Addressing reliability requirements in the Maroubra load area

DRAFT PROJECT ASSESSMENT REPORT

30 APRIL 2020

Ausgrid Connecting communities, empowering lives

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Addressing reliability requirements in the Maroubra load area

Draft Project Assessment Report – April 2020

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Executive Summary

This report investigates the most economic option for mitigating the risks associated with the 132kV Feeder 265 supplying the Maroubra load area

This Draft Project Assessment Report (**DPAR**) has been prepared by Ausgrid and represents the first step in the application of the Regulatory Investment Test for Distribution (**RIT-D**) to options for ensuring reliable electricity supply in the Maroubra load area.

The underground electricity subtransmission cables ('feeders') supplying the Maroubra load area and more broadly the east end of the Eastern Suburbs network include self-contained fluid filled (**SCFF**) feeders, which are now considered an obsolete and outdated technology. They are becoming less reliable and approaching the point at which their replacement maximises the net benefit for the community.

Ausgrid has identified the need to replace 132kV Feeder 265, which connects Maroubra Zone Substation (**ZS**) to Bunnerong Subtransmission Switching Station (**STSS**) and identified a preferred solution to mitigating the identified risks.

Ausgrid has prepared this report consistent with the National Electricity Rules

Rule changes to the National Electricity Rules (**NER**) in July 2017 have meant that the replacement of network assets are subject to the RIT-D. Accordingly, Ausgrid has initiated this RIT-D for replacing 132kV Feeder 265 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.

Two credible network options have been assessed

Ausgrid has identified two network options. The two credible options are summarised below. All costs in this section are in real $2019/20, unless otherwise stated.

Table E.1 – Summary of the credible options considered

Overview	Key components	Length of new feeders	Estimated capital cost
Option 1 – Replacement of the existing Feeder 265 like-for-like	Replacement of existing Feeder 265 like-for-like using modern equivalent technology - Cross Linked Polyethylene (**XLPE**) cable	3.7km	$13.9 million
Option 2 – Replacement of Feeder 265 with spare duct to enable installation of future feeder Bunnerong - Kingsford	Installation of one new 132kV feeder using modern XLPE cable to replace existing Feeder 265 and a spare conduit (for a future feeder) connecting Maroubra ZS to Bunnerong STSS.	3.7km	$15.0 million

As these credible options are part of broader strategies to address network risks associated with SCFF feeders in this network area, consideration has been given to include the cost of future works (i.e. network investments required to retire the SCFF Feeder 262 connecting Clovelly and Double Bay zone substations and the SCFF Feeder 270 connecting Maroubra and Kingsford zone substations). This is relevant to the assessment as one of the credible network options includes the addition of spare conduits for a marginal increase in cost that can facilitate the installation of a future feeder in the area at a materially lower cost than replacing the existing SCFF feeder alone.

Non-network options are not considered viable for this RIT-D

Ausgrid has also considered the ability of non-network solutions to assist in meeting the identified need. A demand management assessment into reducing the risk of Expected Unserved Energy (**EUE**) from the SCFF feeders in this network area 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 EUE 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. If during the course of this RIT-D process, a cost-effective non-network solution emerges, it will be assessed alongside the other options.

Three different ‘scenarios’ have been modelled to deal with uncertainty

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

- Low benefit scenario – Ausgrid has adopted several 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 potential market benefits.

A summary of each scenario and the sets of variable values adopted is presented in the table below.

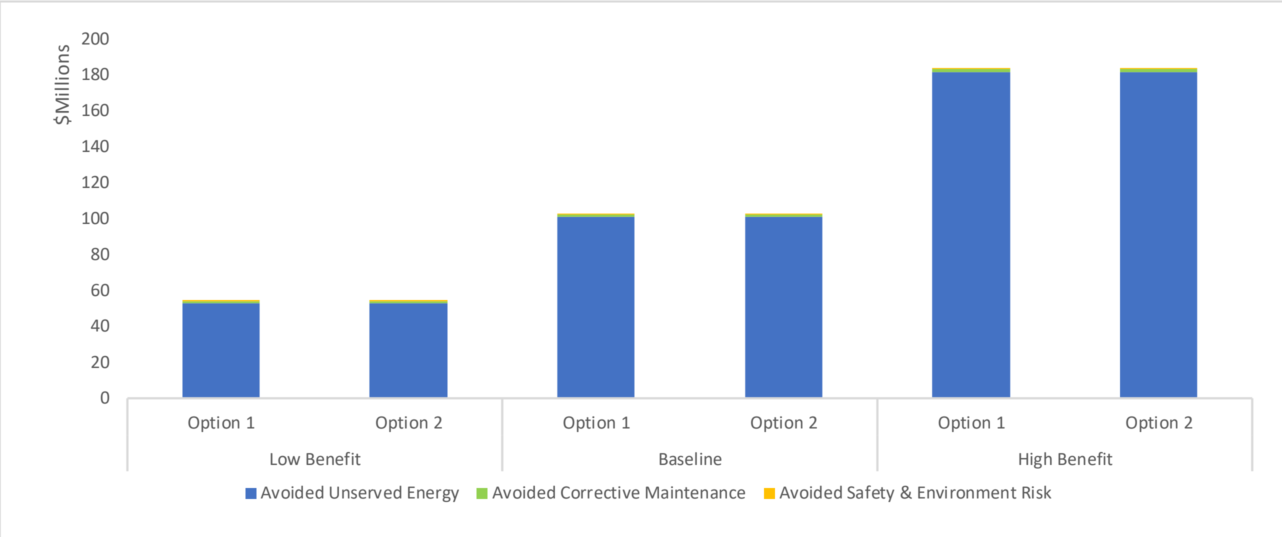
Table E.2 – Summary of the three scenarios investigated

Variable	Scenario 1 – baseline	Scenario 2 – low benefits	Scenario 3 – high benefits
Demand	POE50	POE90	POE10
VCR	$42.12/kWh (Derived from the AER VCR 2019 estimates)	$29.48/kWh (30 per cent lower than the central, AER-derived estimate)	$54.76/kWh (30 per cent higher than the central, AER-derived estimate)
Capital Costs (including future capital costs)	100 per cent of capital cost estimate	125 per cent of capital cost estimate	75 per cent of capital cost estimate
Timing of Future Capital Costs	Target completion in 2031	Target completion in 2033	Target completion in 2029

Option 2 has the highest expected net market benefits, under all scenarios

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.

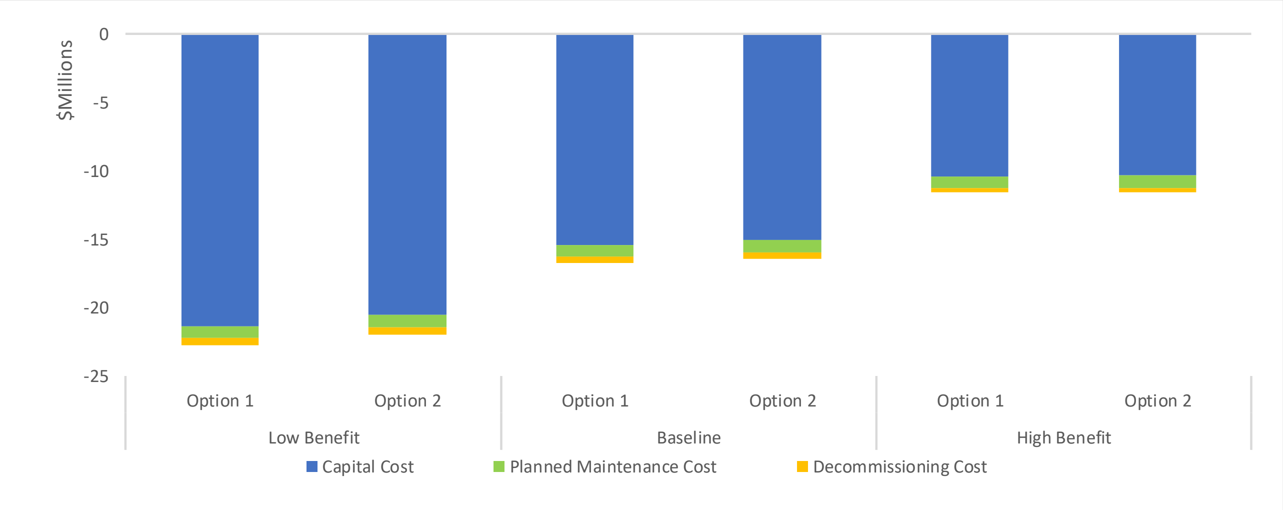
Figure E.1 – Present value of gross benefits of each credible option relative to the base case



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 2 involves the lowest capital cost. The installation of spare conduits for a marginal increase in cost now ($1.1 million higher than Option 1) provides an opportunity to reduce the cost of the future works, which results in a lower net present cost.

