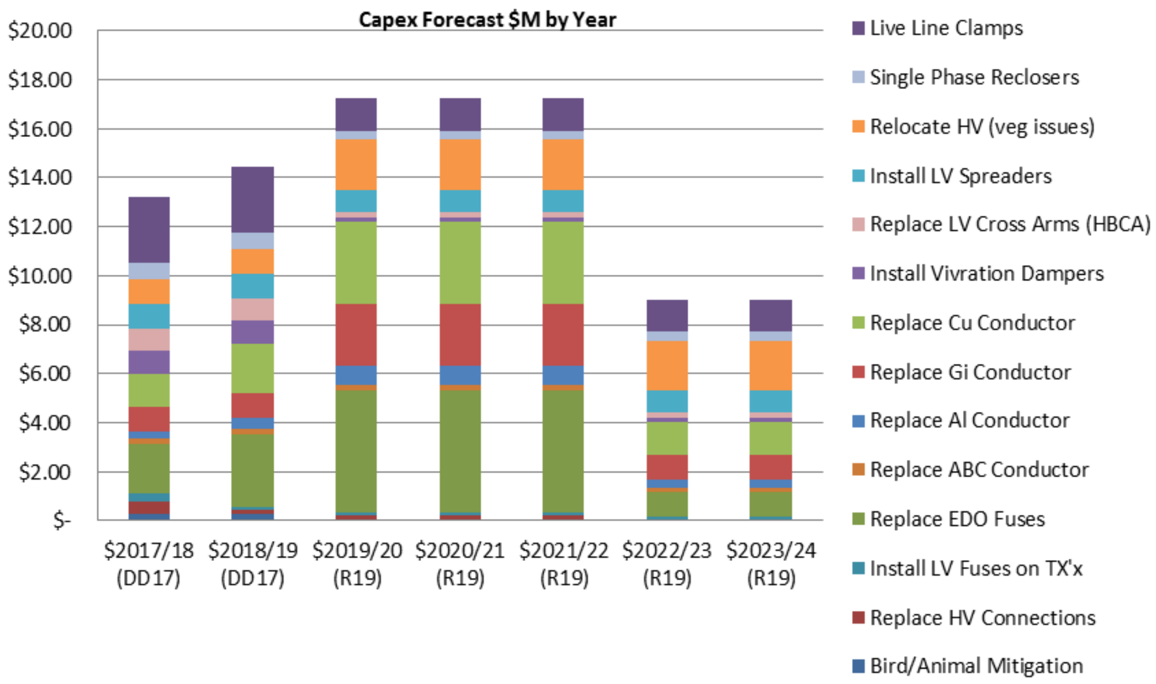

Figure 17 Bushfire management capex forecast by year[68]

3.6.3.3 Risk assessment

TasNetworks has assessed their current bushfire risk rating as ‘high’, reflecting both likelihood and consequence ratings. Recognising that they are more able to influence the likelihood than the consequence of a bushfire rating, TasNetworks has focused their bushfire mitigation program on decreasing the likelihood of consequence occurring.

The current likelihood rating of unlikely reflects a probability of occurrence between 1% and 19%, or ‘may occur but not anticipated’ or ‘could occur in years to decades’.[69] TasNetworks intend to decrease the likelihood rating to ‘rare’, reflecting a probability less than or equal to 1%, or ‘occurrence requires exceptional circumstances’ or ‘exceptionally unlikely, even in the long-term future or a ‘100-year event’.

The current consequence rating of severe reflects events that could cause permanent impairment or fatality, severe impairment to critical habitats and ecosystems, and/or damage greater than $75m in financial costs.

TasNetworks risk matrix assessment for bushfires is represented below in Figure 18.

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[68] TasNetworks, *TN-Response IR019 – Meeting with Consultant Arup – PUBLIC*, slide 31
[69] TasNetworks, *TN-Response IR019 – Meeting with Consultant Arup – PUBLIC*, slide 31 notes

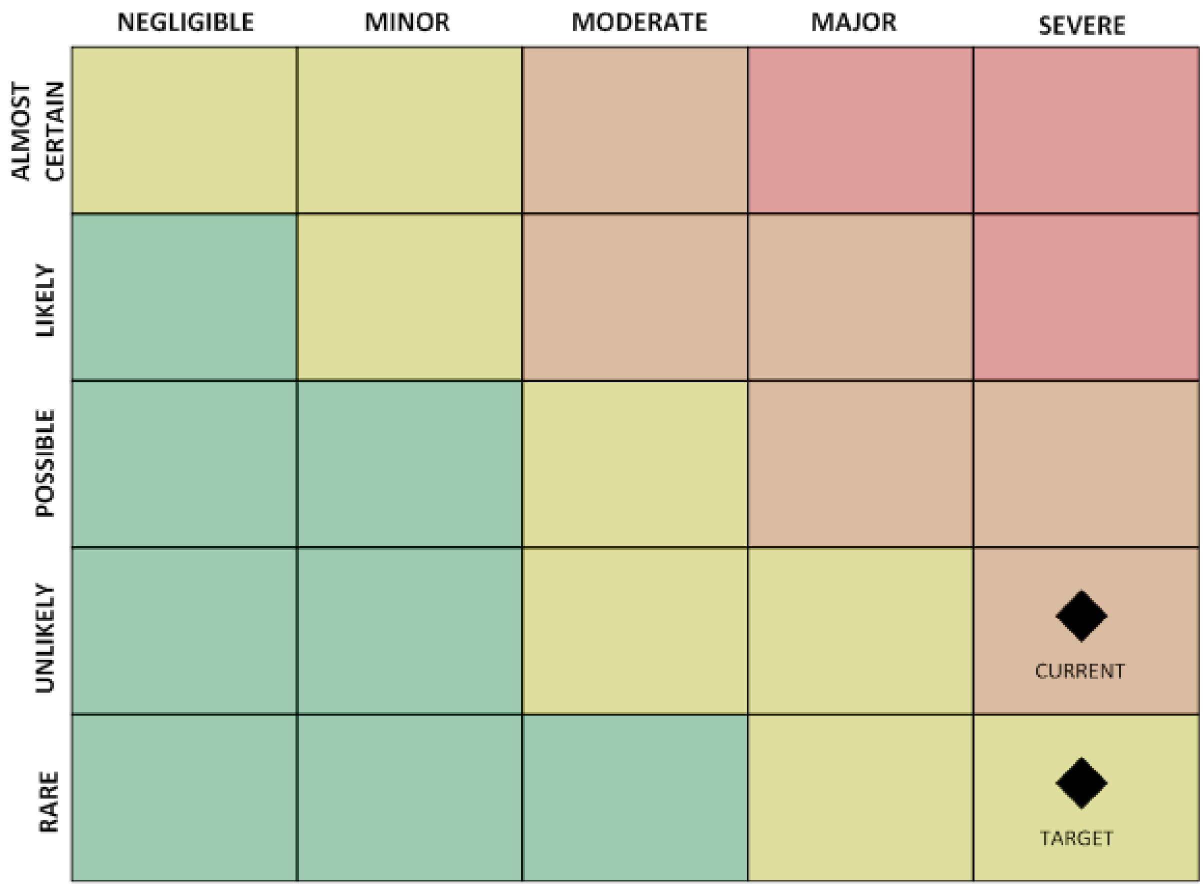


Figure 18 TasNetworks' current bushfire risk assessment[70]

3.6.3.4 Mitigation summary

TasNetworks has followed a reasonably robust process in their bushfire mitigation plan through:

- exploring areas in Tasmania at most risk through engaging consultants to develop the HBLCA
- examining data on potential fire starts from asset failure while excluding data that was deemed unreliable
- developing a bushfire mitigation program to target these high risk assets in high risk areas

Arup observation

TasNetworks consider the consequence of bushfires to be 'severe' in their risk matrix. However, it is not clear they have robustly quantified the risk in accordance to the risk matrix guidelines. In addition, TasNetworks do not appear to have made allowances for Tasmania's different climate compared to other bushfire prone areas in Australia.

In this respect, it appears TasNetworks are only considering the worst-case scenario of outcomes in their bushfire risk assessment. By only considering consequences of this

[70] TasNetworks, *TN-Response IR019 – Meeting with Consultant Arup – PUBLIC*, slide 30

magnitude, TasNetworks appear to be missing nuances in the range of potential consequences of bushfires.

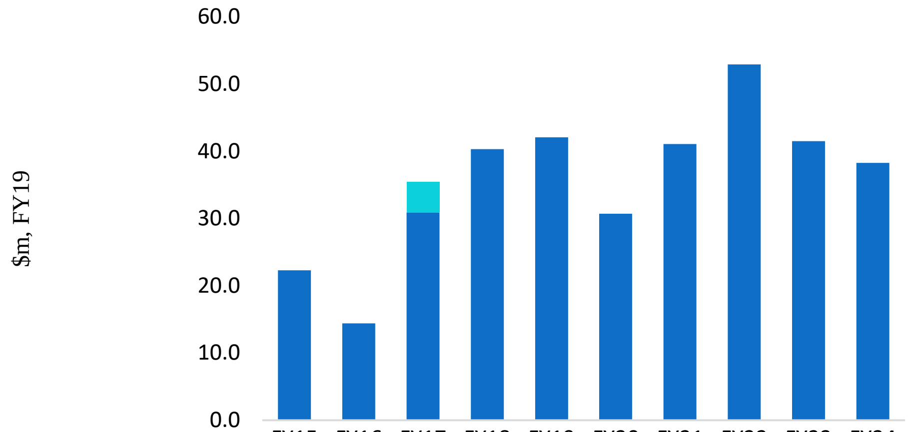
This reflects again on TasNetworks' risk management framework that generally does not quantify risks. In order for TasNetworks to demonstrate that its bushfire mitigation program represents a prudent and efficient response to bushfire risk in Tasmania, further detailed quantified analysis is necessary. This will help TasNetworks understand the magnitude of the risk they are addressing, and therefore guide an appropriate level of capex spend in response.

As it stands now, TasNetworks capex program for bushfire mitigation requires further justification given the:

- lack of quantified risks
- minimal demonstrated allowance made for the Tasmanian climate reflecting the differences to the mainland
- size and scope of the program to address risks in the HBLCA and then HBRA.

4 Transmission renewal capex observations

TasNetworks has proposed an increase in transmission repex over the forecast proposal period with the aim of ensuring that current performance is maintained and safety and reliability risk is managed. The total expenditure on transmission repex has increased from $154.5m in the current period to $204.5 in the forecast period. All of the spend is in replacement expenditure (repex).



	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Inventory/spares	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Reliability and quality maintained	22.3	14.4	30.9	40.3	42.1	30.7	41.1	52.9	41.5	38.3

Figure 19 TasNetworks' transmission replacement capex FY15 to FY24

This section is structured as follows:

4.1 General transmission repex VCR assumptions

4.2 Transmission lines

4.3 Transmission protection and control

4.4 Transmission substations

Arup has reviewed the portfolio of proposed transmission repex programs, and undertaken a detailed assessment of a sample of programs with high materiality to highlight the application of various assumptions within the NPV analysis.

Table 11 Key transmission projects/programs

Project	Proposed expenditure in proposal ($m, FY19)	Capex forecast model ($m, FY17)
Transmission Line Protection Renewal Program	$14.8m	$17.1m
Transmission Line Insulator Assembly Replacement Program	$7.8m	$9.0m
George Town – TEMCO 110kV Transmission Line Replacement	$5.6m	$6.3m
Chapel St 11kV HV switchgear	$3.8m	$4.2m

Our findings are primarily around the assumptions TasNetworks has used for unserved energy, operating and maintenance costs and risk and consequence within the program NPVs.

4.1 General transmission repex VCR assumptions

A general point to note across the transmission IES and NPVs is the assumptions on the value of customer reliability (VCR). AEMO has developed guidelines on the use of appropriate VCR, discussed in detail in Section 3.5.2.

TasNetworks has four direct connections to major industrial customers that operate in either the metals or wood, pulp and paper sectors.

- George Town - Colmalco 220 kV (Metals)
- George Town - Temco 110 kV (Metals)
- George Town - Starwood 110 kV (Wood, pulp and paper)
- Burnie Hampshire - 110 kV (Wood, pulp and paper)

These major users make up over 50% of total electricity consumption for TasNetworks[71]. Given the combined consumption of these four major industrial users is at such a material level, they should be considered by TasNetworks in the VCR assumptions.

In the case of general investment into the transmission network, Arup recommends the use of the VCR for industrial users in metals, wood, pulp and paper, in conjunction with the VCR excluding direct connections.

[71] Consumer Challenge Panel Sub-Panel 13, 2018, *Response to proposals from TasNetworks for a revenue reset for the 2019-24 regulatory period*

Table 12 Weighted average VCR

Type	VCR	Weighting
VCR excluding direct connects in Tasmania ($/kWh)	39.43	50%
VCR industrial users – metals ($/kWh)	5.29	25%
VCR industrial users – wood, pulp, and paper ($/kWh)	1.44	25%
General transmission repex VCR ($/kWh)	**21.40**	**100%**

We note that the exact weights in the above table are unlikely to reflect TasNetworks actual operations, and that the figures need to be inflated to current dollars. However, we do consider a VCR of $21.40 per kWh to represent a more accurate and robust starting point for projects in TasNetworks transmission network than the current blanket assumption of $39.43 per kWh.

4.2 Transmission lines

TasNetworks operate 220kV and 110kV transmission lines that transmit electricity from generators to the distribution network, directly connected customers and across Basslink in the NEM.

TasNetworks has proposed a range of programs to replace overhead earth wires, insulators and foundations that have reached end of life. The following are the key programs that make up the transmission line replacement expenditure. Arup has reviewed these key projects and programs with a focus on assumptions and investment drivers that may be inconsistent with an Arup view on prudency and efficiency.

Table 13 Key transmission line replacement programs ($m, FY19)

Project	Proposed expenditure
Transmission Line Insulator Assembly Replacement Program	$7.8m
George Town – TEMCO 110kV Transmission Line Replacement	$5.6m

4.2.1 Forecast Expenditure

TasNetworks has proposed a total spend of $50.5m on transmission lines in the forecast period.

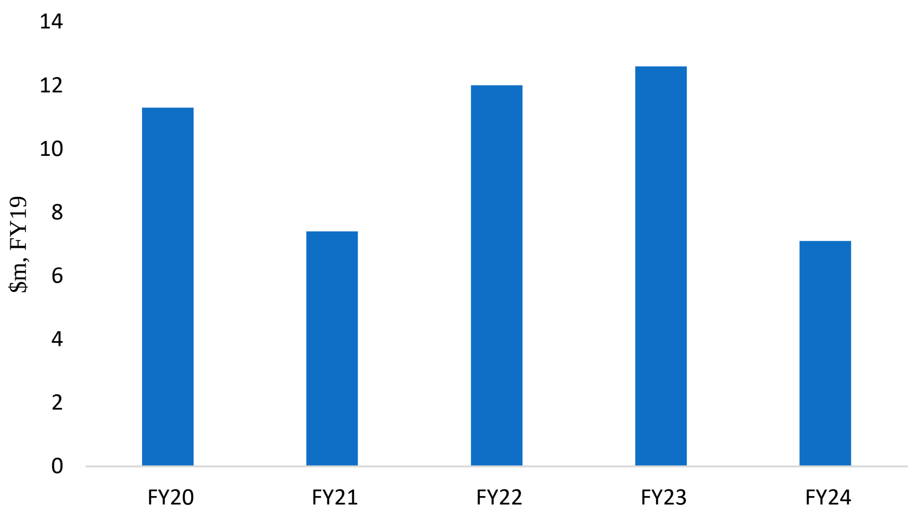


Figure 20 Proposed capex – Transmission lines

4.2.2 George Town – TEMCO 110kV Transmission Line Replacement

TasNetworks has four direct connections to major industrial customer through EHV and transmission lines. Each connection is underpinned by an agreement that describes the level of service and performance obligation. TasNetworks has proposed the replacement of the George Town – TEMCO 110kV transmission line as it has reached end of life. The 3.1km line was originally built to supply a manganese processing plant, via an aluminium smelter, however has now been re-routed to bypass the smelter.

4.2.2.1 Investment Driver

TasNetworks has identified the need to replace the George Town TEMCO transmission line to ensure its reliability as it has reach end of life. The asset is more than 55 years old as it was constructed in 1962 and was expected to have a life span of 60 years. Inspections completed by TasNetworks in 2016 identified numerous defects. These include: corrosion issues on the support towers, bolts, insulator strain assembles, step bolts and anti-climbing devices.

The current TEMCO line has some 19/0.116 copper conductor that is rated at 60 degrees below the standard operating conditions. It is key to note that although the line is reaching end of life there have been minimal faults over its lifetime due to the continuous maintenance. However, due to the fundamental need for the line for the customer’s operations, TasNetworks has a low risk appetite for failure on this line.

4.2.2.2 Replacement Approach

TasNetworks’ replacement strategy involves replacing the current double circuit 110kV transmission line to the standard steel pole double circuit with a 110kV conductor. TasNetworks will bear the cost of the replacement as the line is under a grandfathered agreement with the directly connected user.

4.2.2.3 Financials and Program

Table 14 Financials and Program – TEMCO 110kV transmission line replacement

	FY20	FY21	FY22	FY23	FY24
Proportion of total program	0	0	0.36	0.64	0
Total ($, FY17)	$0	$0	$1,920,810	$3,414,774	$0

4.2.2.4 Options Analysis

TasNetworks has developed three options to replace the transmission line. The options consist of:

- Option 0 Do nothing
- Option 1 Replace transmission line
- Option 2 Refurbish transmission line

TasNetworks has selected Option 1 as the preferred option as it is aligned to the Asset Management Plan and mitigates business, safety and reliability risks. This option ensures that TasNetworks can support the customer load with no constraints. Option 2 mitigates the same long-term risks, however during the maintenance works TasNetworks see an increased safety risk to the business. This is a result of the necessity to maintain supply while containing lead contaminates existing paint during tower painting and the need to take the circuit out of service for replacement of the insulators and conductors.

4.2.2.5 NPV Analysis

The NPV analysis completed for this project is based on capital costs, operating and maintenance costs and unserved energy costs.

Table 15 Economic analysis outputs - George Town TEMCO 110kV line[72]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$5,335,584	$1,500,000
NPV	-$59,963,499	-$5,684,146	-$13,584,979

[72] TasNetworks 2017, *George Town – TE Transmission Line Replacement NPV 01428 pg 8*

Arup observations

Table 16 NPV analysis assumptions

VCR	Risk and consequence assumptions	Other assumptions
$39,430/MWh	Average MW loading: 101.0813 MW Outage duration: 8 hours Population factor: 0.5 Option 1 structure failure rate: 0.01 and 0.005 Option 2 structure failure rate: Exponential increase after 15 years	Refurbishment works for Option 2 have been input into maintenance costs

Based on the assumptions presented in Table 16, Arup has made the following observations:

- The VCR value of $39,430 per MWh is the aggregate VCR value excluding directly connected customers. TEMCO is a direct connect customer in the metals industry which AEMO proscribes a more appropriate VCR value to be $5,290 per MWh[73].
- It is noted that the average MW loading calculation has been averaged over approximately 3 days' worth of data. The NPV has 1 month of data available which is June. The consumer may have seasonal variability in its loads, therefore this value needs further investigation.
    - There may be expected changes to demand from the TEMCO that will affect the value for unserved energy. The high consequence risks associated with TEMCOs expected life and future demand do not appear to be quantified within the NPV analysis.
- Sensitivities on the outage duration hours might be run to give a more thorough understanding on risks.
- The level of rigour behind the population factor estimate of 0.5 is unclear, with TasNetworks stating:

    > *"Population factor is 1 as the whole line is impacted by this project. A 50% chance of survivability of an extreme event (i.e. weather) has been applied as the survivability of the old design is uncertain."*

- Arup cannot be certain that the calculation of the unserved energy for Option 1 has used the historical structure failure rate of 0.01 instead of the new failure rate after 2023 of 0.005.
- TasNetworks appear to have allocated some capital costs as operating and maintenance costs incorrectly as described below.

It appears that the bolded costs in Table 17 should have been considered as capital costs as opposed to operating and maintenance costs as these extend the life of the asset. Painting the

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[73] AEMO, 2015, *Fact Sheet: Value of Customer Reliability*, pg 2

line and undertaking works to the foundation extends the life of the asset and therefore should have been assigned as capital costs.

Table 17 Operating and maintenance inputs for TEMCO replacement

Option	Asset	Maintenance description	Cost
Option 2	**Maintain Existing Transmission Line**	**Tower Painting**	**$100,000**
Option 2	**Maintain Existing Transmission Line**	**Foundation works**	**$30,000**
Option 2	Maintain Existing Transmission Line	New conductor	$1,500,000
Option 0	Existing Assets	Cost of failure	$1.00
Option 1	Renew Transmission Line	Cost of failure	$1.00
Option 2	Maintain Existing Transmission Line	Cost of failure	$1.00

Arup cannot be certain that the installation of a new conductor to maintain the existing transmission network is necessary. This transmission connection is a double-circuit 110kV line, therefore unserved energy is less likely to result from a conductor failure, as the design covers an N-1 contingency on conductors. However, tower failure will affect unserved energy directly as both circuits will be impacted on this radial line. TasNetworks state the transmission connection asset runs primarily through an industrial area and has had very few faults and reliability issues due to the inspection and maintenance regime applied.

Arup notes current condition shows maintenance is required on the towers for steel strut, bolt and joint corrosion, insulation condition and foundation condition particularly as these are located close to the coast. Replacement of the towers will not change this required maintenance. Nor will the double circuit tower replacement lessen the consequence of unserved energy where a tower failure occurs. The risk of a failure remains low where adequate maintenance is provided.

4.2.2.6 Arup findings and recommendations

Refurbishment of the TEMCO appears to be the preferable option as it mitigates the risk that TasNetworks are concerned about and provides economic efficiency. By placing such a large investment into an asset that services a singular customer there are inherent risks that the asset can become stranded. TasNetworks has not shown clear evidence of mitigation of this risk within their IES.

TasNetworks has mentioned that they have strong client relationships with each of their large industrial clients, however, have not completed any investigation into the validity of their business to ensure that the asset is not stranded. Due to grandfathered agreements, the cost of the asset is not shared and TasNetworks would not be reimbursed for a stranded asset. Therefore, refurbishment instead of replacement of the asset can mitigate some of these risks.

The NPV analysis conducted by TasNetworks does not adequately compare the options. The assumptions made, specifically around the VCR and calculation of unserved energy, appear to be unjustified. It is recommended the NPV analysis is amended in light of the observations above. It is also unclear whether the residual value of the options has been included. This is a key factor for renewing the assets in Option 1 as the asset life is given as 60 years.

Arup recommends that TasNetworks revisits their NPV analysis assumptions, in light of the observations above.

4.2.2.7 Key documents

- TN 01428 – TE 110kV Transmission Line Replacement NPV
- TN – GT – TE Transmission Line Replacement
- TN Transmission Line Conductor Assemblies Asset Management Plan

4.2.3 Transmission Line Insulator Assembly Refurbishment Program

Transmission line insulator assemblies mechanically and electrically separate and insulate energised conductors from their support structures. The asset is designed to withstand the high frequency voltage and over-voltages in the network, mechanical load conditions and environmental impacts.

TasNetworks currently have 42,000 insulator assemblies in service, which are predominately glass or porcelain disk assemblies.

Table 18 TasNetworks insulator assemblies' types and population[74]

Insulator material	Size	Population
Glass disc	16mm	159,472
Glass disc	20mm	129,848
Porcelain disc	16mm	45,436
Porcelain disc	20mm	64,553
Porcelain post	-	150
Synthetic	-	2,536

4.2.3.1 Investment Driver

TasNetworks has identified the need to mitigate the risk of conductors failing to the ground, flashover or breaching of the required electrical clearance by maintaining insulators. The potential outcome of a conductor falling to the ground could be the sparking of a bushfire, injury to the public or third-party property damage. TasNetworks has undertaken condition assessment of conductor insulators and has identified the need to replace insulators that are at

[74] TasNetworks 2017, *Transmission Line Insulator Assemblies Asset Management Plan pg 9*

end of life and showing evidence of disc and fitting integrity deterioration. In the case of a failure, TasNetworks has suggested that there may be a need for extended outages for replacement. Additionally, when facilitating asset repairs there are potential security risks.

Based on the assessment that TasNetworks conducted on porcelain and glass disc insulators, approximately 27% (~11,500) are older than the prescribed economic life of 60 years. TasNetworks has stated that although age is not the primary driver for replacement, it provides an indication of the increased risk of deterioration or failure.

4.2.3.2 Replacement Approach

TasNetworks has proposed the replacement of 4,000 insulator strings during the upcoming period to reduce the risk of insulator failure. This replacement this approach will remove all porcelain insulators from service.

The aim of this program is to ensure that replacements are not deferred until such time that defect and failure rates present an unacceptable risk to TasNetworks. To generate efficiency gains TasNetworks are planning to replace groups of insulators in areas where high defects are detected on the transmission circuit. This is the alternative approach to ad-hoc replacement which TasNetworks views as comparatively inefficient.

4.2.3.3 Financials and Program

Table 19 Transmission line insulator replacement program

	FY20	FY21	FY22	FY23	FY24
Proportion of total program [75]	0.07	0.11	0.10	0.07	0.08
Total ($m, FY17)	$1,218,000	$1,914,000	$1,740,000	$1,218,000	$1,392,000

4.2.3.4 Options Analysis

TasNetworks has identified four options as part of the IES:

- Option 0 No planned capital replacement
- Option 1 Maintain all conductors in conjunction with a targeted replacement program
- Option 2 Maintain all insulators in conjunction with a deferred targeted replacement program
- Option 3 Maintain all insulators in conjunction with the replacement of all insulators that have exceeded their economic life

TasNetworks has selected Option 1 as the preferred option as it will replace the insulators which have been identified as end of life. As all porcelain insulators will be removed and the associated operating costs necessary for insulator testing will be reduced.

[75] Includes FY25-29 data which has not been presented

4.2.3.5 NPV Analysis

TasNetworks has completed an economic analysis as part of the NPV analysis for this project. This has been based on capital costs, operating and maintenance costs, unserved energy costs and other benefits.

