Addressing increasing risk of 33kV feeders supplying Darlinghurst Zone Substation

FINAL PROJECT ASSESSMENT REPORT

11 March 2026

Ausgrid

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Final Project Assessment Report – 11 March 2026

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Executive Summary

The Darlinghurst Zone Substation (ZS) was commissioned in 1966 and is located in Ausgrid's Eastern Suburbs network area. The Darlinghurst ZS is currently supplied from the Surry Hills Sub-transmission Substation (STS) through two underground 33 kV gas pressured cables (or 'feeders').

The 33 kV gas pressured feeders from the Surry Hills STS to Darlinghurst ZS are becoming less reliable and are approaching the end of their useful life. Without action, they pose an increased risk of customer outages.

Ausgrid is therefore undertaking a Regulatory Investment Test for Distribution (RIT-D) to assess options for addressing the risk associated with the ageing 33 kV gas pressured feeders to ensure we continue to satisfy our reliability and performance standards. This Final Project Assessment Report (FPAR) represents the final step in the application of the RIT-D to options for addressing this increasing risk and follows publication of an Options Screening Notice.

The 'identified need' for this RIT-D is to ensure we continue to satisfy our reliability and performance standards for customers in the Eastern Suburbs

Ausgrid is obliged to comply with reliability and performance standards as part of its distribution license granted by the Minister for Industry, Resources and Energy under the *Electricity Supply Act 1995 (NSW)*. Under the license, reliability and performance standards are expressed in two measures:

- SAIDI[1] – which means the average derived from the sum of the durations of each sustained customer interruption (measured in minutes), divided by the total number of customers (averaged over the financial year); and
- SAIFI[2] – which means the average derived from the total number of sustained customer interruptions divided by the total number of customers (averaged over the financial year).

These two reliability measures capture two key aspects of supply disruptions to electricity customers, i.e., how long their electricity supply is off for as well as how often their electricity supply is off. Customers experience a better electricity service the lower each of these measures are. Reliability standards applied to distribution networks typically set maximums in relation to each of these two measures.

The main concern this RIT-D is seeking to address relates to increasing customer supply risks derived from the condition of the 33k V cables. If action is not taken to address the deteriorating condition of this equipment, then our analysis shows that the unserved energy modelled will put these performance standards at risk.

By addressing the reliability concerns from the aging cables, the investment will deliver material net market benefits for customers from a reduction in expected unserved energy and avoided maintenance costs.

Two credible network options have been assessed

We have identified and assessed two credible options as part of our network planning activities. Each option has been developed following an assessment of the various potential dimensions for addressing the obsolete 33 kV gas pressured cables and ensuring reliable supply of electricity to the Eastern Suburbs network area.

Table E.1 – Summary of the credible network options considered, $2024/25

Option	Labour	Materials	Contracted Services	Indirect cost	Decommissioning cost	Total
Option 1 – Replace existing 33 kV gas pressured cables	1.1	0.1	6.1	0.7	0.2	**8.2**
Option 2 – Retire Darlinghurst ZS	5.2	4.1	17.0	3.0	2.4	**31.7**

[1] System Average Interruption Duration Index.
[2] System Average Interruption Frequency Index.

Option 1 involves replacing the existing 33 kV gas pressured cables to the existing Darlinghurst ZS with new cables, making use of an existing underground cable tunnel network to minimise disruption to the local community. The use of the existing cable tunnel network reduces the required trenching from approximately 1.2 km to only 0.38 km.

Option 2 involves retiring the existing Darlinghurst ZS and transferring its existing 11 kV loads to the Campbell Street ZS.

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

Ausgrid has considered the ability of any non-network options (NNOs), as well as stand-alone power system (SAPS) solutions to assist in meeting the identified need.

An assessment regarding reducing the risk of unserved energy has shown that these alternatives are unlikely to cost-effectively address the risk, compared to the two network options outlined above. This is driven primarily by the significant amount of unserved energy that each network option can avoid, compared to the base case, and the expected cost of NNOs or SAPS solutions.

In addition, these solutions would not resolve the escalating reactive maintenance costs associated with continued use of the cables.

Our assessment of these solutions is detailed further in the separate Options Screening Notice released in accordance with clause 5.17.4(d) of the NER.

Three different scenarios have been modelled to deal with 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.

The scenarios only differ by the demand forecasts given this is the key parameter affecting the ranking of the credible options. How the results are affected by changes to other variables (i.e. the discount rate and capital costs) have been investigated in the sensitivity analysis.

Table E.2 – Summary of the three scenarios investigated

Variable	Scenario 1 – central demand scenario	Scenario 2 – low demand scenario	Scenario 3 – high demand scenario
Demand	Central forecast (POE50)	Low forecast (POE90)	High forecast (POE10)
VCR	$36.40/kWh across all scenarios		
Discount Rate	3.70% across all scenarios		

Option 1 is found to be the preferred option

Option 1 has the greatest estimated net market benefits of the two options across each of the scenarios investigated. The differences in net market benefits are primarily driven by the cost differences between the options.

Table E.3 – Present value of net benefits relative to the base case by scenario and weighted, NPV $m

Option / scenario	Central demand	High demand	Low demand	Weighted	Rank
Scenario weighting	1/3	1/3	1/3		
Option 1	**71.3**	**83.3**	**64.1**	**72.9**	**1**
Option 2	62.9	73.4	56.6	64.3	2

Ausgrid therefore considers that Option 1 is the preferred option that satisfies the RIT-D. This finding is found to be robust to a range of general sensitivity tests investigated (covering assumed network costs, VCR values and discount rates), as well as a specific sensitivity that assumes that the existing air-insulated 11 kV switchgear also needs to be replaced over the assessment period for Option 1.

The scope of Option 1 includes:

- works at Surry Hills STS and Darlinghurst ZS to facilitate the 33 kV connections;
- construction of a cable shaft in Yurong Street in Darlinghurst to form a connection to the existing City East Cable tunnel (CECT);
- construction of a new 33 kV ductline along Liverpool Street in Darlinghurst;
- installation of two 33 kV Cross Linked Polyethylene (XLPE) feeder cables of approximately 1 km through the CECT shaft and Liverpool Street ductline;
- communication upgrades at both ends; and
- decommissioning of the existing, ageing gas pressured cables between the Surry Hills STS and the Darlinghurst ZS.