Figure E.2 – Breakdown of costs of each credible option relative to the base case



The table below provides a summary of the net market benefit in NPV terms for each credible option, on a weighted basis across the three scenarios. Overall, Option 2 exhibits the highest estimated net market benefit, which is driven primarily by having lower capital costs associated with future replacement investments.

Table E.3 – Present value of weighted net benefits relative to the base case, $m 2019/20

Option	PV of Capital costs	PV of Operating costs	Weighted PV of Gross Benefits	Weighted NPV	Ranking
Option 1	-15.7	-1.3	110.7	93.8	2
Option 2	**-15.2**	**-1.4**	**110.7**	**94.1**	**1**

Option 2 is the preferred option at this draft stage

Option 2 has been found to be the preferred option, which satisfies the RIT-D. It involves the replacement of the existing feeder from Bunnerong STSS ZS to Maroubra ZS with a new 132kV feeder and includes a spare conduit line (for a future feeder) from Bunnerong STSS to Kingsford ZS.

The scope of this project includes:

- works at Bunnerong STSS and Maroubra ZS to facilitate the new 132kV feeder connection;
- installation of one 132kV XLPE feeder of 3.7km from Bunnerong to Maroubra ZS, with a 230MVA firm rating;
- installation of one spare ductline to accommodate a future second circuit to occupy the same trench;
- associated control and protection communication upgrades at Bunnerong STSS and Maroubra ZS; and
- decommissioning of existing SCFF feeder 265 between Bunnerong STSS and Maroubra ZS.

Ausgrid started engaging with key stakeholders such as Randwick City Council in November 2019 to obtain early feedback on the preferred cable route. Engagement with residents and businesses along and around the preferred cable route started in late February 2020. After that, an information session was held at the Maroubra Senior Citizens Centre on 3 March 2020, to seek local information and further community feedback on the preferred cable route. Ausgrid encourages community feedback and has committed to keep the community informed as the project progresses through notification letters and the Ausgrid website.

The estimated capital cost of this option is approximately $15.0 million. Ausgrid assumes that the necessary construction to install the new feeders would commence in 2020/21 and end in 2021/22. Once the new installation is complete, operating costs are expected to be approximately $75,000 per annum (around 0.5 per cent of capital expenditure).

Ausgrid considers that this DPAR, and the accompanying detailed analysis, identify Option 2 as the preferred option and that this satisfies the RIT-D. Ausgrid is the proponent for Option 2.

How to make a submission and next steps

Ausgrid welcomes written submissions on this DPAR. Submissions are due on or before 11 June 2020. Submissions and queries should be addressed to:

Matthew Webb
Head of Asset Investment
Ausgrid
GPO Box 4009
Sydney 2001

Or

email to: assetinvestment@ausgrid.com.au

Submissions will be published on the Ausgrid website. If you do not want your submission to be publicly available please clearly stipulate this at the time of lodgement.

The next step of this RIT-D involves publication of a Final Project Assessment Report (**FPAR**). The FPAR will update the assessment of the net benefit associated with different investment options, in light of any submissions received on this DPAR. Ausgrid intends to publish the FPAR as soon as practicable after submissions are received on this DPAR.

1 Introduction

This Draft Project Assessment Report (**DPAR**) has been prepared by Ausgrid and represents the first step in the application of the Regulatory Investment Test for Distribution (**RIT-D**) to options for ensuring reliable electricity supply to the Maroubra load area and more broadly in the Eastern Suburbs network area.

The underground 132kV electricity subtransmission cables ('feeders') commissioned in the 1960s and 1970s, are now reaching, or past, the end of their technical lives. In particular, the self-contained fluid filled (**SCFF**) feeders are now considered an obsolete and outdated 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 132kV Feeder 265 supplying the Maroubra load area and has identified a preferred solution to mitigate the identified risks.

Ausgrid started engaging with key stakeholders such as Randwick City Council in November 2019 to obtain early feedback on the preferred cable route, and with residents and businesses along and around the preferred cable route in late February 2020. An information session was held at the Maroubra Senior Citizens Centre on 3 March 2020, to seek local information and further community feedback on the preferred cable route. Ausgrid has committed to keep the community informed as the project progresses through notification letters and the Ausgrid website.

Ausgrid has initiated this RIT-D for replacing the ageing Feeder 265 to investigate and consult on options to ensure Ausgrid is able to satisfy 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 draft report

Ausgrid has prepared this DPAR in accordance with the requirements of the NER under clause 5.17.4. It is the first stage of the formal consultation process set out in the NER in relation to the application of the RIT-D.

The purpose of the DPAR 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;
- explain why Ausgrid has determined that classes of market benefits or costs do not apply to credible options;
- present the results of a net present value analysis of each credible option, including an explanation of results; and
- identify the proposed preferred option.

The next stage of this RIT-D involves publication of a Final Project Assessment Report (**FPAR**). The FPAR will update the quantitative assessment of the net benefit associated with different investment options, in light of any submissions received on this DPAR. The entire RIT-D process is detailed in Appendix B. The next steps for this particular RIT-D assessment are discussed further below.

1.2 Submissions and queries

Ausgrid welcomes written submissions on this DPAR. Submissions are due on 11 June 2020 and should be addressed to:

Matthew Webb
Head of Asset Investment
Ausgrid
GPO Box 4009
Sydney 2001

Or

email to: assetinvestment@ausgrid.com.au

Submissions will be published on the Ausgrid website. If you do not want your submission to be publicly available please clearly stipulate this at the time of lodgement.

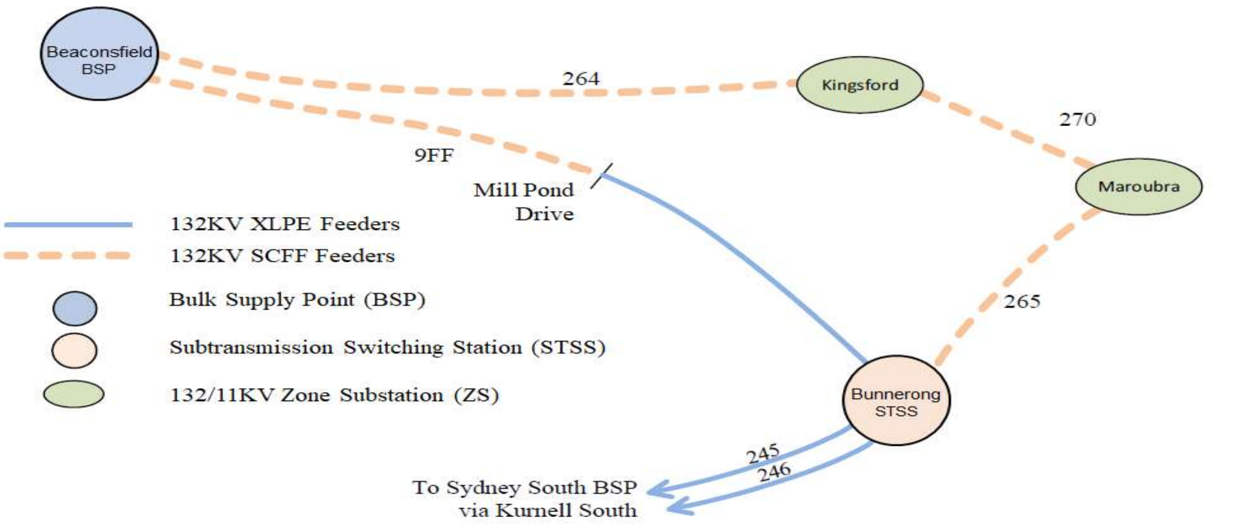
2 Description of the identified need

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 subtransmission network and existing supply arrangements for the Maroubra load area

The Eastern Suburbs network area extends from South Head to La Perouse, inland to Surry Hills, and west as far as Marrickville. Within this area there is a 132kV network which supports the inner metropolitan transmission network. This network consists of 132/11kV and 33/11kV zone substations (**ZS**) as well as gas pressured, SCFF and paper insulated feeders. Feeder 265 forms part of this network.