Table 20 Economic analysis outputs - Transmission line insulator replacement program ($m, FY17)

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2	Option 3
Project Cost	$0	$7,482,000	$0	$22,000,000
NPV	-$22,681,539	-$10,874,145	-$14,815,503	-$19,602,742

Arup observations

Table 21 NPV analysis assumptions

VCR	Risk and Consequence Assumptions	Other Assumptions
$39,430/MWh	Initial mechanical failure rate: 0.2 Failure rate trends: mechanical failure Failure rate trends: electrical test defects Unserved energy trends Population factor: 0.095 for mechanical failure Population factor: 1 for both electrical test and failure	Option 1: 2023/24 Benefit $200,000 Option 2: 2024/25 Additional cost $600,000

Based on the assumptions presented in Table 21, Arup has made the following observations:

- The VCR value of $39,430 per MWh is the aggregate VCR value excluding directly connected customers. However, as this is a general transmission repex program the weighted average VCR might instead be more appropriate, aggregating to a total of $21,400 per MWh.
- The NPV analysis appears to only evaluate the failures of porcelain conductors whereas the IES suggest it evaluates the entire population of insulators.
- The trend in mechanical failure rate has been assumed as exponential. Arup has not seen sufficient evidence to support this trend through historical data and failure rates of both porcelain and composite insulators.
- The IES states that there is a 4% failure rate for porcelain insulators from electrical test defects identified every 5 years. The NPV evaluation does not appear to provide a percentage assessment but rather the number of failures per 5-year period. This has

been evaluated at 0.04 when it appears that it should be 0.04 multiplied by the population of porcelain insulators. Arup has not been provided full access to the NPV sheets, but if this is the case then it would result in a underestimation of the operating and maintenance costs.

4.2.3.6 Arup findings and recommendations

Arup recommends that TasNetworks revisits their NPV analysis assumptions, in light of the observations above.

4.2.3.7 Key documents

- TN – 01281 Transmission Line Insulator Assembly Replacement Program NPV
- TN –Transmission Line Insulator Assembly Replacement Program 01281
- TN –Transmission Line Insulator Assemblies Asset Management Plan

4.3 Transmission protection and control

TasNetworks has described protection and control schemes as a grouping of relays to protect and control a specific electrical circuit. The protection relays are necessary to ensure that faults in the transmission network are detected and isolated. The aim of the protection schemes is to minimise damage to equipment, maintain stability of the system and reduce the risk of injury or death to the public by disconnecting live equipment.

TasNetworks' control relays provide automated commands to control equipment such as changing transformer tapping. The replay can also be used to interface with substation SCADA systems for operational metering and remote control of substation switchgear.

4.3.1 Forecast Expenditure

TasNetworks has proposed a relatively consistent spend on protection and control schemes over the forecast proposal period.

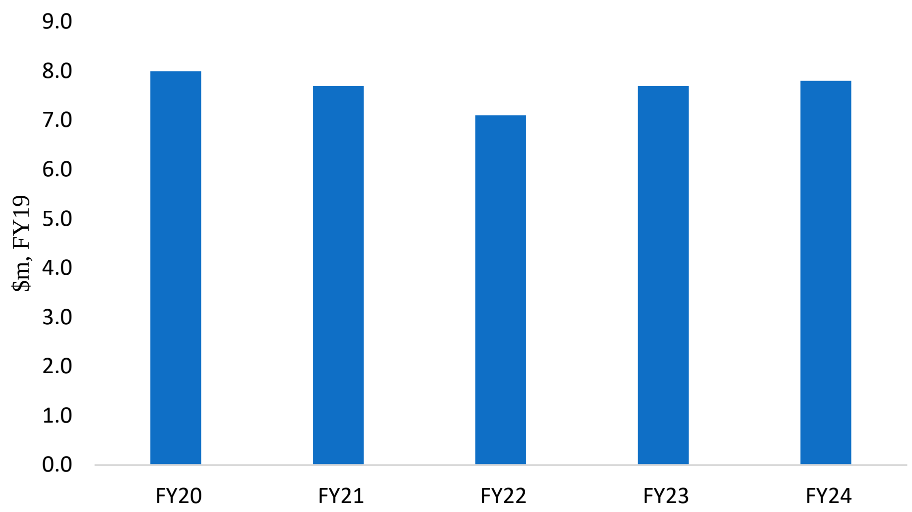


Figure 21 Proposed capex - Transmission protection and control

4.3.2 Transmission Line Protection Renewal Program

TasNetworks has outlined an internal policy that aims to install diverse protection relays to detect and isolate all types of electrical faults that occur on transmission lines. There are two types of relays that have been designated as “A” and “B” for 110kV and 220kV transmission lines. Protection schemes should be able to efficiently clear faults to minimise the secondary damage that can occur to assets, thereby maintaining the stability of the network.

Protection equipment has an undefined life from the manufacturer due to the constant emergence of new technology making older models obsolete. There is a period of time after purchase that manufacturers will provide support and repair, however over time their focus shifts to new technologies. According to TasNetworks, if a protection scheme fails it must be returned to service within the timeframe outlined in the AEMO Power System Security Guidelines.

4.3.2.1 Investment Driver

This program is compliance driven in regard to the need to maintain secure and reliable protection schemes in EHV substations. TasNetworks has identified that the current protection relay models are no longer supported by manufacturers.

TasNetworks determine the condition of transmission line equipment by assessing the failure rate for each specific model, availability of manufacturer support, spare parts as well as any design issues

TasNetworks are aiming to reduce the risk of increased operational costs and extended time to return assets to service. This program aims to minimise any rushed and poor-quality emergency installations to ensure reliability of the network.

4.3.2.2 Replacement Approach

TasNetworks are proposing the renewal of transmission line protection schemes. The investment will stretch over the next two regulatory periods.

TasNetworks will undertake schemes at the following locations:

Table 22 Transmission line protection schemes by location[76]

Location	Number of schemes
Burnie	3
Chapel Street	2
Devonport	2
Gordon	2
Port Latta	2
Palmerston	1
Sheffield	5
Smithton	2
Temco	2
Waddarmana	4
Wesley Vale	2

4.3.2.3 Financials and Program

Table 23 Financials and Program - Transmission line protection and control program

	FY20	FY21	FY22	FY23	FY24
Proportion of total program	0.2	0.2	0.2	0.2	0.2
Total ($, FY17)	$2,832,606	$2,832,606	$2,832,606	$2,832,606	$2,832,606

4.3.2.4 Options Analysis

TasNetworks has proposed three options for the protection renewal program:

- Option 0 Do nothing. No capital investment. Continue planned operational maintenance. Existing risk remains.

[76] TasNetworks 2017, *Transmission Line Protection Renewal Program 01248 pg 7*

- Option 1 Unplanned replacement of the identified transmission line protection schemes with modern equivalents.
- Option 2 Planned replacement of transmission line protection schemes to reduce maintenance costs and mitigate safety, reliability and compliance risk to acceptable levels.

TasNetworks has selected Option 2 as the preferred option as it ensures safety to the public and maintains the security and reliability of the network through proactive replacement.

4.3.2.1 NPV Analysis

TasNetworks has completed an economic analysis based on capital costs and operating and maintenance costs for this project.

Table 24 Economic analysis outputs - Transmission line protection renewal program ($m, FY17)

Economic Analysis	Option 0 – do nothing	Option 1	Option 2 - preferred
Project Cost	$0	$21,244,512	$14,163,008
NPV	$0	-$25,787,073	$21,577,681

Arup observations

The NPV analysis for the transmission line protection programs appears to be unique to the other transmission programs considered in the Arup review. There has been no clear analysis into the risks and consequences associated with the program and therefore the calculation of the cost of unserved energy has not been included. Further analysis of key assumptions in the NPV analysis is outlined below.

Table 25 NPV analysis assumptions

VCR	Risk and Consequence Assumptions	Other Assumptions
$39,430/MWh	No risk and consequence section in the sheet	Option 1: O&M costs are for the first 3 years only – assumed no costs going forward after replacement Option 2: O&M costs are for the 1st year only - assumption there is no costs going forward after replacement

Based on the assumptions presented in Table 21, Arup has made the following observations:

- The VCR value of $39,430 per MWh is the aggregate VCR value excluding directly connected customers. However, as this is a general transmission repex program the weighted average VCR might instead be more appropriate, aggregating to a total of

$21,400 per MWh. This value is included within the NPV analysis, however, appears to have not been taken forward though the analysis.

- An analysis of the risk and consequence associated with the program NPV does not appear to have been completed. Based on the other transmission programs reviewed, it would be would be expected the outputs of this analysis would have been the key inputs into the calculation the cost of unserved energy.
- In the case of both Option 1 and Option 2, operating and maintenance costs are assumed to occur prior to asset replacement only. Although it is fair to assume that operating and maintenance costs would reduce after asset replacement, the assumption that these costs are zero for the life of the asset may require further review by TasNetworks.

4.3.2.2 Arup findings and recommendations

Arup recommends that TasNetworks revisits their NPV analysis assumptions, in light of the observations above.

4.3.2.3 Key documents

- TN – Transmission Protection and Control Asset Management Plan
- TN – Transmission Line Protection Renewal Program 01248

4.4 Transmission substations

TasNetworks are continuing replacement programs of three asset groups as part of the transmission repex on substations. They are continuing projects that replace power transformers and EHV circuit breakers which is condition based. Replacement of HV switchgear is a safety initiative as the asset is non-arc flash contained.

4.4.1 Forecast Expenditure

TasNetworks has forecast an increasing spend on transmission substations, with expenditure reaching its highest in FY22 at $29.7m.

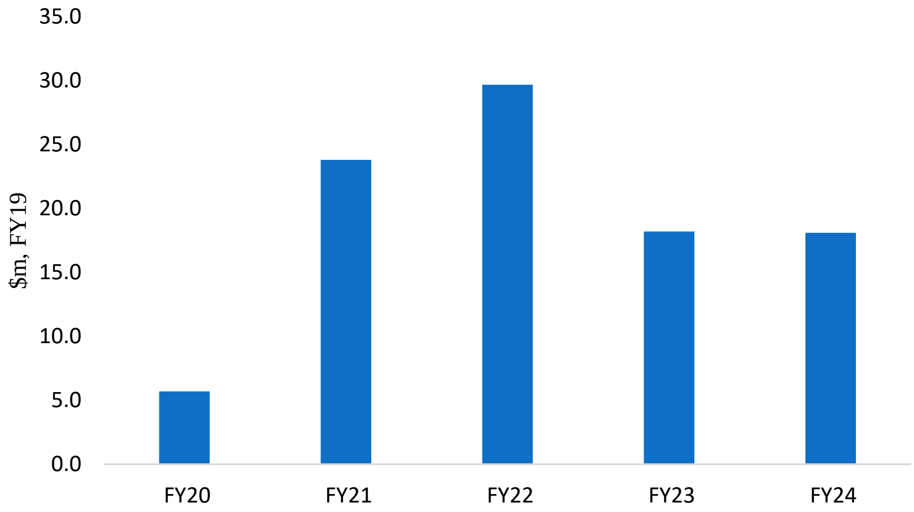


Figure 22 Proposed capex - Transmission substations

4.4.2 Chapel St 11kV HV Switchgear

High voltage switchgear performs a critical function for the reliable operation of the TasNetworks transmission system by providing the connection between substations and the distribution network. In some cases, this switchgear connects directly to the major industrial customers. The TasNetworks high voltage systems operate at 44, 33, 22, 11 and 6.6 kV, with the predominant operating voltages are 22 and 11 kV.

TasNetworks has proposed eight HV switchgear replacement programs. Arup's analysis has focused on the Chapel Street 11kV HV switchgear replacement, a key project in the proposed capex.

4.4.2.1 Investment Driver

TasNetworks has identified the need to replace HV switchgear due to safety risks to personnel and reliability of the customer supply.

TasNetworks has suggested that if the replacement of the switchgear does not take place in the forecast period, future failures could be of a more serious nature that results in high levels of unserved energy. Increasing the level of routine maintenance is apparently not an acceptable option for TasNetworks as this does not mitigate the inherent issues associated with this type of switchgear.

Based on the TasNetworks defects register, there have been a total of 15 defects recorded for HV switchgear at the Chapel Street Substation between 2003 and 2017.

4.4.2.2 Replacement Approach

TasNetworks approach is to replace the current 11kV switchgear with modern switchgear using a vacuum medium for arc interruption. According to TasNetworks this technology is more reliable and safe to operate, reducing the level of routine maintenance required. Additionally, the modern switchgear also provides arc fault containment, providing personnel safety as well as minimising any physical damage to site in the event of a circuit breaker failure.

4.4.2.3 Financials and Program

Table 26 Financials and Program - Chapel St 11kV switchgear program

	FY20	FY21	FY22	FY23	FY24
Proportion of total program	0	.13	.61	.26	0
Total ($m, FY17)	$0	$474,049	$2.224.383	$948,098	$0

4.4.2.4 Options Analysis

TasNetworks has developed three options in replacing the switchgear at Chapel Street:

- Option 0 Do nothing. No planned capital investment – continue current maintenance practices
- Option 1 New 11kV circuit breaker switchgear housed in existing switch room in the 2019-24 regulatory period
- Option 2 Defer new 11kV circuit breaker switchgear housed in existing switch room until the following 2019-24 regulatory period

Option 1 has been selected as the preferred option as it addresses all the condition, safety and design issues that TasNetworks wish to mitigate. As there will be an internal arc contaminant, the asset will be safe for operators and reduce opex.

4.4.2.5 NPV Analysis

TasNetworks has completed an economic analysis as part of the NPV analysis for this project. This has been based on capital costs, operating and maintenance costs and unserved energy costs.

Table 27 Economic analysis outputs - Chapel St 11kV Switchgear replacement ($m, FY17)[77]

Economic Analysis	Option 0	Option 1	Option 2
Project Cost	$0	$3,646,530	$3,646,530
NPV	$0	$777,930	$715,751

[77] TasNetworks 2017, *Chapel St 11kV HV Switchgear 01689*, pg 9

Arup observations

Table 28 NPV analysis assumptions

VCR	Unserved energy assumptions
$39,430/MWh	Failure rate for existing asset: 0.02 Failure rate for new asset: 0.002 Unserved energy calculation based on month of July One month to restore power, monthly peak applied each day Loss of both 11kV busses on failure Time to transfer load: At time of failure full station load is lost for 4 hours and 10MW picked up within each 4 hour period with full load within 24 hours.

Based on the assumptions presented in Table 28, Arup has made the following observations:

- The VCR value of $39,430 per MWh is the aggregate VCR value excluding directly connected customers. However, as this is a general transmission repex program the weighted average VCR might instead be more appropriate, aggregating to a total of $21,400 per MWh.
- The failure rate of the new switchgear has been assumed as 10% of the existing defect rate. This is due to warranty details that have not been clearly explained. The IES states the assumption that the new switchgear will have a failure rate of 0.5% which does not get used in the NPV analysis. This failure rate should be investigated and justified further as it is significant in the NPV evaluation.
- The unserved energy calculation has been based on July, which is the coldest month and has the highest energy use. This appears to be a very conservative assumption as failures occurring in other months would likely result in lower volumes of unserved energy.
- A portion of the unserved energy has been calculated as the load that is in excess of the load transfer capability for a month after a failure. It has been assumed that 1 hour of each day the load is at July's projected peak monthly demand. This appears to overestimate the volume of unserved energy it is calculated uses July as a reference – the highest energy use month – and peak monthly demand has been applied to each day of the month. This in addition to the assumption that it will take one month to restore power, whereas other HV switchgear replacement NPVs assume it will take 24 hours to restore power. It is noted that it may take a month or more to implement a permanent fix which is not the same as restoring power.
- It is unclear if the failure rate has been used correctly in the formula for unserved energy. There are historical *defect* rates provided in the NPV analysis that are not used in the formulas. Rather a 2% *failure* rate for the substation is used. Arup assumes this is due to having only historical data on defects and none on failures. Additionally, TasNetworks has used a constant failure rate for aging assets which does not seem realistic. It would be more appropriate to use an exponentially increasing failure rate after the asset reaches/approaches theoretical end of life. The issues with failure rates

of both aging and new assets should be addressed as it will have a material impact on the NPV results.

- The assumption that a there is a loss of both 11kV bus bars on failure does not appear to be justified. It is assumed that this is due to a coupler or catastrophic failure. Historical data and type of unit could be used to determine the extent of outage and the restoration times as they should differ depending on whether it is a feeder, transformer unit or bus coupler.

- The amount of unserved energy due to time taken to transfer load has not been calculated as per the stated assumption. It has calculated as though 10MW is picked up after 4 hours and then an additional 10MW at 12 hours from failure. The 4 hour and 10MW values have also not been justified and are major contributors to the unserved energy calculation for the Chapel St project. The other HV switchgear replacement project NPVs have assumed that the transfer capability amount will be picked up quickly and the NPVs have not accounted for contribution to unserved energy. Further clarity should be provided around these calculations as to why different techniques were used.

4.4.2.6 Arup findings and recommendations

Arup recommends that TasNetworks reconsider the assumptions within the NPV analysis as discussed above.

The options analysed in the NPV analysis do not differ other than timing. It is therefore recommended to determine the optimum time for replacement/commissioning instead of calculating the NPV for only two different timings.

4.4.2.7 Key documents

- TN-Chapel St 11kV replacement NPV
- TN-Chapel St 11kV HV switchgear 01689
- TN-High Voltage Switchgear Asset Management Plan

4.4.3 Other HV Switchgear NPV Analyses

TasNetworks has completed an economic analysis of each of the HV Switchgear projects as part of the NPV analyses for the projects. The NPV analyses have made similar assumptions to those outlined in Table 28 and subsequent observations. These projects include:

- Ulverstone 22kV HV Switchgear
- Knights Road 11kV HV Switchgear
- Railton 22kV HV Switchgear
- Sorell 22kV HV Switchgear
- Rosebery 44 kV Switchgear and Gantry Bus

The following table presents Arup's observations on assumptions seen consistently across other HV switchgear NPVs, noting crossover with several of our observations regarding the Chapel St project.

NPV Assumptions	Arup Observations
Failures are catastrophic (i.e. bus coupler failure)	The assumption that a there is a loss of both 11kV bus bars on failure does not appear to be justified. It is assumed that this is due to a coupler or catastrophic failure. Historical data and type of unit could be used to determine the extent of outage and the restoration times as they should differ depending on whether it is a feeder, transformer unit or bus coupler.
July used for calculation of unserved energy (i.e. failures occur in July only)	The unserved energy calculation has been based on July, which is the coldest month and has the highest energy use. This appears to be a very conservative assumption as failures occurring in other months would likely result in lower volumes of unserved energy.
24 hours to restore full load	This assumption appears more appropriate and should be considered for the Chapel St NPV analysis.
Peak monthly demand used for unserved energy calculation (i.e. peak demand occurs for the outage duration)	This does not appear a valid assumption as it is extremely unlikely that the peak monthly demand will be experienced each day and for 24 hours until full load is restored after failure.
Transfer capability is picked up quickly (i.e. instantly)	This is not consistent with the Chapel St NPV assumption and a justified approach should be presented.

4.4.3.1 Arup findings and recommendations

Arup recommends that TasNetworks reconsider the assumptions within the NPV analysis as discussed above.

The options analysed in the NPV analysis do not differ other than timing. It is therefore recommended to determine the optimum time for replacement/commissioning instead of calculating the NPV for only two different timings.

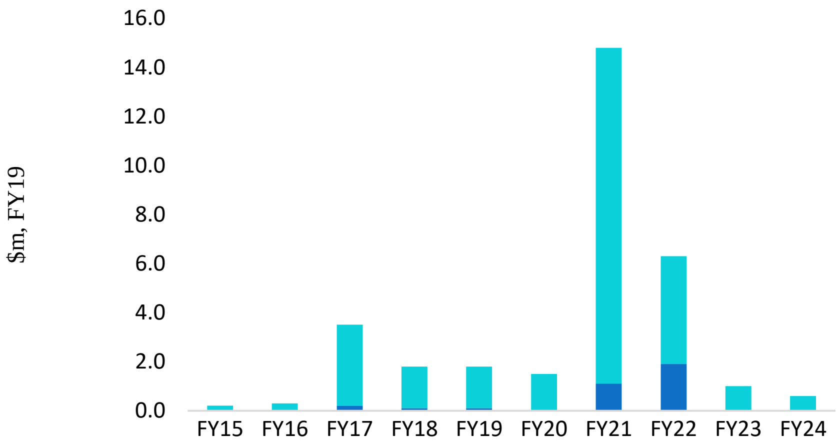
4.4.3.2 Key documents

- TN-Knights Rd 11kV replacement NPV
- TN-Knights Rd 11kV HV switchgear 01690
- TN-Ulverstone 22kV replacement NPV
- TN-Ulverstone 22kV HV switchgear 01691
- TN-Sorell 22kV replacement NPV
- TN-Sorell 22kV HV switchgear 01692
- TN-Railton 22kV replacement NPV

- TN-Railton 22kV HV switchgear 01693
- TN-Rosbery 44kV replacement NPV
- Tn-Rosbery substation 44kV switchgear and gantry bus replacement 01732
- TN-High Voltage Switchgear Asset Management Plan

5 Transmission development capex observations

Transmission development capex is comprised of augex and connection capital expenditure, and is forecast to increase in the upcoming regulatory control period.



	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Augmentation	0.2	0.3	3.3	1.7	1.7	1.5	13.7	4.4	1.0	0.6
Connection	0.0	0.0	0.2	0.1	0.1	0.0	1.1	1.9	0.0	0.0

Figure 23 TasNetworks' transmission development capex FY15-24

5.1 Static var compensator

The major project in development capex, contributing to the step changes in FY21 and FY22 in Table 23, is the proposed static var compensator at the George Town Substation.

TasNetworks state that the $15m augex project will be designed to:

> *"…support more stable and efficient operation of [TasNetworks'] transmission network with changing generation and interconnector flows, and allow dispatch of lower cost generation"*[78]

The project is the next stage on from a 40MVAr capacity bank commissioned in March 2018 at George Town that is the equivalent to an additional 20MW of Basslink export capacity.[79] The drivers behind these capital investments are:

- unprecedented levels of interest and investment in renewable resources applying to connect to the grid
- system security challenges
- existing challenges on wind and high voltage, direct current import
- regulatory drivers such as current non-compliance with system standards

[78] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 87
[79] TasNetworks, 2018, *George Town Reactive Compensation Project -Stage 2: Provision of dynamic reactive support*, presentation to Arup, slide 5

Given the size and scope of this project, the proposed static var compensator will be subject to a RIT-T[80]. It is Arup's view that there are four key considerations in assessing the prudency and efficiency of this project during the RIT-T process:

- is the appropriate technology being utilised?
- has the appropriate location been chosen?
- are consumers going to benefit from this project to the extent that they are being asked to pay for it, or are private operators benefiting disproportionately to their own investment (or lack thereof) in this project?
- will the project reflect an efficient process in competitive tendering?

TasNetworks is currently engaging with the AER and the CCP regarding this proposed project, and has advised the AER that the RIT-T project assessment will be well progressed at the time of the AER's decision.

[80] Regulatory Investment Test for Transmission

6 Distribution renewal capex observations

TasNetworks describe renewal capex as a combination of reliability and quality maintained driven programs as well as inventory and spares. Arup has assumed that reliability and quality maintained capex is equivalent to repex. TasNetworks has not proposed any spend on inventory in the forecast regulatory control period, therefore the following analysis focuses on repex only.

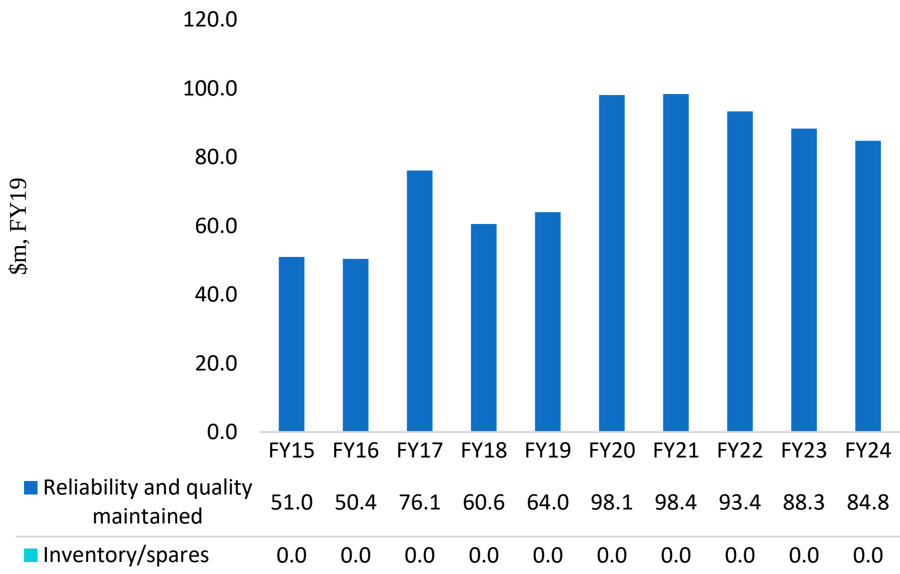


Figure 24 TasNetworks' distribution renewal capex FY15-24

TasNetworks has proposed a material increase in repex over the forecast period. Repex has increased from $302m in the current RCP to $463m in the forecast RCP. This increase in repex spend is attributed to TasNetworks' focus on reliability and safety risk mitigation, particularly bushfire risk.

The following analysis investigates the economic efficiency and prudency of a sample of repex programs within the following asset categories:

- 6.1 Underground Cables
- 6.2 Service Lines
- 6.3 Switchgear
- 6.4 Overhead Conductors
- 6.5 Poles
- 6.6 Transformers

Arup has used the AER's repex model in conjunction with guidance from the AER to determine which asset groups are the drive the increase in total repex spend in the TasNetworks proposal.

6.1 AER repex model[81]

The AER's repex model is a statistical tool used to conduct a top-down assessment of a distributor's replacement expenditure forecast. Discrete asset categories within six broader asset groups are analysed using the repex model. These six asset groups are poles, overhead conductors, underground cables, service lines, transformers and switchgear.

The repex model forecasts the volume of assets in each category that a distributor would expect to replace over a 20-year period. The model analyses the age of assets already in commission and the time at which, on average, these assets would be expected to be replaced, based on historical replacement practices. A total replacement expenditure forecast is derived by multiplying the forecast replacement volumes for each asset category by an indicative unit cost.

The repex model can be used to advise and inform the AER and its consultants where to target a more detailed bottom-up review, and define an alternate repex forecast if necessary. The model can also be used to benchmark a distributor against other distributors in the National Electricity Market.

6.2 Underground cables

The underground cable distribution network is primarily located in urban areas in Tasmania. It operates at three different voltages being 11kV, 22kV, and 33kV, as well as single phase 240V for service lines. There are a range of different types of cables installed, outlined in Table 29.