The estimated capital cost of this option is approximately $8.2 million, comprising:

- $6.8 million for commissioning two new 33 kV feeder cables;
- $1.2 million for the construction of a cable shaft in Yurong Street; and
- $0.2 million for the decommissioning of the old 33 kV feeder cables.

Planned routine network operating costs under this option are expected to be around $14,000/year once commissioned, which is approximately 30% lower than the current annual routine maintenance costs for the two aging cables at the Darlinghurst ZS.

Overall, Option 1 is the lowest cost of the two credible options assessed in this FPAR and delivers the greatest net benefits.

Ausgrid expects that the necessary construction would commence as soon as practicable after this RIT-D and end in 2027/28, with commissioning in the beginning of 2028/29.

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

This FPAR represents the final step in the application of the RIT-D to options for ensuring reliable electricity supply to the Eastern Suburbs load area. A Draft Project Assessment Report (DPAR) is not required for this RIT-D in line with clause 5.17.4(n) of the NER, i.e., since there are not expected to be any non-network or SAPS solutions and the capital cost of the preferred option is less than the $14 million threshold.[3]

Under the NER, parties have 30 days from the date of this report to dispute the application of the RIT-D. Disputes are only able to be made on the grounds that Ausgrid has not applied the RIT-D in accordance with the NER, or that Ausgrid preformed a manifest calculation error in applying the RIT-D. Disputing parties cannot dispute issues in this FPAR that the RIT-D treats as externalities, or relate to an individual's personal detriment or property rights. Clause 5.17.5 of the NER sets out the full process and requirements regarding a dispute of how the RIT-D has been applied.

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

Mark Ragusa
Head of Asset Management & Planning
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GPO Box 4009
Sydney 2001

Or

email to: assetinvestment@ausgrid.com.au

[3] AER, 2024 RIT and APR cost thresholds review: Final determination, November 2024, p 1.

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 Eastern Suburbs network area going forward. It follows publication of the Options Screening Notice for this RIT-D.

The Darlinghurst Zone Substation (ZS) is located in, and contributes to the reliable supply of electricity to, the Eastern Suburbs network area. This ZS currently supplies approximately 9,000 customers in the area, with a summer forecast load of 20 MVA (which is below the substation's rated capacity of 24 MVA).

The Darlinghurst ZS was commissioned in 1966 and many of the original assets are still in service. It is currently supplied from the Surry Hills Sub-transmission Substation (STS) through two underground 33 kV gas pressured cables (or 'feeders').

The 33 kV gas pressured feeders from the Surry Hills STS to Darlinghurst ZS are becoming less reliable and are approaching the end of their useful life, posing an increased risk of customer outages.

In 2018, Ausgrid's Eastern Suburbs area plan review determined that the preferred strategy to address the ongoing asset condition issues at Darlinghurst ZS was to decommission the gas cables in two stages – namely:

- Stage 1 (initiated in 2018, and completed in 2024) – addressing the condition of two of the four 33 kV gas cables (and the 11 kV compound-insulated switchgear) by transferring the 11 kV load to the compound insulated switchgear to Campbell Street ZS and retiring the associated assets; and
- Stage 2 (which had a targeted completion date in 2028/29) – addressing the condition of the two remaining gas cables (and 11 kV air-insulated switchgear) by transferring the residual load to Campbell Street ZS to enable retirement of the assets.

Ausgrid is therefore undertaking a RIT-D to assess options for addressing the risk associated with the ageing 33 kV gas pressured feeders, to ensure we continue to satisfy our reliability and performance standards. This FPAR effectively provides a revised assessment of Stage 2 of the 2018 Eastern Suburbs area plan review.

If action is not taken, it is expected that Ausgrid's electricity distribution license reliability and performance standards will be breached.

Ausgrid has determined that non-network and stand-alone power system (SAPS) solutions are unlikely to form a standalone credible option, or form a significant part of a credible option, for this RIT-D, as set out in the separate Options Screening Notice released in accordance with clause 5.17.4(d) of the National Electricity Rules (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. It is the final stage of the RIT-D process set out in the NER.

The purpose of the FPAR is to:

- describe the need Ausgrid is seeking to address, including the assumptions used in identifying this need;
- 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 determined that some classes of market benefits or costs do not apply to credible options;
- present the results of a net present value (NPV) analysis of each credible option and explain these results; and
- identify the preferred option.

A Draft Project Assessment Report (DPAR) is not required for this RIT-D in line with clause 5.17.4(n) of the NER, i.e., since there are not expected to be any non-network or SAPS solutions and the capital cost of the preferred option is less than the $14 million threshold. The full RIT-D process is detailed in Appendix B.

1.2 Next steps and contact details for queries in relation to this RIT-D

This FPAR represents the final step in the application of the RIT-D to options for ensuring reliable electricity supply to the Eastern Suburbs load area.

Under the NER, parties have 30 days from the date of this report to dispute the application of the RIT-D. Disputes are only able to be made on the grounds that Ausgrid has not applied the RIT-D in accordance with the NER, or that Ausgrid preformed a manifest calculation error in applying the RIT-D. Disputing parties cannot dispute issues in this FPAR that the RIT-D treats as externalities, or relate to an individual's personal detriment or property rights. Clause 5.17.5 of the NER sets out the full process and requirements regarding a dispute of how the RIT-D has been applied.