Figure 2.1 – Schematic view of the 132kV network including feeder 265



Feeder 265 is a SCFF cable commissioned in 1979. It is approximately 3.8km long and connects Maroubra ZS with Bunnerong Subtransmission Switching Station (**STSS**). Its availability is critical to supplying zone substations connected to the ring in the event of an outage of any one of the other cables. While the current design ensures a level of redundancy, any outage on this feeder at the same time as an outage on Feeder 264 would result in the loss of supply to Kingsford ZS and Maroubra ZS, affecting up to 41,600 customers including the University of NSW, the Sydney Children's Hospital and Prince of Wales Hospital, the Sydney Light Rail and the Royal Randwick Racecourse.

To minimise the environmental risks of fluid leaks in SCFF feeders, Ausgrid has a program to replace all SCFF on its network with known leaks and this program has been provided to the Environmental Protection Authority. Replacement of Feeder 265 with modern cables forms part of this program by removing 3.8km of SCFF feeder from service.

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.

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

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 Eastern Suburbs 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 existing 132kV underground Feeder 265 from the Maroubra ZS to Bunnerong STSS and the characteristics of any resultant outages, as well as the fact that maintaining technologies present heightened maintenance and asset failure risks.

This section summarises the key assumption underpinning the identified need for this RIT-D. Appendix D 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 132kV Feeder 265 is expected to increase the risk of involuntary load shedding

A critical assumption underpinning the identified need is that retaining the SCFF 132kV Feeder 265 is expected to increase the risk of involuntary load shedding.

The major factor contributing to the risk of involuntary load shedding is the age of the feeder which is reaching the end of its technical life. The SCFF technology used by the feeder is also obsolete and requires specialist skills to repair and maintain. Consequently, outage times can be lengthy and spares are not readily available.

The performance of this feeder has been poor with the occurrence of oil leaks over the past 15 years, affecting the reliability of supply to the Kingsford-Maroubra area. Tests conducted in 2013 and 2017 confirmed degradation in the insulation of the feeder. This could lead to further fluid leaks and affect reliability of SCFF 132kV Feeder 265.

Therefore, 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 SCFF feeders.

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[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.

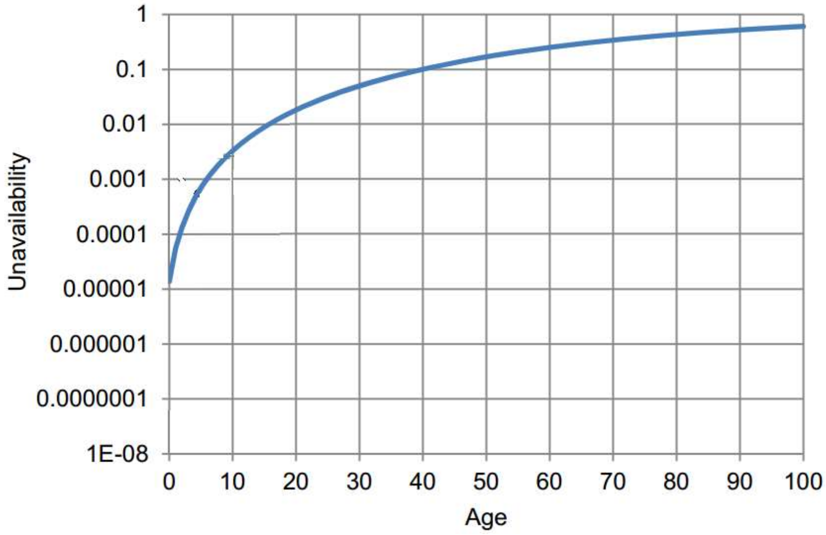
[4] The Hon. Anthony Roberts MP Minister for Industry, Resources & Energy, Reliability and Performance Licence Conditions for Electricity Distributors, 1 December 2016, pp. 18-19 - available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/shared-files/licensing-administrative-electricity-network-operations-proposed-new-licence-conditions/ausgrid-mini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

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 2.2 – 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 to customers 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 the SCFF feeders in this network area.

Current supply arrangements for the Kingsford and Maroubra zone substations have a degree of redundancy. However, outages of multiple feeders supplying each substation would likely lead to some degree of involuntary load shedding. Further, as feeders age, the likelihood of multiple feeder failures increases which, in turn, is likely to lead to involuntary load shedding.

Cable failure modelling indicates involuntary supply interruptions related to predicted failures of the SCFF feeders in this network area is approximately 35MWh in FY20, increasing to 82MWh in 5 years if no corrective action is taken.

Both the degree of redundancy and the ability to transfer load elsewhere have been considered by Ausgrid in forecasting Expected Unserved Energy (**EUE**).

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 132kV feeder between Bunnerong STSS and Maroubra ZS by undertaking a like-for-like replacement of the existing feeder or installing one new 132kV feeder, coupled with a spare conduit for a future feeder. The two credible options are summarised below. All costs in this section are in real $2019/20, unless otherwise stated.

Table 3.1 – Summary of the credible options considered

Overview	Key components	Length of new feeders	Estimated capital cost
Option 1 – Replacement of the existing Feeder 265 Bunnerong STSS to Maroubra ZS like-for-like.	Replacement of existing Feeder 265 like-for-like using modern equivalent technology - Cross Linked Polyethylene (**XLPE**) cable.	3.7km	$13.9 million
Option 2 – Replacement of Feeder 265 with spare ductline to enable installation of future feeder Bunnerong – Kingsford.	Installation of one new 132kV feeder using modern XLPE cable to replace existing Feeder 265 and spare conduits (for a future feeder) connecting Maroubra ZS to Bunnerong STSS.	3.7km	$15.0 million

Other options were considered in addition to those set out in Table 3.1, however these options were found to be not credible. These options are discussed in Section 3.3 in the next page.

3.1 Option 1 – Like-for-like replacement of existing Feeder 265

This option involves a like-for-like replacement of the existing feeders that connect Bunnerong STSS and Maroubra ZS.

The project would include:

- works at Bunnerong STSS and Maroubra ZS to facilitate the new 132kV feeder connection;
- installation of one 132kV XLPE feeder of approximately 3.7km from Bunnerong STSS to Maroubra ZS, with a proposed firm rating of 230MVA;
- metering, control and protection communication upgrades at both ends; and
- decommissioning of the existing SCFF feeder between Bunnerong STSS and Maroubra ZS.

The estimated cost of this option is approximately $13.9 million. Ausgrid assumes that the like-for-like replacement would commence construction in 2020/21, with the replacement scheduled to finish in 2021/22, with commissioning occurring in the same year. Once the replacement is complete, operating costs are expected to be approximately $70k per annum (around 0.5 per cent of capital expenditure).

While cost benefit analysis has not identified Option 1 as the preferred option, it has still been included to provide a point of comparison for Option 2. The analysis underpinning the timing assessment of this option is set out in section 5.4.1.