[81] As described by the AER in email to Arup dated 25/06/2018 @ 3.52pm

Table 29 Underground cables in the distribution network by type[82]

Cable type	Installation period	Installed length (km)
Paper insulated, oil draining	1920 - 1960	30
Paper insulated, Oil - filled Cable (Sub-transmission)	1964 - 1971	16
Paper insulated, mass impregnated non - draining (MIND)	1960 - 1992	505
Submarine cable	1949 - Current	30
XLPE insulated, PVC/HDPE sheathed	1992 - 2010	447
XLPE - TR insulated, PVC/HPDE sheathed	2007 - Current	216
Paper insulated, oil draining	Pre - 1960	15
Paper insulated, mass impregnated non - draining (MIND)	1960 - 1978	207
CONSAC	1971 - 1980	170
XLPE insulated, PVC sheathed (single to four core)	1978 - Current	883

The primary focus of the Arup analysis on underground cables is Concentric Neutral Solid Aluminium Conductor (CONSAC) cables, low voltage cables which were installed between 1971 and 1980. The replacement of these assets is the most material investment in underground cables in the next regulatory period.

6.2.1 Previous & Forecast Expenditure

Underground cable capex has significantly grown in the forecast period when compared to previous and current. Other than FY15 which had an abnormally high spend due to 19.21km of CONSAC replacement, the expenditure on underground cables per year has been less than half than what has been proposed for the forecast period.

[82] Underground System Asset Management Plan

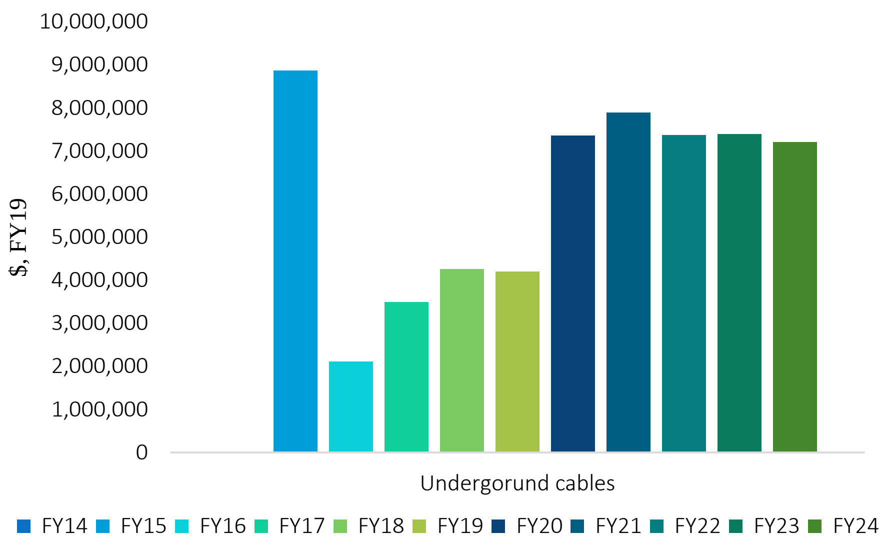


Figure 25 Previous and forecast capex - underground cables[83]

6.2.2 Replace of LV CONSAC cable with XLPE cable

A proactive replacement program was implemented by TasNetworks in 2008 after it was found that 70% of LV cable failures were driven by CONSAC cables, despite the cable only making up 17% of the underground cable population.

The program targets CONSAC cable replacement in areas where failures have been experienced in the past, as the failures appear to be clustered by geographical areas. TasNetworks has suggested that it is the local jointing practices, soil type and other environmental conditions are contributing to the failures.

The program is coordinated with other capital programs where there is a connection to CONSAC cable e.g. the replacement of ground mounted substations, LV switchgear and wide based streetlight poles. Where a substation replacement occurs, the CONSAC cable is replaced from the substation to the first turret or LV cabinet from the substation. Similarly, where a streetlight is being replaced, the associated CONSAC cable is replaced up to at least the first turret or cabinet.[84]

Table 30 The volumes of CONSAC cable replacement undertaken in the years 2013/14 to 2016/17[85]

	FY14	FY15	FY16	FY17
CONSAC Replacements (km)	3.36	19.21	7.31	3.98

[83] Previous and forecast RIN data
[84] TasNetworks 2017, *Underground System Asset Management Plan*
[85] TasNetworks 2018, *Response IR13 Capex*

6.2.2.1 Financials and Program

Table 31 Financials and Program – Replace LV CONSAC cable

	FY20	FY21	FY22	FY23	FY24
Volume (km)	15	15	15	15	15
Total ($)	$6,750,000	$6,750,000	$6,750,000	$6,750,000	$6,750,000

6.2.2.2 Investment driver

The main drivers behind the replacement of CONSAC cables risk reduction given a broken neutral has the potential to elevate the risk of electric shock within a customer's premises. TasNetworks has indicated the project aims to reduce the probability to failure from high to medium as per the TasNetworks' risk matrix.

There are two causes of an electric shock which may result from CONSAC cable failures: an open circuit caused by an unsealed aluminium sheath or a broken neutral. This investment driver is in line with the NEO, as it aims to improve the safety of the network.

TasNetworks expect the number of failures to increase over time as the assets continue to age, with TasNetworks describing the trend shown in Figure 26 as an exponential increase. The failure rate is expected to increase as stated below:

> "*TasNetworks economic evaluation of replacement options compared to a 'do nothing' option takes this into account and assumes a conservative incremental failure rate increase of 1.8% per annum over the remaining life of the assets*"[86]

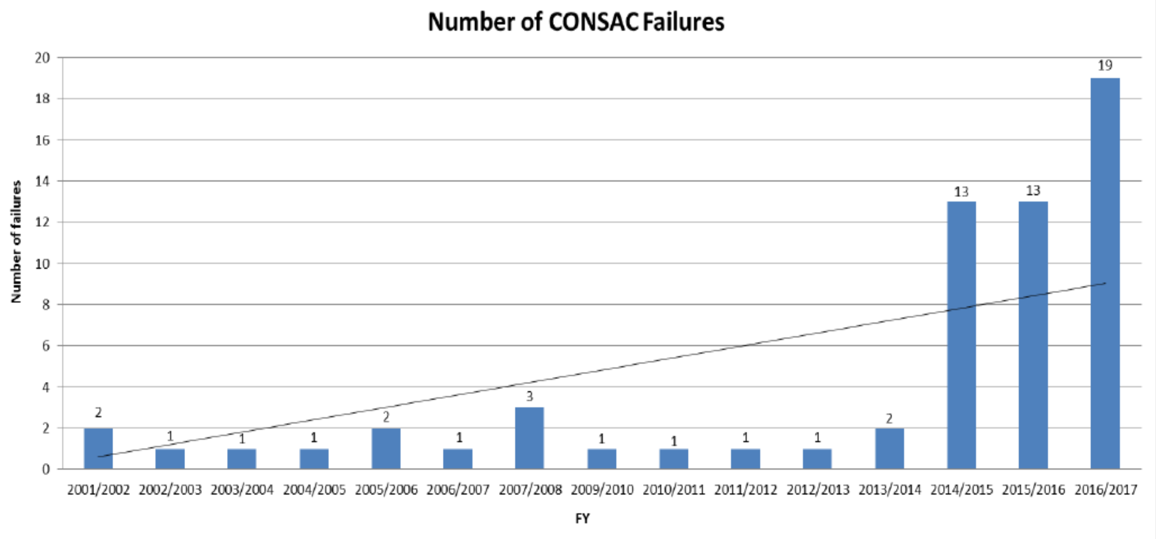


Figure 26 Trend in failure rates of CONSAC cables[87]

The failure rates for CONSAC cables as per the last four financial years is shown in the table below.

[86] TasNetworks 2018, *Response IR019 – Past and forecast capex review*
[87] TasNetworks 2018, *Response IR019 – Past and forecast capex review*

Table 32 Historical CONSAC cable failures by geographical location (11 bolded locations have planned replacements)[88]

Year	FY14	FY15	FY16	FY17
Blackmans Bay			1	5
Bridgewater			1	1
Burnie			1	
Davenport				1
Gagebrook				2
Georgetown		2		
Glenorchy		1		2
Granton			3	
Howrah			1	
Kingston		1		1
Kingston Beach			1	
Launceston	1			
Lindisfarne		1		
Lutana		1		
Moonah Springfield				1
Mt Nelson		1		1
North Hobart			1	
Parklands	1			
Ravenswood		1		
Rokeby		2		

[88] TasNetworks 2018, *Response IR13 Capex pg 5*

Rosetta			1	2
Sandy Bay		1		1
Smithton			1	
Sorell			1	
St Marys		1		
Ulverstone		1	1	1
Total failures	**2**	**13**	**13**	**18**

Arup Observation

There were three CONSAC failures in 2008 failures according to Figure 26. TasNetworks' assertion that CONSAC cables were responsible for 70% of LV cable failures in 2008 suggests there were four LV cable failures that year. However, this does not match the 27 failures in 2008-09 indicated in the Underground System Distribution Asset Management Plan. [89]

This discrepancy may cause a flow on error in determining the trend in failure rates which is used in calculating the benefit of replacement of cables. The increase in failure rate of cables has been based on the trend outlined above, predicting the failure rate to increase by 1.8% per km per year.

This linear increase in failure rate is higher than other DNSP's assessments:

- Endeavour Energy: 1 failure per 100km per year with a 10% cumulative increase per year after the asset is 40 years old
- Ausgrid: 2015 failure rate of 7.9 failures per 100km per year with a 11% cumulative increase per year. 7.9 failures per 100km per year was based on the average number of CONSAC related failures over 10 years[90]

6.2.3 Neutral Integrity (NI) Monitoring

The condition and safety of CONSAC cables is highly dependent on the integrity of the neutral conductor and NI monitoring that can identify CONSAC cables that are deteriorating or have failed. Different strategies exist for NI monitoring with differing levels of function and cost.

The NI monitoring strategy for TasNetworks LV distribution network currently utilises CablePI devices. The CablePI device plugs into the consumer's domestic power point, monitoring the impedance of the neutral and acts to alert the consumer of potentially hazardous situations before a shock occurs.

[89] TasNetworks 2017, *Underground System Asset Management Plan*
[90] Ausgrid 2015, *Revised Regulatory Proposal 2014 – Replacement and Duty of Care Program 2015*

The strategy relies on the consumer to ensure the device is plugged in, turned on, working and that they contact TasNetworks when alarm conditions are raised by the device's indicator lights.

TasNetworks has distributed CablePI to all households but has not keep a register of each individual device. Each Tariff 31 and 22 meter has been supplied with one, so approximately 210,000 devices with a further 30,000 delivered to businesses.

As of 2017, CablePI has detected 190 dangerous neutral faults on the LV network since being distributed in 2009. The success of the CablePI program relies on the consumer keeping the devices plugged in and turned on, on seeing the warning lights and calling TasNetworks if an amber or red light is seen. In 2009 the plug-in rate was 87% which dropped to 6% in 2011. A marketing campaign has been used to address the drop in plug-in rates. TasNetworks has indicated that a plug-in rate of at least 80% is required to effectively manage the risk of broken neutrals.

Power of Choice changes mean that new LV metering installations and equipment on the meter panel are to be installed, owned and maintained by the Customer as they enter the competitive market.[91]

The TasNetworks turret, pit or cabinet is generally positioned at the customer boundary and has the unbroken neutral continue through to the customers metering installation. Typically, two customer connections to a single phase are applied at a single turret.

Arup Observation

The NI monitoring by CablePI does not provide the same monitoring functionalities as the EDMI repurposed smart meters used by Endeavour Energy. The repurposed smart meter devices allow for remote monitoring and alarm systems that provide a higher level of oversight of risks directly to the network service provider.

Due to the extensive uptake of CablePI in the TasNetworks' network the benefit of additional NI monitoring through a separate device would be possible, but its additional effectiveness would likely only come when competition is significantly increased where existing meters are replaced by meters which have NI functionality, and the DNSP is allowed to monitor this output in real time (given meter data is controlled by the retailer and/or customer). Cable PI, or additional sensor installation at the home, would be more effective than if no NI monitoring was taking place.

Power of Choice changes to metering replacement means that going forward new meter installations are not all owned or maintained or monitored by TasNetworks and as new installations progress it will introduce obstacles for additional NI monitoring through enhanced metering functionality.

Monitoring the neutral through smart meter devices at the turret, pit or cabinet may not be possible due to installation space limitations. As the neutral is unbroken through to the customers metering installation it would require the neutral to be either broken or a reference point soldered to the neutral. Depending on the environmental housing this in itself may cause insulation, integrity or corrosion problems on its own.

[91] TasNetworks – Service and Installation Rules – November 2017

The benefit of additional NI monitoring is recommended to be quantified, compared against the current CablePI system with an increased cost of an upgraded awareness and marketing campaign for CablePI, to increase its application and usage by customers.

TasNetworks has not provided sufficient evidence for justification regarding their NI monitoring strategy with regards to the CONSAC cable replacement volumes proposed for Arup to be confident of the prudency and efficiency of the replacement strategy.

6.2.3.1 Replacement approach

Replacement is coordinated where the CONSAC is connected to other asset programs such as replacement of substations, LV switchgear or streetlight. In cases where TasNetworks is proposing a substation replacement, the CONSAC cable will be replaced from substation to the first turret or LV cabinet. When streetlights are being replaced, the connecting CONSAC cable has been proposed to be replaced up to the first turret or cabinet.

The TasNetworks strategy is to replace all 170km of CONSAC cables by 2029, at a rate of 15km per year. The following locations have been proposed as key locations for the replacement of CONAC cables:

Table 33 Proposed timing and location of CONSAC replacement

Year	Location of proposed CONSAC replacement
FY20	Blackmans Bay and Ulverstone
F21	Glenorchy, Granton and Rosetta
FY22	Bridgewater
FY23	Gagebrook, Georgetown and Kingston
FY24	Howrah, Mt Nelson, and Rokeby

These locations were selected by finding locations in the network that:

- have experienced previous CONSAC failure
- where defective installations have been identified
- where CONSAC cable is connected to assets that are scheduled for replacement

DNSP benchmarking

In 2015 Endeavour Energy undertook a strategy review of CONSAC cable replacement. Endeavour Energy are a DNSP in Sydney’s Greater West, Blue Mountains, Southern Highlands, Illawarra and the South Coast for a total of 2.4 million customers. Endeavour Energy has taken an alternative approach in their understanding of the safety risks associated with CONSAC cables. As shown in the figure below, shocks that have resulted from neutral faults are broken down based the number per year per 100km.

Network Neutral Faults	Length (km)	Shocks per 100km 2013-2014	Shocks per 100km 2014-2015
OH	8, 843	0.42	0.48
UG (NON-CONSAC)	7, 294	0.40	0.36
CONSAC	521	0.38	0.38

Figure 27 Endeavour Energy breakdown of reported shocks Vs type of network[92]

Endeavour Energy has suggested that the above data shows that shocks that are caused by a broken neutral on CONSAC cables are not as frequent as previously thought industry wide. Endeavour Energy has taken a quantitative approach to determining the safety risk of CONSAC cables per customer by defining a cost of fatality and determining the likelihood of an event.

TasNetworks has suggested that this is not an approach that it is willing to take. However, Endeavour Energy has used a value of statistical life than is provided by the Australian Government's Office of Best Practice for Regulation and is consistent with international best practice, highlighting that TasNetworks' peers are quantifying the cost of consequence from such high impact failures.

Endeavour Energy has provided evidence that the underground paper insulated neutral sheath cables, which are similar to CONSAC, are still in service in America after 80 to 90 years, and data suggested that there is evidence that the failure rate has not increased with older cables.

Endeavour Energy could estimate a failure model for CONSAC cables with a maximum life of 90 years if a constant failure rate of 1% with cumulative increase of 10% after 40 years was assumed. This alternative approach found that CONSAC cable replacement is not justifiable economically, and installing a neutral integrity meter yields a more efficient result.[93]

Ultimately, Endeavour Energy found that deferring replacement of CONSAC cables until faults are identified and ensuring that they are monitored is a reasonable approach to manage the risks of failure. In some cases, Endeavour Energy has also used alternative approaches to rectifying issues, rather than replacing the entire underground cable.

Endeavour Energy has proposed to monitor the Neutral Integrity (NI) by using a repurposed smart meter rebadged as a network device or sensor. The device is a EDMI Mk7C and is installed in series with the revenue meter on the network side of the customer meter. [94]

Although Endeavour Energy may be a network that is set up in a different manner to TasNetworks, it is clear from the evidence above that alternative approaches can be used to managing the risk associated with the potential failure of neutral sheath conductor on CONSAC cables.

In 2015 Essential Energy performed an options analysis on the replacement of CONSAC cables and looked at five options including:

- Do nothing – run to fail and repair

[92] Endeavour Energy 2015, *CONSAC replacement strategy review pg 2*
[93] As noted later in this report, TasNetworks itself has provided neutral integrity meters to all of its customers.
[94] Important Notice IN 019/17 – Neutral Integrity Monitor

- Planned replacement of all cable in one year
- Planned replacement over 5 years
- Planned replacement over 15 years
- Reactive replacement upon failure

Option 5 was selected as it was deemed the most cost-effective outcome, and Essential Energy deemed the systematic replacement of all CONSAC cables in the regulatory control period to be unnecessary based on the failures experienced.[95]

Arup Observation

TasNetworks is proposing a replacement volume of 15km per year which is approximately 9% of the total installed CONSAC cable. By comparison, Ausgrid has proposed to also replace 15km per year which is approximately 2% of the total installed CONSAC cable on their network. It is also not clear that TasNetworks has considered alternatives to the extent that Endeavour Energy explored the same issue.

In this respect, TasNetworks replacement approach appears conservative, particularly given the lack of apparent research into alternatives compared to their peers.

6.2.3.2 Options Analysis

The IES includes an assessment of four options to replace CONSAC cables. The four options comprise of:

- Option 0 Do nothing
- Option 1 Replace 6km of CONSAC cable
- Option 2 Replace 15km of CONSAC cable
- Option 3 Replace 24km of CONSAC cable

Option 2 has been selected as the preferred option, as it has the highest NPV. This is not the lowest cost option, however TasNetworks believe this option best reduces the risk associated with CONSAC cable failure.

Arup observations

The options analysis that has been conducted does not appear to be comprehensive or provide clear indication of a favourable option. This is apparent in the observations on the economic analysis. A number of areas that TasNetworks might want to explore in the options assessment are as follows:

- Option 0 has been used as a base case and is also identified as a reactive approach to CONSAC cable replacement in the secondary analysis. Based on the data provided it is not clear that the current proactive/reactive approach is covered in the options assessment. The total amount of installed cable remains at 167km. An additional option that includes the current approach that aligns with historical CONSAC cable replacement volumes outlined in TN – Response IR13- Capex would be desirable.

[95] Essential Energy distribution determination 2015-16 to 2018-19 – April 2015

- Options 1, 2 and 3 appear to only show the proactive CONSAC replacement volumes and not account for volumes replaced through reactive replacement (if any).
- The difference between proactive replacement volumes for Options 1, 2 and 3 are substantial and give a large range of time for complete replacement of CONSAC cables. It may be prudent to have an additional Option with a replacement timeframe of 15 years.
- An option for reactive replacement with the use of Neutral Integrity monitoring via CablePI or other monitoring means is not presented. The volume of replacement CONSAC cable could be dependent on the monitoring outcomes.
- Reactive replacement may be expected to reduce the failure rate of the cables, which does not appear to be the case.
- Cable failure that occurs at joints and pillar connections may be able to be rectified without replacement of the entire cable. This approach does not feature in the options list considered by TasNetworks. TasNetworks must be comfortable that this does not represent a viable and lower cost approach than the one they are taking.
- The options analysis does not quantify safety risks which are the primary driver for this program, making comparison between options challenging. Risks must be further quantified in order to have a robust understanding of current risk and what option to proceed with.

6.2.3.3 Economic Analysis

The economic analysis is based on the reduction in operating and maintenance costs as well as the unserved energy (USE) costs associated with each option.

Table 34 Economic analysis of each option

Economic Analysis	Option 0	Option 1	Option 2 (preferred)	Option 3
Project Cost	$0	$13,500,000	$33,750,000	$54,000,000
NPV	$0	$3,489,933	$3,517,000	$2,165,679

Arup observation

The CCP submission has suggested that the incorrect inputs may have been used as part of the calculation of unserved energy costs. The following method has been used by TasNetworks to determine this unserved energy cost:

- Unserved Energy (USE) costs = estimate of USE (MWh) x Value of Customer Reliability (VCR) [96]

CCP have suggested that value used for VCR is too high at $39,430, which was taken from the AEMO VCR Study. Based on the replacement of the CONSAC cables, the customer type

[96] CCP Sub-panel 13 2018, *Consumer Challenge Panel Sub-Panel 13*, pg 35

which should have been utilised in the NPV analysis is residential. As shown in the figure below, CCP have indicated the residential VCR of $28,580 in the AEMO Application Guide is more suitable and a sensitivity analysis on the VCR should be conducted.

APPENDIX A. VCR VALUES

Please note that New South Wales includes Australian Capital Territory.

Table 1 NEM-wide and state VCR values ($/kWh)

	NEM	New South Wales	Victoria	Queensland	South Australia	Tasmania
VCR excluding direct connect customers	39.00	38.35	39.5	39.71	38.09	39.43
VCR including direct connect customers	33.46	34.15	32.62	34.91	34.06	25.62

Table 2 Residential VCR values ($/kWh)

Location	NEM	New South Wales	Victoria	Queensland	South Australia	Tasmania
Residential VCR	25.95	26.53	24.76	25.42	26.88	28.58

Table 3 Business VCR values ($/kWh)

Sector[1]	Agriculture	Commercial	Industrial
Sector average	47.67	44.72	44.06
Small size[2]	54.87	57.13	69.66
Medium size	51.81	57.28	64.44
Large size	46.41	42.13	39.13

Figure 28 Extract from Appendix A of AEMOs 2014 VCR study (taken from the CCP submission)[97]

CCP found that when this revised VCR is input into the NPV model, the option with the highest NPV is in fact Option 1 to replace 6km of CONSAC cables per year. Arup has confirmed the findings of CCP in our analysis.

It is also of note that the NPV analysis has been evaluated over 20 years until 2037. Option 0 and 1 both have residual costs that have not been accounted for. For example, Option 1, would replace all CONSAC cables by 2045, leaving 59 km of CONSAC cable by 2037. Therefore, the it is not clear that the NPV analysis has been conducted over a sufficient number of years.

6.2.3.4 Arup findings and recommendations

TasNetworks has not appeared to adequately justify the prudency of the CONSAC cable replacement strategy. The options analysis does not provide a comprehensive set of options, and the NPV has key assumptions that appear questionable.

The Neutral Integrity monitoring has not been analysed in relation to informing the cable replacement strategy. Options for increasing CablePI plug-in rates to mitigate risks and incorporate into a more reactive cable replacement strategy have not been investigated.

Additional NI monitoring using smart meters at the residential premises or smart network devices has not been quantified, although it is noted that there are additional obstacles due to new metering arrangements from the Power of Choice changes.

[97] AEMO 2014, *Value of Customer Reliability final report appendix, pg 5*

Arup recommends that the options analysis and supporting economic analysis is revisited to provide a more thorough comparison to optimise the time-frame, strategy and volume of replacement. Based on the information provided Arup recommends that the following changes should be made to the options and NPV analysis:

- Options for a 15 year replacement timeframe and for a reactive cable replacement approach could be included in the NPV analysis.
- The options analysis could provide further sensitivity analyses on the VCR and risk costs and failure rate trends.
- The NPV evaluation could account for residual risks for CONSAC cable remaining in the network after the evaluation period.
- As targeting of areas based on geographical and NI monitoring could reduce the failure rate and therefore the risk cost due to safety and unserved energy, these factors could be considered when doing a sensitivity analysis on the failure rate trend.
- TasNetworks should be quantifying risk or the potential consequence of failure in order to justify this significant investment in CONSAC cables. This will ensure that that the cost of investment does not significantly outweigh the potential benefits.

6.2.3.5 Key Documents

- TN – Replace low voltage CONSAC cable 00671
- TN- Response IR13 - Capex
- TN Response IR13 – Replace LV CONSAC Cable NPV
- Underground System Distribution Asset Management Plan
- Consumer Challenge Panel Sub-Panel 13 Submission
- TN Response IR019 – TasNetworks Past and Present Capex Review
- TN Response IR019 – Replace LV CONSAC Cable Planned vs run to failure

6.3 Service lines

The Tasmanian distribution network has a population of 213,000 overhead low voltage (LV) service wires. TasNetworks is currently using ABC aluminium conductors as standard service lines, and the network is made up of the following types of service wires:

- 25mm LV ABC Aluminium conductor
- Open wire copper
- 10 and 16mm twisted pair copper
- Figure 8 copper
- PVC and twisted copper PVC

6.3.1 Previous & Forecast Expenditure

The proposed spend on service lines has increased to a spend of over $6m per year in the forecast period. The total historical spend on service lines from FY14 to FY18 is approximately equal the total proposed capex in one year in the forecast period. TasNetworks is placing a significant level of focus and investment on services lines over the coming years compared to recent investment.

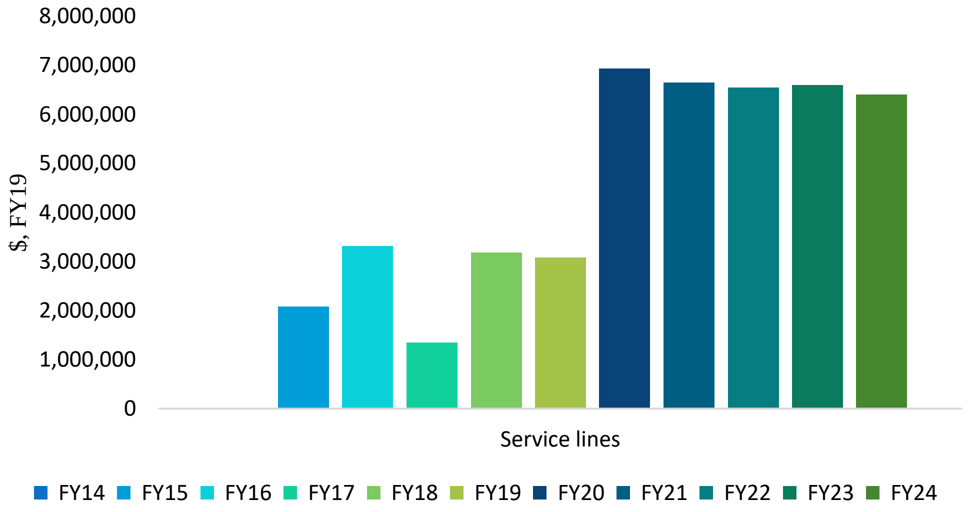


Figure 29 Previous and forecast capex - service lines[98]

6.3.2 Replacement of overhead LV services

The proposed scope of works is a continuation of a program to replace LV service wires. The previous program was based on a strategy to replace faults once service lines had already failed. This strategy was deemed as inadequate by TasNetworks to address the risks associated with overhead LV services.