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

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Sydney 2001

Or

email to: assetinvestment@ausgrid.com.au

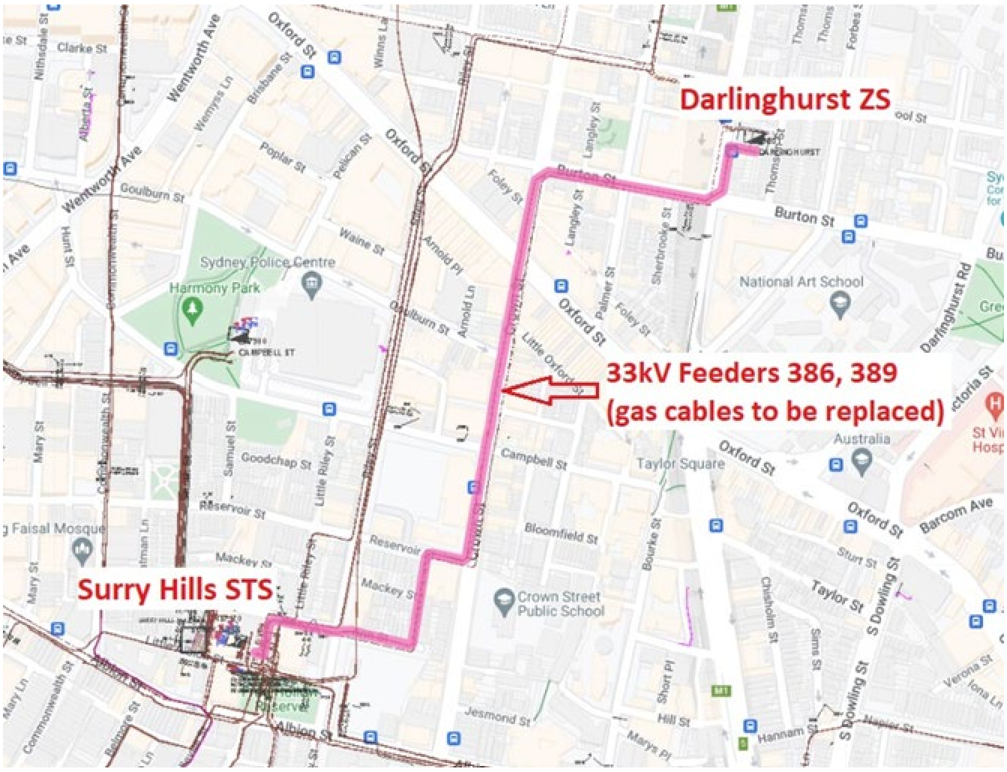
2 Description of the identified need

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

2.1 Overview of the relevant network area

The Darlinghurst ZS is a 33/11 kV ZS that was commissioned in 1966 and is currently supplied by the Surry Hills STS via two 33 kV gas pressured feeders (feeders 386 and 389). The ZS supplies customers located in the Eastern Suburbs network area, including residential, commercial and industrial customers.

Figure 2.1 – Existing location of 33 kV gas pressured feeder cables



The gas pressured cables that connect the Darlinghurst ZS to the Surry Hills STS are approaching the end of their useful life and are becoming more difficult to maintain. Gas pressured insulated cables have been used in Ausgrid's network from 1906 until the mid-1980s for sub-transmission feeders, and these types of cables are prone to leaks due to the high operating pressures.

Gas pressured cables are difficult to effectively repair, such that any repairs themselves take a prolonged period to complete and require the entire cable to be re-gassed. Once repaired, it takes a considerable amount of time for the gas to diffuse throughout the cables and displace any air that was introduced by the defects or during the repair work. For these reasons, gas pressured cables are becoming obsolete in modern electricity distribution networks.

Since early 2012, Ausgrid has developed and implemented a strategy to replace or retire its fleet of 33 kV gas pressured cables and, since the strategy was proposed, only 26 km of the original 185 km of gas pressured cables remain in service. The two gas pressured cables between the Darlinghurst ZS and the Surry Hills STS make up approximately 2 km of the cables still in service.

Between 2018 and 2024, Ausgrid addressed the condition of two of the initial four 33 kV gas cables (and the 11 kV compound-insulated switchgear) at the Darlinghurst ZS by transferring the 11 kV load to the compound insulated switchgear to Campbell Street ZS and retiring the associated assets. This work predated the requirement in the NER for the RIT-D to be applied to replacement works.

Without action, the remaining two 33 kV gas pressured cables supplying Darlinghurst ZS are expected to continue to deteriorate, resulting in long repair times and prolonged outages to customers in the Eastern Suburbs network area.

2.2 Summary of the identified need

Ausgrid is obliged to comply with reliability and performance standards as part of its distribution license granted by the Minister for Industry, Resources and Energy under the *Electricity Supply Act 1995 (NSW)*. Under the license, reliability and performance standards are expressed in two measures:

- SAIDI[4] – which means the average derived from the sum of the durations of each sustained customer interruption (measured in minutes), divided by the total number of customers (averaged over the financial year); and
- SAIFI[5] – which means the average derived from the total number of sustained customer interruptions divided by the total number of customers (averaged over the financial year).

These two reliability measures capture two key aspects of supply disruptions to electricity customers, i.e., how long their electricity supply is off for as well as how often their electricity supply is off. Customers experience a better electricity service the lower each of these measures are. Reliability standards applied to distribution networks typically set maximums in relation to each of these two measures.

The main concern this RIT-D is seeking to address relates to increasing customer supply risks derived from the condition of the 33k V cables. If action is not taken to address the deteriorating condition of this equipment, then the analysis shows that the unserved energy modelled will put these performance standards at risk.

By addressing the reliability concerns from the aging cables, the investment will deliver material net market benefits for customers from a reduction in expected unserved energy (EUE) and avoided maintenance and repair costs.

