Addressing reliability requirements in the Clovelly load area

FINAL PROJECT ASSESSMENT REPORT

10 AUGUST 2018

Ausgrid

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Final Project Assessment Report – August 2018

Contents

Glossary of Terms

Term	**Description**
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
DNSP	Distribution Network Service Provider
DPAR	Draft Project Assessment Report
FPAR	Final Project Assessment Report
IPART	Independent Pricing and Regulatory Tribunal
NPV	Net Present Value
NER	National Electricity Rules
POE	Probability of Exceedance
RIT-D	Regulatory Investment Test for Distribution
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
USE	Unserved Energy
VCR	Value of Customer Reliability

Executive Summary

This report is the final stage in a RIT-D investigating the most economic option for mitigating the risks associated with fluid-filled feeders installed in the Clovelly area in the late 1960s and early 1970s

This Final Project Assessment Report (FPAR) has been prepared by Ausgrid and represents the final step in the application of the Regulatory Investment Test for Distribution (RIT-D) to options for ensuring reliable electricity supply to the Clovelly zone substation (ZS) load area going forward.

In particular, the underground electricity distribution lines (‘feeders’) supplying the Clovelly ZS were commissioned in the 1960s and 1970s, and are now reaching, or past, the end of their technical lives. These feeders are self-contained fluid filled (SCFF) cables, which are now considered an obsolete and dated technology. They are becoming less reliable and approaching the point at which their replacement maximises the net benefit for the community.

A draft report was released in June 2018 and received no submissions

A Draft Project Assessment Report (DPAR) for this RIT-D was published on 22 June 2018. The DPAR presented two credible options for addressing asset condition concerns in the Eastern Suburbs network area, assessed in accordance with the RIT-D framework and concluded that the preferred option was to replace two existing feeders from Zetland ZS to Clovelly ZS with a new feeder from Kingsford ZS. Specifically, this option involves the installation of one new 132kV feeder and a spare conduit line (for a future feeder) from Kingsford ZS to Clovelly ZS.

The DPAR also summarised Ausgrid’s assessment of the ability of non-network solutions to contribute the identified need, which concluded that such solutions were not viable for this particular RIT-D. The DPAR was accompanied by a separate non-network screening notice that provided further detail on this assessment, in accordance with clause 5.17.4(d) of the NER.

The DPAR called for submissions from parties by 3 August 2018. However, no submissions were received on either the DPAR or the separate non-network screening notice.

This report therefore re-presents the assessment in the draft report and maintains the conclusion that Option 1 is the preferred option

In light of there being no submissions made to either the DPAR or the separate non-network screening notice, as well as there being no significant exogenous changes to factors affecting this RIT-D assessment since the DPAR was released, this FPAR re-presents the assessment undertaken in the DPAR.

Ausgrid has identified two network options that either replace the existing Clovelly ZS feeders by installing one new 132kV feeder, coupled with a spare conduit for a future feeder, from the nearby Kingsford ZS or undertaking a like-for-like replacement of the existing Clovelly to Zetland ZS feeders.

The two credible options are summarised below. All costs in this section are in real $2017/18, unless otherwise stated.

Table E.1 – Summary of the credible options considered

Overview	Key components	Length of new feeders	Estimated capital cost
Option 1 – new feeders from Kingsford ZS to Clovelly ZS	Installation of one new 132kV feeder and a spare conduit (for a future feeder) connecting Kingsford ZS to Clovelly ZS using modern XLPE cable to replace existing SCFF feeders.	4.1km	$14.7 million
Option 2 – like-for-like replacement of existing Zetland ZS to Clovelly ZS feeders	Replacement of existing Zetland ZS to Clovelly ZS feeders like-for-like using two new XLPE cable feeders.	4.5km (for each feeder)	$26.8 million

Option 1 has been found to be the preferred option, which satisfies the RIT-D. It involves the replacement of the two existing feeders from Zetland ZS to Clovelly ZS with a new feeder from Kingsford ZS. Specifically, this option involves the installation of one new 132kV feeder and a spare conduit line (for a future feeder) from Kingsford ZS to Clovelly ZS.

The scope of this project includes:

- works at Clovelly ZS and Kingsford ZS to facilitate the new 132kV feeder connection;
- use of the existing 132kV circuit breaker at Kingsford ZS to connect the new feeder;
- installation of one 132kV XLPE feeder of 4.1km from Clovelly ZS to Kingsford ZS, with a firm rating of 230MVA;
- installation of one spare duct to accommodate a future second circuit to occupy the same trench;
- associated control and protection communication upgrades at Clovelly ZS and Kingsford ZS; and
- decommissioning of existing SCFF feeders between Clovelly ZS and Zetland ZS.

The preferred route runs south from the Clovelly ZS along St Marks Road to Oswald Street, east to Courland Street and south to Dolphin Street. At Dolphin Street, the route would travel south along St Luke Street and Dudley Street to Howard Street, crossing Coogee Bay Road. From Howard Street, the cables would run south along Canberra Street and west along Bundock Street and Sturt Street, crossing Avoca Street, to Anzac Parade. The cables would cross Anzac Parade into Hayward Street and Anderson Street where they would connect into the Kingsford substation.

Ausgrid has engaged with the local community and already has held two community information sessions in April 2018 on the preferred route as part of the community consultation process. Ausgrid encourages community feedback and has committed to keep the community informed as the project progresses through notification letters, door knocks and the Ausgrid website. Ausgrid has also notified Randwick City Council and RMS regarding the proposed project.

The estimated capital cost of this option is approximately $14.7 million. Ausgrid assumes that the necessary construction to install the new feeders would commence in 2018/19 and end in 2019/20. Once the new installation is complete, operating costs are expected to be $70,000 per annum (around 0.5 per cent of capital expenditure).

Ausgrid considers that this FPAR, and the accompanying detailed analysis, identify Option 1 as the preferred option and that this satisfies the RIT-D. Ausgrid is the proponent for Option 1.

Next steps

Ausgrid intends to commence work on delivering Option 1 in 2018. In particular, we intend to award the construction contract in October 2018, have environmental approvals also finalised by end of 2018 and to commence construction in late 2018.

Any queries relating to this Final Project Assessment Report should be addressed to:

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Or

email to: assetinvestment@ausgrid.com.au

1 Introduction

This Final Project Assessment Report (FPAR) has been prepared by Ausgrid and represents the final step in the application of the Regulatory Investment Test for Distribution (RIT-D) to options for ensuring reliable electricity supply to the Clovelly zone substation (ZS) load area going forward.

In particular, the underground electricity distribution lines (‘feeders’) supplying the Clovelly ZS were commissioned in the 1960s and 1970s, and are now reaching, or past, the end of their technical lives. These feeders are self-contained fluid filled (SCFF) cables, which are now considered an obsolete and dated technology. They are becoming less reliable and approaching the point at which their replacement maximises the net benefit for the community.

Ausgrid identified the need to replace the feeders supplying the Clovelly ZS in 2017 and identified a preferred solution to mitigating the identified risks.

Since early 2018, Ausgrid has engaged with the local community seeking feedback on the preferred replacement option identified in 2017. These activities included notifying Randwick City Council and RMS, holding community information sessions, as well as having representatives from the Ausgrid project team speak to many businesses and visiting residents in the area. This consultation included visiting and distributing project information to residents along the impacted streets. Ausgrid encourages community feedback and has committed to keep the community informed as the project progresses through notification letters, door knocks and the Ausgrid website. Ausgrid wishes to thank all those consulted with for their time and suggestions.

Rule changes to the National Electricity Rules (NER) in July 2017 have meant that the replacement plans for ageing feeders are now subject to the RIT-D. Accordingly, Ausgrid has initiated this RIT-D for replacing ageing feeders supplying the Clovelly ZS in order to investigate and consult on options to ensure Ausgrid is able to satisfy the reliability and performance standards that it is obliged to meet.

Ausgrid has determined that non-network solutions are unlikely to form a standalone credible option, or form a significant part of a credible option, as set out in the separate notice released in accordance with clause 5.17.4(d) of the NER.

1.1 Role of this final report

Ausgrid has prepared this FPAR in accordance with the requirements of the NER under clause 5.17.4.

The purpose of the FPAR is to:

- describe the identified need Ausgrid is seeking to address, together with the assumptions used in identifying it;
- provide a description of each credible option assessed;
- quantify relevant costs and market benefits for each credible option;
- describe the methodologies used in quantifying each class of cost and market benefit;
- provide reasons why Ausgrid has determined that classes of market benefits or costs do not apply to a credible option(s);
- present the results of a net present value analysis of each credible option and accompanying explanation of the results; and
- identify the proposed preferred option.

This FPAR follows the DPAR released in June 2018. The FPAR represents the final stage of the formal consultation process set out in the NER in relation to the application of the RIT-D as outlined in Appendix B. The entire RIT-D process is detailed in Appendix B.

1.2 No submissions were received on the DPAR

The DPAR presented two credible options for addressing reliability concerns in the Eastern Suburbs network area, assessed each in accordance with the RIT-D framework and concluded that the preferred option was to replace two existing feeders from Zetland ZS to Clovelly ZS with a new feeder from Kingsford ZS. Specifically, this option involves the installation of one new 132kV feeder and a spare conduit line (for a future feeder) from Kingsford ZS to Clovelly ZS.

The DPAR also summarised Ausgrid’s assessment of the ability of non-network solutions to contribute, which concluded that such solutions were not viable for this particular RIT-D. The DPAR was accompanied by a separate non-network screening notice which provided further detail on this assessment, in accordance with clause 5.14.4(d) of the NER.

The DPAR called for submissions from parties by the 3 August 218. However, no submissions were received on either the DPAR or the separate non-network screening notice.