6.3.2.1 Financials and Program

Table 35 Financials and Program – Replace overhead LV services

	FY20	FY21	FY22	FY23	FY24
Distance (km)	9,446	9,446	9,446	9,446	9,446
Total ($, FY17)	$4,625,000	$4,625,000	$4,625,000	$4,625,000	$4,625,000

6.3.2.2 Investment Driver

TasNetworks has proposed a significant spend in LV service line replacement to mitigate the safety and reliability risks associated with the asset. TasNetworks has suggested that services

98 Previous and forecast RIN data

lines are the primary driver of faults, which can result in flickering lights, loss of supply, electric shocks and possible fire starts.

Based on an audit completed in 2016, 56% of all LV service wire failures are caused by 10mm copper wires, suggesting that it is the predominant cause of failure and safety risk. The minimum age of 10mm wires is 40 years, with the last installation of the asset occurring in 1978. According to TasNetworks, the age of the asset in conjunction with poor condition is driving the need for investment and replacement. The following set of data provided by TasNetworks confirms that 10mm wires have been the primary driver of failure in the past three years, with the failure rate increasing over time.

Asset Class	2016						2017												2018				
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	Total
10mm	44	20	25	24	29	56	34	30	39	19	20	11	21	42	25	23	26	39	44	56	55	46	728
16mm		2	1	1	3	3		5	4	5		4	2	1	1	1	1	2	4	1	1		42
ABC	9	8	3	16	8	8	8	13	13	7	7	3	6	7	5	9	13	15	7	19	14	6	204
Open Wire	6	2	2	2	4	2	1	2	4	2	4	1	2	2	1	2	1	5	4	3	3	1	56
Unknown	32	12	9	13	9	10	8	5	12	9	8	4	8	8	2	6	9	10	9	11	15	16	225
Grand Total	**91**	**44**	**40**	**56**	**53**	**79**	**51**	**55**	**72**	**42**	**39**	**23**	**39**	**60**	**34**	**41**	**50**	**71**	**68**	**90**	**89**	**69**	**1256**

Figure 30 Failures of LV service lines by line type[99]

TasNetworks has outlined that there have been limitations in attributing a cause to conductor failures and determining the service line type. This is shown in Table 36 where the failure by asset class is unknown for a large proportion of failures. However, TasNetworks believe that 10mm lines are over-represented, and that this is a strong indicator for the need for proactive replacement. TasNetworks has suggested that the new SAP system will have the capability to determine the failure by type of service line. It is key to note that TasNetworks has limited information on LV service assets as it is not captured in the TasNetworks Spatial Data Warehouse. Based on a random audit of 1,000 sample service lines, 10mm copper wires are approximately 21% of installed services.

An additional driver of service line replacement is the potential electric shocks that can occur because of broken neutrals. Broken neutrals have the potential to result in electrocution and serious injury. Records of reported shocks that are caused by network owned LV service assets is displayed in the table below.

Table 36 Service line faults by incident type[100]

Year	2010	2011	2012	2013	2014	2015	2016
Age deterioration					2	2	2
Conductor broken						1	
Incorrect connection							1

[99] TasNetworks 2018, *IR019 – Past and Forecast Capex review pg 31*
[100] TasNetworks, *Service Replacements Spreadsheets*

Lightning						1	
No cause found					2	3	3
To be investigated					1		
Vandalism						1	
Wind					2	1	2
Unknown	4	13	25	15	11	13	12
Grand Total	**4**	**13**	**25**	**15**	**18**	**22**	**20**

TasNetworks has provided evidence that suggests that there are 3,220 service faults per year, which equates 9.5 per day. There are three reasons behind these faults: connection asset fault, customer installation fault and human interference. As shown in Figure 31 the connection asset itself is responsible for a small proportion of faults, with the customer installation the largest driver of the fault itself.

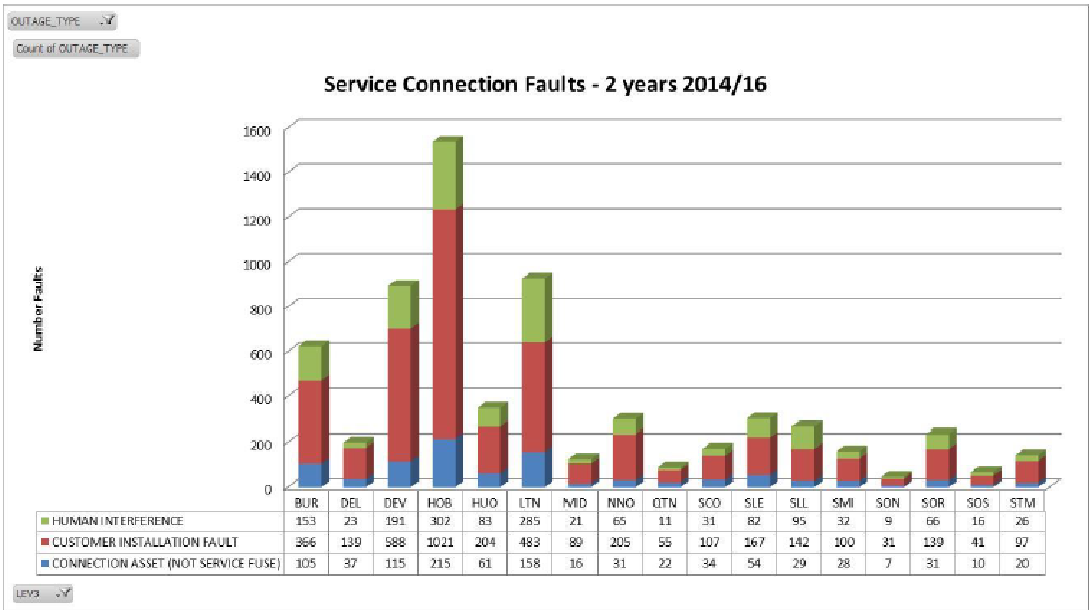


Figure 31 Service Connection faults (2014-2016)[101]

Arup observation

TasNetworks has suggested that it is confident that the major cause of shocks is poor asset condition rather than other factors such as weather or vandalism. However, the primary reason for faults is unknown. When TasNetworks were asked to provide further detail on this, the response was "With 10mm service conductors being over-represented in incidents this indicates that the service conductor condition is also a contributing factor". [102] This does not

[101] TasNetworks 2017,*Bradey's Lake Audit Report pg 3*
[102] TasNetworks 2018, *IR019 – Past and Forecast Capex review pg 33*

provide sufficient evidence or reasoning that 10mm are the primary driver of faults or shocks, or that it is in fact the result poor asset condition instead of external factors which cannot be mitigated. The need for more accurate asset and failure information as a necessity for increased sophistication in asset management is further reinforced by the fact that the cause of failure is determined by anecdotal evidence, rather than robust data.

6.3.2.3 Replacement Approach

TasNetworks is proposing a proactive replacement program that will remove all 10mm copper services from the network over the five years in the forecast period. The proactive program will replace the service lines once they have been identified as substandard or poor condition via inspection audits. Areas with the longest response times have been prioritised as part of the program's strategy to minimise the period of time customers in these areas are exposed to risks or interruption to supply.

These audits will identify the scope of the remedial works (project category AICOI) and revisits for reactivation and replacement works (project category SCRE). This strategy was trialled as part of the replacements undertaken in the area of Bradys Lake. This trial included 119 replacements that were planned after audits were undertaken and defective spans were identified. Based on the Connection Assets Asset Management Plan, Aluminium LV ABC has been the standard conductor type in TasNetworks since 2001. As TasNetworks has not specified as part of IES what the replacement asset for the 10mm copper wires will be, it is assumed that the Aluminium LV ABC wires will be utilised.

6.3.2.4 Options Analysis

As part of the replacement of overhead LV services, five options were considered by TasNetworks. The options are outlined below:

- Option 0 Do nothing.
- Option 1 Adhoc replacement of substandard services as they are reported through BAU and under fault.
- Option 2 Proactively replace substandard overhead services. Replace overhead services that have been identified as substandard/poor condition via audits (Program of Work AIOCI), including a 3-year proactive replacement of all 10mm copper services which have been identified as substandard and beyond end of life.
- Option 3 Execute a state-wide audit to identify defective services and equipment (Program of Work AIOCI). Proactively replace the identified substandard overhead services and equipment, including a 5-year proactive replacement of all 10mm copper services.
- Option 4 Execute a state-wide audit to identify defective services and equipment (Program of Work AIOCI). Proactively replace the identified substandard overhead services and equipment), including a 10-year proactive replacement of all 10mm copper services.

The option which has been selected to progress is Option 3. Although this does not have the highest NPV, TasNetworks has suggested that an improvement to public safety and increases to the security and reliability of the network can be achieved with this program at a lower cost than Option 2. TasNetworks has shown some evidence of economic efficiency in selecting Option 3, as it is the lowest cost option that provides an NPV which is relatively similar to the other proactive options.

6.3.2.5 Economic Analysis

A full IES and NPV has been completed for the overhead LV replacement program. The main inputs into the NPV were capital expenditure and operating and maintenance costs.

Table 37 Economic analysis outputs - Replace LV Service Lines ($, FY17)[103]

Economic Analysis	Option 0 – do nothing	Option 1	Option 2	Option 3 - preferred	Option 4
Project Cost	$0	$24,950,000	$41,388,000	$13,875,000	$31,719,000
NPV	$0	-$22,423,980	-$29,288,829	-$26,332,448	-$25,950,689

Of note, there is no sensitivity analysis conducted as part of the NPVs, despite there appearing to be scope for it in the calculation spreadsheets.

6.3.2.6 Arup findings and recommendations

Arup’s primary concern with the investment in this program is the insufficient evidence provided to validate that 10mm service lines are the driver of faults and failures, or pose a heightened risk to customers. It appears that TasNetworks does not have a high level of visibility into services lines in the network. Its spatial data warehouse does not store information on services lines, therefore TasNetworks does not know how many 10mm service lines are in the network and are relying on a sample of the network. This sample only looked at 1,000 service lines to determine that 21% of installed service lines are 10mm copper cables.

TasNetworks has suggested that the poor condition of service lines is the main driver of electric shocks in the network. However, based on the electric shock data provided the cause of failure is generally unknown. TasNetworks has not provided sufficient reasoning when questioned that shocks are caused by 10mm lines. There appears to be a need for increased sophistication for service line data to justify this significant investment. As TasNetworks is unable to determine which lines will fail based on condition, this program may be more akin to a proactive replacement as opposed to evidence based replacement.

TasNetworks has selected Option 3 as it is lower cost while providing a similar NPV to the other options. The NPV analysis does not appear to be as thorough as it could otherwise be given it only looks at the direct costs associated with the options. There doesn’t appear to have been consideration of the potential benefits associated with the program in the NPV, such as in avoiding unserved energy costs.

It may be an option to postpone investment until TasNetworks has increased data sophistication in terms of service line data on cable type, condition, ownership, age and

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[103] TasNetworks 2017, *Replace Overhead LV Services 00757 pg 9*

connection and fuse configurations. As TasNetworks intends to use the SAP system to store failure rates and causes, it could wait until it can undertake a more targeted approach. TasNetworks could also undertake a full cost benefit analysis for the program, providing a probabilistic approach to consequence that quantifies the benefits of investment. This will ensure that the cost of the investment does not outweigh the potential benefits.

6.3.2.7 Key Documents

- TN Replace Overhead LV Services 00787
- TN Response IR13 – Capex
- TN Response IR13 – R2A Safety Risk Review Report (LV Services)
- TN Response IR13 – Service Replacements Spreadsheet
- TN Response IR019 – TasNetworks Past and Present Capex Review
- TN Connection Assets Asset Management Plan
- TN Brady Lake Audit Report 2017

6.4 Switchgear

Assets categorised as switchgear control and regulate circuits in the distribution system include switches, fuses, reclosers and links. Arup has focused on the replacement of expulsion drop out fuses (EDOs) as part of the capex review as this is the primary driver of switchgear expenditure. Expulsion drop out fuses are the most commonly used and efficient to install high voltage fuses in the Tasmanian distribution network.

EDOs are made up of a porcelain insulator with a hinged fibre tube that is held in place by a fusible link. The asset is most commonly used to protect pole mounted transformers and spur lines. The secondary purposes of the asset include the protection of HV cable rises and to act as the in-line fusing in feeder trunks. EDOs are used to protect the network from fault currents so that when the fuse experiences a fault current, the fusible link melts, opening the circuit to isolate the equipment or section of the network it is protecting.

6.4.1 Previous & Forecast Expenditure

The proposed capital expenditure on switchgear is displaying a general upwards trend early in the forecast period when comparted to previous and current expenditure. The forecast spend appears to be front loaded, with a large proportion of investment in the first two years of the period.

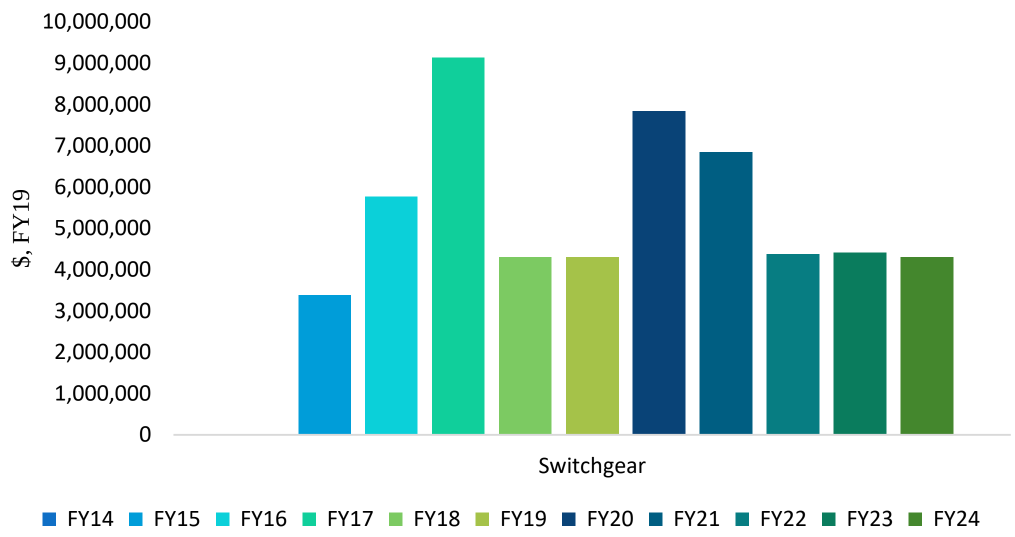


Figure 32 Previous and forecast capex - switchgear[104]

6.4.2 Replacement of EDOs with alternative device related to BFM

This program to replace EDOs is a continuation of an existing replacement program in the HBLCA. TasNetworks has suggested that this program will significantly reduce the risk of bushfire through elimination of burnt fuses falling to the ground, however, the function and otherwise safety of the network will remain un-altered.

6.4.2.1 Financials and Program

Table 38 Financials and Program – BFM replace EDOS with alternative device

	FY20	FY21	FY22	FY23	FY24
Volume	1,666	1,666	1,666	333	333
Total ($, FY17)	$5,000,0000	$5,000,0000	$5,000,0000	$1,000,000	$1,000,000

6.4.2.2 Investment Driver

According to TasNetworks, maloperation of EDO fuses is a safety risk to employees, customers and the general public. EDO fuse elements and tube failure have been the third highest cause of ground fire starts between 2012 and 2017 in TasNetworks, starting 8.6% of fires.[105]

There are two primary causes of failure. The first cause of failure is a result of overcurrent faults, where the fuse holder drops out to interrupt the supply of the current, resulting in hot particles being expelled from the tube. TasNetworks has suggested that depending on the situation these hot particles have the potential to fall to the ground and ignite a fire.

[104] Previous and forecast RIN data
[105] TasNetworks 2017, BFM - *Replace EDOs with alternative device 01518 pg 3*

The second is their ability to become stuck, TasNetworks labelling this as a "Hang Up". This is a direct result of exposure to the elements that can result in corrosion or moisture ingress into the fibreglass. According to TasNetworks this has the potential to start a fire at pole level if the fuse element melts from a fault current or overload so that the element sticks inside the tube, resulting in the fuse holder remaining hung up. TasNetworks see the risk associated with the potential for the fuse tube to ignite from electrical tracking as high.

This program is a part of the Bushfire Mitigation Plan and intends to reduce the bushfire risk in the HBLCA by removing the assets from the network. According to TasNetworks the risk of bushfire is high, as "2% of the 4,000 EDI operations since January 2014 caused, or had the potential to cause a pole top or grass fire"[106]. This program aims to reduce the risk of safety hazards - mechanical, electrical, bushfire ignition risk - and supply outage, ultimately avoiding the high costs associated with EDO emergency repair.

6.4.2.3 Replacement Approach

TasNetworks intends to replace all the EDOs within the HBLCA over the forecast period. Replacement in low risk sites outside the HBLCA is covered in another program under the IES 1729. TasNetworks are proposing to replace 6,666 EDOs within the HBLCA with fuse saving technology such as dropout reclosers or fuse devices such as boric acid fuses.

Fuse Saving Devices

Transient faults are a common fault on distribution networks. Fuse saving devices work by tripping before the fuse operates and then testing the line for the fault. If the fault remains after a number of checks the fuse or sectionaliser is allowed to operate isolating the fault. If the fault does not remain, indicating a transient fault, then fuse saver restores power. There are a number of fuse-saving technologies available:

- Dropout Sectionalisers: replace the dropout fuse with a sectionaliser which works with an upstream recloser to clear transient faults. This fits into a standard dropout mount and SCADA capability upstream
- Dropout reclosers: a combined dropout fuse and recloser with SCADA communication capability options. This fits into a standard dropout mount
- Fuse-saving circuit breaker: stand alone unit installed downstream of the fuse to test for transient faults with a SCADA communication option

Boric Acid Fuses

Boric Acid fuses are a type of expulsion fuse-link type fuse that are used extensively for medium voltage, SWER and high voltage applications where higher fault levels are present.[107]

At high temperatures, boric acid decomposes producing a blast of water vapour and inert boric anhydride. Electrical interruption is caused by the steam extinguishing the arc, as the arc is being elongated through the cylinder. After interruption, the gases are expelled from the bottom of the fuse. Boric acid type fuses are covered by AS 1033.1:1990 for the classification

[106] TasNetworks 2017, BFM - *Replace EDOs with alternative device 01518 pg4*
[107] Endeavour Energy 2017, *12kV and 24kV expulsion drop-out fuse pg 4*

the Spark Production as either Class A, B or C. Class A has the lowest fire risk with zero sparks during tests as defined in section 3.1.4 of the standard. [108]

Switchgear Asset Management Plan

In the Switchgear Asset Management Plan TasNetworks has suggested that it is reviewing the technology for the EDO replacement by trialling digital sectionalisers in fuse cut-out. This technology would be used for EDO spur fuses or series in line feeder locations to reduce the number of Boric Acid fuse operations.

TasNetworks has suggested that this "digital era technology" in the form of sectionalisers or reclosers by Network Planning review can be installed now. [109] Additionally, TasNetworks has provided detail on an evolving need for Smart Network, Distributed Generation/Distributed Energy Storage in the form of SCADA sensor connectivity that is more strategically located to existing EDO switch sites.

TasNetworks has planned trials for the assessment of new technologies in digital sectionalisers that can replace EDO fuselink, minimising the change out cost. It is important to note that these potential new technologies have not been mentioned in the IES as a alternative option that can reduce the cost of EDO replacement.

DNSP Benchmarking

TasNetworks has suggested that other NSPs are undertaking a similar strategy to EDO replacement in order to manage risks. AusNet Services is a similar Victorian DNSP in to TasNetworks in terms of size and the largely rural customer base. As Victoria is prone to high consequence bushfires, AusNet introduced a strategy to replace EDOs based upon their type and location in 2005. This strategy included replacing devices with failure rates exceeding 0.28% per year or replacing EDOs with signs of mounting bracket corrosion. In areas with high bushfire risk SP AusNet was only replacing units where the maximum fault current exceeds 1,800 amps.[110]

Ergon Energy is a retailer and DNSP in regional Queensland. It has proposed an EDO replacement program as part of the 2015 to 2020 regulatory period that aims to reduce bushfire risk. Ergon have stated that in high bushfire areas it is including firebreaks around poles, trialling fire retarding paint and replacement EDO and fuse carries to meet the Spark Production Class A requirements as part of AS1033.1.[111]

Endeavour Energy utilise EDO fuses across its HV distribution network up to 12kV and 8kA fault levels. Boric acid fuses are used for 24kV, 12kV when fault levels exceed 8kA and with low fault level and high soil resistivity locations generally with transformers up to 50kVA.[112] Endeavour Energy require EDO fuses to comply with AS 1033.1:1990. Specifically, they must be verified to spark production class A outlined in section 3.1.4 of the standard.[113] Interestingly Endeavour Energy use EDOs even though "Eighty-five percent of Endevour

[108] AS 1033.1:1990, *High Voltage Fuses (for rated voltages exceeding 1000V): Part 1: Expulsion Type*
[109] TasNetworks 2017, *Overhead Switchgear Distribution Asset Management Plan pg 18*
[110] SP Ausnet 2010, *Asset Management Plan pg 18*
[111] Ergon Energy 2017, *Summer Preparedness Plan 2017-18 pg16*
[112] Endeavour Energy 2016, *Equipment Technical Specification: Distribution Fuses*
[113] AS 1033.1:1990, *High Voltage Fuses (for rated voltages exceeding 1000V): Part 1: Expulsion Type*

Energy's franchise is in areas considered to be prone to bushfires by NSW Rural Fire Service."[114]

It is not known what TasNetworks technical specifications are for the EDO fuses that are intended for replacement, therefore information regarding the spark production class and distribution within the TasNetworks has not been analysed.

AusNet, Ergon Energy and Endeavour Energy appear to have a detailed plan that targets specific EDOs in high risk areas or attempts to mitigate bushfire risk using a range of approaches. TasNetworks do not appear to be using such a combined method to mitigate the bushfire risk that EDOs pose by planning to replace all EDOs regardless of their location and operation within the HBLCA. This suggests TasNetworks' options identification and analysis is insufficient to identify the least cost option to mitigate the risks identified.

6.4.2.4 Options Analysis

Three options were compared as part of the BFM program. The options are outlined below:

- Option 0 Do nothing. Continue using conventional EDO fuses
- Option 1 Replace all HV EDO fuses in the HBLCA with boric acid fuses or dropout reclosers
- Option 2 Replace all HV EDO fuses in the HBLCA with alternate fault reducing device

The option which has been selected from the IES is Option 1 as it reduces the risk of severe bushfires within the HBLCA and reduces the ongoing replacement and repair costs associated with fuse repairs.

Arup observation

The option which has been selected as preferable has the lowest NPV. The main reason that this option was selected is its potential to reduce bushfire risk. As the consequence of this risk has not been quantified, we cannot be confident that the option representing the best outcome from an economic point of view has been chosen.

There does not appear to be an option that provides any analysis into the new technology that TasNetworks is currently trialling. As TasNetworks has mentioned some of this technology has progressed beyond trials and can be installed into the network, an option considering the new technologies might have been included for consideration.

6.4.2.5 Economic Analysis

A full NPV and IES has been completed as part of the economic analysis for the EDO replacement program. The economic analysis is based on the differentials between capital expenditure as well as operating and maintenance costs. The importance TasNetworks places on this analysis is not clear in the program, as the economically efficient option was not selected.

[114] Endeavour Energy Website 2018, *www.endeavourenergy.com.au: Bushfire Safety*

Table 39 Economic analysis outputs - BFM EDO Replacement Program ($, FY17)[115]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$17,000,000	$16,148,575
NPV	-$3,132,440	-$18,799,844	-$17,933,768

TasNetworks has completed a sensitivity analysis as part of the NPV. Sensitivity on the operating and maintenance costs as well as capital costs has been applied, however the same option remains preferable. The main differences from the sensitivities is the scale of the NPV.

Arup observation

The IES states that the preferred option is to "Replace all HV EDO fuses in the HBLCA with boric acid fuses or dropout reclosers", however the NPV has described the option as "Replace with Boric Acid HV fuses in HBLCA". The economic analysis includes capital and operating costs associated with Boric Acid HV fuses only, with no mention of dropout reclosers. As TasNetworks has not provided a strategy that defines the suitability of each device it is unclear whether TasNetworks is intending to use both of the devices at each location.

An additional issue with this program is the fact that the increased functionality, monitoring, risk reduction and operational cost savings from fuse saving devices has not been quantified.

6.4.2.6 Arup findings and recommendations

This investment is a response to TasNetworks perception of the bushfire risks the network poses. The replacement of EDOs has been adopted by other DNSPs as a bushfire risk mitigation strategy. DNSPs such as AusNet Services has used a targeted approach to replacement, based on the location and circumstance. In contrast TasNetworks is proposing to replace all assets.

It appears that TasNetworks wish to undertake a proactive replacement program to minimise risk despite the outcomes of the economic analysis. Essentially, it has not chosen the option with the lowest NPV in order to minimise the risk of bushfires. The risk or consequence associated with bushfire risk has not been quantified. Therefore, using a subjective qualitative level of risk associated with EDO failure and the associated bushfire risk appears insufficient to justify this investment as prudent and efficient.

The NPVs undertaken by TasNetworks could provide more detail on the options analysed. TasNetworks needs to provide a clear strategy that highlights the particular circumstances that will dictate whether to use Boric Acid HV fuses versus dropout reclosers. Arup recommends that TasNetworks undertake an NPV that explores the two devices to replace the current EDOs.

Mitigating bushfire risk should be priority for TasNetworks and so should the provision of a sophisticated network that is economically efficient. However, TasNetworks should be mitigating bushfire risk in a reasonable way. Based on the documents provided, TasNetworks could either investigate a strategy that uses a targeted approach to replace high risk EDOs until advanced technology is ready to install, or quantify risk in order to justify the

[115] TasNetworks 2017, BFM - *Replace EDOs with alternative device 01518 pg 9*

investment to replace assets. This approach would align with the technological approach that TasNetworks has mentioned it wishes to take and meets the requirements of the NEO.