2.3 Key assumptions underpinning the identified need

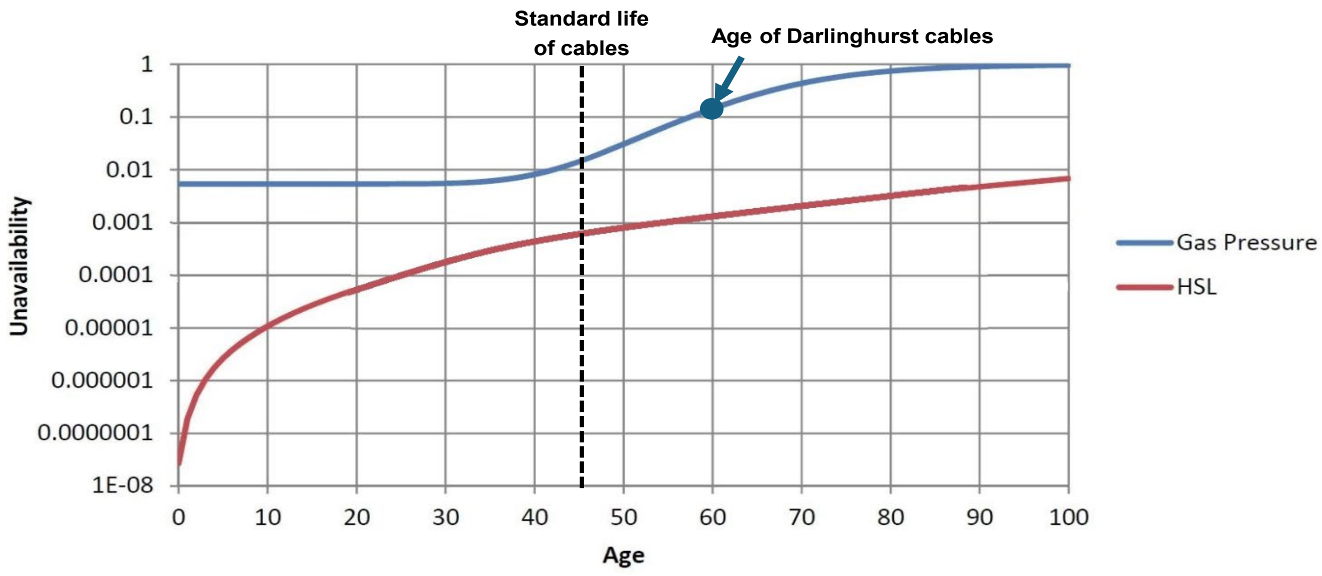
This section summarises the key assumption underpinning the identified need for this RIT-D. Appendix D provides additional detail on the assumptions used, and methodologies applied, to estimate the costs and market benefits.

2.3.1 Probability of assets failing increases with age

Ausgrid has adopted well-accepted models for each major class of network asset to estimate the probability of failure. In general, the probability of failure increases with asset age.

Figure 2.2 below shows unavailability plotted, on a logarithmic scale, for a representative 10 km stretch of cables aged zero to one hundred years.[6] It also maps to these curves the age of the current underground gas pressure cables at the Darlinghurst ZS and, in doing so, highlights how these cables are now 15 years past the 'standard' asset life for such cables (noting that they will be 18 years passed their standard asset life by the time corrective action is implemented).

Figure 2.2 – Unavailability of underground cable technologies



[4] System Average Interruption Duration Index.
[5] System Average Interruption Frequency Index.
[6] For this RIT-D, it is only 'gas pressure' cables that are relevant for the Darlinghurst ZS, i.e., the blue line.

Gas pressured cables typically exhibit unavailability rates 3 to 10 times higher that modern equivalent cable technology (i.e., Cross Linked Polyethylene or 'XLPE' cables). For gas cables over 40 years old, there is an unavailability 'elbow' where forced outages increase exponentially.

The Crow-AMSAA model is used to determine the probability of failure and unavailability for underground cables. For gas pressured cables, the model is also based on the assumption that the condition of a cable is age dependent. The model shows that the availability of gas pressure cables is expected to decline if the cables are retained past an age of 50 years.

For switchboards, Weibull analysis is used to derive a probability distribution function for the asset's age at time of failure.

Ausgrid considers the methodologies applied are consistent with industry practice. A detailed discussion of the probability of failure and asset availability for both cables and switchboards are provided in Appendix D.

2.3.2 Supply restoration takes time but load transfers are possible

The cost associated with involuntary load shedding is dependent on assumptions relating to supply restoration times.

Ausgrid considers that the time required for restoration after a typical cable failure of the type in the Darlinghurst ZS can vary between 24 and 28 days depending on the type of failure, with some complex failure cases requiring up to 60 days. Detailed restoration assumptions are set out in Appendix D.

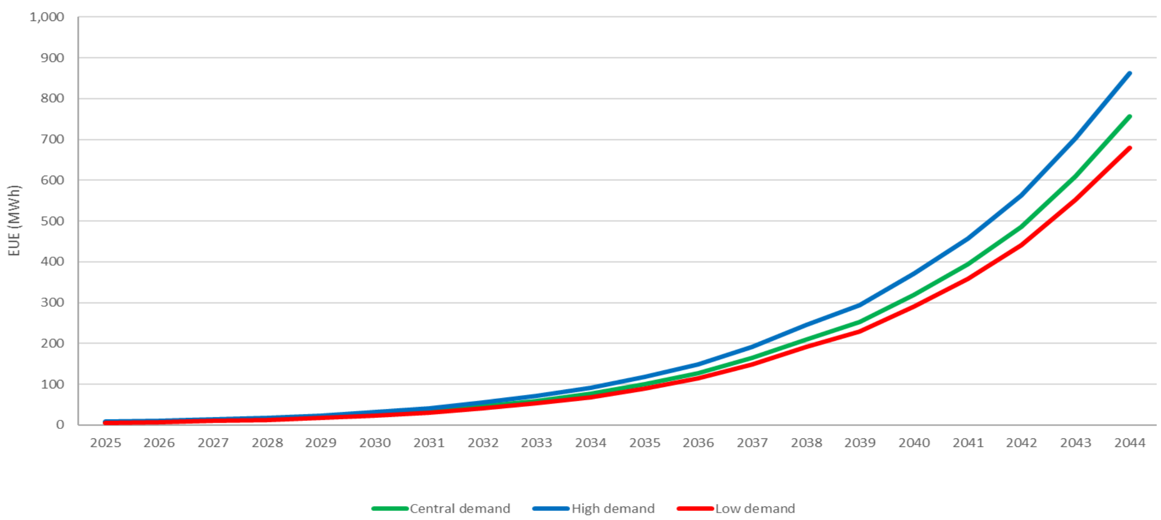
As part of restoring supply after an outage, the Darlinghurst ZS has load transfer capabilities that can mitigate the severity of involuntary load shedding. It has 11 kV interconnections with the Campbell St, Paddington and Surry Hills zone substations. In the event of a total loss of supply, up to 63 per cent of the load can be recovered by switching to adjacent substations via the 11kV network after a time delay (i.e., by closing and opening normally open points on the network).