3.2 Option 2 – Replacement of Feeder 265 with spare ductline

Option 2 involves the installation of a new 132kV Feeder and spare conduits (for a second future feeder) from Bunnerong STSS to Maroubra ZS including civil works, to replace 132kV SCFF Feeder 265. The scope would be the same as for Option 1 with the addition of the installation of one spare duct line to accommodate a future second circuit in the same trench.

Ausgrid has identified the following benefits that are related to proceeding with Option 2 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 $15.0 million. Ausgrid plans that the necessary construction to install the new feeders would commence in 2020/21 and end in 2021/2022, 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 $75k per annum (around 0.5 per cent of capital expenditure).

3.3 Options considered but not progressed

Ausgrid has considered one additional network option involving the decommissioning of the existing Feeder 265 and no works considered to replace the subtransmission feeder. However, this option was ruled out as it leaves Kingsford and Maroubra zone substations with only one source of supply.

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.

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.

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

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.

Given that no non-network options have been found to be viable, the appropriate discount rate is considered to be the regulated cost of capital. As a result, Ausgrid has adopted a real, pre-tax discount rate of 3.22 per cent, equal to the latest AER final decision for a DNSP's regulatory proposal at the time of preparing this FPAR[5].

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.

As the credible options are part of broader strategies to address network risks associated with SCFF feeders in this network area, consideration has been given to include the cost of future works (i.e. network investments required in approximately ten years to retire SCFF Feeder 262 connecting Clovelly and Double Bay ZS's and SCFF Feeder 270 connecting Maroubra and Kingsford ZS's). This is relevant to the assessment as one of the credible network options includes the addition of spare conduits for a marginal increase in cost that can facilitate the installation of a future feeder in the area at a materially lower cost than replacing the existing 132kV Feeder 265 alone.

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 corrective maintenance 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. Details of the assumptions and methodologies adopted to estimate these avoided costs are presented in Appendix D.

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[5] See AER Final Decision – Ausgrid distribution determination 2019-24 - Overview, section 2.2, available at https://www.aer.gov.au/system/files/AER%20-%20Final%20decision%20-%20Ausgrid%20distribution%20determination%202019-24%20-%20Overview%20-%20April%202019.pdf

4.3 Market benefits are expected from reduced involuntary load shedding

Ausgrid considers that the relevant categories of market benefits prescribed under the NER for this RIT-D relate to changes in involuntary load shedding and to account for option value.

The approach Ausgrid has made to estimating reductions in involuntary load shedding are outlined in section 4.3.1 below. Further details on the assumptions and methodology considered are presented in Appendix D.

In addition, Appendix C outlines the market benefit categories that Ausgrid considers are not material for this RIT-D.

4.3.1 Reduced involuntary load shedding

Involuntary load shedding occurs when a customer's load is interrupted from the network without their agreement or prior warning. This relates to the availability of network connectivity and design configuration at the substation. It also arises from the unavailability of network elements and the resulting reduction in network capacity to supply the load.

The EUE is the probability weighted average amount of load that customers request to utilise but would need to be involuntarily curtailed due to loss of network connectivity or a network capacity limitation. Ausgrid has forecast load over the assessment period and has quantified the EUE 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.

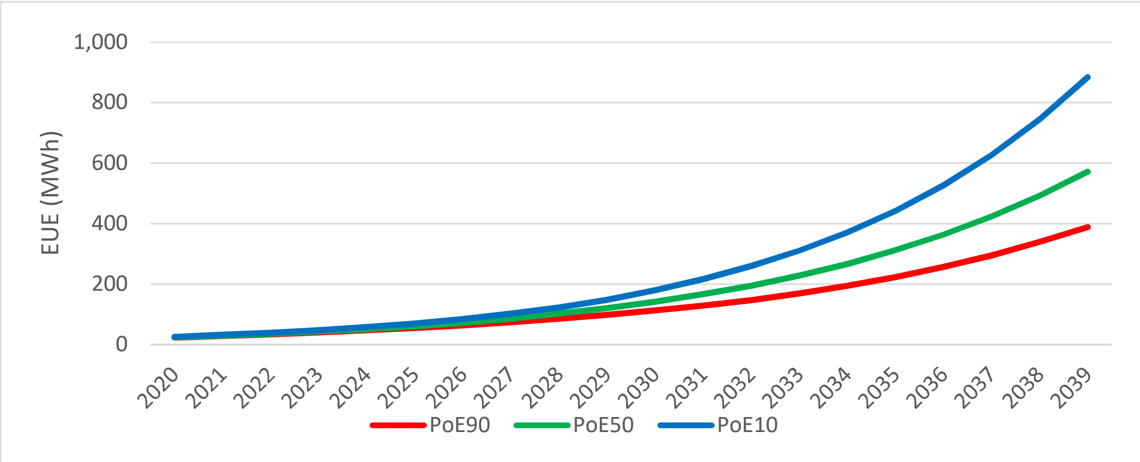
The market benefit that results from reducing the involuntary load shedding with a network solution is estimated by multiplying the quantity of EUE in MWh by the Value of Customer Reliability (**VCR**). The VCR is measured in dollars per MWh and is used as proxy to evaluate the economic impact of unserved energy on customers under the RIT-D.

Ausgrid has applied a central VCR estimate of $42.12/kWh, which is the load weighted value calculated for the NSW and ACT region by the AER in its VCR Final Report[6] (table 5.22 of the report). The report also recommends using values of ± 30% of the base case VCR for the purposes of testing how sensitive investment decisions are to the VCR input (section 7.2 of the report). Thus, a lower VCR of $29/kWh and a higher VCR of $55/kWh have been chosen as reasonable for the low and high benefit scenarios.

In addition, while load forecasts are not a determinant of the identified need, Ausgrid has investigated how assuming different load forecasts going forward changes expected market benefits under each option. In particular, three future load forecasts for the area in question were investigated – 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 EUE, under each of the three underlying demand forecasts investigated over the next twenty years. For clarity, this figure illustrates the MWh of unserved energy prior to feeder replacement minus the MWh of unserved energy post feeder replacement, taking into consideration the underlying demand forecasts and the assumed failure rates associated with keeping the network asset in service.

Figure 4.1 – Assumed expected unserved energy (EUE) under each of the three demand forecasts



[6] AER, *Values of Customer Reliability Review* – Final Report on VCR values – December 2019. https://www.aer.gov.au/system/files/AER%20-%20Values%20of%20Customer%20Reliability%20Review%20-%20Final%20Report%20-%20December%202019.pdf

4.3.2 Option Value

One of credible options has built-in flexibility to facilitate and reduce the cost of future investment needs in this network area. Given that excavation of a trench and civil works required to install a subtransmission cable account for approximately 70% of the overall capital expenditure incurred, it is possible to add spare conduits in the same trench at a marginal cost. Such conduits can be used to facilitate the installation of a future feeder between Bunnerong STSS and Kingsford ZS, enabling the retirement of SCFF feeders 262 and 270. Considering that the retirement of these feeders is expected to occur by 2030, this provides an opportunity to reduce the cost of the future works in present value terms when compared with an option where no spare conduits are installed.

Consistent with the approach proposed in the RIT-D guidelines, Ausgrid has applied scenario analysis to capture the benefits of retaining this built-in flexibility and therefore capture option value as a market benefit. Whilst there is no uncertainty associated to the need to replace those SCFF feeders in the future, there is material uncertainty about the timing and magnitude of the future replacement investments to replace such cables. The scenario analysis will also provide an opportunity to test the benefits of retaining network flexibility against changes in load forecast.