6.4.2.7 Key Documents

- TN Overhead Switchgear Distribution Asset Management Plan
- BFM Replace EDOs with alternative device 01518
- TN Response IR10 – BFM EDO Replacement Program NPV
- TN Response IR019 – TasNetworks Past and Forecast Capex Review

6.5 Overhead conductors

Overhead conductors are assets in the distribution network that provide a mechanism for electricity to be transported over medium to long distances. Bare open wire type conductors are the most common conductor used in the Tasmanian network as they are noted to be the simplest and most efficient conductor to install. TasNetworks is currently using the following standard conductors for new installations in the network:

- All Aluminium Conductor 19/3.25 AAC (Neptune)
- All Aluminium Conductor 7/4.50 AAC (Mercury)
- All Aluminium Alloy Conductor 7/3.00 AAAC (Fluorine)
- Steel Conductor 3/2.75 SC/GZ

Galvanised iron (GI) [116] make up the largest proportion of conductors in the network as shown in the table below. When comparing the population of each conductor with the corresponding number of failures, copper conductors are the worst performing and AAC the best. Historically, aluminium conductors have a high failure rate, with AAC responsible for 24% of conductor failure between 2006 and 2014.

Table 40 Conductor population and failure rates[117]

Conductor type	Percentage of population	Proportion of failures (2006 to 2014)
AAC	35%	24%
AAAC	16%	18%
ABC	0.10%	-
ACSR	5%	7%
Cu	8%	17%
GI	36%	35%

[116] TasNetworks interchange the terms galvanised iron(GI) and steel to describe the same conductor type
[117] TasNetworks 2015, *Overhead Conductor Replacement Programs Prioritisation Guideline pg 28*

TasNetworks has used a condition based assessment that uses the asset age in conjunction with the risk based approach cited in SAA AS7000-2016 to determine the failure risk of conductors. As a result, TasNetworks has identified the need to undertake the following conductor replacement programs as part of business as usual replacement and bushfire risk mitigation:

- Copper overhead conductor – multi-strand conductor
- GI overhead conductor – single strand (No.8 GI) and multi-strand (3/12 GI)
- Aluminium conductor- steel reinforced (ASCR/GZ) and multi-strand with a strengthening galvanised steel core
- Low clearance LV conductors
- Replace/relocate bare open wire HV

DNSP Assessment

Arup conducted a broad assessment of overhead conductors used by other DNSPs. Our findings indicate that the following bare overhead conductors are currently used for new and replacement installations for 415V-132kV network voltages:

- All Aluminium Conductor (AAC, specifically 1350)
- All aluminium alloy conductor (AAAC, specifically 1120)
- Aluminium conductor steel reinforced (ACSR/GZ)

Other DNSPs also require that all bare overhead conductors shall be greased.[118]

Ausgrid's network standard outlines the commonly used overhead conductors on their network as AAC and ACSR/GZ.[119]

Energex utilise AAC and ACSR conductors. Energex states that ACSR is stronger, has less conductivity and is more prone to corrosion than AAC. It uses ACSR where large stringing tensions are required and light electrical loads are present, such as rural areas.[120]

Energex state that hard drawn copper and galvanised steel (GI) conductors are obsolete and would normally only be specified for sleeving of short sections onto existing mains.[121]

6.5.1 Previous & Forecast Expenditure

The proposed capital expenditure on conductors has increased since the previous determination periods. From FY14 to FY19 the spend on conductors was relatively consistent with low growth. The forecast proposal period has seen the total spend on overhead conductors more than double, highlighting a significant increase in investment in the asset.

[118] Ausgrid/ Endeavour Energy/ Essential Energy 2014, *Bare Overhead Conductors: Technical Specification*
[119] Ausgrid 2015, *NS125 Construction of Low Voltage Overhead Mains pg 9*
[120] Energex 2015, *Overhead Design Manual*
[121] Energex 2015, *Overhead Design Manual*

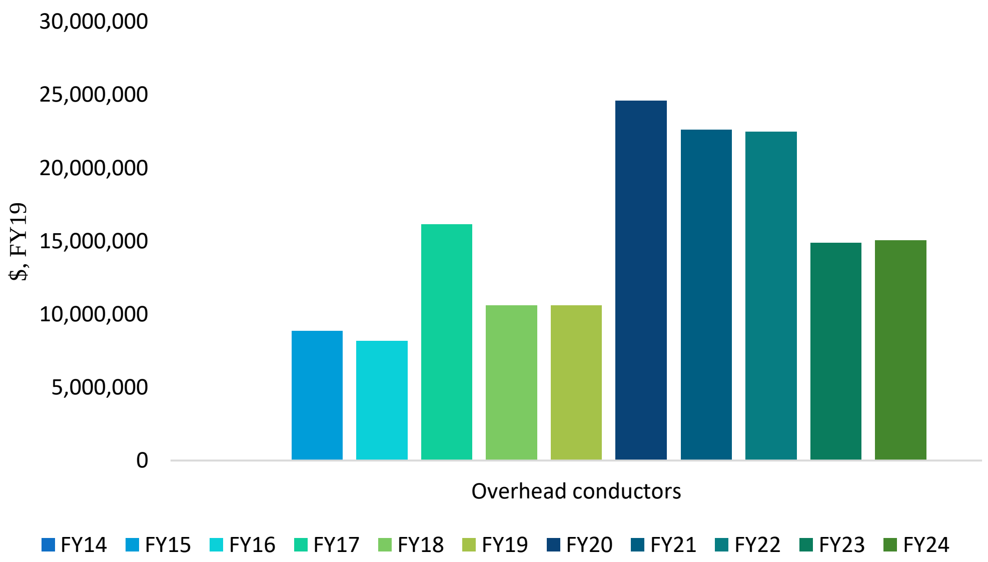


Figure 33 Previous and forecast capex - overhead conductors[122]

6.5.2 Replacement of Substandard Overhead Copper Conductor (REMCU)

This replacement program is a continuation of the current REMCU program. In 2013 a total of 24km of copper conductors were replaced, followed by 65km in 2014. The program runs in parallel with the BFM copper conductor program, replacing conductors outside the HBLCA once they are identified as condemned.

Copper conductors make up 8% of the total installed overhead conductor population. The following graph outlines the age profile of copper conductors, highlighting the proportion that are high bushfire risk areas.

[122] Previous and forecast RIN data

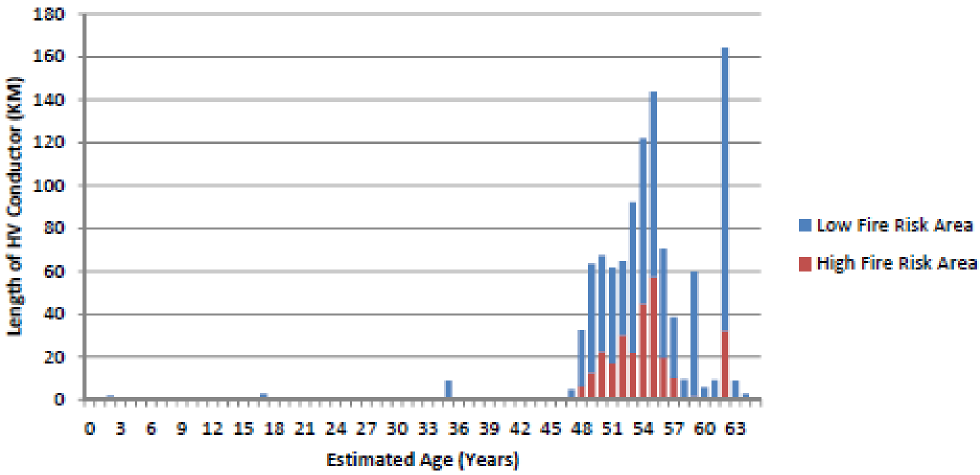


Figure 34 Copper HV Conductor Estimated Age Profile[123]

6.5.2.1 Financials and Program

Table 41 Financials and Program – Replace substandard overhead copper conductor

	FY20	FY21	FY22	FY23	FY24
Distance (km)	33	33	33	33	33
Total Cost ($, FY17)	$1,704,648	$1,704,648	$1,704,648	$1,704,648	$1,704,648

6.5.2.2 Investment driver

Based on TasNetworks data, the highest proportion of conductor failures in the network are the result of copper conductor failure, with the trend increasing. This mechanical failure has the potential to reduce reliability, resulting in bushfire and safety risks. A preliminary assessment completed in 2010 has highlighted the potential need to replace approximately 35% of poor condition assets.

The main risks from copper conductor failures are:

- Damage to assets
- Electric shocks/electrocution
- Fire starts

Copper conductors are subject to annealing that reduces tensile strength, as well as scale which reduces conductor diameter. In addition, copper conductors appear particularly susceptible to corrosion in marine environments, as 22% of failures have occurred less than 5km from the coastline since 2015.

[123] TasNetworks 2017, *Conductors and Hardware - Distribution Asset Management Plan pg 26*

Based on the Conductor Priority Tool the condition of more than 60% of conductors is unknown[124]. TasNetworks has justified this investment by providing the outputs of a study completed by the University of Tasmania (UTas). According to TasNetworks "this assessment informed which conductors were in poor condition and required replacement" and has been the driver of investment.[125] There appears to be a significant increase in the number of faults in copper conductors, particularly between 2015 and 2017. Therefore, TasNetworks has proposed two separate programs that will target at risk copper conductor that are either BFM or non BFM related.

Table 42 Number of Copper Conductor Failures by year[126]

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of failures	5	7	7	8	4	5	1	11	13	89	47	78

6.5.2.3 Replacement approach

The current strategy is to replace them with Aluminium 19/3.25AAC conductors, however TasNetworks has suggested that new technologies are also being investigated. There does not seem to be a detailed justification that outline the reasons that TasNetworks has chosen to install AAC conductors over other types such as AAAC or ACSR in the NPV analysis.

TasNetworks have stated that the aluminium alloy 7/3.00 AAAC conductor "allows for longer spans which make it suitable as replacement for the single strand GI conductor and smaller size copper conductor"[127].

The calculated breaking loads for AAC and AAAC conductors are shown below for the same size wires:

Table 43 AAC and AAAC calculated breaking loads[128]

	7/3.00 AAAC (Fluorine)	19/3.25 AAAC (Krypton)	19/3.25 AAC (Neptune)	7/3.00 AAC (Libra)
Calculated Breaking Load (kN)	11.8	37.4	24.7	7.98

The added complexity in AAC conductor installation such as damper inclusion has not been clearly shown in the NPV analysis. Therefore, it is unclear if TasNetworks has considered these additional costs in their estimations.

[124] TasNetworks 2018, *Conductor Priority Tool (Static Extract 13Apr2018)*
[125] TasNetworks 2018, *IR019- Past and Forecast capex review pg 37*
[126] TasNetworks 2017, *BFM Replace Aged Deteriorated Cu Conductor 01509 pg 7*, TasNetworks 2018, *Response IR10 – Capex pg 6*
[127] TasNetworks 2015, *Overhead Conductor Replacement Programs Prioritisation pg 12*
[128] Olex 2012, *Aerial: Bare Overhead Conductors*

6.5.2.4 Options Analysis

The IES provides an assessment of three options to substandard copper conductors. The three options comprise of:

- Option 0 Do nothing
- Option 1 Review and replace defective substandard copper conductor based on condition
- Option 2 Replace copper conductors after 50 years

Option 1 has been selected as the recommended option as it reduces the risk of conductor failure, maintains network reliability and maximised the lifespan of the asset. This option ensures that TasNetworks can maintain the low level of risk they have stipulated in the risk management framework.

Arup observation

The options analysed by TasNetworks appear limited. Arup cannot be confident that option 1 represents the best approach, considering it is only compared to do nothing, or replace in 50 years. Other options, with other technologies or other timeframes are necessary for consideration before TasNetworks can be sure that option one represents a prudent and efficient program.

6.5.2.5 Economic Analysis

The costs and NPV for the selected option are shown in the table below. The economic analysis has been based on the differences in the operating and maintenance costs between the options. Although it does not have the highest NPV, option one was selected instead of the do nothing as it addresses the risks that TasNetworks wish to mitigate. A sensitivity analysis has not been included as part of the economic analysis for this program.

Table 44 Economic analysis outputs – REMCU ($, FY17)[129]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$8,523,240	$30,580,380
NPV	-$1,242,502	-$14,755,355	-$44,271,809

6.5.2.6 Arup findings and recommendations

Based on the data provided there appears to be a lack of sophistication in the options and economic analysis associated with this program. Reassessing the NPV calculations in light of the above observations would result in a more robust analysis.

[129] TasNetworks 2017, *Replace Substandard Overhead Copper Conductor (REMCU) IES pg 7*

6.5.2.7 Key Documents

- TN – Replacement Substandard Overhead Copper Conductor (REMCU) 00591
- Guideline – Overhead Conductor Replacement Programs Prioritisation
- TN Conductors and Hardware – Distribution Asset Management Plan
- TN Response IR10 – Capex
- TN Response IR10 – Conductor Priority Tool (Static Extract 13Apr2018)
- Ausgrid - NS125 Construction of Low Voltage Overhead Mains
- Energex - Overhead Design Manual 2015

6.5.3 Replacement of aged/deteriorated Cu conductor related to BFM

The Bushfire Mitigation Plan has identified the need to replace aged or deteriorated conductors that have the potential to cause fire starts. This program is a continuation of an existing project to replace copper conductors which commenced in FY18 as part of the Bushfire Risk Mitigation Strategy.

6.5.3.1 Financials and Program

Table 45 Financials and Program – Replace ages/deteriorated copper conductor

	FY20	FY21	FY22	FY23	FY24
Distance (km)	48	48	48	19.2	19.2
Total ($, FY17)	$3,360,000	$3,360,000	$3,360,000	$1,346,003	$1,346,003

6.5.3.2 Investment driver

When aged and deteriorated copper conductors are subject to fault currents, they are rapidly heated which can result in annealing. Consistent exposure over time can result in broken wires that have the potential to cause bushfires. Of the total conductor population 17% are within the HBLCA. Based on TasNetworks' data, 13% of fires between 2012 and 2017 have been caused by conductor failure. No data has been provided on the extent of the damage from the fires started from the conductors, or whether they started in low or high bushfire risk areas.

6.5.3.3 Replacement approach

TasNetworks' current strategy is to replace copper conductors with Aluminium 19/3.25AAC conductors, however new technologies are under the process of investigation. There does not seem to be a detailed justification that outlines the reasons that TasNetworks has chosen to install AAC conductors over other types such as AAAC or ACSR in the NPV analysis.

TasNetworks has stated that the aluminium alloy 7/3.00 AAAC conductor "allows for longer spans which make it suitable as replacement for the single strand GI conductor and smaller size copper conductor."[130]

The added complexity in AAC conductor installation such as damper inclusion has not been clearly shown in the NPV analysis. Therefore, it is unclear if TasNetworks has considered these additional costs in their estimations.

6.5.3.4 Options Analysis

The IES includes an assessment of three options to replace the aged and deteriorated copper conductors. The three options comprise of:

- Option 0 Do nothing
- Option 1 Review and replace HV copper conductor based and risk of fire start
- Option 2 Replace HV copper conductors after 50 years

Option 1 has been selected as the recommended option by TasNetworks to ensure that risk remains low in accordance with the risk management framework. This is also the option with the highest NPV.

Arup observation

The IES and options analysis should aim to achieve economic efficiency through the exploration of different technologies and varied rates of installation. The options analysis does not show this level of complexity as there does not appear to be a detailed consideration of different methods and rates of replacement.

6.5.3.5 Economic Analysis

The costs and NPV associated with the preferred option are outlined in the table below. As the NPV analysis was not provided to Arup, the drivers of the model are unknown.

Table 46 Economic analysis- BFM replace aged/deteriorated conductor ($, FY17)[131]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$12,772,000	$30,580,380
NPV	$0	-$16,327,319	-$48,887,709

6.5.3.6 Arup findings and recommendations

This program displays a proactive replacement approach of copper conductors that focuses on reducing the risk of bushfires in the HBLCA rather than purely economic efficiency. The options analysis does not appear to be thorough in its analysis of various options and technologies that differ in scale, costs and benefits. This program shows the importance of

[130] TasNetworks 2015, *Overhead Conductor Replacement Programs Prioritisation pg 12*
[131] TasNetworks 2017, *BFM Replace Aged/Deteriorated Copper Conductor pg 8*

quantifying the consequence of bushfires, as the qualitative analysis appears to be insufficient in robustly comparing the options.

The do-nothing option does not act as a complete base case as there are no costs or benefits associated with it. Although there are no planned replacements in the do nothing there should be considerations of the costs associated with failure and replacement.

There appears to be a lack of justification or evidence for this level of investment. The condition of most assets is unknown based on the conductor priority tool, suggesting that TasNetworks do not have sufficient visibility into the network to justify the investment. This investment is reliant on a number of assumptions on the condition of assets and the imminent need for replacement. This is demonstrated in the fact that TasNetworks has stated in the IES that program expenditure has been difficult to predict as conductor deterioration is not always detectable.

6.5.3.7 Key Documents

- TN – BFM Replace Aged Deteriorated Cu Conductor 01509
- Guideline – Overhead Conductor Replacement Programs Prioritisation
- TN Conductors and Hardware – Distribution Asset Management Plan
- TN Response IR10 – Capex
- TN Response IR10 – REMCU NPV
- TN Response IR10 – Conductor Priority Tool (Static Extract 13Apr2018)
- Olex - Aerial: Bare Overhead Conductors 2012

6.5.4 Replacement of aged deteriorated GI conductor related to BFM

GI conductors have been used as a standard conductor by TasNetworks since the 1940s, making up 36% of the conductor population. The standard rural installations to private properties are 3/2.75 GI conductors. They make up approximately 36% of the total network, with the majority in the low fire risk areas. The following figure shows the age profile of GI conductors within 2km of the coast.

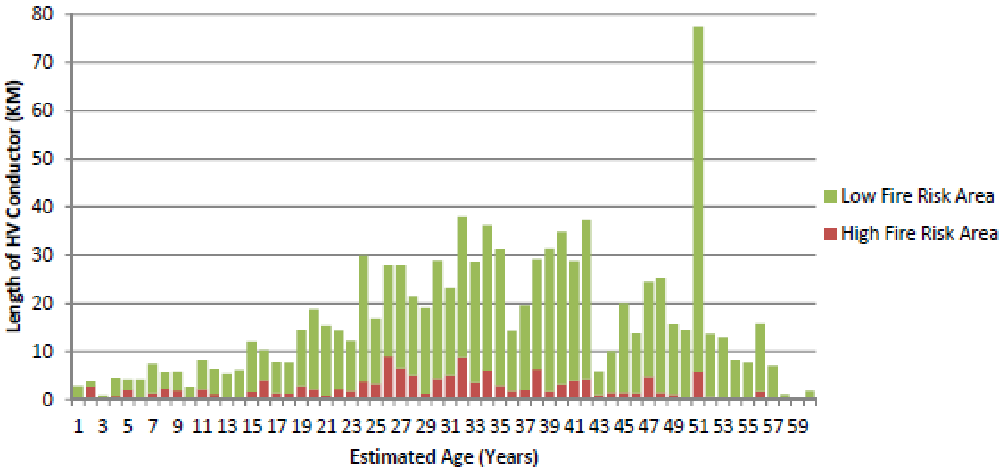


Figure 35 GI conductor estimated age profile within 2km of the coast[132]

This program is a continuation of a program which was commenced in 2017/2018 as part of the Bushfire Mitigation Strategy. Prior to 2012, GI conductors were replaced under the Replace HV Feeders (Safety) program.

6.5.4.1 Financials and Program

Table 47 Financials and Program – BFM Replace aged/deteriorated GI conductor

	FY20	FY21	FY22	FY23	FY24
Distance (km)	36	36	36	14	14
Total ($, FY17)	$2,520,000	$2,520,000	$2,520,000	$1,008,787	$1,008,787

6.5.4.2 Investment Driver

TasNetworks has developed this program to address the safety and reliability risk associated with GI conductors.

GI conductors perform poorly in marine environments. When these conductors are subjected to salt spray, crystals are deposited on the surface forming a galvanic cell that cause corrosion. Corrosion has the potential to cause in loss of mechanical strength that results in failure. This program aims to address the risk associated with conductor failure in areas where the bushfire risk is high.

Approximately 12% of conductors are located within 2 km of the coastline, however these assets are causing 53% of failures between 2010 and 2014. Based on TasNetworks data, GI conductors are responsible for 36% of conductor failures, with this number expected to increase.

It is key to note that the Conductor Priority Tool shows the condition of most conductors is unknown. This highlights the low level of visibility in the condition of the assets.

[132] TasNetworks 2017, *Conductors and Hardware - Distribution Asset Management Plan pg 27*

Additionally, no information has been provided on the number of fire starts that are occurring near the coast that is within the HBLCA.

Table 48 Number of GI Conductor Failures by year[133]

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of failures	7	20	13	15	4	14	9	17	28	13	27	32

6.5.4.3 Replacement Approach

This program aims to replace 136 km of GI conductor length over the next five years within the HBLCA. However, in the NPV analysis, this number has been stated as 192km, shown in the following excerpt from the assumptions:

> *"Replace 192 km remaining in HBCA, noting 1132 km state-wide of bare galvanised iron (GI) conductor to reduce risk of conductor failure damage and to avoid higher cost of emergency repair"*

There are two programs to address GI conductor safety and reliability risk, one within the HBLCA and one for other areas. Based on the table below, the majority of GI conductor asset replacement is aimed at addressing bushfire risk. When comparing the proportion of GI conductors in high bushfire risk areas to the expenditure, it appears that it is disproportionally high. The volume of asset replacements for both the programs are shown in the table below. No data has been provided on the location of assets relative to the coast.

Table 49 Replace GI Conductor Programs

Year	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27
BFM	36	36	36	14	14	14	14	14
Non BFM	13	13	13	13	13	13	13	13

TasNetworks has specified that although they are investigating new technologies, their replacement strategy is like for like.

As part of the reports provided by UTas in 2001, recommendations of suitable materials within marine environments were provided. It was recommended that steel/GI conductors should be used within marine environments as the they have a galvanising protective layer that provides protection of the steel core whist the coating is intact.[134]

The AS/NZS 7000:2016 provides recommendations and a table for conductor selection for differing environments. The standard contradicts the UTas findings stating that GI conductors (referred to as SC/GZ in the standard) perform poorly in salt spray pollution environments and in acidic industrial environments and they perform average in Alkaline industrial

[133] TasNetworks 2017, *BFM Replace GI Conductor Program 01510*, TN-Response 010 - Capex
[134] UTas 2001, *Risk Assessment of aged conductors pg 1*

environments.[135] The expected life of the GI conductor is dependent on the life of the zinc coating (galvanic coating) which has corrosion rates given in AS/NZS 7000:2016. Additionally, protective greases can also provide protection in corrosive environments. [136]

No analysis has been provided in the IES on the feasibility of other materials.

6.5.4.4 Options Analysis

The IES provides an assessment of three options to substandard GI conductors. The three options comprise of:

- Option 0 Do nothing
- Option 1 Review and replace defective substandard GI based on condition
- Option 2 Replace GI conductors after 50 years

Option 1 has been selected as the preferable option as it maintains network reliability, fault replacements are reduced and the expenditure is sustainable. This option maintains TasNetworks overall low risk level by mitigating the safety and reliability risks.

Arup observation

As with previous observations, this options analysis does not appear to consider various replacement methods or rates. In not doing so, Arup cannot be confident that the selected option represents a prudent and efficient approach.

6.5.4.5 Economic Analysis

The economic analysis for the GI conductor programs is based on the operating and maintenance costs associated with the different options. Sensitivities have been run on changes in the capital costs, producing a similar result.

Table 50 Economic analysis outputs - BFM replace GI Conductor Program ($, FY17)[137]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$9,577,574	$24,033,765
NPV	-$3,599,804	-$9,255,004	-$20,374,044

6.5.4.6 Arup findings and recommendations

There does not appear to be sufficient information within the IES to justify the investment in GI conductor replacements within the HBLCA. Based on the justification for this investment, this project appears to be addressing a corrosive environment issue rather than mitigating

[135] AS/NZS 7000:2016, Overhead Line Design: *Appendix X pg 263*
[136] AS/NZS 7000:2016, Overhead Line Design: *Appendix X pg 263*
[137] TasNetworks 2017, *BFM Replace GI Conductor Program 01510 pg 9*

bushfire risk. Insufficient evidence has been provided on the investment driver for this investment to show that is targeted at mitigating bushfire risk.

GI performs poorly in the sites that TasNetworks has mentioned are the drivers for this investment, therefore the use of the same asset for replacement appears to be questionable. AS/NZS 7000:2016 indicates that GI performs poorly in marine environments and alternative conductors, such as AAC and AAAC, for replacement of GI in such environments should be investigated. Greased conductors for extra corrosion protection could also be investigated. TasNetworks has not demonstrated analysis into the performance of other types of conductors in this environment compared to GI or investigation into new technologies that could have a longer life.

Assets outside the HBLCA have the potential for an extended life, highlighting the ability to take a risk or as needs based approach for GI conductor replacement as opposed to a proactive approach. The drivers of this investment appear to be based on assumptions of risk as well as asset condition. The condition of majority of the assets is unknown by TasNetworks as shown in the conductor priority tool, highlighting a clear information gap.

The options analysis should be reviewed to show a range of feasible options that investigate a range of technologies, approaches and installation techniques.

6.5.4.7 Key Documents

- TN – BFM Replace Aged Deteriorated Galvanised Iron (GI) Conductor 0510
- Guideline – Overhead Conductor Replacement Programs Prioritisation
- TN Conductors and Hardware – Distribution Asset Management Plan
- TN Response IR10 – Capex
- TN Response IR10 – Conductor Priority Tool (Static Extract 13Apr2018)
- TN Response IR10 – BFM Replace GI Conductor NPV
- Standards Australia - AS/NZS 7000:2016
- UTas 2001 - Risk Assessment of aged Conductors 2001

6.5.5 Replacement of aged/deteriorated aluminium conductor

There have been three types of aluminium conductors installed in Tasmania since the 1960s: All Aluminium Conductor (AAC), All Aluminium Alloy Conductors (AAAC) and Aluminium Conductor Steel Reinforced (ASCR/GZ). The breakdown of the population of the HV Aluminium Conductors is shown in the table below:

Table 51 Breakdown of the population of HV Aluminium Conductors[138]

Conductor type	Percentage of total conductor population
AAC	35%
AAAC	16%
ABC	0.1%
ACSR	5%

The age profile of the aluminium conductors is shown in the figure below. Most aluminium conductors were installed from 1963 and will have an average age of 53 years old by the end of the current period.