1.3 Contact details for queries in relation to this RIT-D

Any queries in relation to this RIT-D should be addressed to:

Matthew Webb
Head of Asset Investment
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GPO Box 4009
Sydney 2001

Or

email to: assetinvestment@ausgrid.com.au

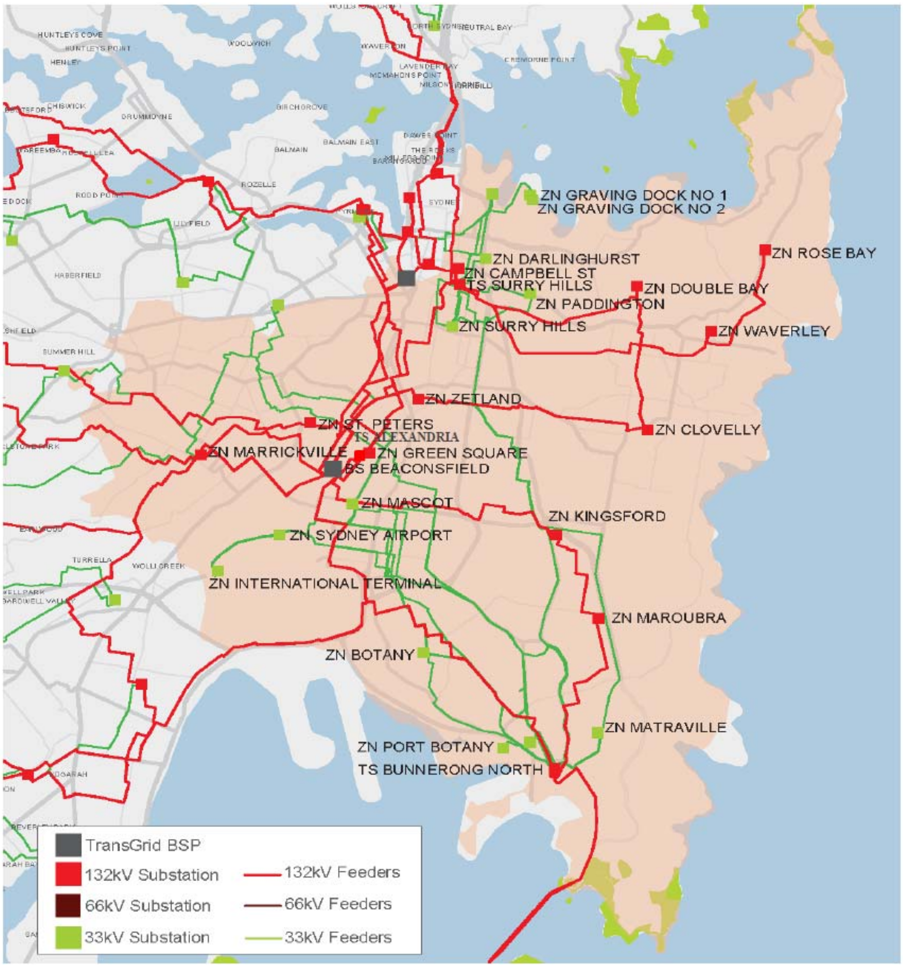
2 Description of the identified need

This section provides a description of the network area and the 'identified need' for this RIT-D, before presenting a number of key assumptions underlying the identified need.

2.1 Overview of the Eastern Suburb distribution network and existing supply arrangements for Clovelly Zone Substation

The Eastern Suburbs network area includes Sydney's eastern seaboard from South Head to La Perouse, and extends inland to Surry Hills, and west as far as Marrickville. The Eastern Suburbs area is supplied from the Inner Metropolitan transmission network, including Bunnerong subtransmission substation (STS) and TransGrid's Beaconsfield and Haymarket Bulk Supply Points (BSP). This network consists of 132/11kV and 33/11kV zone substations (ZS) as well as gas, oil and HSL feeders.

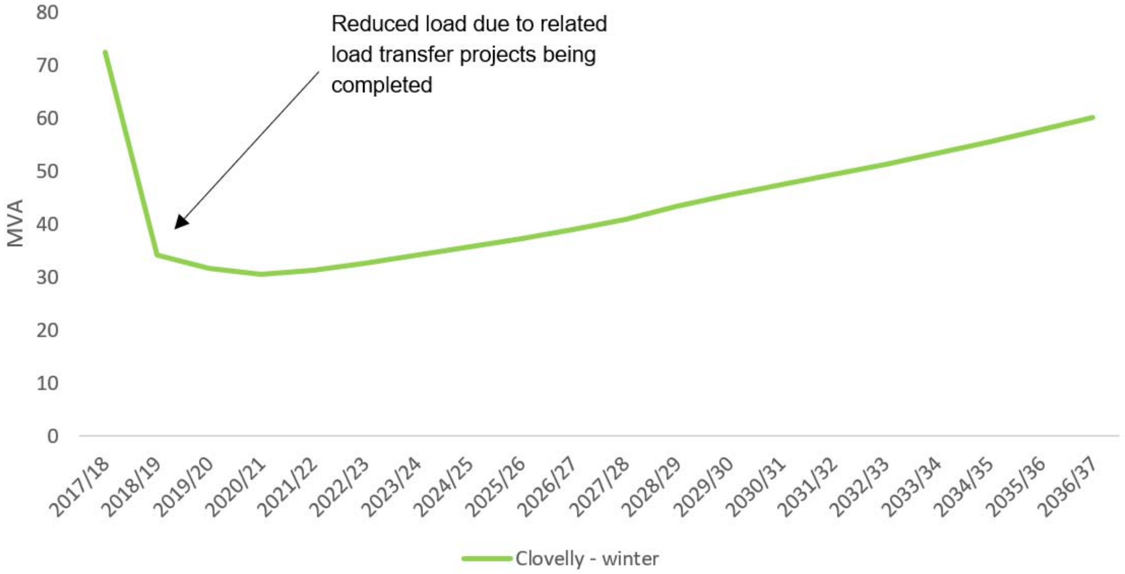
Figure 2.1 – Eastern Suburbs geographical network area



As a subset area of the eastern suburbs network, Beaconsfield BSP supplies several 132/11kV zone substations including Clovelly ZS. Clovelly is a 132/11kV ZS in the Eastern Suburbs network serves approximately 34,000 customers, which are predominantly residential customers.

The peak load at Clovelly ZS occurs in the winter season (i.e. the difference in peak load between winter and summer is approximately 15MVA at present). The figure below illustrates the winter load forecast for the Clovelly ZN. Ausgrid has committed to a project to decommission compound 11 kV at the Clovelly ZN and transfer load to nearby Waverley and Kingsford ZNs in 2019.

Figure 2.2 – Clovelly ZS winter load forecasts

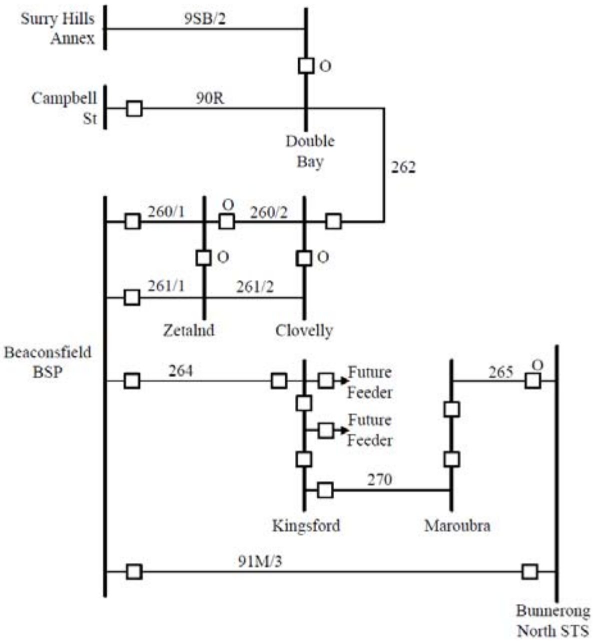


A central factor to the enduring need for the Clovelly ZS is its role in supplying major customers including Prince of Wales Hospital, Randwick Racecourse, the University of New South Wales and Sydney Light Rail, which will all need to be supplied for the foreseeable future.

Clovelly ZS is normally supplied by two existing 132kV Self Contained Fluid Filled (SCFF) feeders 261/2 from Beaconsfield BSP via Zetland ZS and 262 from Double Bay ZS with a third normally open 132kV cable 260/2 also from Zetland ZS. The existing 132kV feeders 260/2 and 261/2 are approximately 4.5km long and were commissioned in 1969 and 1972 respectively. These 132kV feeders form part of the major supply to the Eastern Suburbs network area.

Figure 2.3 sets out a schematic of the distribution network around Clovelly ZS and its connections to Double Bay ZS, Zetland ZS and Beaconsfield BSP.

Figure 2.3 – Existing Eastern Suburbs 132kV feeder network



Having been commissioned in the late 1960s and early 1970s, the condition of feeders 260/2 and 261/2 is deteriorating and has been responsible for fluid leaks, failures, and increased rates of corrective works. Insulation resistance testing indicates that there are potential problems with the outer serving of the feeders, with failure models forecasting that the reliability of these feeders will deteriorate and lead to breaches of distribution reliability standards if they are not replaced.

Furthermore, an assessment of the environmental risk derived from using fluid filled cables conducted in 2017 has determined that these feeders contributed 3.3% of the total environmental risk assigned to Ausgrid's fluid filled cable network.

To minimise disruption and environmental risks from the use of SCFF cables, Ausgrid plans to progressively replace and/or retire fluid filled cables from its network by 2034, including feeders 260/2 and 261/2 supplying the Clovelly ZS.

2.2 Overview of Ausgrid's relevant distribution reliability standards

All New South Wales electricity distribution businesses, including Ausgrid, are obliged to comply with reliability and performance standards as part of their distributor's license.[1] These standards are determined by the New South Wales Government.

At a high-level, the reliability and performance standards are specified in terms of both:

- the average frequency of interruptions a customer may face each year; and
- the average time those outages may last.

Specifically, under the current Ausgrid license, reliability and performance standards are expressed in two measures – namely:

- the System Average Interruption Frequency Index – 'SAIFI' – which measures the number of times on average that customers have their electricity interrupted over the year;[2] and
- the System Average Interruption Duration Index – 'SAIDI' – which measures the total length of time (in minutes) that, on average, a customer would have their electricity supply interrupted over a given period.[3]

These two reliability measures capture two key sources of inconvenience to electricity customers from supply disruptions, i.e. how long their electricity supply is off for as well as how often their electricity supply is off. Customers experience less inconvenience (i.e. a better level of supply reliability), the lower these measures are. Reliability standards applied to distribution networks typically set minimum requirements in relation to each of these two measures.

The current reliability standards applying to the Clovelly network area (classified as an 'urban' feeder type) are shown in Table 2.1.