These load transfers can help mitigate any EUE to customers following failures of assets at the Darlinghurst ZS. Ausgrid has factored the ability to transfer load into its assessment of forecast EUE. In addition, mobile generation sets can also be used to restore loads. Whilst load to many customers can be restored through switching operations in the 11 kV network combined with the use of mobile generation sets, the full incident recovery process (i.e., cable and/or substation equipment repairs) can take several weeks (which may result in EUE over this period).

We have investigated how assuming different load forecasts going forward changes the EUE (and therefore net market benefits) under the proposed options. Three future load forecasts have been considered for the area in question – namely a central forecast that represents expected load growth using our 50 per cent probability of exceedance ('POE50') forecasts, as well as a low forecast using the POE90 forecasts and a high forecast using the POE10 forecasts.

Figure 2.3 below shows the modelled 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 EUE assumed under each load forecast if no credible option is commissioned (i.e. under the 'do nothing' base case for that load forecast).

Figure 2.3 – Forecast EUE under each of the three demand forecasts – base case



Appendix D provides additional detail on the assumptions underpinning the identified need (i.e. the assumed load duration curve and how the probability of failure has been modelled).

3 Two credible options have been assessed

This section provides details of the two credible network options that Ausgrid has identified as part of its network planning activities. Each option has been developed following an assessment of the various potential dimensions for addressing the obsolete 33 kV gas pressured cables and ensuring reliable supply of electricity to the Eastern Suburbs network area.

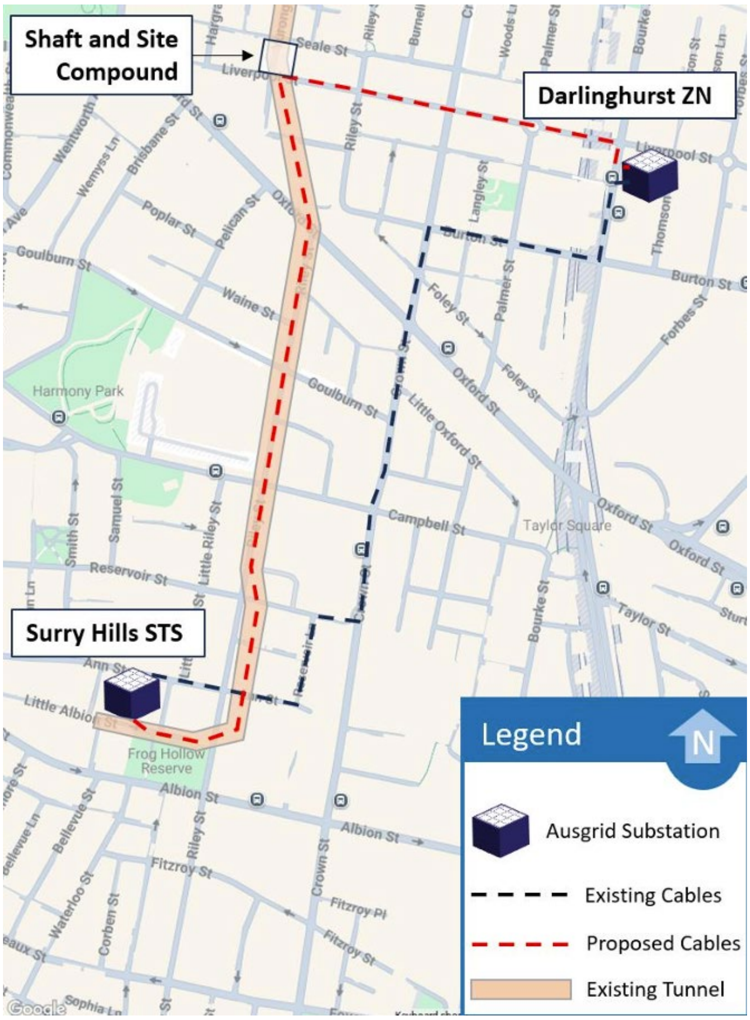
All costs and benefits presented in this FPAR are in 2024/25 dollars, unless otherwise stated.

3.1 Option 1 – Replace ageing 33 kV gas pressured cables

Option 1 involves replacing the existing 33 kV gas pressured cables 386 and 389, with new cables, making use of an existing underground cable tunnel network to minimise disruption to the local community. The use of the existing cable tunnel network reduces the required trenching from approximately 1.2 km to only 0.38 km.

Figure 3.1 shows the location of the existing 33 kV gas cables (to be decommissioned) and the proposed new cables.

Figure 3.1 – Option 1 proposed new cable location and existing cable location

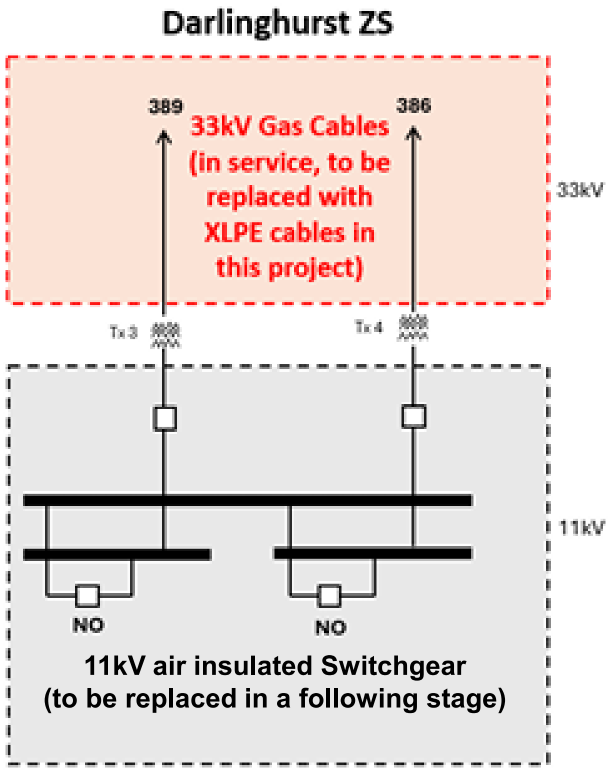


This option involves the installation of two new 33 kV feeders between the Surry Hills STS and the Darlinghurst ZS. These feeders will utilise 630Cu3 XLPE cable in ducts. The new feeders will be connected to the:

- existing 33 kV feeder panels at the Surry Hills STS; and
- existing Tx.3 and Tx.4 primary side at the Darlinghurst ZS.