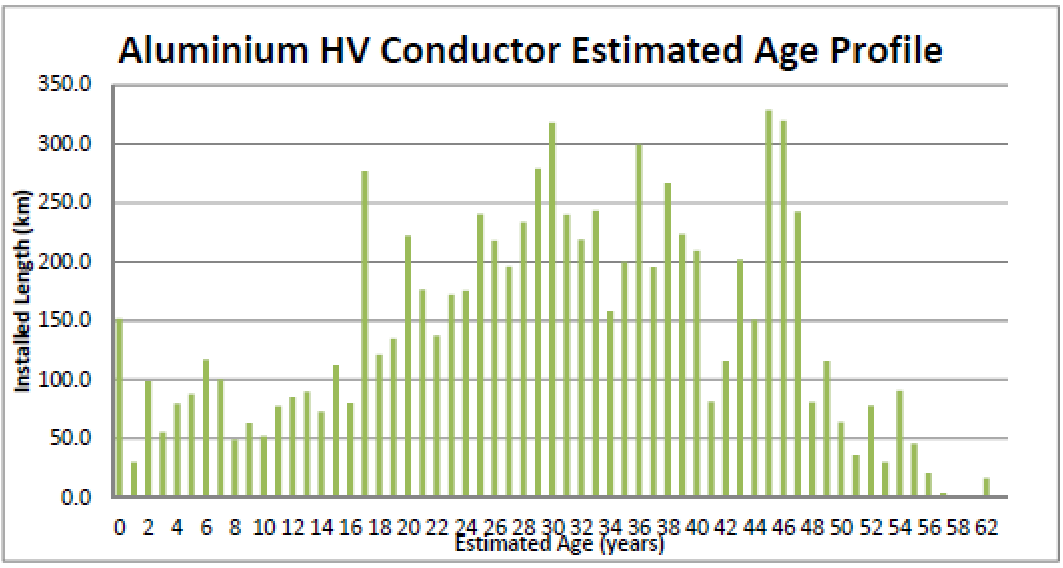


Figure 36 Aluminium HV conductor estimated age profile[139]

6.5.5.1 Financials and Program

Table 52 Financials and Program – Replacement of aged/deteriorated aluminium conductor

	FY20	FY21	FY22	FY23	FY24
Distance (km)	13.75	13.75	13.75	13.75	13.75
Total ($)	$982,165	$982,165	$982,165	$982,165	$982,165

[138] TasNetworks 2015, *Overhead Conductor Replacement Programs Prioritisation Guideline pg 28*
[139] TasNetworks 2017, *Conductors and Hardware - Distribution Asset Management Plan pg 27*

6.5.5.2 Investment Driver

TasNetworks currently use AAC 19/3.25 (Neptune) and AAAC 7/3.00 (Fluorine) as standard conductors in the distribution system. These are used when higher load carrying capacity is required, where the line is a feeder trunk or when the future load forecast is high.

The bare and small diameter aluminium conductors that have been identified as high risk include the AAC 7/2.50 and the ACSR 6/1/2.50. These assets are subject to mechanical failure for two reasons: metal fatigue and fretting.

Failure is driven by unideal installation and fretting from the absence of vibration damper installation. AAC and AAAC conductors are responsible for 43% of conductor failures. According to TasNetworks, these mechanical failures have the potential to result in safety and bushfire risk.

The NPV analysis has highlighted that mechanical failure, electrical shock, bushfire risk and supply outages are the main drivers for investment. The table below shows the failure for each aluminium asset type over 2006 to 2014.

Table 53 Asset failures by aluminium asset type[140]

Number of Failures	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
AAC	10	13	11	9	3	12	9	12	8
AAAC	1	6	10	9	8	3	5	10	13
ACSR	0	4	6	2	1	4	3	4	1
Total	**11**	**23**	**27**	**20**	**12**	**19**	**17**	**26**	**22**

6.5.5.3 Replacement Approach

The program aims to replace 69km of HV aluminium overhead conductors over the forecast period. There has been insufficient information in the IES on what type of aluminium conductors will be replaced, and what the replacement asset will be, however it is assumed that the standard conductors mentioned above will be utilised.

6.5.5.4 Options Analysis

The IES provides an assessment of three options to address substandard aluminium conductors:

- Option 0 Do nothing

[140] TasNetworks 2015, *Overhead Conductor Replacement Programs Prioritisation Guideline pg 28*

- Option 1 Continue a targeted replacement of substandard HV aluminium conductor based on condition
- Option 2 Replace Aluminium conductors after 50 years

Option 1 has been selected as the preferred option in accordance with the Overhead Conductor Replacement Programs Prioritisation Document as well as the Asset Management Plan. TasNetworks has selected this option to maintain the low level of risk TasNetworks has stipulated in the risk management framework.

Arup observation

As with previous observations, this options analysis does not appear to consider various replacement methods or rates. In not doing so, Arup cannot be confident that the selected option represents a prudent and efficient approach.

6.5.5.5 Economic Analysis

The benefits associated with each of the options are based on the differences in the operating and maintenance costs of each option.

Table 54 Economic analysis outputs - Aluminium Conductor Program ($, FY17)[141]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$4,910,825	$6,150,540
NPV	-$7,920,950	-$14,848,311	-$16,575,305

A sensitivity analysis was completed on this program, although it appears to be inconsistent in its application across the programs. As the sensitivities have been applied to costs only, there is no difference in the actual ranking of the options compared to each other. Applying sensitivities to other key assumptions would have given a more thorough understanding of the various options.

6.5.5.6 Arup findings and recommendations

Arup's major concerns with this program are around the IES and options analysis process. This program appears to be underpinned by an IES and option analysis that does not show sufficient investigation into the costs and benefits associated with the replacement of conductors.

Inconsistency in the application of the do-nothing option is also highlighted in this program. In most programs no costs or benefits have been associated with the no nothing option, however in this case TasNetworks has assigned maintenance costs with the do-nothing option. Although this maintenance cost has been included in the NPV, there has been no costs included that highlight the consequence of failure or the resulting replacement. Additionally, the options considered do not appear to cover the various rates of replacement available to TasNetworks.

[141] TasNetworks 2017, *Replace aged deteriorated aluminium conductor pg 9*

6.5.5.7 Key Documents

- TN – Response IR10 – Replace Aged Deteriorated Aluminium Conductor 01719
- Guideline – Overhead Conductor Replacement Programs Prioritisation
- TN Conductors and Hardware – Distribution Asset Management Plan
- TN Response IR10 – Conductor Priority Tool (Static Extract 13Apr2018)
- TN Response IR10 – Aluminium Conductor Program NPV

6.5.6 Low conductor span rectification

This program aims to rectify any conductor clearances that do not meet the Australian standards through using range of capex measures.

6.5.6.1 Financials and Program

Table 55 Financials and Program – Low conductor span rectification

Year	FY20	FY21	FY22	FY23	FY24
Distance (km)	341	139	139	139	139
Total ($, FY17)	$3,572,998	$1,456,442	$1,456,442	$1,456,442	$1,456,442

6.5.6.2 Investment Driver

TasNetworks is replacing conductors that do not comply with the Australian Standard AS/NZ 7000. The replacement of low conductors aims to address the safety issues that result from members of the public, machinery or plants contacting conductors. TasNetworks experience 30 incidents each year where third-party vehicles either contact or pull down overhead services or conductors. However, none of these incidents have resulted in the injury to members of the public.

The Light Detection and Ranging (LiDAR) program has increased visibility on the height of conductors in the network, resulting in greater defect detection. As of August 2017, there were approximately 2,000 conductor clearance defects. As the LiDAR program will provide a complete survey of the network over the next five years, TasNetworks has made assumptions concerning the amount of work that needs to be completed over the next regulatory period.

6.5.6.3 Replacement Approach

The total investment in low clearance conductor programs is displayed on the figure below, showing that TasNetworks' focus is replacement of LV conductors through capex. There are four work categories that TasNetworks has developed to rectify defects related to low clearance spans, with this particular program highlighted below.

- Replace/relocate HV OH low clearances – REHCR (capex)

- Replace/relocate LV OH building clearances – RELCL (capex)
- **Replace/relocate LV OH low clearances – RELCR (capex)**
- Overhead system low conductor clearance rectification - AROLC (opex)

TasNetworks has suggested that investment is front loaded in the forecast period due to a backlog from the first LiDAR inspection program.

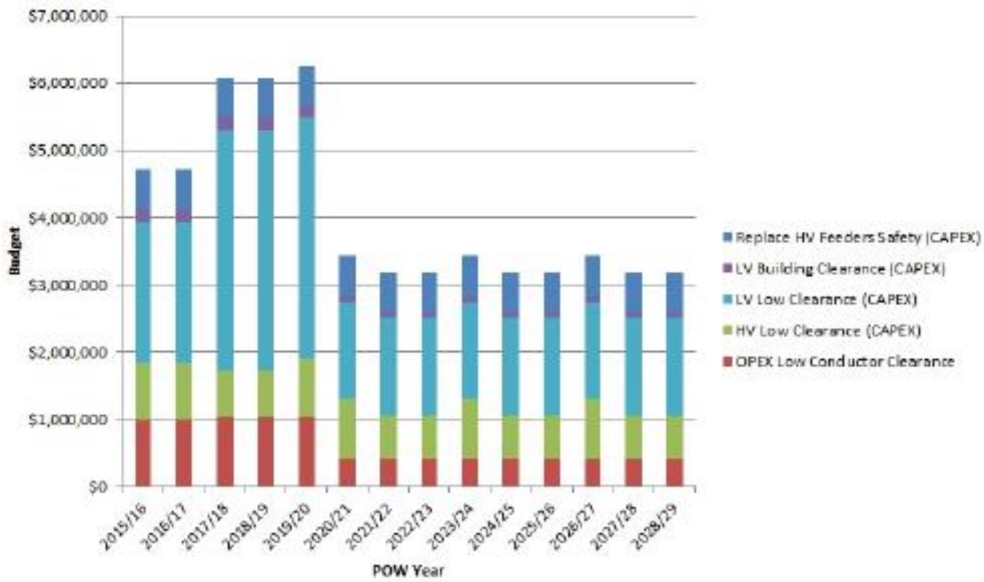


Figure 37 Low conductor clearance related programs by asset type[142]

High risk sites will be prioritised as part of the program and will be actioned immediately. Where a defect has been identified, TasNetworks will take one of the following corrective actions:

1. Where the conductor under clearance is a result of insufficient conductor tension, the issue may be resolved by re-tensioning the conductor appropriately
2. Where the under clearance is a result of sufficient pole height, it may be appropriate to address the under clearance by removing that pole and installing a taller pole
3. Where the under clearance is caused by a conductor span being too long, it may be appropriate to address the issue by installing an additional pole between the two poles

Arup observation

TasNetworks mentioned in the IES assumptions that the breakdown of opex and capex for low clearance defect rectification is based on a historical analysis. The analysis showed that 66% of work is conducted as opex and the remaining 34% is divided between the relevant capex programs.

The IES refers to one opex program to replace low clearance conductors, which has been assumed to be the AROLC program shown in Figure 38.

[142] TasNetworks 2017, *Low Conductor Span Rectification Low Clearance LV Capex 00545 pg 4*

The majority of low conductor defects could be addressed with opex according to the industry benchmark of 60 to 80% opex by volume.[143] Based on the evidence provided by TasNetworks, the majority of this rectification is coming under capex.

Description	Work Category	Risk Level	Driver	Expenditure Type	Residual Risk
OH System Feeder Inspections by Helicopter	AIOFD	High	Safety	OPEX	Medium
Thermal Inspection – O/H Feeders (Defined)	AIOTI	High	Safety	OPEX	Medium
OH System Asset Repair (Defects)	AROCO	High	Safety	OPEX	Medium
OH System Low Conductor Clearance	AROLC	High	Safety	OPEX	Medium
Maintain access tracks and weed management	RMOTC	High	Safety	OPEX	Medium
Low HV Conductors	REHCR	High	Safety	CAPEX	Medium
Replace/relocate HV due to vegetation issues	REHVE	High	Safety	CAPEX	Medium
Rectify low LV clearances public safety	RELCR	High	Safety	CAPEX	Medium
Replace Cross arms	RELSA	High	Safety	CAPEX	Medium
HV Feeders (Safety)	REHSA	High	Safety	CAPEX	Medium
Replace/relocate LV OH (Building Clearances)	RELCL	High	Safety	CAPEX	Medium
Replace/relocate LV OH (Building Clearances) with UG	RELCU	High	Safety	CAPEX	Medium
Endangered species	SIWES	High	Environment	CAPEX	Medium

Figure 38 Summary of rectification of low conductor clearance expenditure programs, main drivers and risks[144]

6.5.6.4 Options Analysis

The IES provides an assessment of three options to address low conductor clearances:

- Option 0 Do nothing. Allow defects to remain in the distribution network.
- Option 1 Audit 20% of spans per year assuming work will be required on 10%
- Option 2 Replace Clear known defect backlog then rectify LV clearance defects identified in the LiDAR inspection

Option 2 has been selected as the preferred option as it is the lowest cost option after the do nothing option, and has a greater NPV. This option maintains TasNetworks risk appetite in accordance with the risk management framework.

6.5.6.5 Economic Analysis

The cost of the project as well as the NPV is shown in the table below. A full IES has been completed as part of the project, however, the NPV analysis was not provided as part of the Arup review.

[143] Based on AER guidance on the industry standard
[144] TasNetworks 2017, *Conductors and Hardware - Distribution Asset Management Plan pg 52*

Table 56 Economic analysis: Low Conductor Span Rectification ($, FY17)[145]

Economic Analysis	Option 0 – do nothing	Option 1 - preferred	Option 2
Project Cost	$0	$26,771,290	$9,398,766
NPV	$0	-$32,394,848	-$10,628,142

Arup observation

The IES for this program does not appear to show sufficient investigation into a range of options that are feasible to implement. TasNetworks has not demonstrated a detailed investigation into converting the increased visibility from the LiDAR program into a risk based approach.

Additionally, the negative impact of leaving defective assets in the network has not been captured on the do nothing option as it has both a cost and an NPV of $0. There should be a cost associated with failure and maintenance. This reinforces the necessity for the quantification of consequence to compare the economic costs and benefits of the options in a robust manner.

6.5.6.6 Arup findings and recommendations

TasNetworks has suggested a significant increase in expenditure on rectifying low conductor clearances, in part driven by greater visibility from the LiDAR program. Arup recommends that TasNetworks use this increased visibility from the LiDAR program to target high risk conductors in the forecast period.

This risk based approach is one that is compliant as part of the Australian Standards on the defined clearances that between the conductors and the ground or vegetation. The standards provide guidance that departures from specified distances are permissible if a comprehensive risk management assessment has been carried out. [146]

6.5.6.7 Key Documents

- TN – Low Conductor Span Rectification Low Clearance LV Capex 00545
- TN Conductors and Hardware – Distribution Asset Management Plan
- Standards Australia – AS/NZ 7000 Overhead line design

6.5.7 Replacement or relocation of open wire HV with insulated alternative related to BFM

TasNetworks most prevalent installed type of conductor is the bare open wire conductor. The support structures, including the pole and pole top equipment, have been designed to provide clearance between the ground and third-party infrastructure.

[145] TasNetworks 2017, *Low Conductor Span Rectification Low Clearance LV Capex 00545 pg 4*
[146] Standards Australia, *Overhead line design AS/NZ* 7000

This program addresses the issue of vegetation contacting bare wire conductors in locations where clearing the vegetation is not practical or cost effective. The program has prioritised replacing or relocating bare open wire powerlines that are located within the HBLCA, aiming to minimise the risk of vegetation contacting bare wire powerlines.

6.5.7.1 Financials and Program

Table 57 Financials and Program – BFM replace/relocate open wire HV with insulated alternative

	FY20	FY21	FY22	FY23	FY24
Volume	227	227	227	227	227
Total ($, FY17)	$2,043,000	$2,043,000	$2,043,000	$2,043,000	$2,043,000

6.5.7.2 Investment Driver

The most prominent cause of fires from the distribution network is vegetation contacting bare wire powerlines. Vegetation contact with bare conductors is the cause of 32% of fire starts and is a major contributor to unplanned outages.

The driver behind the increase in investment is the recently captured tree data which has increased visibility and thus highlights the need to remove the hazard. The areas that have been identified within the HBLCA are those with unacceptable outage performance, with heavy vegetation that cannot be cleared using tree clearing regimes.

According to the Vegetation Asset Management Plan, this program is the only way the TasNetworks believes they can meet TEC requirements in terms of vegetation management.

6.5.7.3 Replacement Approach

TasNetworks' replacement strategy prioritises the replacement or relocation of bare wire conductors in the HBLCA due to the potential high consequence of the loss associated with bushfires. TasNetworks has proposed a variety of methods to replace or relocate bare wire conductors based on the site conditions, including:

- HV ABC
- Spacer (Hendrix) cable
- Hybrid HV underground
- LV ABC
- Insulating bare conductors

6.5.7.4 Options Analysis

TasNetworks has proposed three options to mitigate the risks associated with vegetation contacting bare open wire powerlines. These include:

- Option 0 Do nothing. Allow defects to remain in the distribution network.

- Option 1 Replace or relocate bare wire conductors with alternative engineering or technical solutions to minimise exposure to problematic vegetation areas
- Option 2 Intensify vegetation management program annually in order to minimise bushfire risk
- Option 3 Underground feeders in problematic vegetation areas

Option 1 has been selected as the preferred option as it has the highest NPV after the do-nothing option. This option reduces the risk of bushfires as well as safety risk associated with vegetation contacting bare open power lines. The added benefit of this option is the reduction of the operating expenditure associated with vegetation management.

Arup observation

The options analysis appears robust in exploring three different options in mitigating the issue associated with bare open wires contacting vegetation. The option to intensify vegetation management does not appear to be feasible, as TasNetworks has suggested that a driver behind this program is the inability to clear vegetation due to barriers such as legislative requirements.

6.5.7.5 Economic Analysis

The cost of the project as well as the NPV is shown in the table below. This NPV is based on capital expenditure as well as operating and maintenance costs only.

Table 58 Economic analysis outputs – Replace/Relocate bare open wire conductor ($, FY17)[147]

Economic Analysis	Option 0 – do nothing	Option 1 – preferred	Option 2	Option
Project Cost	$0	$10,215,000	$13,215,000	$30,645,000
NPV	$0	-$9,605,885	-$11,626,257	-$42,760,462

6.5.7.6 Arup findings and recommendations

TasNetworks has proposed this program to reduce the risk of vegetation conducting bare wire conductors in the HBLCA. TasNetworks has benchmarked to the Victorian Black Sunday Bushfires when providing a justification for the project and have stated that the following:

> *"Victorian Distribution Network Service Providers are in the process of investing approximately $200 million (over 10 years between 2012 and 2022) for undergrounding/relocating powerlines in high bushfire loss consequence areas"*

TasNetworks has mentioned that they believe investment in undergrounding powerlines in high bushfire risk areas is prudent, without elaborating on economic efficiency. In order to prove prudency in this program, it advised that TasNetworks quantify the risk and consequence to ensure that this level of investment is justified.

[147] TasNetworks 2017, *BFM Replace relocate open wire HV with insulated alternative, 01514 pg 7*

Based on the information provided, Arup is unaware of the extent that TasNetworks is non-compliant with the TEC requirements for vegetation management.

It is recommended that TasNetworks undertake an options analysis that quantifies the risk and consequence associated with bushfire risk.

6.5.7.7 Key Documents

- TN – BFM Replace Relocate Open Wire HB with insulated alternative 01514
- Guideline – Overhead Conductor Replacement Programs Prioritisation
- Vegetation Asset Management Plan

6.6 Poles

Poles in the distribution network are the structures that provide support, insulation and clearances between overhead conductors, overhead switchgear, pole mounted transformers, vegetation and buildings. TasNetworks has categorised the structures into two parts: poles and pole accessories. Pole accessories include stays, stakes, operating platforms, fauna guards, anti-climbing barriers and pole caps.

TasNetworks use a range of different wood, concrete and steel poles in the network, with some owned by the network and privately owned. The following table outlines the pole population by type and ownership.

Table 59 TasNetworks poles by type and population[148]

Description	TasNetworks owned	Privately owned	Total
Natural wood poles	2,935	1,092	4,027
CCA treated wood poles	204,528	33,843	238,371
Insulated composite concrete poles	3	0	3
Steel and concrete (stobie) poles	6,464	190	6,654
Spun concrete/prestressed concrete poles	161	14	175
Steel lattice poles	1,300	50	1,350
Steel lattice towers	151	190	341

[148] TasNetworks 2017, *Overhead line structures – Distribution asset management plan pg 12*

Railway section steel poles	200	269	469
Steel other	14,229	33,046	47,275
Other/unknown	161	123	284
Total	**230,129**	**68,817**	**289,946**

TasNetworks stake poles in scenarios where the wood becomes impaired by rot growth. This is limited by the moisture availability and antifungal treatment such as Cooper Chrome Arsenate (CCA) or boron. As shown in the table above, CCA treated poles are the most common in the network. Steel staking a pole at the rotted based extends the pole life by approximately 15 years.

6.6.1 Previous & Forecast Expenditure

TasNetworks has proposed a significant increase in spend on poles over the forecast proposed period when compared to the current regulatory period. TasNetworks has stated that that increase in spend is driven by the aging pole population increasing the pole condemnation rates.

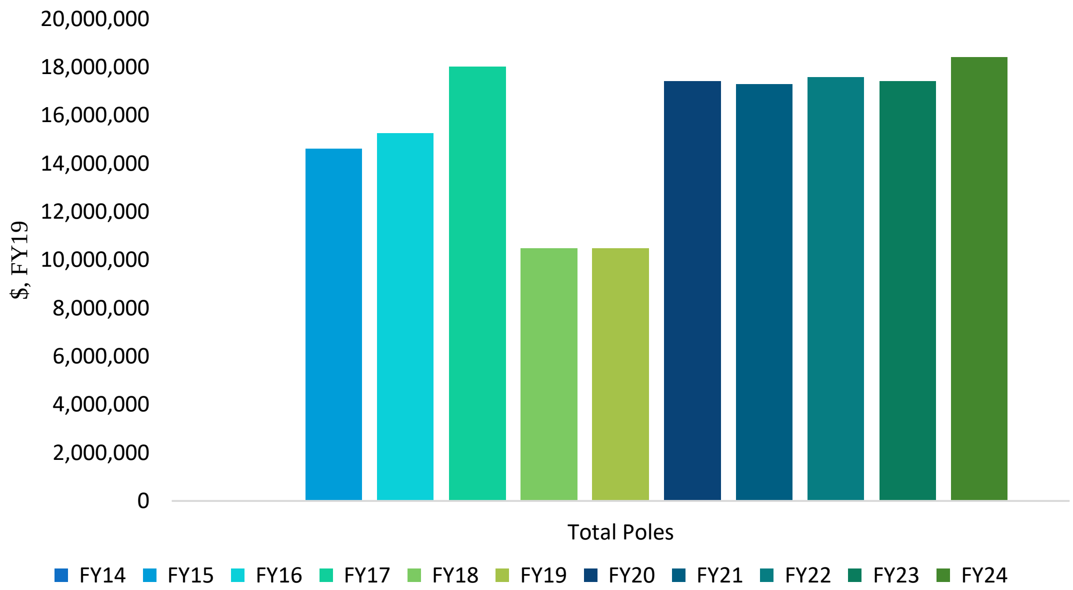


Figure 39 Previous and forecast capex - poles[149]

6.6.2 Pole Replacements

TasNetworks use two types of wooden poles in the distribution network: natural and CCA poles.

[149] Previous and forecast RIN data

Natural wooden poles were sourced from untreated eucalypt from the St Marys district until 1994. The number and treatment of CCA poles has increased over time. These poles are locally harvested and treated in Tasmania and are therefore considered by TasNetworks the most cost-effective poles in the network.

6.6.2.1 Financials and Program

Table 60: Financials and Program – Pole replacements

	FY20	FY21	FY22	FY23	FY24
Volume	1362	1490	1532	1575	1703
Total ($, FY17)	$12,571,260	$13,752,700	$14,140,360	$14,537,250	$15,718,690

6.6.2.2 Investment Driver

Analysis into the condition and performance of poles informed TasNetworks' decision to invest in pole replacement. The population of wooden poles is aging, therefore TasNetworks is predicting an increase in pole condemnation rates over the forecast regulatory control period.

This investment will ensure that TasNetworks can manage the number of poles exceeding their service life. The aim of this proposed program is to ensure that poles do not fail, resulting in potential injury or death to a member of the public. Wooden poles are vulnerable to deterioration regardless of whether they are treated or not. Soft rot is responsible for damage on the outside of poles at a depth of 300 to 400mm from the ground. On the other hand, heart rot is the result of fungal attach on the interior of the pole at a height up to 300mm from the ground.

TasNetworks has mentioned that they will increase monitoring to ensure that failure rates do not increase. TasNetworks has proposed this investment to sustain the performance of the wooden pole population into the future, ensuring that poles are replaced before they fail. As shown below, although the population of poles is aging there has been no significant increase or upwards trend in the number of unassisted pole failures.

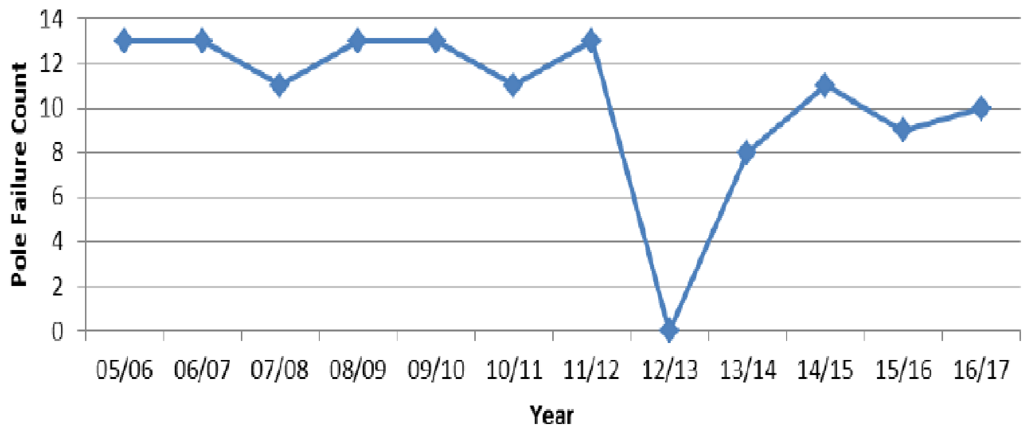


Figure 40 Number of unassisted pole failures[150]

6.6.2.3 Replacement Approach

This program includes the replacement of condemned poles as well as the replacement of poles following Major Event Days (MED), which usually occur after storms or severe weather conditions.