Table 2.1 – Current distribution reliability standards applying to Ausgrid[4]

Feeder type	Network Overall Reliability Standards		Individual Feeder Reliability Standard	
	SAIDI (Minutes per customer)	SAIFI (Number per customer)	SAIDI (Minutes per customer)	SAIFI (Number per customer)
Urban	80	1.2	350	4

2.3 Key assumptions underpinning the identified need

The need to undertake action is predicated on the deteriorating condition of the two existing 132kV underground feeders from the Zetland ZS to Clovelly ZS and the characteristics of any resultant outages, as well as the fact that maintaining technologies present heightened maintenance and asset failure risks.

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[1] Granted by the Minster for Industry, Resources and Energy under the *Electricity Supply Act 1995 (NSW)*.

[2] SAIFI is calculated as the total number of interruptions that have occurred during the relevant period, divided by the number of customers. Momentary interruptions (which in NSW are currently defined as interruptions less than one minute) are typically not included.

[3] SAIDI is calculated as the sum of the duration of all customer interruptions over the period divided by the number of customers. Momentary interruptions (i.e. those of less than one minute) are typically not included.

[4] The Hon. Anthony Roberts MP Minister for Industry, Resources & Energy, Reliability and Performance Licence Conditions for Electricity Distributors, 1 December 2016, pp. 18-19 - available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/shared-files/licensing-administrative-electricity-network-operations-proposed-new-licence-conditions/ausgrid-ministerial-licence-conditions-1-december-2016.pdf

This section summarises the key assumption underpinning the identified need for this RIT-D. Appendix C provides additional detail on assumptions used, and methodologies applied, to estimate the costs and market benefits as part of this RIT-D.

2.3.1 Ageing SCFF feeders supplying Clovelly ZS are expected to increase the risk of involuntary load shedding leading to breaches of distribution reliability standards

A critical assumption underpinning the identified need is that retaining SCFF feeders supplying Clovelly ZS are expected to increase the risk of involuntary load shedding that leads to breaches of distribution reliability standards.

The major factor contributing to the risk of involuntary load shedding is the age of the feeders (132kV feeders 260/2 and 261/2) supplying Clovelly ZS, which are therefore reaching the end of their useful life. The SCFF technology used by the feeders is also obsolete and requires specialist skills to repair and maintain. Consequently, outage times can be lengthy, and spares are not readily available.

Performance of these feeders has been poor with the occurrence of significant oil leaks over the past 15 years, affecting the reliability of supply to Clovelly ZS. More recently, a cable failure occurred on feeder 261/2 in 2016, this was attributed to cable leaking from a cable joint while the feeder was out-of-service. The cable's fluid pressure alarms did not register a decrease in fluid volume and the cable was considered suitable to be returned to service. Upon switching the cable into service, the cable system failed, resulting in two link box lids blowing-out (one along Bourke Road, Alexandria and the other within the Moore Park Golf Course) and a joint falling in the Moore Park Gold Course. This resulted in a substantial amount of insulating fluid entering the environment and presented a risk to public safety. The cost to repair this failure was approximately $1.3 million over a 12-month period, which was predominately driven by direct equipment repair costs.

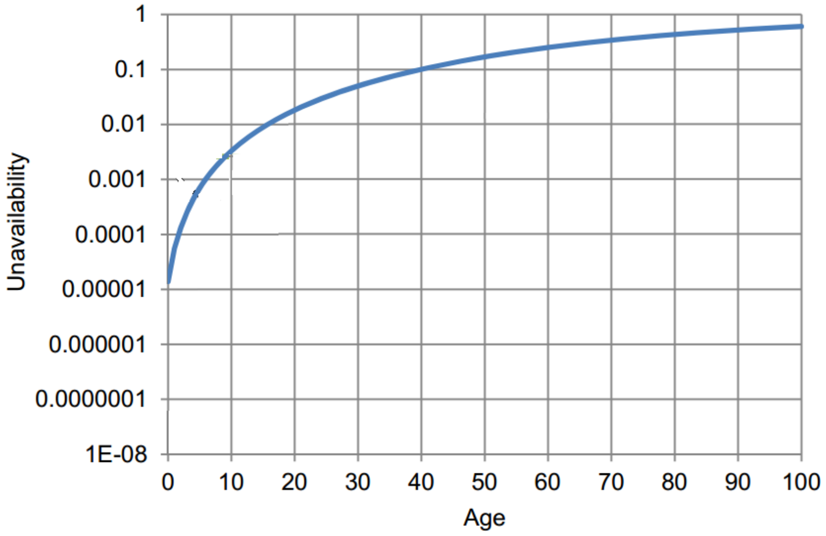
The potential for further cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace the remaining sections of aged fluid filled cables.

2.3.2 Probability of assets failing increases with age

Network asset failure probabilities and asset unavailability have a significant effect on the expected level of involuntary load shedding. Ausgrid has adopted well-accepted models for feeders to estimate the probability of failure. In general, the probability of failure increases with asset age.

The figure below shows unavailability plotted, on a logarithmic scale, for a representative 10km stretch of fluid-filled cables aged zero to one hundred years.

Figure 2.4 – Unavailability of fluid-filled feeders



This model is also based on the assumption that the condition of a cable is dependent upon its age. The Crow-AMSAA model shows that the availability of fluid-filled cables is expected to decline significantly if the cables are retained past an age of 50 years. Ausgrid considers this methodology is consistent with industry practice. A detailed discussion of the probability of failure and asset availability is provided in Appendix D.

2.3.3 Feeder redundancy exists but capacity to undertake load transfers are limited

The level of cost expected from any involuntary load shedding is dependent on underlying assumptions relating to the level of redundancy in feeders and the capacity to transfer load to other substations that could supply load currently served by Clovelly ZS.

Current supply arrangements for these zone substations have a degree of redundancy. As noted above, multiple feeders supply Clovelly ZS and therefore load could be transferred to the two remaining feeders should one of the fluid-filled feeders experience a fault or be out of service. However, outages of multiple feeders supplying each substation would likely lead to some degree of involuntary load shedding. While there is existing transfer capacity, this is not a viable solution given that the capacity will be limited to 3MVA upon the completion of related projects in the Clovelly ZS area (2019 onwards). Further, as feeders age, the likelihood of multiple feeder failures increases that in turn is likely to lead to involuntary load shedding.

A concurrent outage of feeders 262 and 261/2 would initially result in the temporary loss of supply to Clovelly ZS. Supply restorations can be achieved via manual switching operations or by manually closing the normally open 132kV feeder 260/2 between Clovelly ZS and Zetland ZS. Additionally, supply can be partially restored after a time delay (i.e. switching time) via manual switching operations and/or by changing network open points on the existing 11kV interconnected network between Clovelly ZS and nearby zone substations.

Consequently, the aggregated expected involuntary load shedding associated with these feeders has been calculated to be approximately 50MWh in total in the FY2020-2024 regulatory period. This is the result from the low risk of the complete failure of supply to Clovelly ZS resulting in unplanned shedding of around 50MVA of load for several hours each year.

Both the degree of redundancy and the ability to transfer load elsewhere have been considered by Ausgrid in forecasting expected unserved energy.

3 Two credible options have been assessed

This section provides descriptions of the two credible options Ausgrid has identified as part of its network planning activities to date.

In particular, Ausgrid has identified two network options that either replace the existing Clovelly ZS feeders by installing one new 132kV feeder, coupled with a spare conduit for a future feeder, from the nearby Kingsford ZS or undertaking a like-for-like replacement of the existing Clovelly to Zetland ZS feeders. The two credible options are summarised below. All costs in this section are in real $2017/18, unless otherwise stated.

Table 3.1 – Summary of the credible options considered

Overview	Key components	Length of new feeders	Estimated capital cost
Option 1 – new feeders from Kingsford ZS to Clovelly ZS	Installation of one new 132kV feeder and a spare conduit (for a future feeder) connecting Kingsford ZS to Clovelly ZS using modern XLPE cable to replace existing SCFF feeders.	4.1km	$14.7 million
Option 2 – like-for-like replacement of existing Zetland ZS to Clovelly ZS feeders	Replacement of existing Zetland ZS to Clovelly ZS feeders like-for-like using two new XLPE cable feeders.	4.5km (for each feeder)	$26.8 million

One further option was considered in addition to those set out in Table 3.1, which involves the use of demand management to defer the timing of the network solution. However, this option was found to be non-credible. This option is discussion in section 3.3 below.

3.1 Option 1 – New feeders from Kingsford ZS to Clovelly ZS

The project involves the installation of a new 132kV feeder and spare conduit (for a second future feeder) from Clovelly ZS to Kingsford ZS including secondary systems works and civil works. This feeder will replace existing 132kV SCFF feeders 260/2 and 261/2 between Clovelly ZS and Zetland ZS.

The project includes:

- works at Clovelly ZS and Kingsford ZS to facilitate the new 132kV feeder connection;
- installation of one 132kV XLPE feeders of approximately 4.1km from Clovelly ZS to Kingsford ZS, with a proposed firm rating of 230MVA;
- installation of one spare duct to accommodate a future second circuit to occupy the same trench;
- associated control and protection communication upgrades at Clovelly ZS and Kingsford ZS; and
- decommissioning of existing SCFF feeders between Clovelly ZS and Zetland ZS.

Ausgrid has identified the following benefits that are related to proceeding with Option 1 as set out above:

- improved reliability and mitigate identified risks;
- aligns with overall Eastern Suburbs area plan strategy

The estimated capital cost of this option is approximately $14.7 million. Ausgrid assumes that the necessary construction to install the new feeders would commence in 2018/19 and end in 2019/20, with commissioning occurring in the same year.

It is anticipated that a turn-key design-and-construct model using external contractors will be used. This will incorporate trenching and feeder installation to achieve the nominated feeder ratings. However, commissioning and other electrical works will be carried out by Ausgrid staff.

Once the new installation is complete, operating costs are expected to be $70,000 per annum (around 0.5 per cent of capital expenditure).

3.2 Option 2 – Like-for-like replacement of existing Zetland ZS to Clovelly ZS

This option involves a like-for-like replacement of the existing feeders that connect Zetland ZS to Clovelly ZS.

The scope of the project includes:

- replacing the existing feeders connecting Zetland ZS to Clovelly ZS like-for-like using modern XLPE cables totalling 9.0km in length (4.5km for each feeder).