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	$42.12/kWh (Derived from the AER VCR 2019 estimates)	$29.48/kWh (30 per cent lower than the central, AER-derived estimate)	$54.76/kWh (30 per cent higher than the central, AER-derived estimate)
Capital Costs (including future capital costs)	100 per cent of capital cost estimate	125 per cent of capital cost estimate	75 per cent of capital cost estimate
Timing of Future Capital Costs	Target completion in 2031 (11 years from now)	Target completion in 2033 (13 years from now)	Target completion in 2029 (9 years from now)

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 benefits of credible options relative to the base case, $m 2019/20

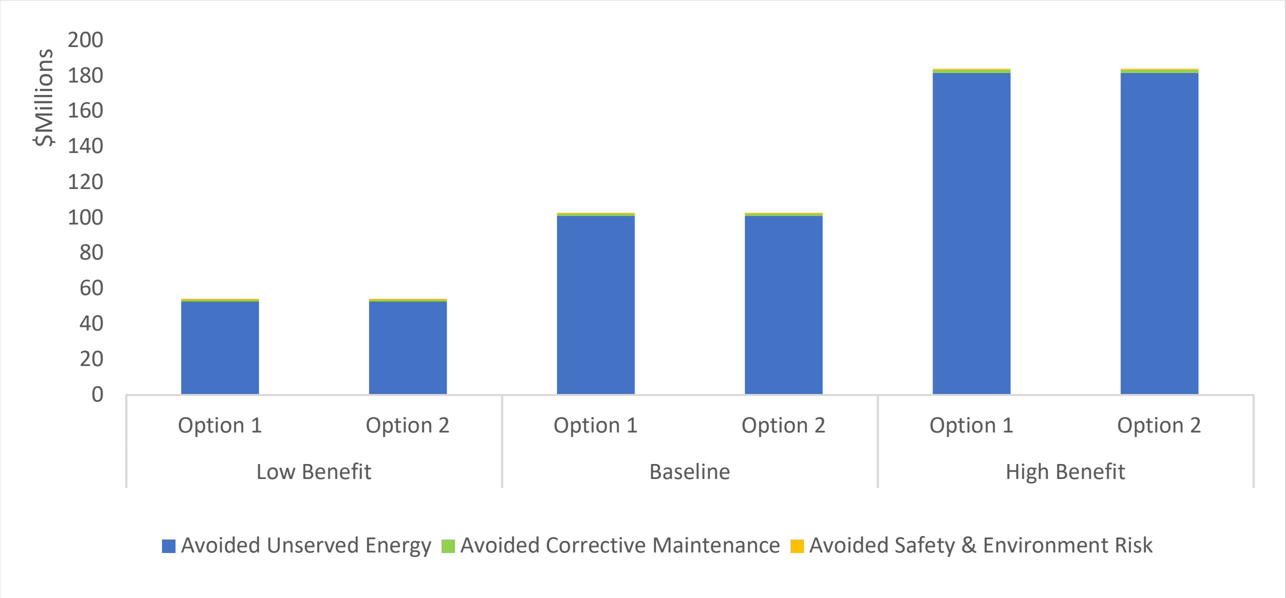
Option	Baseline scenario	Low benefit scenario	High benefit scenario	Weighted benefits
Scenario weighting	50%	25%	25%	
Option 1	102.5	54.0	183.7	110.7
Option 2	102.5	54.0	183.7	110.7

The figure below provides a breakdown of all benefits relating to each credible option. For clarity, we have combined in this chart 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 benefits of the credible options 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 sections 4.2 and 4.4.

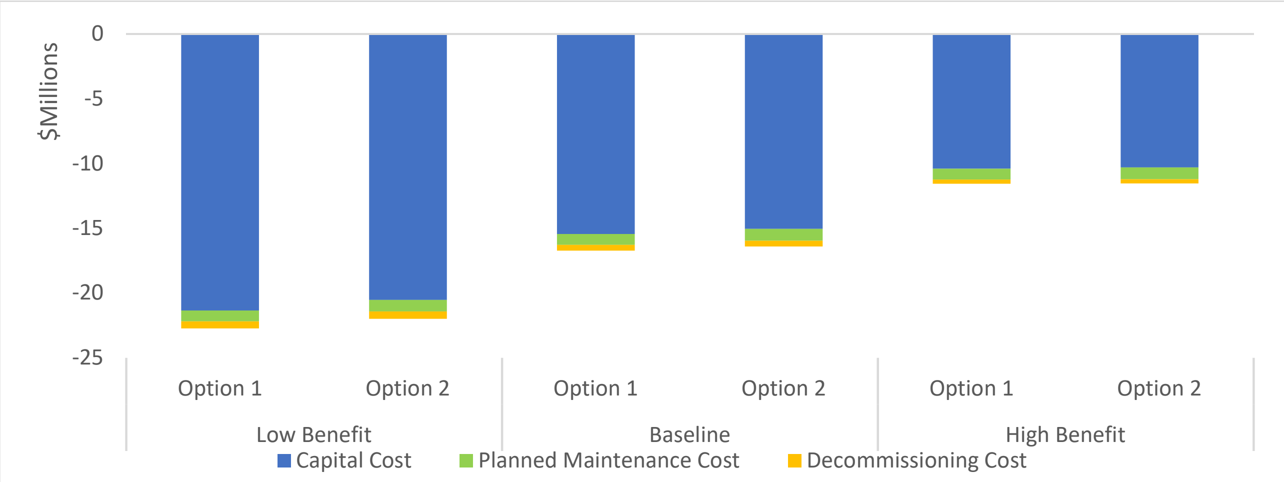
Table 5.2 – Present value of costs of the credible options relative to the base case, NPV $m 2019/20

Option	Baseline scenario	Low benefit scenario	High benefit scenario	Weighted costs
Scenario weighting	50%	25%	25%	
Option 1	-16.7	-22.8	-11.6	-16.9
Option 2	-16.4	-22.0	-11.6	-16.6

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 2 has the lowest capital cost. The cost analysis takes into consideration the broader strategy to address risks of SCFF feeders in the Eastern Suburbs network area. The installation of spare conduits for a marginal increase in cost now ($1.1 million higher than Option 1) provides an opportunity to reduce the cost of the future works, which results in a lower net present cost. Such future works will comprise the installation of new 132kV feeders utilising the spare ducts installed now to enable retirement of other SCFF feeders in this network area.

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 section 5.1) minus the cost of each option (as set out in section 5.2), all in present value terms. Overall, Option 2 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 2019/20

Option	PV of Capital costs	PV of Operating costs	Weighted PV of Gross Benefits	Weighted NPV	Ranking
Option 1	-15.7	-1.3	110.7	93.8	2
Option 2	**-15.2**	**-1.4**	**110.7**	**94.1**	**1**

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 ($29/kWh) and a higher VCR ($55/kWh); and
- 2-year early/late completion of Stage 2 investment

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 2022/23; for Option 2 is assumed to have the optimal trigger year of 2021/22.