A schematic diagram of this option is presented in Figure 3.2 below, with the specific new network elements shown in red.

Figure 3.2 – Option 1 proposed network arrangement



The scope of works for Option 1 includes:

- works at Surry Hills STS and Darlinghurst ZS to facilitate the 33 kV connections;
- construction of a cable shaft in Yurong Street to form a connection to the existing City East Cable tunnel (CECT);
- construction of a new 33 kV ductline along Liverpool Street in Darlinghurst;
- installation of two 1 km long 33 kV XLPE feeder cables through the CECT shaft and Liverpool Street ductline;
- communication upgrades at both ends; and
- decommissioning of the existing gas pressured cables between the Surry Hills STS and the Darlinghurst ZS.

The estimated construction capital cost of this option is $8.0 million, with an estimated decommissioning cost of $0.2 million.

Table 3.1 shows the breakdown of the estimated construction capital costs for this option.

Table 3.1 – Breakdown of Option 1's expected construction capital cost, $m

Component	Labour	Materials	Contracted Services	Indirect cost	Total
Option 1 – Replace 33 kV gas pressured cables	**1.1**	**0.1**	**6.1**	**0.7**	**8.0**

The estimated capital costs above include approximately $364,000 of design and scoping costs that Ausgrid has incurred to-date. These costs are not specific to Option 1 and are also included equally in the cost estimate below for Option 2 (and so are not considered material to the outcome of the RIT-D assessment).

Option 1 is expected to take three years to complete, with commissioning expected in 2028/29. Once commissioned, it will require approximately $14,000 / year in planned routine maintenance costs.

While the existing air-insulated 11 kV switchgear is not currently forecast to need to be replaced over the 20-year assessment period for this RIT-D, it will form an eventual future stage of works at the Darlinghurst ZS. We have considered the impact of including the switchgear replacement in the scope of works for this option, by way of a sensitivity. This enables a 'like-for-like' comparison with Option 2 (i.e., since that option also decommissions this switchgear). Including these additional replacement works in the scope of Option 1 is found to not be material to the assessment and does not change the conclusion of this FPAR (see section 5.4.2 for the results of the sensitivity).

Only minor remedial work is expected to be required more generally at the Darlinghurst ZS over the assessment period. The cost of these works has not been included in the assessment as the minor nature of the works makes them immaterial to the findings of this FPAR.

3.2 Option 2 – Retire Darlinghurst 33/11 kV ZS

Option 2 involves retiring the existing Darlinghurst ZS and transferring its existing 11 kV loads to the Campbell Street ZS.

The scope of works includes:

- decommissioning the existing 33 kV gas pressured cables between the Surry Hills STS and the Darlinghurst ZS;
- decommissioning the existing 11 kV switchgear and other remaining assets at the Darlinghurst ZS;
- selling the existing land where the Darlinghurst ZS in currently situated; and
- installing an additional 50 MVA transformer unit and 11 kV switchgroup at the Campbell Street ZS.

The estimated construction capital cost of this option is $29.3 million, with an estimated decommissioning cost of $2.4 million.

Table 3.2 below shows the breakdown of the estimated construction capital costs for this option.

Table 3.2 – Breakdown of Option 2's expected construction capital cost, $m

Component	Labour	Land and Materials	Contracted Services	Indirect cost	Total
Option 2 – Retire Darlinghurst ZS	**5.2**	**4.1**	**17.0**	**3.0**	**29.3**

This option also involves the sale of the land where Darlinghurst ZS is located (estimated at $10 million after remediation), which partially offsets the total cost of this option.

Once commissioned, Option 2 is expected to require $19,000 / year in planned routine maintenance costs.

Option 2 is expected to take three years to complete, with commissioning assumed in 2035/36.

While this commissioning date has been determined through the optimal timing assessment (i.e., that outlined in section 5.4.1), we note that the optimal timing analysis only considers EUE and option costs and it does not explicitly model the two reliability measures stipulated in Ausgrid's reliability and performance standards as part of its distribution license (i.e., SAIDI and SAIFI). This may result in breaches of the reliability standards between now and then given the length of time involved. In addition, we note that, even if the assumed timing of Option 2 is brought forward to align with Option 1 (to avoid these breaches), it is found to have lower expected net market benefits than those estimated for Option 1(as is shown in Step 2 of the sensitivity analysis in section 5.4).

3.3 Options considered but not progressed

Ausgrid also considered several other options that have not been progressed. In general, these options were not progressed because they were found to be technically infeasible or economically infeasible.

The table below summarises Ausgrid's consideration and conclusion on each of these options.