The estimated cost of this option is approximately $26.8 million. Ausgrid assumes that the like-for-like replacement would commence in 2018/19, with the replacement scheduled to finish in 2019/20, with commissioning occurring in the same year. Once the replacement is complete, operating costs are expected to be approximately $126,000 per annum (around 0.5 per cent of capital expenditure).

While Option 2 has been found not to be economically justified at any point over the assessment period (due to its relatively high costs), it has still been included to provide a point of comparison for Option 1. Specifically, Option 2 has been included so that Option 1 can be compared to a like-for-like replacement option. The analysis underpinning the timing assessment of this option is set out in section 5.4.1

3.3 Options considered but not progressed

Ausgrid has considered one additional network option involving the transfer of load from Clovelly ZS to other adjacent zone substations, leading to the full retirement of the Clovelly ZS. This option would resolve existing asset condition issues but would involve several drawbacks:

- decrease load capacity in the area;
- lower reliability;
- requires installation of additional transformer at Waverley ZS; and
- involve a significantly higher capital cost estimated to be $37.6 million, owing to the complex network augmentation associated with this option.

These drawbacks lead Ausgrid to conclude that transferring load away from Clovelly ZS is not economically feasible and technically disadvantageous. Consequently, Ausgrid has elected not to progress this option.

Ausgrid has also considered the ability of other non-network solutions to assist in meeting the identified need. Specifically, an analysis of non-network options considered how demand management could defer the timing of the preferred network solution and whether the estimated unserved energy at risk could be cost effectively reduced. A cost benefit assessment of demand management options has shown that non-network alternatives would not be cost effective due to the magnitude of the load reduction required. As part of the review, an estimate of option value, realised as a result of any deferral of the network investment, was included in the cost benefit assessment. The addition of this option value did not change the conclusion that non-network alternatives cannot cost-effectively address the risk.

In particular, a demand management assessment into reducing the risk of unserved energy from the 132kV feeders showed that non-network alternatives cannot cost-effectively address the risk, compared to the two network options outlined above. This result is driven primarily by the significant amount of unserved energy that each network option allows to be avoided, compared to base case, and is detailed further in the separate notice released in accordance with clause 5.17.4(d) of the NER.[5]

If during the course of this RIT-D process, a cost-effective non-network solution emerges, it will be assessed alongside the other options.

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[5] Ausgrid notes that as part of its recently published regulatory proposal for the 2019-24 regulatory control period, it states that a Non-Network Options Report ('NNOR') will be published as part of the demand management engagement process associated with this RIT-D (see: Ausgrid, *Proposal for the 2019-24 Regulatory Control Period*, Attachment 5.14.2, pp. 24-25). Since the regulatory proposal was finalised and submitted to the AER, Ausgrid has further assessed the capability of non-network solutions to form a credible option, or form a significant part of a credible option, for this RIT-D and has decided that they cannot. Ausgrid has consequently released a non-network screening notice in-place of a NNOR, in accordance with NER clause 5.17.4(c), which sets out the methodologies and assumptions used in reaching this conclusion.

4 How the options have been assessed

This section outlines the methodology that Ausgrid has applied in assessing market benefits and costs associated with each of the credible options considered in this RIT-D.

4.1 General overview of the assessment framework

All costs and benefits for each credible option have been measured against a ‘business as usual’ base case. Under this base case, Ausgrid will escalate regular and reactive maintenance activates as the probability of failure and outages increases over time in the absence of an asset replacement program.

The RIT-D analysis has been undertaken over a 20-year period, from 2019 to 2039. Ausgrid considers that a 20-year period takes into account the size, complexity and expected life of the relevant credible options to provide a reasonable indication of the market benefits and costs of the options. While the capital components of the credible options have asset lives greater than 20 years, Ausgrid has taken a terminal value approach to incorporate capital costs in the assessment, which ensures that the capital cost of long-lived options is appropriately captured in the 20-year assessment period.

Ausgrid has adopted a central real, pre-tax discount rate of 6.13 per cent as the central assumption for the NPV analysis presented in this report. Ausgrid considers that this is a reasonable contemporary approximation of a ‘commercial’ discount rate (a different concept to a regulatory WACC), consistent with the RIT-D.[6]

Ausgrid has also tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound real, pre-tax discount rate of 4.19 per cent (equal to the latest AER Final Decision for a DNSP’s regulatory proposal at the time of preparing this FPAR[7]), and an upper bound discount rate of 8.07 per cent (i.e., a symmetrical upwards adjustment).

4.2 Ausgrid’s approach to estimating project costs

Ausgrid has estimated capital costs by considering the scope of works necessary under each credible option together with costing experience from previous projects of a similar nature. Where possible, Ausgrid has also estimated capital costs for each credible option using supplier quotes or other pricing information.

Operating and maintenance costs have been determined for each option by comparing the operating and maintenance costs with the option in place to the operating and maintenance costs without the option in place. These costs are included for each year in the planning period. If operating and maintenance costs are reduced with an option in place, the cost savings are effectively treated as a benefit in the assessment.

Operating costs have been estimated for each credible option and the base case by taking into account:

- the probability and expected level of network asset faults, which translates to the level of corrective maintenance costs; and
- the level of regular maintenance required to maintain network assets in good working order, including planned refurbishment costs.

All options reduce the incidence of asset failures relative to the base case, and hence the expected operating and maintenance costs associated with restoring supply.

Ausgrid has also included the financial costs associated with safety and environmental outcomes that are assumed to be avoided under each of the options, relative to the base case. These costs have been estimated using internal Ausgrid estimates, and are found to be immaterial in the analysis, both in terms of absolute values as well as being the same across the options, as illustrated in section 5.1.

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[6] Ausgrid notes that it has been sourced from the discount rate recently independently estimated as part of the Powering Sydney’s Future RIT-T. See: TransGrid and Ausgrid, *Project Assessment Conclusions Report*, Powering Sydney’s Future, November 2017, p. 62 – available at: https://www.transgrid.com.au/news-views/lets-connect/consultations/current-consultations/Documents/Powering%20Sydney%27s%20Future%20-%20PACR.pdf

[7] See TasNetworks’ PTRM for the 2017-19 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2017-2019/final-decision

4.3 Market benefits are expected from reduced involuntary load shedding

Ausgrid considers that the only relevant category of market benefits prescribed under the NER for this RIT-D relate to changes in involuntary load shedding.

The approaches and assumptions Ausgrid has made to estimating valuing reductions in involuntary load shedding are outlined in section 4.3.1 below.

Appendix C outlines the categories of market benefit that Ausgrid considers are not material for this particular RIT-D.

4.3.1 Reduced involuntary load shedding

Involuntary load shedding is where a customer's load is interrupted from the network without their agreement or prior warning. Ausgrid has forecast load over the assessment period and has quantified the expected unserved energy by comparing forecast load to network capabilities under system normal and network outage conditions. A reduction in involuntary load shedding expected from an option, relative to the base case, results in a positive contribution to market benefits of the credible option being assessed.

Involuntary load shedding of a credible option is derived by the quantity in MWh of involuntary load shedding required assuming the credible option is completed multiplied by the Value of Customer Reliability (VCR). The VCR is measured in dollars per MWh and is used as a proxy to evaluate the economic impact of unserved energy on customers under the RIT-D.

Ausgrid has applied a central VCR estimate of $40/kWh, which has been derived from the 2014 AEMO VCR estimates.[8] In particular, Ausgrid has escalated the AEMO estimate to dollars of the day and weighted the AEMO estimates according to the make-up of the specific load considered.

We have also investigated the effect of assuming both a lower and higher underlying VCR estimate. The lower sensitivity has been derived by reducing the AEMO-derived estimate by 30 per cent, consistent with the AEMO-stated level of confidence in its estimates, and results in an estimate of $28/kWh.[9] The higher sensitivity involves applying a VCR of $90/kWh, consistent with the recent Independent Pricing and Regulatory Tribunal (IPART) review of the transmission reliability standards for Inner Sydney, as well as the recently finalised Powering Sydney's Future RIT-T.[10]

In addition, while load forecasts are not a determinant of the identified need (since the reliability standards expected to be breached relate to the duration and frequency of supply interruptions – neither of which are affected by underlying load), Ausgrid has investigated how assuming different load forecasts going forward changes the expected net market benefits under the options. In particular, we have investigated three future load forecasts for the area in question – namely a central forecast using our 50 percent probability of exceedance ('POE50', as well as a low forecast using the POE90 and a high forecast using the POE10 forecasts.

The figure below shows the assumed levels of unserved energy (USE), under each of the three underlying demand forecasts investigated over the next ten years. For clarity, this figure illustrates the MWh of unserved energy assumed under each load forecast if no credible option is commissioned, i.e. it reflects both the underlying demand forecasts and the assumed failure rates associated with keeping assets in service.

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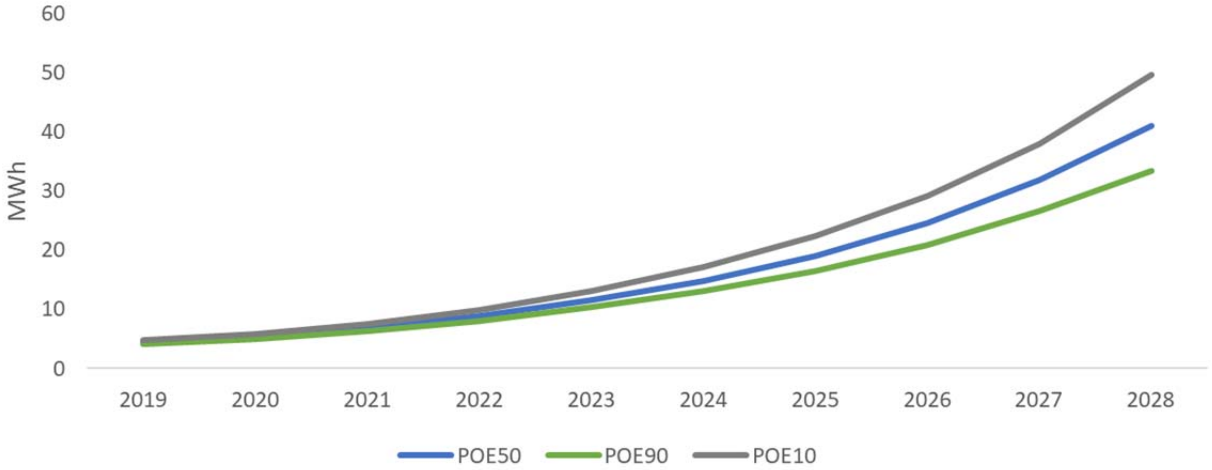
[8] AEMO, *Value of Customer Reliability Review*, September 2014, Final Report.