TasNetworks has proposed that they will replace poles that are deemed condemned by the pole inspection program. TasNetworks has proposed that approximately 25% of all the impaired poles will be replaced and the remaining 75% will be staked. This assumption is based on historical data and condition assessment audits. The success of the pole replacement strategy is reliant on the effective execution of the parallel pole staking program.

Alternatively, under MED related pole replacements the work program is reactive, replacing poles after severe weather events. Replacements are initially performed under the fault and emergency budget and later transferred to the pole replacement program.

As TasNetworks has identified an increase in the number of condemned poles after carrying out pole inspection, proposed investment in pole replacement has increased in the forecast period. This is shown in the figure below, where pole replacements are increasing linearly.

[150] TasNetworks 2017, *Pole Replacements 00661*, pg 4

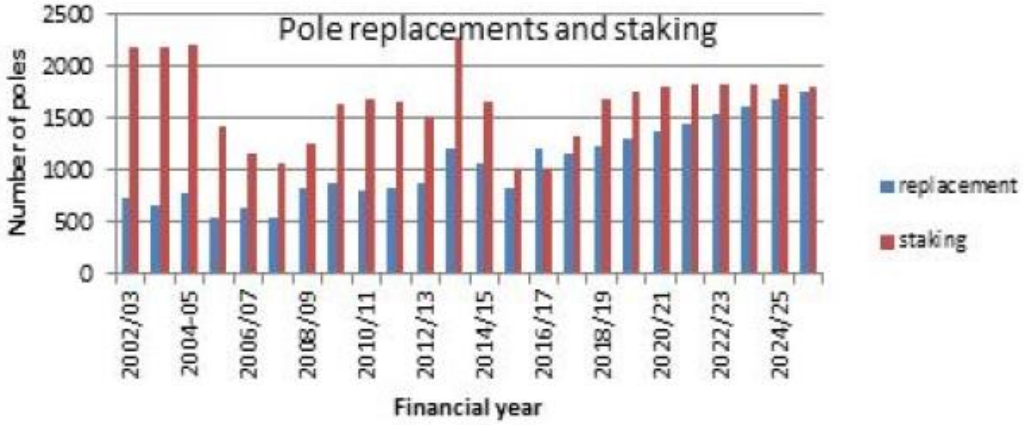


Figure 41 Historic and forecast pole replacements and staking[151]

The table below is an Arup estimation of the number of poles that will be replaced as part of the proposed program based on the figure above. It appears that a total of 8,300 poles will be replaced over the forecast period.

Table 61 Estimated number of pole replacements

	FY20	FY21	FY22	FY23	FY24	Total
Proposed replacement	1300	1400	1450	1550	2600	8,300

When compared to the age profile of the profile of the assets a replacement of 8,300 poles will condemn all poles that are more than 54 years old, and half of the population that are 53 years old. If TasNetworks is primarily replacing the 8,300 oldest poles this would equate to the removal of all staked poles that are more than 50 years old.

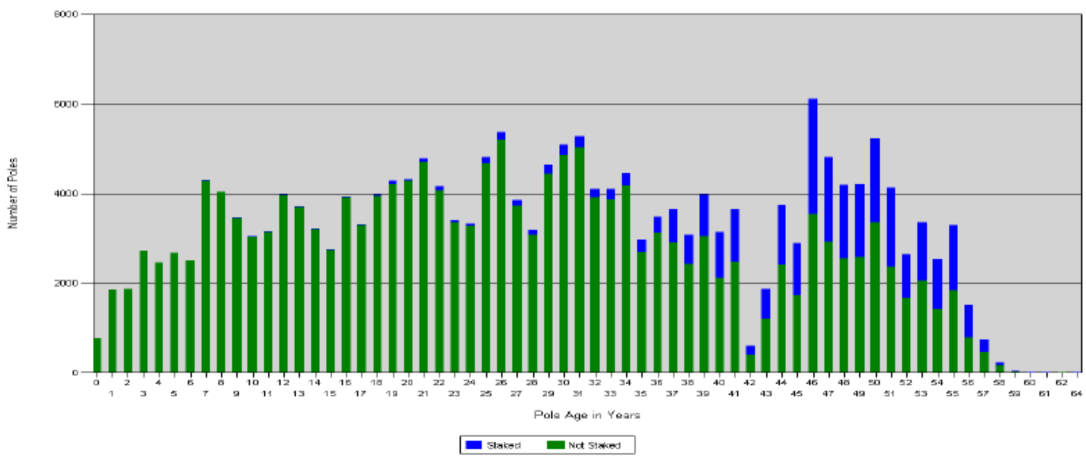


Figure 42 Wooden pole and staked pole age profile

Based on the information provided in the IES, TasNetworks is supporting the replaced volumes with trials of alternative wood testing and rot management. TasNetworks has

[151] TasNetworks 2017, *Pole Replacements 00661 pg 5*

suggested that these tests will improve their ability to assess the life of poles, increase their economic life and increase the staking rates.

In a partnership with the University of Tasmania, TasNetworks has tried to determine the type of fungi present in wooden piles. The outcomes of the study found that additional research is required to understand timber rot as no single causation agent was found. Additionally, a range of DNSPs including TasNetworks have partnered to develop detection of fungi in eucalyptus power poles. Through this research TasNetworks hope that they can minimise the impacts of timber rot in order to increase the life of wooden poles.

Arup observation

Based on the investment driver and replacement approach it appears that TasNetworks is replacing all poles that are aging to ensure that failure does not occur. Historical failure rates do not appear to be increasing even though the expenditure on poles was less in the past than is forecast for the next regulatory period.

6.6.2.4 Options Analysis

TasNetworks has proposed three options as part of the options analysis. The options are:

- Option 0 Do not replace poles due to poor condition or that have been damaged.
- Option 1 Replace poles based on condition
- Option 2 Replace poles based on age once they reach 45 years old

TasNetworks has progressed with Option 1 as it reduces the risk of exposure to fallen poles for the general public. Additionally, as TasNetworks has suggested that this is condition based and preventative program, it will minimise the risk of unplanned outages at a cost that is sustainable.

Arup observation

The options analysis appears to be limited in terms of covering a range of feasible options. TasNetworks has only provided two realistic options, with Option 2 appearing to be somewhat underdeveloped by comparison. There has been no option included that is reactive.

6.6.2.5 Economic Analysis

TasNetworks has completed an IES and NPV analysis as part of the pole replacement programs.

Table 62 Economic analysis outputs – Pole replacements ($, FY17)[152]

Economic Analysis	Option 0 – do nothing	Option 1 – preferred	Option 2
Project Cost	$0	$70,720,260	$198,306,550
NPV	-$12,530,317	-$111,961,190	-$291,454,219

[152] TasNetworks 2017, *Pole replacements 00661 pg 10*

6.6.2.6 Arup findings and recommendations

Replacement of condemned poles is a necessary investment for the safety and reliability of the distribution network in Tasmania. However, Arup has not seen adequate evidence for a need to replace such a substantial number of poles given the number of pole failures is not increasing at the same rate as the level of investment.

TasNetworks has stated that there has been no material reduction in the performance of poles, therefore this level of investment to prevent the potential of failures appears to lack justification.

Additionally, TasNetworks has not portrayed evidence of a thorough and robust options analysis. Arup recommends that TasNetworks undertake a more sophisticated options and economic analysis that takes into account a wide variety of feasible options.

6.6.2.7 Key documents

- TN-Overhead Line Structures Distribution Asset Management Plan
- TN – Pole Replacements 00661

6.7 Transformers

TasNetworks' distribution network has a total of 30,000 overhead pole mounted transformers. These devices are used for changes in voltages in the network, with majority stepping down from high voltage to low voltage. Generally, pole mounted transformers are less than 50kVA in size. The distribution transformers are separated into three categories:

- Single phase and three phase transformers
- Single Wire Earth Return (SWER) transformers
- Isolating transformers

The population of pole mounted transformers is summarised in the following table. There are an additional 1,441 transformers in the network with no installation data.

Table 63 TasNetworks pole mounted transformer population by type

Transformer size	22kV	11kV	6.6kV	12.7kV SWER	LV Isolating	Total
0 kVa to <50 kVa	11,222	4,093	2	0	2	**15,319**
50 kVa to <100 kVa	4,638	1,926	0	0	0	**6,564**
100 kVa to < 500 kVa	5,988	1,850	2	0	0	**7,844**
500 kVa	316	88	0	0	0	**404**

SWER	0	0	0	375	0	**375**
Isolating transformers	-	-	-	64	2	**66**
Total	**22,164**	**7,957**	**4**	**439**	**4**	**30,506**

TasNetworks has provided an estimate of the age profile of transformers in the asset management plan. There are an unknown number of transformers that do not have the installation date recorded. TasNetworks is planning to increase the number of inspections and audits to improve the data integrity in terms of transformers.

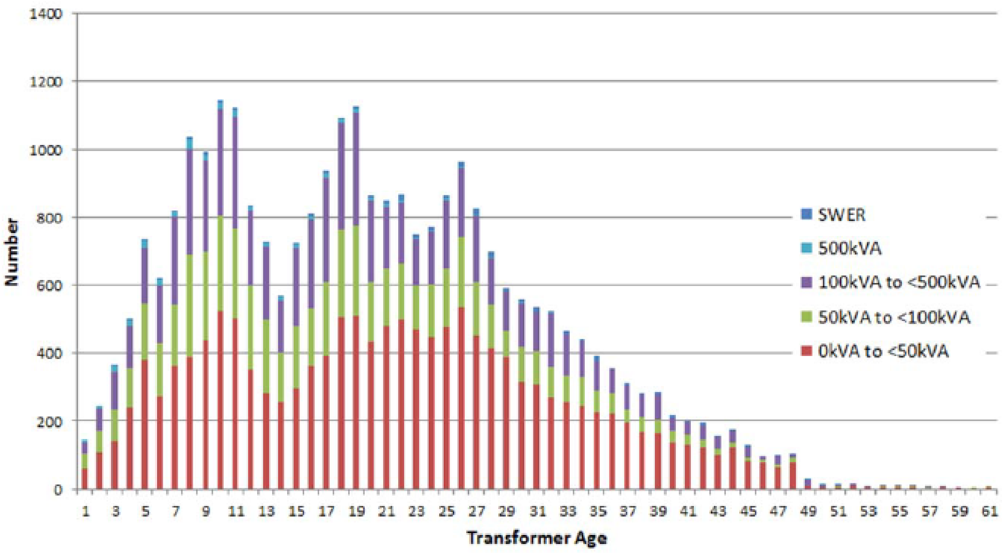


Figure 43 Transformer age profile[153]

6.7.1 Previous & Forecast Expenditure

Compared to the historical spend on transformers over the last five years, TasNetworks has forecast a significant increase in capex. Across the current regulatory period, TasNetworks spent between $4m to $8m on transformer replacement per year. There has been an increase over the forecast period, where proposed expenditure is between $8m to $13m each year.

[153] TasNetworks 2017, *Pole mounted transformers asset management plan pg 12*

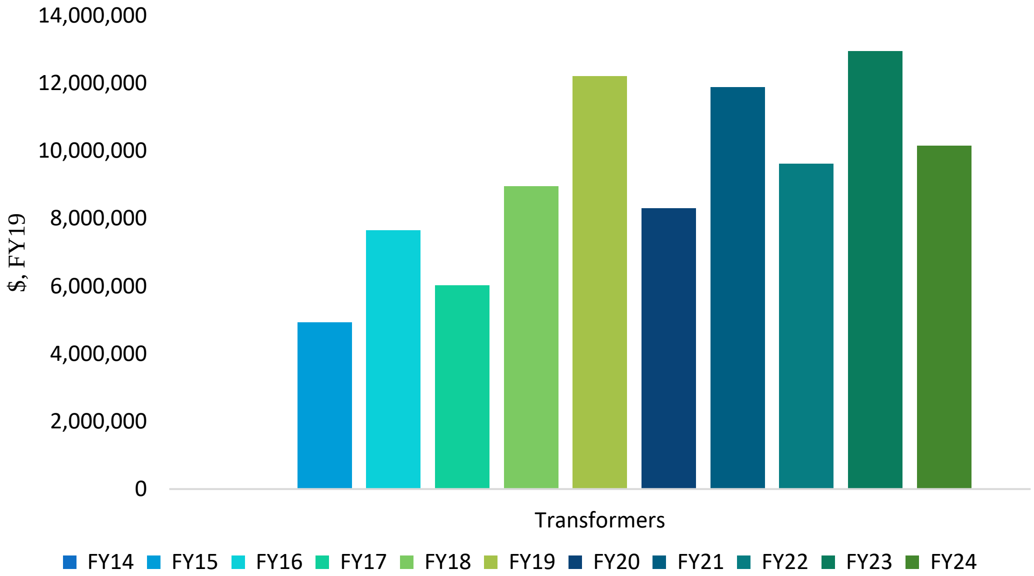


Figure 44 Previous and forecast capex - transformers[154]

6.7.2 Replace transformers

6.7.2.1 Financials and Program

Table 64 Financials and Program – Replace transformers

Year	FY20	FY21	FY22	FY23	FY24
Volume	105	130	171	183	194
Total ($2, FY17)	$2,100,000	$2,600,000	$3,420,000	$3,060,000	$3,880,000

6.7.2.2 Investment Driver

Transformer failures are responsible for approximately 7% of TasNetworks' outages, with a duration of approximately 550 hours per year on average. Approximately 4.5% of transformers with a known age are more than 40 years old. Transformers have a range of failure mechanisms: overloading, internal or external failure breakdown and damage from extreme weather events.

6.7.2.3 Replacement Approach

TasNetworks replacement approach is based on the historical number of failures as well as the age profile of transformers. The strategy is to run transformers until failure and then replace them on a like for like basis. TasNetworks is also proposing the replacement of old transformers that can be replaced opportunistically during the maintenance of the pole.

[154] Previous and forecast RIN data

6.7.2.4 Options Analysis

TasNetworks has proposed three options as part of options analysis. The options include:

- Option 0 Run to failure strategy
- Option 1 Aged based replacement strategy: Proactively replace all transformers at 45 years of age
- Option 2 Condition monitoring strategy

TasNetworks is progressing with Option 0 as the preferred option, which is the lowest cost option. Although this option will result in unplanned outages when the transformers fail, TasNetworks is willing to take the risk in order to reduce costs.

Arup observation

Consistency in the options analysis is an issue that Arup has flagged previously. This program demonstrates an options analysis that is lacking consistency with other programs. This is one of the few cases where the do nothing option is also business as usual. In the other cases, do nothing refers to TasNetworks in fact doing nothing when the asset fails. Arup recognises that this particular options analysis displays a more prudent practice by TasNetworks in this respect, however, this is not consistent across the programs.

6.7.2.5 Economic Analysis

The outcomes of the IES and NPV are summarised in the table below.

Table 65 Economic analysis outputs – Replace transformers ($, FY17)[155]

Economic Analysis	Option 0 – do nothing (preferred)	Option 1	Option 2
Project Cost	$15,060,000	$100,800,000	$76,800,000
NPV	-$25,586,292	-$36,413,227	-$28,533,839

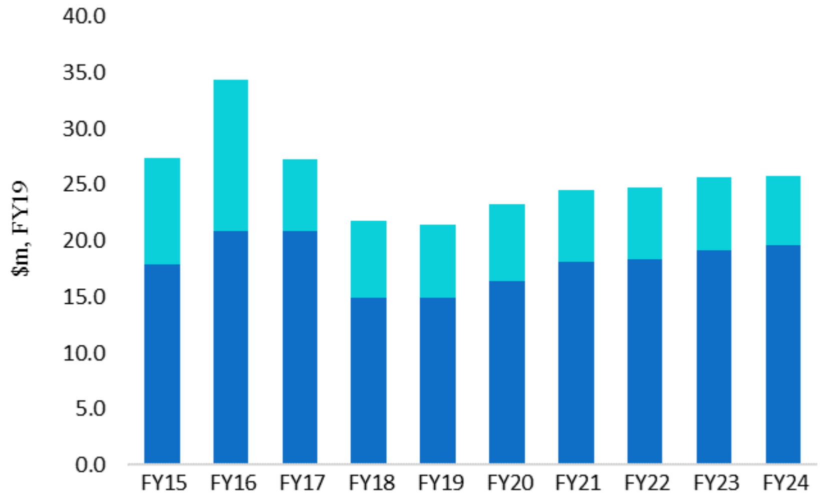
6.7.2.6 Arup findings and recommendations

Investment in the replacement of transformers is essential for the successful operation of the distribution network. In considering a robust base case, the options analysis appears to one that is more in line with Arup's expectations than in other IES's.

[155] TasNetworks 2017, *Replace Transformers 00699*, pg 8-9

7 Distribution development capex observations

Distribution development capex is comprised of augmentation expenditure and connection capital expenditure, and is forecast to remain relatively consistent during the upcoming regulatory control period.



	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Augmentation	9.5	13.4	6.4	6.9	6.5	6.9	6.4	6.4	6.5	6.2
Net Connections	17.9	20.9	20.9	14.9	14.9	16.4	18.1	18.3	19.2	19.6

Figure 45 TasNetworks’ distribution development capex FY15-24

Arup has assessed key programs in TasNetworks’ distribution development capex for prudency, discussed in:

7.1 High voltage feeder program

7.2 Connection expenditure

7.1 High voltage feeder program

The high voltage feeder program is the largest component of TasNetworks’ proposed distribution augex over the 2019-24 regulatory control period, contributing over 75% of the total distribution augex.[156]

The program involves the development of a number of existing and new HV distribution feeders and associated elements operating at the distribution level. The individual programs within the high voltage feeder program are:[157]

- Augment HV Control Station - Fault level
- Augment HV Feeder - Fault Level
- Augment HV Feeder - Network access development
- Augment HV Feeder (Capacity)
- Augment HV GI Feeder - Capacity

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[156] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 118
[157] Arup’s analysis of TN-Capex Forecast Model - Standard Control

- Derwent Bridge 22 kV supply development
- East Coast South supply development
- Hobart CBD 11 kV supply development
- Install HV and LV Conduit with other UG works (Capacity)
- Install/Augment Ground Mounted Voltage Regulator for Capacity
- Install/Augment Pole Mounted Voltage Regulator for Capacity
- Meadowbank 22 kV supply development

Arup has reviewed two key projects within the HV program: the Hobart CBD 11 kV supply development and the augmentation of HV overhead Galvanised Iron (GI) feeders.

7.1.1 Previous & Forecast Expenditure

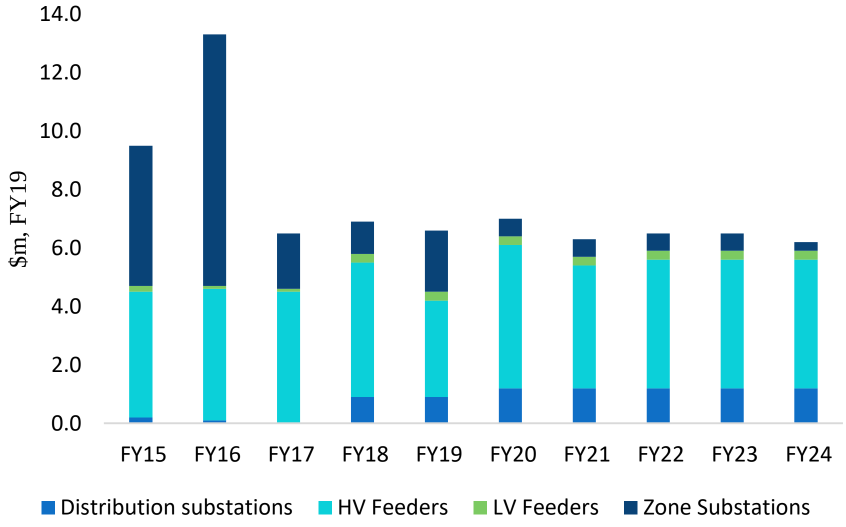

Figure 46 Distribution augmentation capital expenditure ($m, FY19)[158]

7.1.2 Investment driver

Considering the high voltage feeder program is made up of several smaller programs, TasNetworks has identified a number of key investment drivers, including:[159]

- asset capability
- forecast new load and generation connection requests
- network access requirements
- demand forecasts
- network performance requirements and reliability improvements

[158] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*
[159] TasNetworks, 2017, *Network Development Asset Management Plan*, pg 14

- National Electricity Rules (NER) compliance

7.1.3 Hobart CBD 11 kV supply development

The Hobart CBD 11 kV supply development involves the augmentation of existing substation sites to include additional switching capability, SCADA, and develops the cable networks towards meshed 11 kV feeder networks.[160]

TasNetworks expects the program will improve the reliability and service performance of Hobart which is subject to the most stringent targets in the network, by allowing TasNetworks to manage thermal loadings on its underground cable networks and improve the network's ability to host new commercial developments.[161]

Additionally, TasNetworks anticipates that the program will result in a capex / opex trade off, whereby the capex expenditure benefits TasNetworks through lower ongoing operating expenditure. Arup's understanding is that TasNetworks has not yet quantified the magnitude of the capex / opex trade off.[162]

Table 66 Hobart CBD 11 kV supply development capex[163]

	FY20	FY 21	FY22	FY23	FY24
Total ($, FY17)	$644,049	$909,655	$866,984	$600,805	$601,077

7.1.4 Augmentation of HV overhead Galvanised Iron (GI) feeders

As part of the HV feeder program, TasNetworks has proposed to augment large 3/12 GI conductor spurs where the connected load on these feeder sections has grown in excess of the conductor capability, and is resulting in voltage and power quality issues.

TasNetworks has undertaken an asset assessment and identified the spur sections that are most likely exposing customers to unacceptable voltage levels. The proposed expenditure is based on reinforcing these sites so that the remaining load supplied from GI conductor is < 300 kVA and < 600 kVA in the 11 kV and 22 kV networks respectively.[164]

TasNetworks propose that during the 2019-24 period a program, a total of 50 km of overhead conductor is augmented.

[160] TasNetworks, 2017, *Network Development Management Plan*
[161] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 177
[162] Interviews between Arup and TasNetworks, May 21-22 2018
[163] Arup's analysis of TN-Capex Forecast Model – Standard Control
[164] TasNetworks, 2017, *Network Development Management Plan*, pg 35

Table 67 Augmentation of HV overhead GI feeders' capex and volume[165] [166]

	FY20	FY 21	FY22	FY23	FY24
Distance (km)	10	10	10	10	10
Total ($2016/17)	$835,225	$832,710	$843,251	$849,977	$850,360

7.1.5 Arup findings and recommendations

Overall, TasNetworks' proposed distribution augex for the 2019-24 regulatory control period appears to be reasonable, and is consistent with their historical level of expenditure.

Arup would expect that TasNetworks has undertaken and completed an Investment Evaluation Summary for each proposed project or program within the wider augmentation program to ensure that the most efficient and prudent investment solution has been identified. As identified elsewhere in this report, it is essential that TasNetworks use an appropriate VCR depending on whether the project or program impacts residential customers, commercial customers or a combination of both.

Arup would also expect TasNetworks to quantify expected capex / opex trade-offs to ensure that an appropriate level of opex is being displaced or deferred to justify the capex investment.

7.2 Connection expenditure

Distribution connection capital expenditure is the direct cost associated with a new customer requesting connection to the distribution network or an existing customer requesting a change to their existing connection.

Depending on the nature of the connection, customers may be required to make a contribution towards the total cost of the connection works. The customer contribution is offset against the gross connection expenditure to equal net connection expenditure, which is the amount included in TasNetworks' regulatory asset base.

165 Arup's analysis of TN-Capex Forecast Model – Standard Control

166 TasNetworks, 2017, *Network Development Management Plan*, pg 30

7.2.1 Previous & Forecast Expenditure

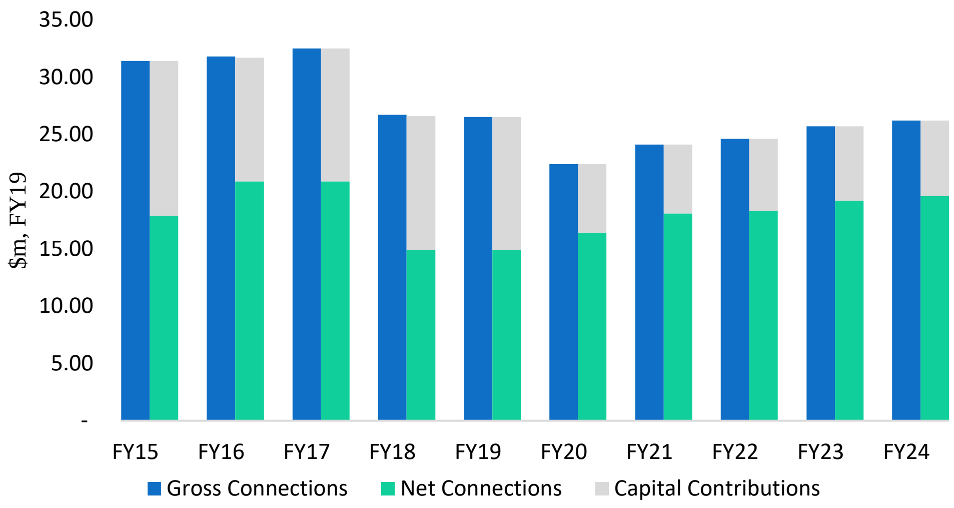

Figure 47 TasNetworks' historical and forecast distribution connection expenditure[167]

7.2.2 Investment driver

Distribution connection capital expenditure is driven primarily by new customers requesting connection to the distribution network or existing customers requesting a change to their existing connection.

Figure 48 shows TasNetworks' historical and forecast new residential connections (basic),[168] highlighting the number of new residential connections (basic) is expected to increase from approximately 2,200[169] connections in 2016-17 to 2,800[170] connections in 2023-24, representing a 3.5%[171] annual increase over the 7-year period.