Table 3.3 – Options considered but not progressed

Description	Reason why option was not progressed
	Network options
Complete greenfield project – New Darlinghurst 33/11 kV ZS.	Under this option a new Darlinghurst ZS would be established. The scope of works would consist of those outlined in Option 2 as a temporary transfer, prior to establishing a new Darlinghurst ZS at the original site. This option is estimated to cost upwards of $60 million, making it approximately double the cost of Option 2 and triple the cost of Option 1. In addition, under this option, the land that the existing site is located on would likely not be sold (and, if it were, a new site would need to be acquired), which would further increase the capital costs compared to Option 2 (where the land would be sold). Due to materially higher costs, and the fact that no additional benefits (or cost reductions) are expected, Ausgrid considers this option is not economically feasible and has not considered it further.
	Non-network and SAPS options
Using non-network solutions either in combination with, or in-place of, a network option.	Ausgrid has considered how non-network solutions (e.g., demand management) could potentially defer the timing of the preferred network solution and whether the EUE could be cost effectively reduced. An assessment of the potential for non-network options has shown that these alternatives would not be cost effective due to the magnitude of the load reduction required. This result is driven by the significant amount of EUE that the identified network options allow to be avoided, compared to the base case, and the likely cost of non-network solutions. In addition, these solutions would not resolve the escalating reactive maintenance costs associated with continued use of the cables. This is detailed further in the separate Options Screening Notice released in accordance with clause 5.17.4(d) of the NER.
Transferring and/or connecting customers to SAPS	Ausgrid has considered the feasibility of SAPS, informed by its trial of SAPS with selected customers living in fringe-of-grid areas of Ausgrid's network. Based on Ausgrid's trial, the cost of SAPS would limit the number of customers available to reduce demand given the deferral funds available and consequently, the reduction in demand would not be sufficient to defer or postpone the network solution. In addition, these solutions would not resolve the escalating reactive maintenance costs associated with continued use of the cables. This is detailed further in the separate Options Screening Notice released in accordance with clause 5.17.4(d) of the NER.

4 How the options have been assessed

This section outlines the methodology that Ausgrid has applied in assessing market benefits and costs associated with the credible options considered in this RIT-D. Appendix D presents additional detail on the assumptions and methodologies employed to assess the options.

4.1 All options have been assessed against a 'base case'

All costs and benefits for each credible option have been measured against a 'business as usual' base case.

Under this base case, Ausgrid will experience an increasing risk of failure for the 33 kV gas pressured cables connecting the Darlinghurst ZS to the Surry Hills STS resulting in an increasing risk of prolonged unserved energy in the Eastern Suburbs network area, as well as escalating reactive maintenance costs.

4.2 General overview of the assessment framework

The RIT-D analysis has been undertaken over a 20-year period, from 2024/25 to 2043/44. The analysis starts in 2024/25 to capture the scoping and design costs that have been incurred to-date (as mentioned in section 3.1, these costs are minor and are common to both credible options). Construction has not started yet for the preferred option.

Ausgrid considers that a 20-year period is appropriate as it 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.

Where 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 assessment period. This ensures that all options have their costs and benefits assessed over a consistent period, irrespective of option type, technology or asset life. The terminal values have been calculated as the undepreciated value of capital costs at the end of the analysis period and can be interpreted as a conservative estimate for benefits (net of operating costs) arising after the analysis period.

Ausgrid has adopted a real, pre-tax discount rate of 3.70% as the central assumption for the NPV analysis. This represents Ausgrid's opportunity cost for its capital investments. As non-network or SAPS options have been found to be not viable, Ausgrid considers that the appropriate discount rate is the regulated cost of capital.

To test the results against variations in the discount rate, an upper value sensitivity of 10% has been adopted to align with the parameters prepared and consulted on by AEMO in the 2025 Inputs, Assumptions and Scenarios Report.[7] For a lower value sensitivity for this RIT-D, we have applied 3.69% based on the latest AER Final Decision for a DNSP's regulated weighted average cost of capital (WACC) at the time of preparing this FPAR.[8]

4.3 Ausgrid's approach to estimating project costs

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

All cost estimates are prepared in real, 2024/25 dollars based on the information and pricing history available at the time that they were estimated. The cost estimates do not include or forecast any real cost escalation for materials.

Ausgrid does not generally apply the Association for the Advancement of Cost Engineering (AACE) international cost estimate classification system to classify cost estimates. Doing so for this RIT-D would involve significant additional costs, which would not provide a corresponding increase in benefits compared with the use of our standard estimates and so this has not been undertaken.

Different levels of cost accuracy exist for Option 1 and Option 2 due to the difference in the scope of works proposed under each option. Specifically, a cost accuracy of -10% to +25% applies to Option 1 while a cost accuracy of -10% to +30% applies to Option 2 due to the higher risk of cost overruns from the associated works on major and congested roads. Given this, we have considered sensitivity bounds in the range of -10% to +30% of the capital costs for this FPAR.

[7] AEMO, *2025 Inputs, Assumptions and Scenarios Report*, Final report, August 2025, p 158.

[8] Specifically, the 2025/26 pre-tax real WACC for Energex, see: AER, *Energex - 2025-30 Distribution determination revenue proposal – PTRM*, Final Decision, April 2025, 'WACC' tab.

Routine operating and maintenance costs are based on a fleet level assessment of assets and works of similar nature. These costs are included for each year in the planning period from the time options are commissioned, as well as in the base case.

4.4 Market benefits are expected from avoided unserved energy

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. While the options also provide avoided maintenance cost benefits compared to the base case (i.e., reduced corrective maintenance costs and lower planned routine maintenance costs), these are not considered 'market benefits' under the NER (but have been estimated in the NPV assessment).

The approach Ausgrid has adopted to estimate the financial impact of avoided unserved energy are outlined in section 4.4.1 below. Further details on the assumptions and methodology considered are presented in Appendix D.

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

4.4.1 Avoided unserved energy

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.

Involuntary load shedding is where a customer's load is interrupted from the network without their agreement or warning. 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 for the credible option assessed.

The benefit from avoided involuntary load shedding for each option is derived by the estimated quantity in MWh of involuntary load shedding avoided under the base case, compared to the case with the option in-place, multiplied 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 $36.40/kWh reflecting a customer load weighted average VCR for the load in question, drawing on the most recent VCR estimates published by the AER. Table 4.1 presents the calculation of the customer load weighted average VCR.

Table 4.1 – Customer load weighted average VCR

Customer type	Load (MWh)	Weighting (%)	AER VCR ($/kWh, $2024/25)
Residential (NSW)	26,630	22	39.99
Commercial	60,898	51	35.70
Industrial	32,491	27	34.77
Customer load weighted VCR			**36.40**

Source: AER, Values of Customer Reliability 2025 – Annual Adjustment Summary, December 2025, p. 2.