[9] AEMO, *Value of Customer Reliability Review*, September 2014, Final Report, p. 31.

[10] TransGrid and Ausgrid, *Project Assessment Conclusions Report*, Powering Sydney's Future, November 2017 – available at: https://www.transgrid.com.au/news-views/lets-connect/consultations/current-consultations/Documents/Powering%20Sydney%27s%20Future%20-%20PACR.pdf

Figure 4.1 – Assumed level of unserved energy (USE) under each of the three demand forecasts



Notwithstanding the slight reduction in load expected between 2019 and 2021 (as reported in Figurer 2.2 previously), the level of USE is not impacted because of the concurrent effect of an increasing unavailability of the SCFF feeders, combined with a decreasing load transfer capability at Clovelly ZS.

Ausgrid has capped the level of USE under each of these assumed demand forecasts at the value in the tenth year for all remaining years in the assessment period. Since the base case reflects a 'do nothing' approach, in which the reliability standard is breached (and which is therefore unrealistic), Ausgrid considers it appropriate to cap the level of USE at the level reached after ten years, since it is considered particularly uncertain after this. This also avoids a situation where an exponential increase in USE in later years[11] dwarfs other market benefits and skews the results,[12] and does not affect identification of the preferred option at all.

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[11] An exponential increase in USE results from assumptions that failure rates increase exponentially with asset age. 'Capping' the USE level recognises that in reality action would be taken before this occurred.

[12] Ausgrid notes that this approach was commented on and supported by Dr Darryl Biggar in his recent review of the modelling undertaken for the Powering Sydney's Future RIT-T. See: Biggar, D., *An Assessment of the Modelling Conduced by TransGrid and Ausgrid for the "Powering Sydney's Future" Program*, May 2017, available at: https://www.aer.gov.au/system/files/Biggar%2C%20Darryl%20-%20An%20assessment%20of%20the%20modelling%20conducted%20by%20TransGrid%20and%20Ausgrid%20for%20the%20%20Powering%20Sydney%20s%20Future%20%20program%20-%20May%202017.pdf

4.4 Three different ‘scenarios’ have been modelled to address uncertainty

RIT-D assessments are required to be based on cost-benefit analysis that includes an assessment of ‘reasonable scenarios’, which are designed to test alternate sets of key assumptions and whether they affect identification of the preferred option.

Ausgrid has elected to assess three alternative future scenarios – namely:

- low benefit scenario – Ausgrid has adopted a number of assumptions that give rise to a lower bound NPV estimate for each credible option, in order to represent a conservative future state of the world with respect to potential market benefits that could be realised under each credible option;
- baseline scenario – the baseline scenario consists of assumptions that reflect Ausgrid’s central set of variable estimates which, in Ausgrid’s opinion, provides the most likely scenario; and
- high benefit scenario – this scenario reflects an optimistic set of assumptions, which have been selected to investigate an upper bound on reasonably expected market benefits.

A summary of the key variables in each scenario is provided in the table below.

Table 4.1 – Summary of the three scenarios investigated

Variable	Scenario 1 – baseline	Scenario 2 – low benefits	Scenario 3 – high benefits
Demand	POE50	POE90	POE10
VCR	$40/kWh (Derived from the AEMO VCR estimates)	$28/kWh (30 per cent lower than the central, AEMO-derived estimate)	$90/kWh (Consistent with the recent IPART review of transmission reliability standards for this area)
Commercial discount rate	6.13 per cent	8.07 per cent	4.19 per cent

Ausgrid considers that the baseline scenario is the most likely, since it is based primarily on a set of expected/central assumptions. Ausgrid has therefore assigned this scenario a weighting of 50 per cent, with the other two scenarios being weighted equally with 25 per cent each. However, Ausgrid notes that the identification of the preferred option is the same across all three scenarios, i.e., the result is insensitive to the assumed scenario weights.

5 Assessment of credible options

This section summarises the results of the NPV analysis, including the sensitivity analysis undertaken. All credible options assessed as part of this RIT-D have been compared against a 'business as usual' base case.

5.1 Gross market benefits estimated for each credible option

The table below summarises the gross benefit of each credible option relative to the base case in present value terms. The gross market benefit for each option has been calculated for each of the three reasonable scenarios outlined in the section above.

Table 5.1 – Present value of gross economic benefits of each credible option relative to the base case, $m 2017/18

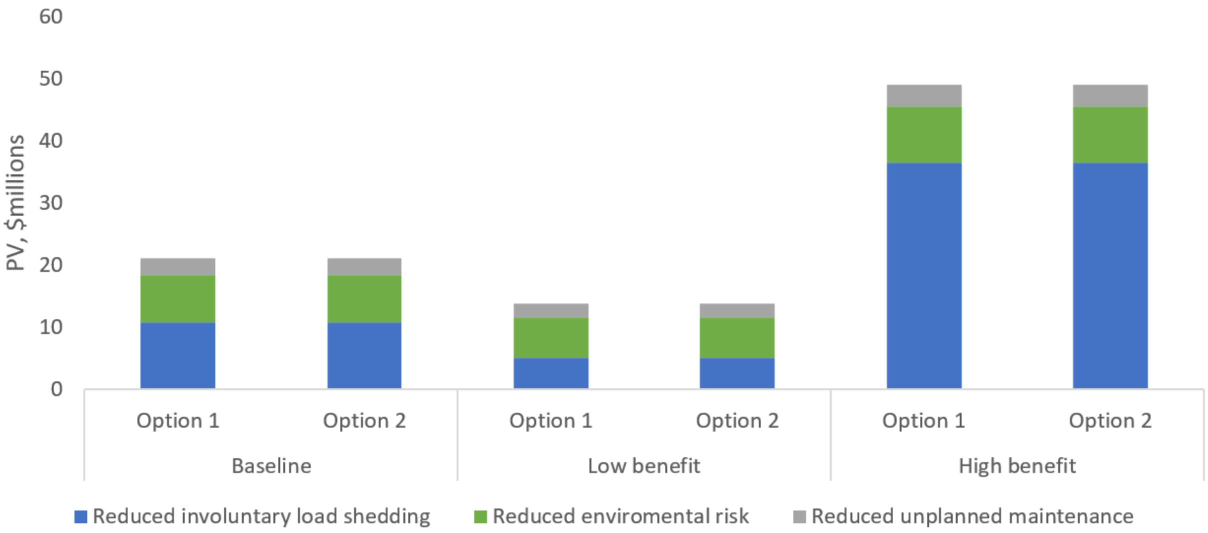
Option	Baseline scenario	Low benefit scenario	High benefit scenario	Weighted benefits
Scenario weighting	50%	25%	25%	
Option 1	21.2	13.8	49.1	26.3
Option 2	21.2	13.8	49.1	26.3

The figure below provides a breakdown of all benefits relating to each credible option. For clarity, we have combined in this chart with the categories of 'market benefit' (i.e. reduced involuntary load shedding) with avoided corrective maintenance cost benefits (i.e. reduced unplanned corrective maintenance when assets fail and reduced operating costs associated with environmental costs).

Both options are found to have the same overall benefit. This is driven by the fact that both options are assumed to be commisioned in the same year and so avoid identical levels of expected unserved energy and corrective maintenance costs.

The primary benefit is estimated to be avoided unserved energy for both options on account of the increasing likelihood of failure of the assets in question, which are nearing the end of their technical lives.

Figure 5.1 – Breakdown of gross economic benefits of each credible option relative to the base case



5.2 Estimated costs for each credible option

The table below summarises the costs of each credible option relative to the base in present value terms. The cost is the sum of the project capital costs and the operating costs associated with running and maintaining the new cables.

The cost of each option has been calculated for each of the three reasonable scenarios, in accordance with the approaches set out in Section 4.

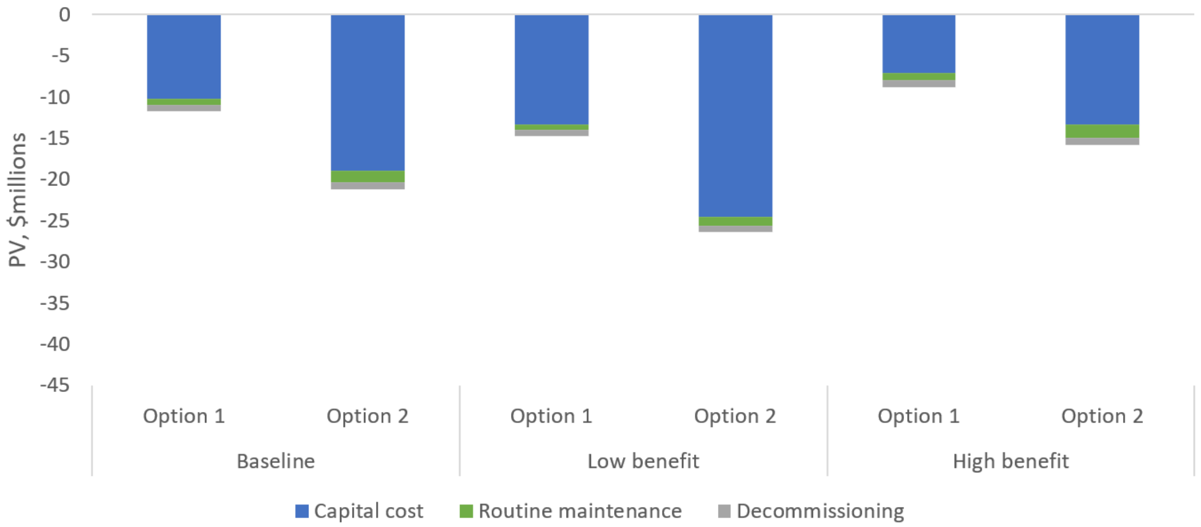
Table 5.2 – Present value of costs of each credible option relative to the base case, NPV $m 2017/18

Option	Baseline scenario	Low benefit scenario	High benefit scenario	Weighted costs
Scenario weighting	50%	25%	25%	
Option 1	-11.8	-14.7	-8.8	-11.8
Option 2	-20.0	-25.2	-14.7	-20.0

The figure below provides a breakdown of costs relating to each credible option. Capital costs are the determining factor for the ranking of the credible options considered.