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

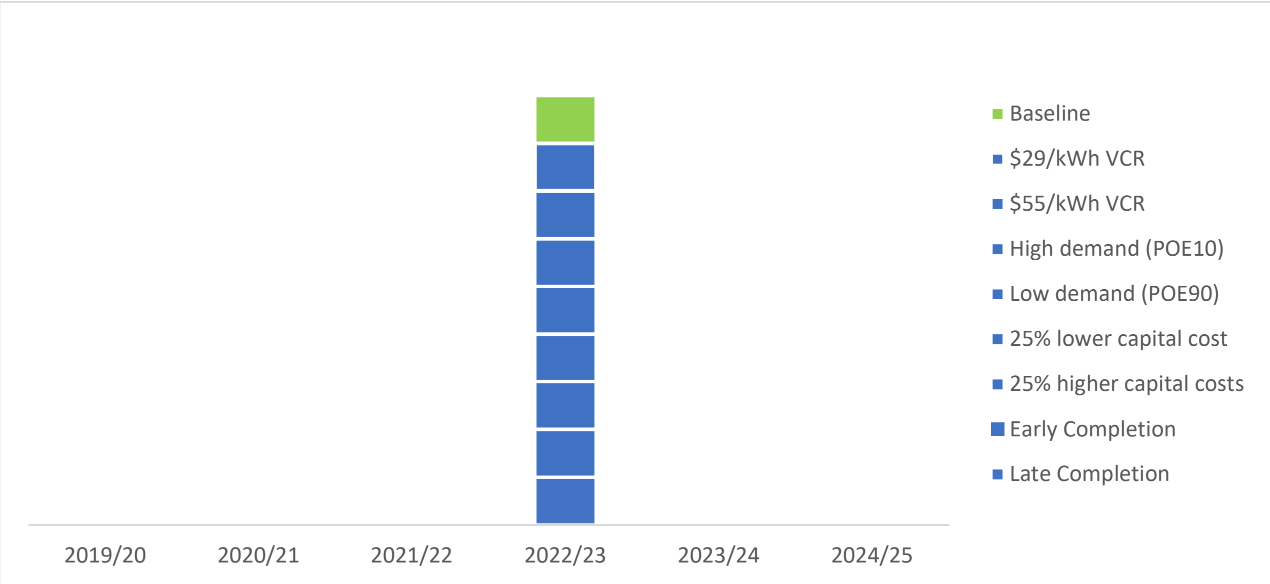
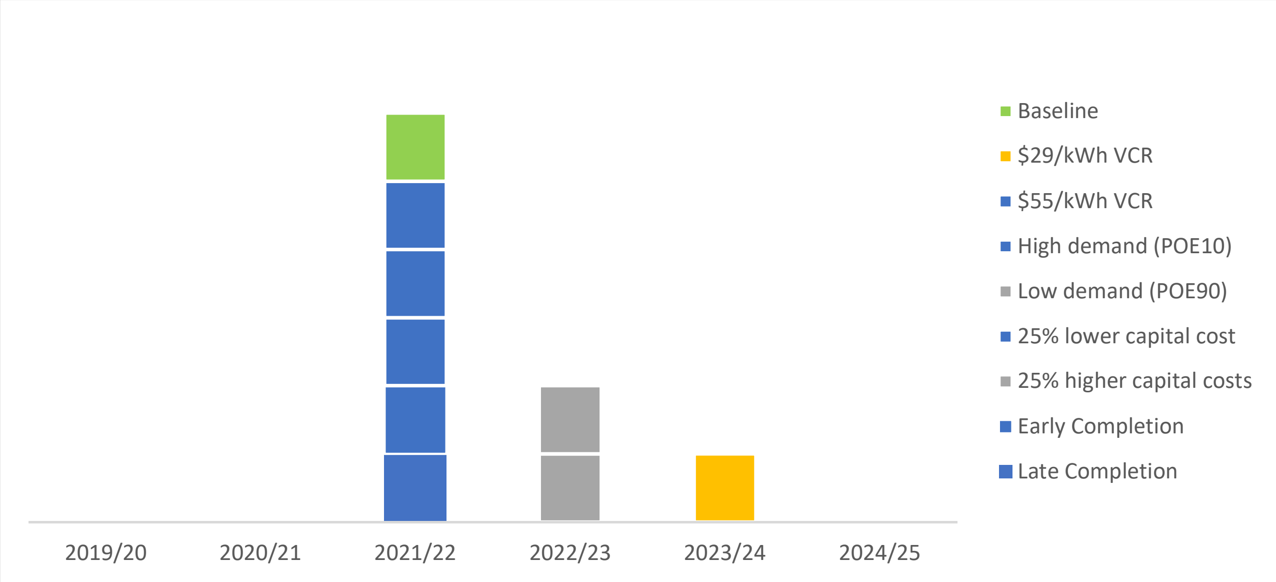


Figure 5.4 – Option 2's distribution of optimal project commissioning years under each sensitivity



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, ie:

- 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 ($29/kWh) and a higher VCR ($55/kWh); and
- 2-year early/late completion of Stage 2 investment

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 2 is found to be the preferred option across all sensitivities investigated.

Table 5.4 – Sensitivity testing results, $m PV 2019/20

Sensitivity	Option 1	Option 2
Baseline	85.8	**86.1**
25 per cent higher capital cost	81.9	**82.4**
25 per cent lower capital cost	89.7	**89.9**
Unserved energy under POE10	124.7	**125.0**
Unserved energy under POE 90	60.3	**60.6**
VCR $55/kWh	116.0	**116.3**
VCR $28/kWh	55.6	**56.0**
2-year early completion	84.2	**84.8**
2-year late completion	87.3	**87.4**

6 Proposed preferred option

Option 2 has been found to be the preferred option, which satisfies the RIT-D. It involves the replacement of the existing SCFF Feeder from Bunnerong STSS ZS to Maroubra ZS with a new 132kV feeder 3.7km long and includes a spare ductline to facilitate the installation of a future feeder. Once installed, the existing SCFF feeder will be decommissioned.

The route of the proposed feeder under Option 2 is depicted in Figure 6.1 below.

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

Ausgrid started engaging with key stakeholders such as Randwick City Council in November 2019 to obtain early feedback on the preferred cable route. Engagement with residents and businesses along and around the preferred cable route started in late February 2020. After that, an information session was held at the Maroubra Senior Citizens Centre on 3 March 2020, to seek further local information and feedback. Ausgrid encourages community feedback and has committed to keep the community informed as the project progresses through notification letters and the Ausgrid website.

The estimated capital cost of this option is $15.0 million. Ausgrid assumes that the necessary construction to install the new feeders would commence in 2020/21 and end in 2021/22. Once the new installation is complete, operating costs are expected to be approximately $75,000 per annum (around 0.5 per cent of capital expenditure).

Ausgrid considers that this DPAR, and the accompanying detailed analysis, identify Option 2 as the preferred option and that this satisfies the RIT-D. Ausgrid is the proponent for Option 2.

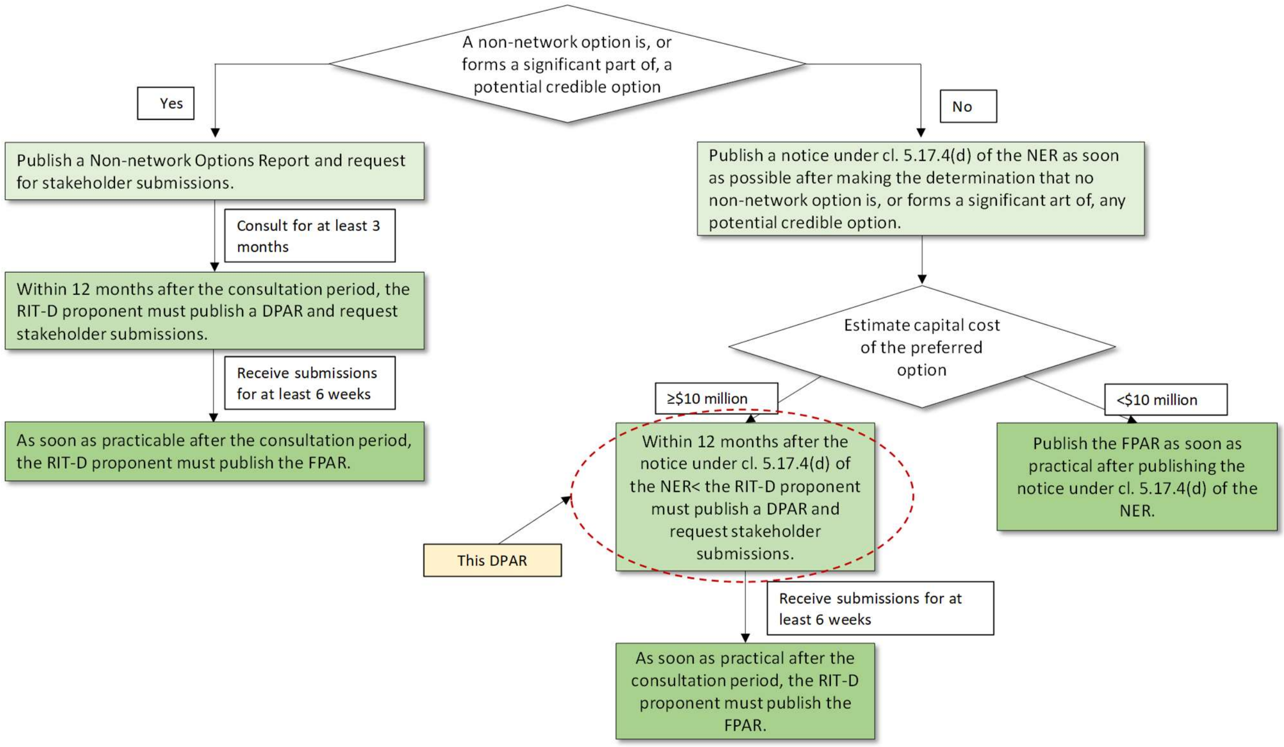
Appendix A – Checklist of compliance clauses

This section sets out a compliance checklist that demonstrates the compliance of this DPAR 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 DPAR
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 draft report may be directed.	1.2

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.