[167] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*
[168] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 72
[169] Based on Arup's estimate of the number of connections in 2016-17 presented in Figure 48
[170] Based on Arup's estimate of the number of connections in 2023-24 presented in Figure 48
[171] Calculated using the geometric mean

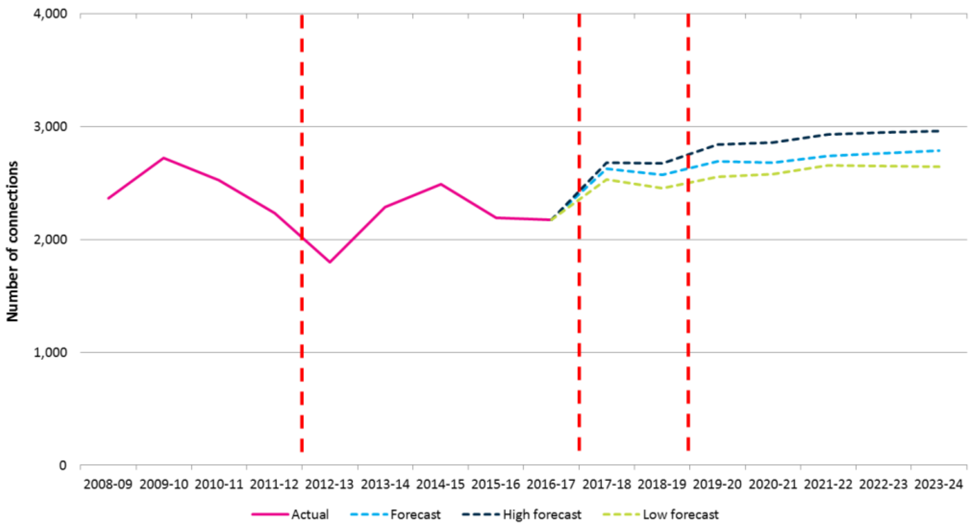

Figure 48 New residential connections – basic[172]

Figure 49 shows that GSP is expected to grow by between 0.5% and 2.2% each year in the coming RCP. TasNetworks has proposed gross connection expenditure to increase by approximately 4% per annum from FY20 to FY24.

[172] TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory Proposal*, pg 75

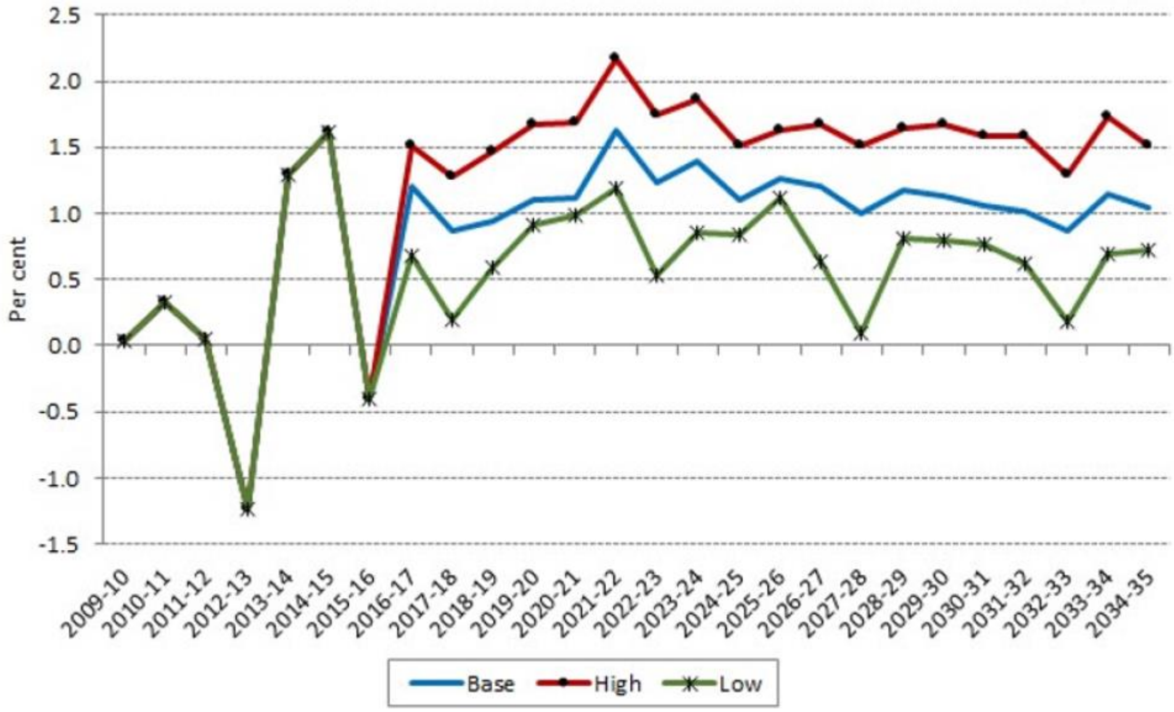

Figure 49 Tasmanian GSP growth by scenario – 2009-10 to 2034-35[173]

7.2.3 Arup findings and recommendations

TasNetworks' proposed net distribution connection expenditure for the 2019-24 regulatory control period appears to be consistent with their historical level of expenditure despite expecting an increase in the number of connections over the same period.

In TasNetworks' submission, customer contributions for the 2019-24 regulatory control period decrease as a percentage of gross distribution connection expenditure compared to previous years as highlighted in Figure 50.

[173] TasNetworks, 2018, *AER Information Request: TasNetworks response to questions raised by the AER ID017*, pg 7

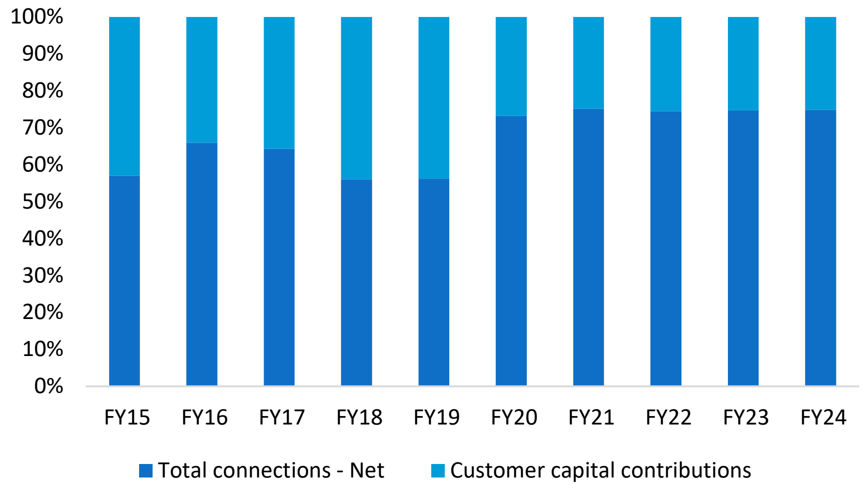

Figure 50 Proportion of customer contributions and net connection expenditure to gross connection expenditure[174]

Arup has not seen any justification for the decreasing ratio of contributions to connections. TasNetworks has indicated it will review its forecasting methodology for capital contributions:

> *The forecast value of customer contributions for the 2019-24 period is lower than experienced in recent years and the expected amount for both 2017-18 and 2018-19. TasNetworks is in the process of reconsidering its forecast capital contributions for the 2019-24 in light of updated actual data, using data from 2017-18 (being the first year of application of our new connection policy). Our expectation is to increase our forecast capital contributions for the 2019-24 period as part of the revised regulatory proposal process.*[175]

Otherwise, TasNetworks forecasting methodology and proposed capex for connections using GSP as reference appears robust, noting that net connections are expected to decrease pending a review that is expected to result in increased forecast of contributions.

Gross connection capex is also proposed to increase at a higher rate than GSP, though as TasNetworks do not rely solely on GSP to forecast connections and the current RCP has seen a step change down in gross connections despite growing GSP. As such, we do not consider the difference between growth in proposed gross connections capex and GSP to necessarily undermine TasNetworks' forecasts.

Additionally, Arup welcomes the comment provided by the CCP13 submission that a "user pays" approach, that avoids smaller consumers cross subsidising larger consumers' individual connection requirements, is a positive step by TasNetworks.[176] However, Arup notes that this should only apply where consumers' and large customers' tariffs are cost reflective of the assets they use within the shared network and for connection to the shared network, reflecting the voltage level, load profile, and frequency and inertia benefits that large loads bring to the overall operation and performance of the grid.

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[174] Arup analysis of TasNetworks, 2018, *Tasmanian Transmission Revenue and Distribution Regulatory*

[175] TasNetworks, 2018, *AER Information Request: TasNetworks response to questions raised by the AER ID017*, pg 8

[176] Consumer Challenge Panel Sub-Panel 13, 2018, *Response to proposals from TasNetworks for a revenue reset for the 2019-24 regulatory period*

8 ICT capex observations

TasNetworks' proposed ICT capex of $103.8m in the FY20-24 regulatory periods represent a 32% increase from the actual and expected ICT capex of $78.5m from FY15-19.

The non-recurrent expense of the Market System Meter Data Management System (MDMS) replacement and upgrade is the major capex program in this period, with TasNetworks forecasting $62.7m of capex over the full life of the project[177].

The delivery of core IT infrastructure services is the next largest proposed program at $16.1m in the upcoming regulatory period[178].

This chapter focuses on the prudency of these two programs.

8.1 MDMS replacement

8.2 IT infrastructure, security and support services

8.1 MDMS replacement

The Meter Data Management System (MDMS) is responsible for maintaining installation details for all 280,000 distribution connection points including unmetered supplies.

Installation details include:

- installation address and configuration
- customer names and postal address (received from Retailers)
- route details
- access details
- potential hazards
- generation and storage of consumption data for unmetered supplies (streetlights, traffic lights, etc.)
- metering configuration details for all distribution connection points (500,000 meters)
- reading rounds and interface to Meter Reading System
- validation, substitution and storage of meter reading / consumption data for all basic meters

The data within the MDMS supports various internal processes and downstream systems including: service order processing, customer facing processes, distribution billing and market interfaces. It also supports the retail billing of customers via the meter data collected, validated / substituted and supplied to retailers.

TasNetworks has specified a project with the objective of replacing the existing MDMS system.

[177] TasNetworks, 2018, Market Systems MDMS Replacement 1897, pg 1
[178] TasNetworks, 2018, Core Services 2422, pg 1

8.1.1 Project drivers

The main drivers for this project are:

- the current MDMS system has been in operation for over twelve years, which would be eighteen years at the end of the FY20-24 regulatory control period
- potential future modifications driven by regulatory change may be difficult to implement to the existing system
- the underlying database platform that the system uses will be unsupported by the end of the FY20-24 regulatory control period
- the system lacks a number of features that users expect in modern systems
- alignment with TasNetworks Enterprise Architecture Principles

8.1.2 Project options

TasNetworks has proposed four options for the future state of the Meter Data Management System (MDMS). These are:

- Option 0: Do nothing
- Option 1: Deploy a new ERP module and transfer functionality into their existing ERP
- Option 2: Upgrade the MDMS to a new version with the current vendor
- Option 3: Go to market and source a new vendor / product

The option which has been selected to progress is Option 1. Although this option does not have the lowest cost, TasNetworks has suggested that the improved integration with other ERP modules will improve efficiency, provide greater functionality and improve customer service. It also aligns with their strategy of a centralised data platform.

Arup observation

The investment evaluation summary for the MDMS replacement project has the assumption that the accuracy for the costs associated with the project are ±30%. The costs also do not allow for an additional 20% project contingency. With the amount of analysis and planning accomplished we would expect a submission with an accuracy of no more than +/- 10%.

The IES states in the MDMS IES that there will be a year on year gradual reduction in the customer base as customers move to other MDP's. With an estimated decline over the next ten years to be between 30-60%. However, the IES does not include the results of any sensitivity analysis. Arup suggest that TasNetworks explore the impact of customer migration on the project; we would expect that whether 30% or 60% of customers moved would have a material impact on the validity of the project. TasNetworks may have chosen a middle point but this is not clear in the IES.

The preferred selection (Option 1) is to deploy a new ERP module and transfer functionality into their existing ERP system. This option is more expensive than upgrading the existing MDMS system. It could be argued that the option of adding additional modules to an existing system should provide some economies of scale. These could be in overall licencing costs or

TCO costs that would include licencing, infrastructure, business continuity management, support and maintenance savings. The additional cost of support and maintenance for the existing system was listed as a disadvantage for option 2 in the options analysis.

It could be argued that from the analysis of options 1 and 2, the key criteria for selecting Option 1 over Option 2 is TasNetworks strategic goal of:

> *"Maximise the value from our enterprise platform (ERP) investment by further integrating business solutions within the environment and aligning access to it."*

However, there is a strong argument against this 'Silo' strategy as it significantly reduces the organisations agility and ability to change and utilise newer technologies and tools. With the common use of cloud services and the agility benefits that cloud provides, systems are being designed to be more 'loosely coupled', with coupling is a characteristic that defines the degree to which components of a system depend on one another.

Furthermore, Option 2 provides a strong argument as it is lower cost, has less risk, is less complex, has lower business impact and can be delivered in a more effective time. TasNetworks state:

> "*TasNetworks' Technology Strategy seeks to leverage economies of scale, lower cost and risk profiles, provide a higher return to shareholders and increase customer satisfaction through lower market pricing and innovative services and solutions."*

It should also be noted that there have been no details or metrics specified by TasNetworks for the improvements to administrative and operational costs, customer service and business efficiency and effectiveness.

The advantages and disadvantages of options 1 and 2 are as follows:

Option 1 – Advantages:

- can satisfy the business requirements
- strong strategic alignment
- will contribute to a reduction in administrative and operational costs.
- will contribute to increase business efficiency and effectiveness
- improved customer service.
- more contemporary system – however has this been compared to the newer Gentrack MDMS?
- can be made compliant

Option 1 – Disadvantages:

- is $10m more expensive than Option 2
- Requires customisation to the base ERP product – something we would recommend to avoid
- full benefits not realised until all systems are integrated
- requires complex business process change

- high project complexity – particularly in data migration
- modifications may be required for it to be compliant
- higher risk profile than Option 2
- project to be completed in a less effective time than Option 2

Option 2 – Advantages:

- satisfies the business requirements
- $10m less than Option 1
- will have a lower business impact than Option 1
- has partial strategic alignment – with the possibility of filling the gap with functionality provided by the data warehouse, business intelligence and analytics initiatives
- the project complexity is lower than Option 1
- is compliant
- has the lowest risk profile of all the options
- project can be completed in a more effective time

Option 2 – Disadvantages:

- higher administrative and operational costs – due to ineffective information flow
- separate support and maintenance vs ERP – could have cost implications
- lacks strategic alignment with ERP system
- cannot provide a single view of customer data
- has a 'sub-optimal' BI tool – this functionality could be provided by the data warehouse, business intelligence and analytics initiatives

Listed under the disadvantages for Option 1 is 'High volume processes will move to the ERP requiring complex process change for the business'. There are no obvious costs associated with upgrades to the infrastructure for the Production, Test, Development and DR ERP instances. Therefore, we assume that due diligence has been done to ascertain that they have the required performance and capacity to handle the 'high volume processing' that the additional module will bring. If this is not the case, then TasNetworks should explore this analysis.

We note that a correction in TasNetworks' NPV calculations has resulted in the further divergence of the NPVs between Option 1 and Option 2, increasing the expected savings that would result in pursuing Option 2 over Option 1[179]. TasNetworks has noted that:

[179] TasNetworks, 2018, *AER Information Request: TasNetworks response to questions raised by the AER IR18*, pg 9

> *TasNetworks will engage with the Option 2 vendor to further refine our understanding of vendor costs relating to Option 2. We are pursuing the vendor to provide a budgetary estimate for this initiative. We will update, and if necessary revise, our position on Option 1 versus Option 2 following the review of our current assumptions.*[180]

If TasNetworks confirm the material NPV difference between Option 2 and Option 1 then we would expect them to revise their position accordingly, understanding that while Option 1 might align more with strategic goals, the significant savings of Option 2 should be reflected in TasNetworks final decision.

Finally, the costs in general for the MDMS replacement appear high, particularly when considered against TasNetworks' previous forecasts for the MDMS replacement project in their previous estimates provided to the AER[181][182]. We note that what constituted the three major capex project (MDMS replacement, upgrades, and core services), didn't change between proposals. The forecasts for MDMS upgrades and IT core services also didn't change materially, however the forecast for the MDMS replacement appears to have more than doubled. TasNetworks increased forecasts require further justification before being judged as prudent or efficient.

8.1.3 MDMS upgrades

The TasNetworks Software Asset Management plan states that the current MDMS requires ongoing upgrades to address requirements from the biannual change program from AEMO.

These changes are primarily driven by regulatory changes, imposed by the AEMC. These may affect a variety of market processes, participant interactions and obligations.

For compliance purposes TasNetworks state that they need to make biannual changes to the current MDMS. These changes will be across the entire regulatory period 01.07.2019 – 30.06.2024. The cost of these upgrades is estimated at $10.6m (±30%) and do not include 20% for project contingency, information included in the IES for MDMS upgrades.

Arup observation

TasNetworks suggest there is approximately $2m of change required to the current MDMS system per year for the next five years of the regulatory period. The impact of these changes to the MDMS is hard to ascertain as there is very little detail around the scope and impact these have.

MDMS upgrades would also be predicated to an extent on the MDMS replacement option. There are also potential interrelationships between the two projects in terms of timing of replacement, as well as the proposed investment in Data Warehouses, Business Intelligence and Analytics, as well as the Enterprise Architecture Evolution and Enterprise Information Management. For example, investment in enterprise functions may provide a better understanding of the 'current state', analysing the impact of change and planning change in the technology landscape.

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[180] TasNetworks, 2018, *AER Information Request: TasNetworks response to questions raised by the AER IR31*, pg 4

[181] TasNetworks, 2015, *Corporate IT – Software Asset Management Plan*, pg 46 and pg 56-57

[182] TasNetworks, 2015, *Corporate IT – Infrastructure Asset Management Plan*, pg 28

The relationships between these proposed investments must be thoroughly understood and mapped out by TasNetworks in order to realise the full potential benefits of the projects.

8.1.4 Arup findings and recommendations

Given the observations detailed above, there can be a strong argument made for deferring much of the proposed MDMS replacement expenditure into the next RCP (FY25-29). Much of the expenditure is already planned for that period, and deferring the majority of expenditure planned for FY23-24 would result in a more thorough understanding of the need for the system, consumer preferences, and the technology options available.

This would not negate the need for MDMS capex entirely, as additional upgrades and maintenance would be required for the upcoming RCP in order to meet compliance requirements. The opex / capex trade-off of additional opex in maintaining the current system to the next RCP versus deferred capex benefits would have to be considered by TasNetworks.

8.2 IT infrastructure, security and support services

The TasNetworks Information Technology (IT) team is responsible for delivering Architecture, Infrastructure and data network services; desktop services and application support; data management and development and project delivery, testing and governance. IT Infrastructure systems are the shared hardware, software, monitoring and administration tools forming the foundation of shared IT capabilities upon which business systems are built.

TasNetworks has produced a high-level plan of expenditure for their Core Services, consisting of:

Network

- local area and wide area networking equipment;
- core networks;
- monitoring and management software for network platforms.

Compute

- physical servers and hardware appliances;
- associated system software, including server virtualisation and operating system software;
- monitoring and management software for computer platforms.

Storage

- shared storage solutions;
- enterprise backup system;
- monitoring and management software for storage and backup platforms

For each of these areas the following items are considered:

- maintenance, upgrade, extension and replacement of storage arrays, compute (server) and core network hardware;
- maintenance, upgrade, extension and replacement of supporting software and management components dedicated to these core components;
- maintenance, upgrade, extension and replacement of supporting hardware dedicated to the storage arrays and storage access platforms (storage fabric).

TasNetworks has proposed three options for the future state of the IT Infrastructure. These are:

- Option 0: Do nothing.
- Option 1: Upgrade and replace with annual increases to capacity
- Option 2: Defer Upgrading and replacement of core IT Infrastructure.

The option which has been selected to progress is Option 1

The investment in IT Infrastructure seeks to address two challenges:

1. Asset end of usable life and end of supported life; at the time of writing, the current support state of various operating systems is made up of 209 (28%) servers in Extended Support (end of Mainstream Support), and 85 (11%) servers are Out Of Support.
2. Need for increased capability, performance and capacity to support the organisation.

TasNetworks in the IT Core Services IES state that[183]:

> *If the Information Technology team does not invest in the Storage, Computer and Network infrastructure assets, it is extremely likely (close to certain) that asset failures in one or more of these asset classes will occur each year after asset end of life, leading to a loss of the Information Technology service that supports critical business processes for internal and external customers.*

Arup observation

The options analysis listed is somewhat limited and is very much a 'traditional' approach to IT infrastructure by having a recurring cycle of replacing the existing infrastructure with newer devices that aim to provide an improved performance or greater capacity than the current equivalent.

TasNetworks has documented their projected Capex spend in IT Core Services Investment Summary to be $16.194m for the regulatory period of 2019 – 2024 and a circa 1.6% increase in spend of $16.462m for the period 2024 – 2029. We therefore presume that TasNetworks is to carry on with this 'traditional' approach for the next ten years.

It could be argued that the increased strategic use of Cloud services could provide significant benefits to TasNetworks provision of IT services. However, we believe that this approach has

[183] TasNetworks, 2018, *IT Infrastructure Core Services - Investment Evaluation Summary*, pg 5

been discounted by the assumption in TasNetworks IT Core Services Investment Summary ITA-079 which states that no significant move to externally hosted services (cloud)[184].

TasNetworks state that:[185]

> "*The goal of maintaining IT Core Services is to ensure prudent and timely investment through annual incremental expansion or refresh as well as scheduled major uplifts (as technology advances are realised or components reach the end of their extendable and supportable life)*."

We would argue that the management of services is to ensure that services fully align with the needs of the business and meet the customer's requirements for functionality, availability and performance. This often does not align with annual incremental change.

Cloud services can provide the following benefits:

- Agility - Cloud services enable IT to respond rapidly to changing business demands. New resources can be enabled in hours not days or weeks and be utilised for only as long as the business requires them. The 'elasticity' of cloud services means that you can provide greater processing power, memory, storage capacity in minutes and use it for just as long as you need it. Services can be powered down when they are not required, such as test and development systems.
- Improved Service Performance - Moving services onto cloud platforms allows us to reorganise our service provision by enabling a single coordinated team that has the skills and tools to provide the highest levels of service to customers. Use of Automation tools with enable IT to be more efficient and improve service stability.
- Accessibility & Collaboration - Utilising the Cloud, IT could provide users with access to Digital Technology services from anywhere they have a connection across a range of end user devices. Providing secure platforms and access to information for collaboration.
- Capex Reduction - Utilising cloud services significantly reduces the requirement for major capital expenditure in infrastructure. Instead, it provides a detailed and predictable operating cost, that offers a mechanism for recharging for services and stops any long-term commitment in a technology stack.
- Business Continuity & Disaster Recovery - Architected correctly, cloud services will provide a significant improvement in Business Continuity Management (BCM) & Disaster Recovery (DR). Native cloud applications can easily be configured to remove single points of failure. Automation tools can perform health checks, detecting and reacting to issues. The availability of multiple cloud Data Centre's within a region provide improved options for BCM and service levels to our business.
- New Service Offerings & Innovation - Cloud providers provide access to a huge range of global services that otherwise would be cost prohibitive. Allowing IT to consume on a small scale for innovation, combining services to create new offerings both internally and externally. Again, only paying for what they consume. These

[184] TasNetworks, 2018, *IT Infrastructure Core Services - Investment Evaluation Summary*, pg 22
[185] TasNetworks, 2018, *IT Infrastructure Core Services - Investment Evaluation Summary*, pg 3

services include large scale compute, analytics, machine learning, AI, IoT, AR and VR

- Operational Cost Reductions - Moving services to a cloud environment can provide a number of cost benefits. This includes: a significantly reduced footprint for Data Centre's, reduction of infrastructure investment, reduced number of resources to manage the cloud estate. Freeing up resource to do more value add activities.
- Application Rationalisation - Moving to a cloud environment provides an opportunity to rationalise the portfolio of applications. Standardising on applications that support business capabilities. This will allow a reduction in spend, improve performance, support and maintenance on a set of services that will support common practices.

There are a number of requirements within the TasNetworks IT Infrastructure documentation that align very well with the above benefits that Cloud services provide:

> *"Increasing reliance on IT systems and growing trends in business intelligence and big data are resulting in rapidly increasing demands on TasNetworks IT infrastructure. It is an ongoing challenge to maintain an appropriate capacity in terms of servers, CPUs, memory and storage."*[186]

8.2.1 Arup findings and recommendations

TasNetworks do acknowledge cloud computing as a transformative technology, and anticipate their further use to deliver material benefits to the network.[187]

Arup does not advocate a 100% move to Cloud services but consider their use to enable IT systems to become more flexible and scalable to meet business demand. IT operations could become more automated reducing run costs and allowing staff to focus their efforts on value add work, such as improving existing or supporting new Services.

We understand that any further transition to the Cloud will cause disruption as people, processes and technology changes. During such transitions, skills and delivery teams to support the work will need to be enhanced by training and external support required from cloud service providers and partners. Dual running of on premises IT systems and cloud services would likely be required which will add resource and cost to IT operations during the transition to cloud.

It does appear from the lack of detail around cloud computing in the core services IES that TasNetworks could allocate additional resources into cloud computing to realise the benefits described above.

[186] TasNetworks, 2017, Corporate IT – Software *Asset Management Plant*, pg 9
[187] TasNetworks, 2017, *Asset Management Plant: IT-Infrastructure*, pg 10-11

9 Next steps for TasNetworks

It is clear that TasNetworks has a detailed understanding of its network and a commitment to ensuring the ongoing safe and reliable provision of services to Tasmanians. However, the organisation lacks sophistication in some of the key considerations behind capex investment, particularly in regards to IES processes and risk quantification.

As a result, TasNetworks has been unable to demonstrate that the proposed uplift in distribution and transmission capex represents a prudent and efficient investment for its customers.

TasNetworks is expected to submit a revised capex proposal in accordance with the regulatory process for NSPs in the NEM. TasNetworks management is committed to improving the business, and has acknowledged that the network needs to mature in its assessment of risk. We would expect to see this reflected in its revised proposal to the AER.

10 Glossary

AEMC: Australian Energy Market Commission

AEMO: Australian Energy Market Operator

AER: Australian Energy Regulator

Augex: Augmentation expenditure

Capex: Capital expenditure

CBD: Central Business District

DNSP: Distribution Network Service Provider

FY: Financial Year

HV: High Voltage

IES: Investment Evaluation Summary

LV: Low Voltage

NEL: National Electricity Law

NEM: National Electricity Market

NEO: National Electricity Objectives

NER: National Electricity Rules

NSP: Network Service Provider

RCP: Regulatory Control Period

Repex: Replacement expenditure

SAIDI: System Average Interruption Duration Index

SAIFI: System Average Interruption Frequency Index

TEMCO: Tasmanian Electro Metallurgical Company

VCR: Value of Customer Reliability