Under all scenarios, Option 1 involves the lowest capital cost due to it requiring only installing one new feeder compared to replacing two feeders under Option 2. Not only does this result in fewer materials in terms of actual cables, but also the materials associated with facilitating the use of the feeders. For instance, by reducing the length of the feeder, there is a commensurate decrease in the need for other infrastructure such as joints and bays.

Figure 5.2 – Breakdown of costs of each credible option relative to the base case



5.3 Net present value assessment outcomes

The table below summarises the net market benefit in NPV terms for each credible option under each scenario. The net market benefit is the gross market benefit (as set out in Table 5.1) minus the cost of each option (as set out in Table 5.2), all in present value terms.

Overall, Option 1 exhibits the highest estimated net market benefit, which is primarily driven by it having the lowest capital costs out of the three credible options considered.

Table 5.3 – Present value of weighted net benefits relative to the base case, $m 2017/18

Option	Capital costs	Operating costs	Avoided costs	USE benefits	Weighted NPV	Ranking
Option 1	-10.2	-1.5	10.5	15.9	14.5	1
Option 2	-18.9	-2.2	10.5	15.9	5.2	2

5.4 Sensitivity analysis results

Ausgrid has undertaken a thorough sensitivity testing exercise to understand the robustness of the RIT-D assessment to underlying assumptions about key variables.

In particular, we have undertaken two tranches of sensitivity testing – namely:

- step 1 – testing the sensitivity of the optimal timing of the project (‘trigger year’) to different assumptions in relation to key variables; and
- step 2 – once a trigger year has been determined, testing the sensitivity of the total NPV benefit associated with the investment proceeding in that year, in the event that actual circumstances turn out to be different.

That is, Ausgrid has undertaken sensitivity analysis to first determine the optimal timing of the project, to conclude that a particular year represents the ‘most likely’ date at which the project will be needed.

Having assumed to have committed to the project by this date, Ausgrid has also looked at the consequences of ‘getting it wrong’ under step 2 of the sensitivity testing. That is, if demand turns out to be lower than expected, for example, what would be the impact on the net market benefit associated with the project continuing to go ahead on that date.

We outline how each of these two steps has been applied to test the sensitivity of the key findings.

5.4.1 Step 1 – Sensitivity testing of the assumed optimal timing for the credible option

Ausgrid has estimated the optimal timing for each option based on the year in which the NPV of each option is maximised. This process was undertaken for both the baseline set of assumptions and also a range of alternative assumptions for key variables.

This section outlines the sensitivity of the identification of the commissioning year to changes in the underlying assumptions. In particular, the optimal timing of the options is found to be largely invariant to the assumptions of:

- a 25 per cent increase/decrease in the assumed network capital costs;
- alternative forecasts of maximum demand growth, based on POE10 (high) and POE90 (low);
- a lower VCR ($28/kWh) and a higher VCR ($90/kWh); and
- a lower discount rate of 4.19 per cent as well as a higher rate of 8.07 per cent.

The figures below outline the impact on the optimal commissioning year for each option, under a range of alternative assumptions. They illustrate that for Option 1, the optimal commissioning date is found to be in 2019/20 for almost all of the sensitivities investigated (with the exception of a high discount rate). They also illustrate that Option 2 does not have an optimal trigger year as net benefits under Option 2 do not exceed the benefit from deferring the project. For the purposes of the analysis and comparison to Option 1, Option 2 is assumed to have the same trigger year of 2019/20.

Figure 5.3 – Option 1's distribution of optimal project commissioning years under each sensitivity

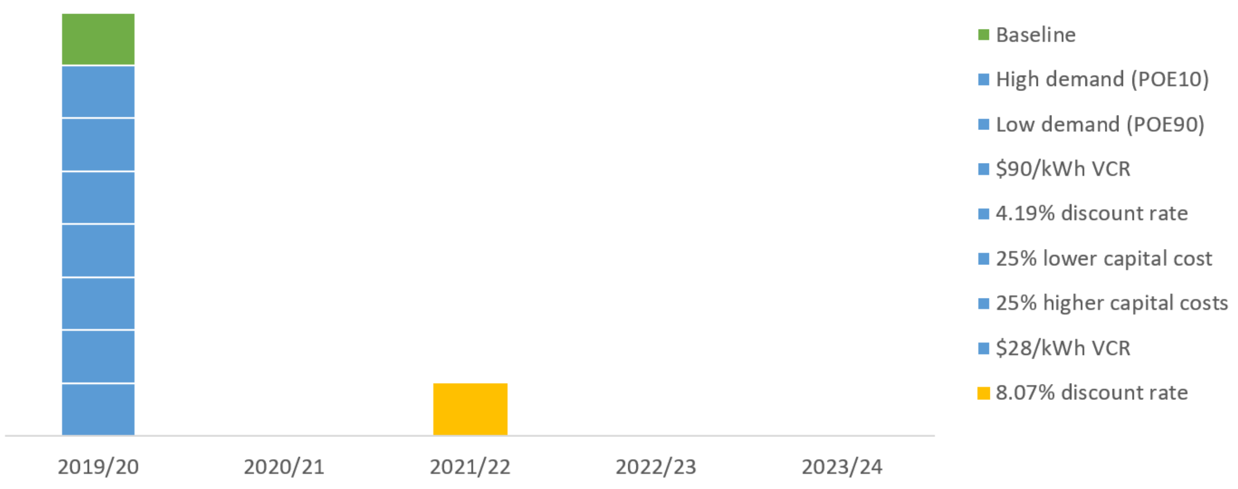
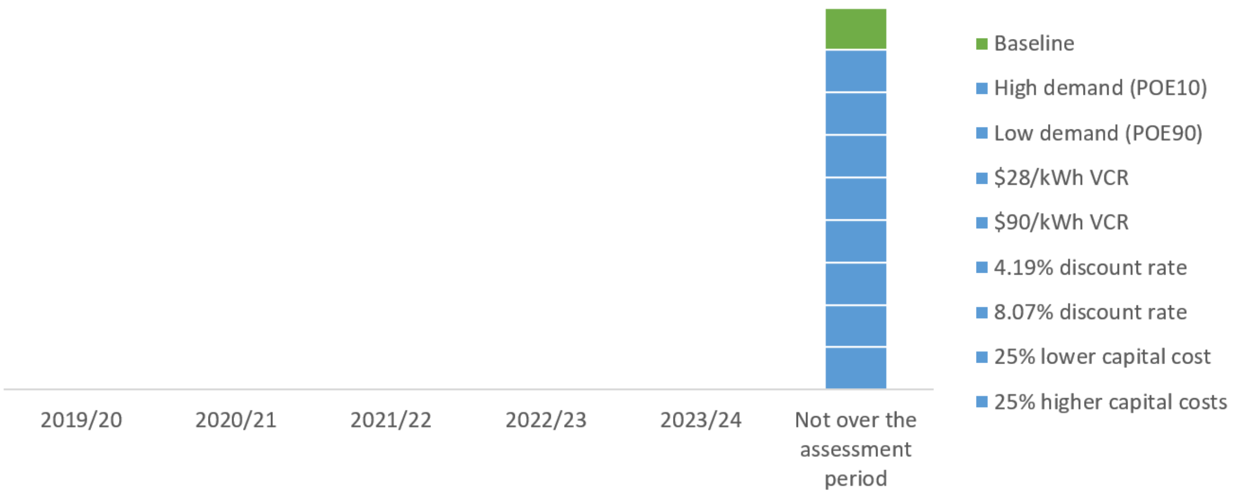


Figure 5.4 – Option 2's distribution of optimal project commissioning years under each sensitivity



5.4.2 Step 2 – Sensitivity of the overall net market benefit

Ausgrid has also conducted sensitivity analysis on the overall NPV of the net market benefit, based on the assumption option timing established in step 1.

Specifically, Ausgrid has investigated the same sensitivities under this second step as in the first step, i.e.:

- a 25 per cent increase/decrease in the assumed network capital costs;
- alternative forecasts of maximum demand growth, based on POE10 (high) and POE90 (low);
- a lower VCR ($28/kWh) and a higher VCR ($90/kWh); and
- a lower discount rate of 4.19 per cent as well as a higher rate of 8.07 per cent.

All these sensitivities investigate the consequences of 'getting it wrong' having committed to a certain investment decision. The table below presents the results of these sensitivity tests for option 1 and option 2 respectively. Option 1 is found to be the preferred option across all sensitivities investigated.

Table 5.4 – Sensitivity testing results, $m PV 2017/18

Sensitivity	Option 1	Option 2
Baseline	**9.4**	1.2
25 per cent higher capital cost	**6.9**	-4.7
25 per cent lower capital cost	**12.0**	4.8
Unserved energy under POE10	**11.5**	2.1
Unserved energy under POE 90	**7.6**	-1.8
VCR $90/kWh	**23.0**	13.6
VCR $28/kWh	**6.2**	-3.2
4.19 per cent discount rate	**14.8**	5.8
8.07 per cent discount rate	**5.4**	-4.1

6 Proposed preferred option

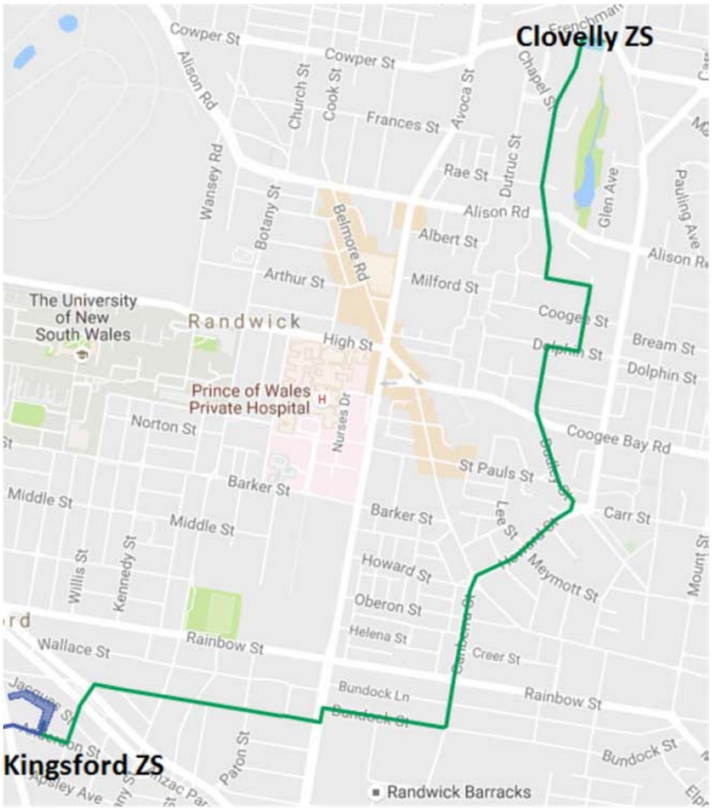
Option 1 has been found to be the preferred option, which satisfies the RIT-D. It involves the replacement of the two existing feeders from Zetland ZS to Clovelly ZS with a new feeder from Kingsford ZS. Specifically, this option involves the installation of one new 132kV feeder and a spare conduit line (for a future feeder) from Kingsford ZS to Clovelly ZS.