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 the timing of unrelated expenditure;
- changes in voluntary load curtailment;
- changes in costs to other parties;
- changes in load transfer capability and capacity of embedded generators to take up load; and
- changes in 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.
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 and assumptions

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

D.1 Characteric load duration curves

The load duration curves for Kingsford, Maroubra and Clovelly ZSs is presented in Figure D.1, Figure D.2 and Figure D.3 below.

It is assumed that the load types supplied by these substations 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 Kingsford, Maroubra and Clovelly.

No load transfer capability has been included at Clovelly ZS as there is negligible impact on the assessment of this project.

Figure D.1 – Load duration curve for Kingsford

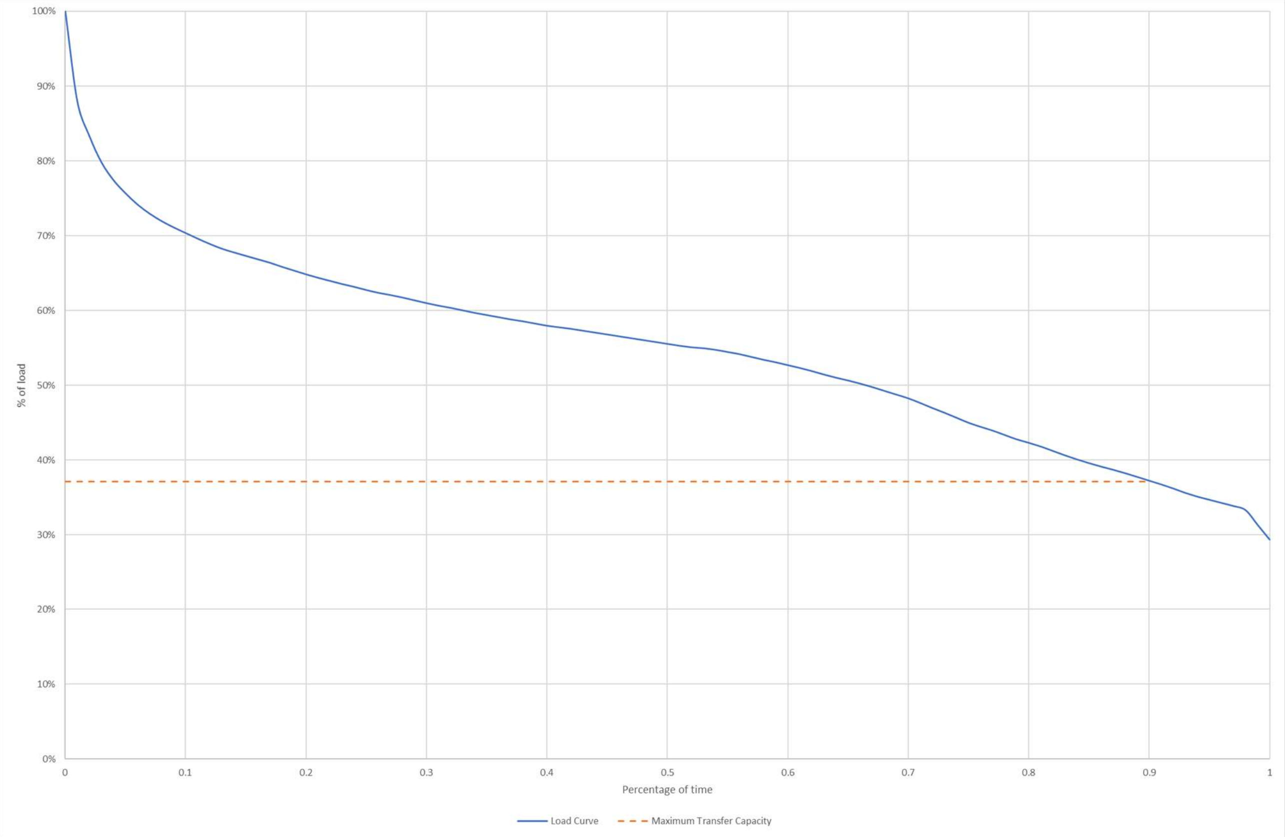


Figure D.2 – Load duration curve for Maroubra

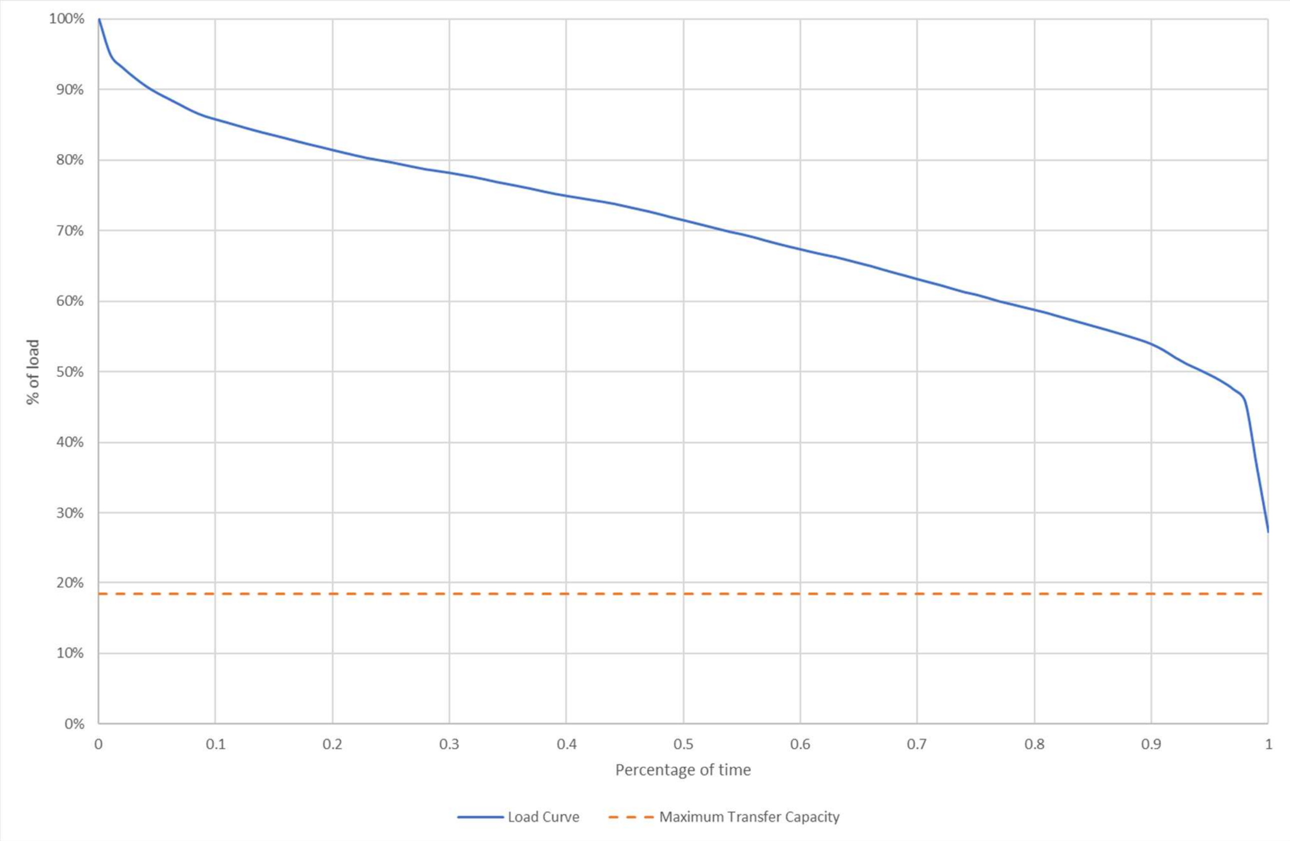
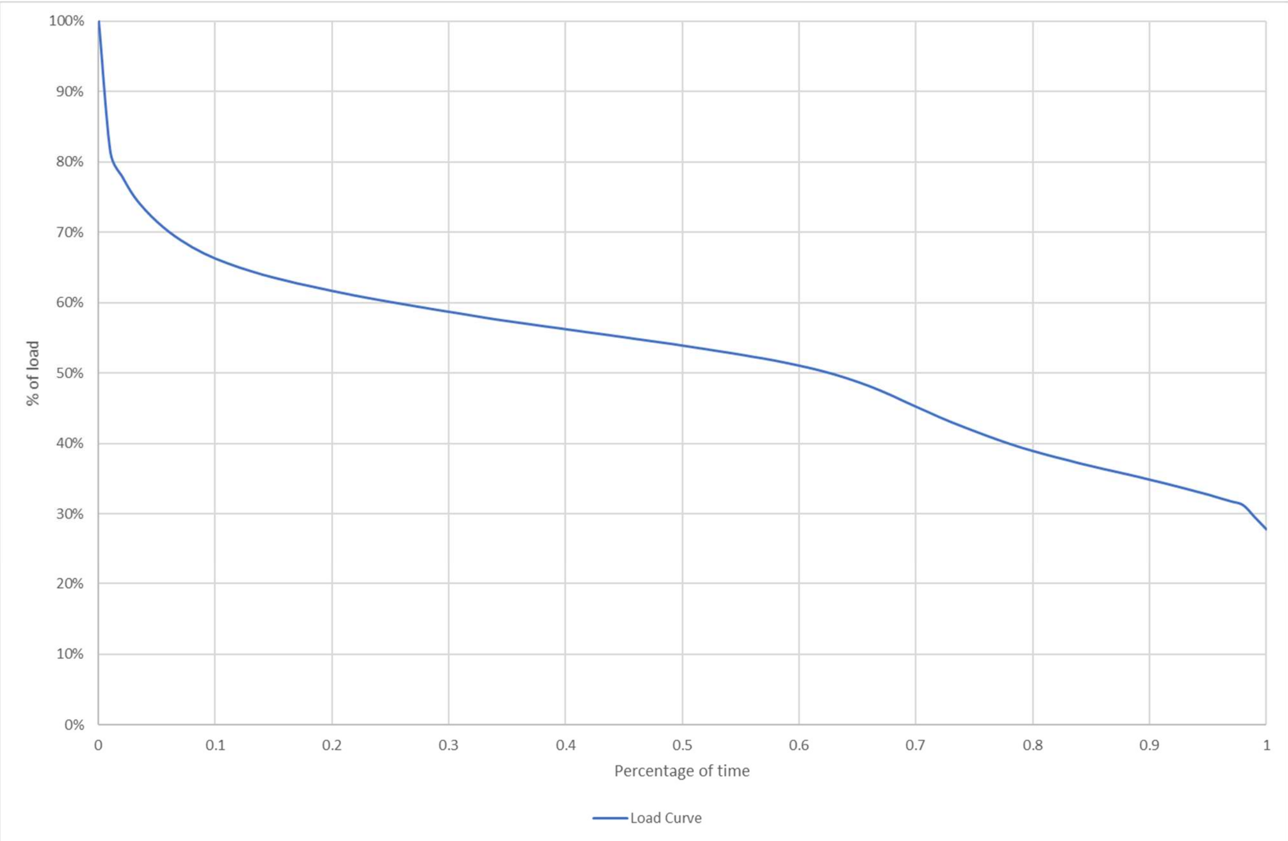


Figure D.3 – Load duration curve for Clovelly



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
XLPE cable failure	Repair The cable is repaired on site.	2.0 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 fluid filled, 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 Crow-AMSAA parameters for each cable type.

Table D.3 – Underground cable parameters

Feeder	Type	Β factor	Λ factor	MTTR[7] (weeks)
264	Corrective action	4.73	1.93E-08	1.06
264	Breakdowns	5.67	1.35E-11	7.00
264	Third party damage	1.44	8.78E-05	5.50
265	Corrective action	4.71	1.93E-08	1.06
265	Breakdowns	5.65	1.35E-11	7.00
265	Third party damage	1.43	8.78E-05	5.50
270	Corrective action	4.72	1.93E-08	1.06
270	Breakdowns	5.66	1.35E-11	7.00
270	Third party damage	1.43	8.78E-05	5.50
26C	Breakdowns	0.24	0.02	2.00
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

* XLPE cables do not have corrective actions as they are not fluid filled
* There is insufficient data on third party damage of XLPE cables to develop Crow-AMSAA parameters

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 2.4 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.

[7] Mean Time To Repair

D.4 Enviromental costs

Ausgrid has experienced major leaks from SCFF cables and some Ausgrid cables leak smaller amounts of oil into the environment that are difficult to locate and repair. Ausgrid policy is to minimise environmental impact to the extent it is practical. Regardless, fluid leaks expose Ausgrid to a risk of liability under the Protection of the Environment Operations Act 1997 (NSW), particularly in relation to pollution of water and pollution of land.