The scope of this project includes:

- works at Clovelly ZS and Kingsford ZS to facilitate the new 132kV feeder connection;
- use of the existing 132kV circuit breaker at Kingsford ZS to connect the new feeder;
- installation of one 132kV XLPE feeders of approximately 4.1km from Clovelly ZS to Kingsford ZS, with a proposed firm rating of 230MVA;
- installation of one spare duct to accommodate a future second circuit to occupy the same trench;
- associated control and protection communication upgrades at Clovelly ZS and Kingsford ZS; and
- decommissioning of existing SCFF feeders between Clovelly ZS and Zetland ZS.

The preferred route runs south from the Clovelly ZS along St Marks Road to Oswald Street, east to Courland Street and south to Dolphin Street. At Dolphin Street, the route would travel south along St Luke Street and Dudley Street to Howard Street, crossing Coogee Bay Road. From Howard Street, the cables would run south along Canberra Street and west along Bundock Street and Sturt Street, crossing Avoca Street, to Anzac Parade. The cables would cross Anzac Parade into Hayward Street and Anderson Street where they would connect into the Kingsford substation. The route of the proposed feeder under Option 1 is depicted in Figure 6.1 below.

Figure 6.1 - Proposed Route Plan for the new 132kV feeder



Ausgrid has engaged with the local community and already has held two community information sessions in April 2018 on the preferred route as part of the community consultation process. Ausgrid encourages community feedback and has committed to keep the community informed as the project progresses through notification letters, door knocks and the Ausgrid website. Ausgrid has also notified Randwick City Council and RMS regarding the proposed project.

The estimated capital cost of this option is approximately $14.7 million. Ausgrid assumes that the necessary construction to install the new feeders would commence in 2018/19 and end in 2019/20. Once the new installation is complete, operating costs are expected to be $70,000 per annum (around 0.5 per cent of capital expenditure).

Ausgrid considers that this FPAR, and the accompanying detailed analysis, identify Option 1 as the preferred option and that this satisfies the RIT-D. Ausgrid is the proponent for Option 1.

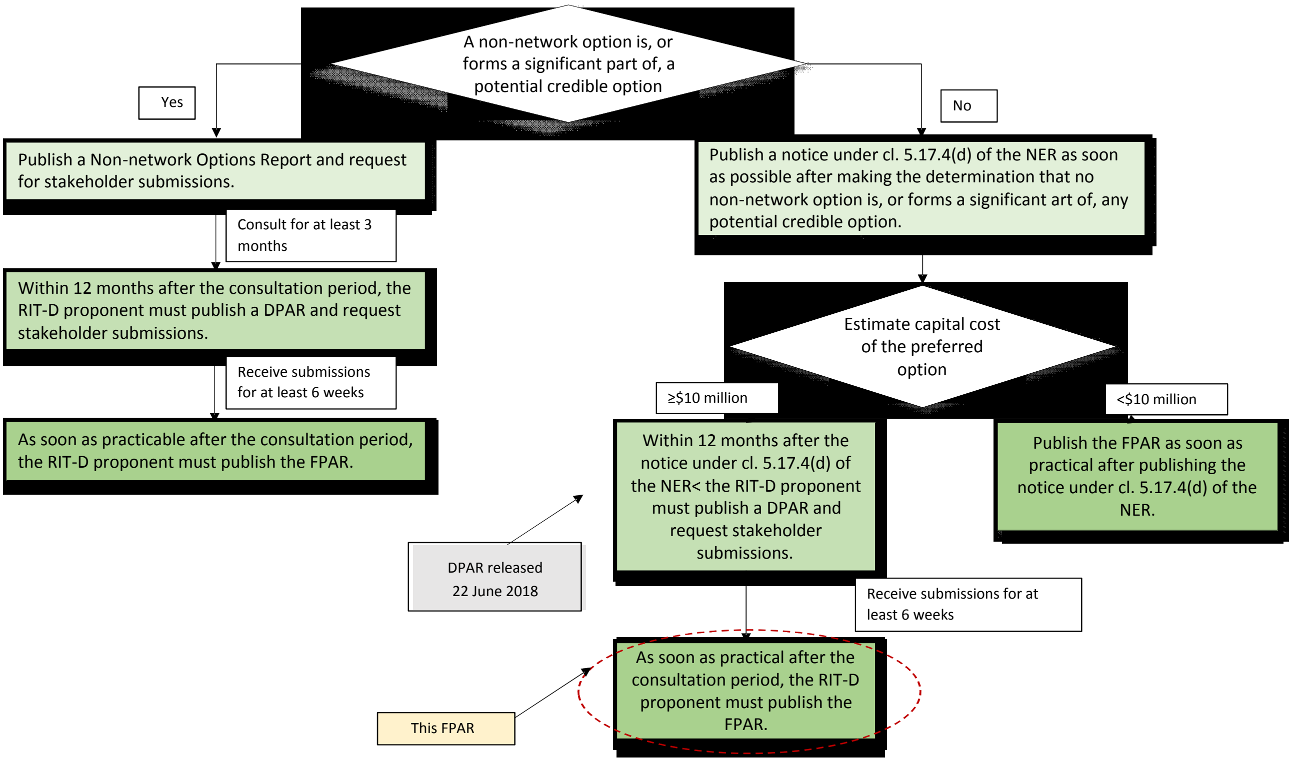
Appenidx A – Checklist of compliance clauses

This section sets out a compliance checklist that demonstrates the compliance of this FPAR with the requirements of clause 5.17.4(j) of the National Electricity Rules version 107.

Rules clause	Summary of requirements	Relevant sections in the FPAR
5.17.4(r)	The matters detailed in that report as required under 5.17.4(j)	See rows below
	A summary of any submissions received on the DPAR and the RIT-D proponent's response to each such submission	Section 1.2
5.17.4(j)	(1) a description of the identified need for the investment	2
	(2) the assumptions used in identifying the identified need	2.3
	(3) if applicable, a summary of, and commentary on, the submissions on the non-network options report	NA
	(4) a description of each credible option assessed	3
	(5) where a DNSP has quantified market benefits, a quantification of each applicable market benefit for each credible option;	5.1
	(6) a quantification of each applicable cost for each credible option, including a breakdown of operating and capital expenditure	5.2
	(7) a detailed description of the methodologies used in quantifying each class of cost and market benefit	4
	(8) where relevant, the reasons why the RIT-D proponent has determined that a class or classes of market benefits or costs do not apply to a credible option	Appendix C
	(9) The results of a net present value analysis of each of credible option and accompanying explanatory statements regarding the results	5
	(10) the identification of the proposed preferred option	6
	(11) for the proposed preferred option, the RIT-D proponent must provide: (i) details of technical characteristics; (ii) the estimated construction timetable and commissioning date (where relevant); (iii) the indicative capital and operating cost (where relevant); (iv) a statement and accompanying detailed analysis that the proposed preferred option satisfies the regulatory investment test for distribution; and (v) if the proposed preferred option is for reliability corrective action and that option has a proponent, the name of the proponent	6
	(12) Contact details for a suitably qualified staff member of the RIT-D proponent to whom queries on the final report may be directed.	1.3

Appendix B – Process for implementing the RIT-D

For the purposes of applying the RIT-D, the NER establishes a three stage process: (1) the Non-Network Options Report (or notice circumventing this step); (2) the DPAR; and (3) the FPAR. This process is summarised in the figure below.



A non-network option is, or forms a significant part of, a potential credible option

Publish a Non-network Options Report and request for stakeholder submissions.

Within 12 months after the consultation period, the RIT-D proponent must publish a DPAR and request stakeholder submissions.

As soon as practicable after the consultation period, the RIT-D proponent must publish the FPAR.

Publish a notice under cl. 5.17.4(d) of the NER as soon as possible after making the determination that no non-network option is, or forms a significant art of, any potential credible option.

Estimate capital cost of the preferred option

Within 12 months after the notice under cl. 5.17.4(d) of the NER< the RIT-D proponent must publish a DPAR and request stakeholder submissions.

Publish the FPAR as soon as practical after publishing the notice under cl. 5.17.4(d) of the NER.

DPAR released 22 June 2018

As soon as practical after the consultation period, the RIT-D proponent must publish the FPAR.

Appendix C – Market benefit classes considered not relevent

The market benefits that Ausgrid considers will not materially affect the outcome of this RIT-D assessment include:

- changes in voluntary load curtailment;
- costs to other parties;
- load transfer capability and embedded generators;
- option value; and
- electrical energy losses.

The reasons why Ausgrid considers that each of these categories of market benefit is not expected to be material for this RIT-D are outlined in the table below.

Table C.1 – Market benefit categories under the RIT-D not expected to be material

Market benefits	Reason for excluding from this RIT-D
Timing of unrelated expenditure	Ausgrid does not expect the project will have any effect on unrelated expenditures in other parts of the network. Accordingly, Ausgrid considers the market benefit from changes in timing of unrelated expenditure is not material.
Changes in voluntary load curtailment	Ausgrid notes that the level of voluntary load curtailment currently present in the NEM is limited. Where the implementation of a credible option affects pool price outcomes, and in particular results in pool prices reaching higher levels on some occasions than in the base case, this may have an impact on the extent of voluntary load curtailment. Ausgrid notes that none of the options are expected to affect the pool price and so there is not expected to be any changes in voluntary load curtailment.
Costs to other parties	This category of market benefit typically relates to impacts on generation investment from the options. Ausgrid notes that none of the options will affect the wholesale market and so we have not estimated this category of market benefit.
Changes in load transfer capacity and embedded generators	Load transfer capacity between substations is predominantly limited by the high voltage feeders that connect substations. Credible options under consideration do not affect high voltage feeders and therefore are unlikely to materially change load transfer capacity. Further, credible options are unlikely to enable embedded generators in Ausgrid's network to be able to take up load given the size and profile of the load serviced by network assets currently considered for replacement. Consequently, Ausgrid has not attempted to estimate any benefits from changes in load transfer capacity and embedded generators.
Option value	Option values arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change, and the credible options considered have sufficient flexibility to respond to that change. Ausgrid notes that none of the credible options assessed involve stages or any other flexibility and so we do not consider that option value is relevant with respect to staging. Ausgrid considered an estimated option value as part of its assessment of non-network alternatives but the inclusion of an option value resulted in no change in the viability of non-network options to form part of the least cost solution.
Changes in electrical energy losses	Ausgrid does not expect that any of the credible options considered would lead to significant changes in network losses and so have not estimated this category of market benefits.

Appendix D – Additional detail on the assessment methodology

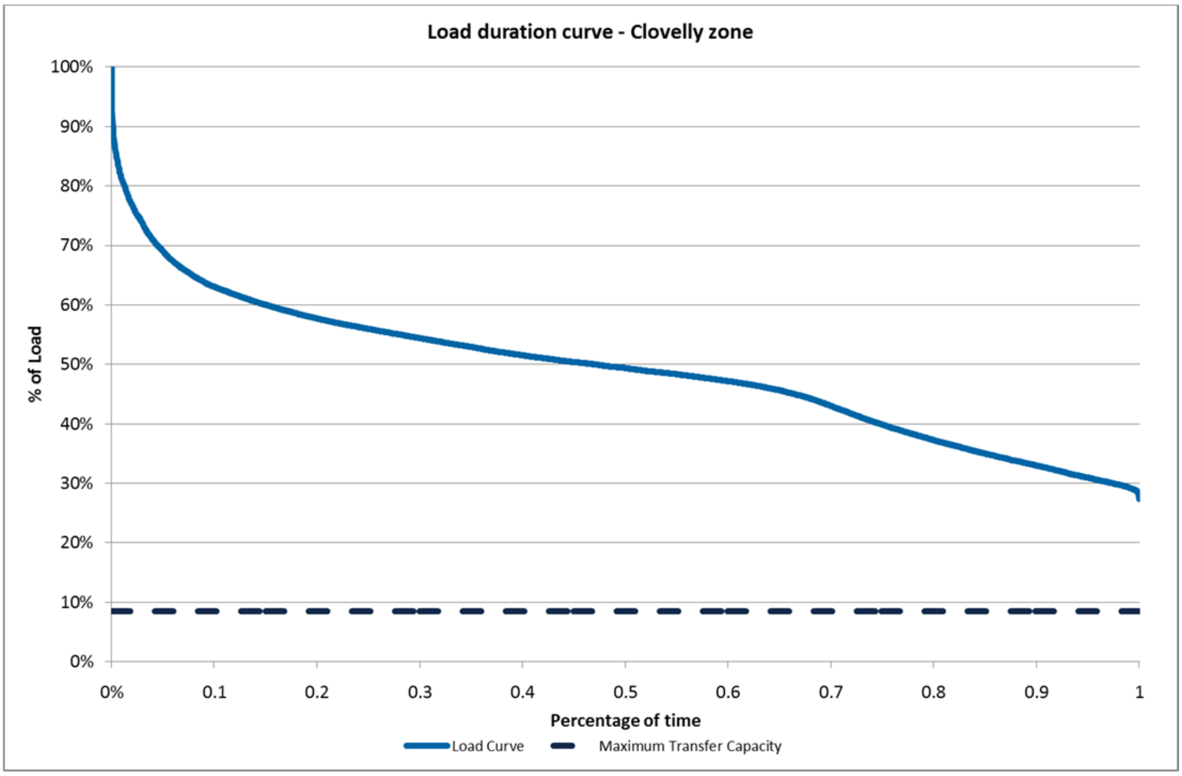
This appendix presents additional detail on the supply restoration assumptions and probability of failure assumptions.

D.1 Characteric load duration curves

The load duration curve for the Clovelly ZS is presented in Figure D.1 below.

It is assumed that the load types supplied by this substation will not change substantially into the future and therefore the load duration curves will maintain their characteristic shape regardless of the zone substation supplying the existing load at Clovelly.

Figure D.1 – Load duration curve for Clovelly



D.2 Supply restoration assumptions

Table D.1 – Supply restoration assumptions

Equipment outage	Action	Outage duration
Fluid filled cable failure	Repair The cable is repaired on site.	7.0 weeks
Fluid filled cable third party damage	Repair The cable is repaired on site. Additional time is typically required to repair third party damage.	5.5 weeks
Fluid filled cable corrective action	Repair One of the following repairs may take place depending on the failure mode: 1. in service repair (65 per cent) 2. out of service repair (35 per cent)	1. In service repair (no outage) 2. 1.06 weeks

D.3 Probability of failure

Ausgrid has adopted probability models to estimate expected failure of different network assets. A summary of the models adopted and the key parameters used are summarised in the table below.

Table D.2 – Summary of failure probability models used to estimate failure probability

Network asset type	Failure probability model	Key parameters
Underground cables	Crow-AMSAA model	Cumulative number of failures per km Age of cable at failure in years Measure of the failure rate

Underground cables

The Crow-AMSAA model is used to determine the probability of failure and unavailability for underground cables. Crow-AMSAA models are fitted for gas pressure, HSL and XLPE cables.

The Crow-AMSAA model can be used to evaluate probability of failure for repairable systems. As a result, it can be used to model a cable section that has failed and has been repaired multiple times over its lifetime. The model is also capable of handling a mixture of failure modes. Events affecting Ausgrid's underground sub-transmission cables are classified as corrective action, failure or third-party damage.

An analysis is undertaken of failure data to ascertain the age of the cable at the time of each event. A log-log plot of cumulative failures (per km) versus cumulative time (i.e. age in years) is produced and a line of best fit determined. The resulting log-log plot is linear and the line of best fit can be described by Equation 1.

Equation 1

$$z(T) = \lambda \beta T^{\beta - 1}$$

where:

$z(T)$ is the current failure intensity at time T (normalised per km length)

T is the cumulative time (i.e. age of the cable at failure, in years)

β is the shape parameter

λ is a scale parameter

The above process is carried out for corrective actions, failures and third party damage for fluid filled cables. Table D.3 shows the modelled Cow-AMSAA parameters for each cable type.

Table D.3 – Underground cable parameters

Feeder	Type	B factor	Λ factor	MTTR (weeks)
260/2	Corrective action	4.79	1.93E-08	1.06
260/2	Breakdowns	5.74	1.35E-11	7.00
260/2	Third party damage	1.45	8.78E-05	5.50
261/2	Corrective action	4.88	1.93E-08	1.06
261/2	Breakdowns	5.85	1.35E-11	7.00
261/2	Third party damage	1.48	8.78E-05	5.50
262	Corrective action	4.75	1.93E-08	1.06
262	Breakdowns	5.70	1.35E-11	7.00
262	Third party damage	1.44	8.78E-05	5.50

* Mean Time to Repair

The frequency of corrective action, failure or third party damage can then be determined by applying Equation 2 to each cable section.

Equation 2

$$f = L\lambda((T+1)^{\beta} - T^{\beta})$$

Where:

f is the frequency of failures

L is the length of the cable segment (km)

Failures and third party damage result in cables being taken out of service. Corrective actions do not typically result in cables being taken out of service. Equation 3 shows how the frequency is used to calculate unavailability for failures or third party damage.

Equation 3

$$U = \frac{f \times MTTR_{weeks}}{52 + f \times MTTR_{weeks}}$$

The total cable section unavailability is calculated taking the union of the failure and third-party damage unavailabilities as shown in Equation 4. If a feeder consists of multiple cable sections, the feeder unavailability is calculated by taking the union all the respective section unavailabilities.

Equation 4

$$U_{total} = U_{failure} \cup U_{TPD}$$

Figure 3 in section 2.3.2 shows unavailability plotted on a logarithmic scale when the above equations are applied to 10km cables aged 0 – 100 years. This model is also based on the assumption that the condition of a cable is dependent upon its age. The Crow-AMSAA model shows that the availability of fluid filled cables is expected to decline if the cables are retained past an age of 50.

D.4 Enviromental costs

Environmental costs have been estimated based in Ausgrid's standard methodology of quantifying business risks, including environmental risks. These risks are assessed in accordance with Ausgrid's Risk Management Board Policy.

The methodology follows the following steps:

1. identify a hazardous event that relates to a particular business risk category
2. calculate the likelihood of the hazardous event occurring (L)
3. assess the consequence associated with the hazardous event as insignificant, minor, moderate, major or severe
4. determine the equivalent consequence cost ($C) by referring to the consequence assessment table
5. determine if there are any qualifying conditions that must be met in order for the hazardous event to result in the assessed consequence
6. when relevant, calculate the likelihood that the qualifying conditions would be met (β). If there are no qualifying conditions, β is assumed to be 1.
7. quantify the risk ($R) by applying the equation below

$$\$R = L \,.\, \beta \,.\, \$C$$

Ausgrid's population of fluid-filled cables is currently leaking oil over a relatively large geographic area resulting in a moderate amount of remediation required each year. This is classified as 'moderate' environmental consequence with an equivalent cost of $22.4 million, as reported in Ausgrid Risk Matrix from Ausgrid's Risk Management Board Policy.[13] Given that cables 261/2 and 260/2 contribute 2.4% and 0.9% of the total volume of oil leaked in the network, the annual environmental risk relating to ongoing leaks on these cables is $22.4 million x (2.4 per cent + 0.9 per cent) = $739,200/year.

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[13] $22.4 million is sourced from the consequence assessment table contained in the Ausgrid's Risk Management Board Policy (GV0000-Y0014).

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