It is necessary to include the environmental risk in the cost benefit analysis as the continued service of SCFF cables will result in further deterioration in condition and an increasing number of failures that are random in nature. These failures have the potential to cause damage to the environment. The quantification of environmental risk is calculated as follows.

Equation 5

$$Environmental\ risk\ cost = F \times EC \times \beta$$

Where;

F is the failure rate of the equipment

EC is the environmental criticality

β is a factor calculated based on the conditional probability of ground water impacts from a fluid leak

The Environmental Criticality (EC) is calculated for the three feeder failure types outlined in table D.1, namely;

- corrective actions;
- breakdowns; and
- third party damage.

Each failure type is made up by a group of possible failure modes. For each failure type, the Mean Time To Repair is determined by taking the average of the repair times for each failure mode assuming equal likelihood for each failure mode within that failure type. The proportion of the year that would be impacted by a single equivalent failure is then used to weight the monetised consequence of a significant fluid leak to produce the Environmental Criticality for each failure type.

Equation 6

$$Environmental\ Criticality = \frac{MTTR}{52} \times Sig.oil\ leak\ cost$$

Where;

$MTTR$ is the Mean Time To Repair in weeks

$Sig.oil\ leak\ cost$ is the monetised worth of a detectable fluid leak of 5L per day for one year multiplied by $3,000/L[8] (5L x 365 days x $3,000 = $5.475M) plus an amount of $21,198 being a weighted tier two and/or three fine under the POEO Act.

Table D.4: Environmental Criticality for each failure type

Environmental Criticality		
Corrective Action	Breakdown	Third Party Damage
$103,468	$916,033	$581,328

D.5 Direct costs of equipment failures

In the event of a serious failure of a fluid filled cable, repairs would need to be done to return the cable into service. As this cost is avoided if the cable is replaced before any failure takes place, this repair cost represents a saving and is factored into the cost benefit analysis. The following equation is used to calculate the impact of repair cost.

Equation 7

$$Repair\ cost = F \times D$$

Where;

F is the failure rate

D is the repair cost per event

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[8] NSW EPA's Regulatory Impact Statement – Proposed Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2014 – states "*Petroleum can contaminate large volumes of groundwater. For example, according to Environment Canada, one litre of gasoline can contaminate 1,000,000 litres of groundwater. If water used for domestic purposes is priced at about $3,000/ML (Deloitte Access Economics 2013)*"

Ausgrid