We have tested the VCR as a sensitivity with values that are 30% lower and 30% higher than the central rate, consistent with the AER's most recently specified +/- 30% confidence interval.[9]

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. Three future load forecasts have been considered for the area in question – namely a central forecast using POE50 forecasts, as well as a low forecast using the POE90 and a high forecast using the POE10 forecasts.

Figure 2.3 in chapter 2 shows the assumed levels of unserved energy, under each of the three underlying demand forecasts investigated over the assessment period. For clarity, this figure illustrates the MWh of unserved energy assumed under each load forecast in the base case, if neither of the credible options is commissioned.

[9] AER, *Values of Customer Reliability – Final Report on VCR values*, December 2019, p. 84. While the AER re-estimated its VCR values in 2024, we note that no confidence level was provided. We have therefore continued to apply the previous confidence level stipulated in the 2019 AER VCR report.

4.5 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.

The scenarios adopted for this RIT-D only differ by the demand forecasts, given this is the key parameter affecting the ranking of the credible options. How the results are affected by changes to other variables (i.e. the discount rate and capital costs) have been investigated in the sensitivity analysis.

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

Table 4.2 – Summary of the three scenarios investigated

Variable	Scenario 1 – central demand scenario	Scenario 2 – low demand scenario	Scenario 3 – high demand scenario
Demand	Central forecast (POE50)	Low forecast (POE90)	High forecast (POE10)
VCR	$36.40/kWh across all scenarios		
Discount Rate	3.70% across all scenarios		

Ausgrid has weighted each of the demand scenarios equally in the NPV assessment. Option 1 is found to be preferred across all scenarios and so the weightings do not influence the RIT-D outcome. Ausgrid therefore considers that adopting equal weightings is a proportionate approach for this RIT-D.

5 Assessment of the 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 'do nothing' base case (as outlined in section 4.1).

5.1 Gross benefits

The table below summarises the gross benefit of the credible options relative to the base case in present value terms. The gross benefit has been calculated for each of the three demand scenarios outlined in the section above and is also provided on a weighted basis.

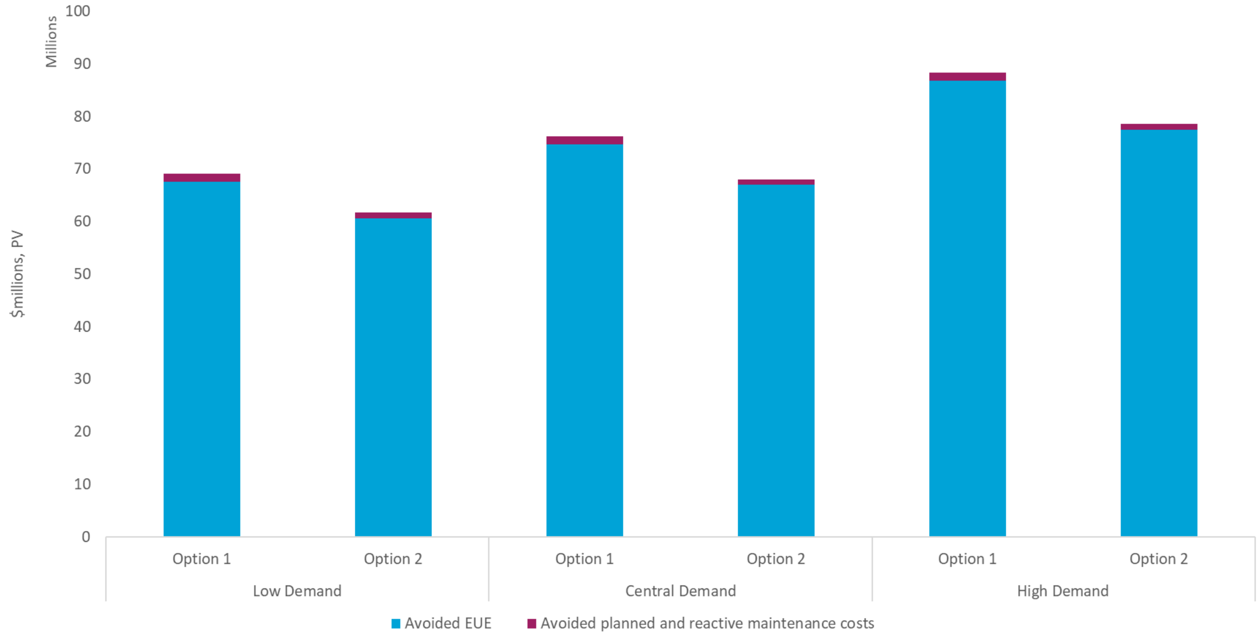
Table 5.1 – Present value of gross benefits of credible options relative to the base case, $m

Option / scenario	Central demand	High demand	Low demand	Weighted benefits
Scenario weighting	1/3	1/3	1/3	–
Option 1	74.7	86.8	67.6	76.4
Option 2	66.9	77.4	60.6	68.3

Option 1 is found to deliver greater overall benefits in all scenarios than Option 2. This is driven by the fact that Option 1 is assumed to be commissioned earlier in 2028/29, while Option 2 is assumed to be commissioned later in 2035/36, and so Option 1 avoids greater levels of expected unserved energy and corrective maintenance costs.

The figure below provides a breakdown of all benefits relating to each credible option. For clarity, we have combined in this chart the 'market benefit' under the RIT-D (i.e., reduced involuntary load shedding) with avoided maintenance cost benefits (i.e., reduced corrective maintenance costs and avoided planned routine maintenance costs).

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



5.2 Estimated costs

The table below summarises the cost of the options in present value terms. Option costs comprise capital costs and ongoing operating and maintenance costs.

Option costs do not vary across demand scenarios. Variations in the capital costs have been tested as part of the sensitivity analysis.

Table 5.2 – Present value of costs of the credible options relative to the base case, PV $m

Option / scenario	Central demand	High demand	Low demand	Weighted costs
Scenario weighting	1/3	1/3	1/3	
Option 1	(3.5)	(3.5)	(3.5)	(3.5)
Option 2	(4.1)	(4.1)	(4.1)	(4.1)

5.3 Net present value assessment

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

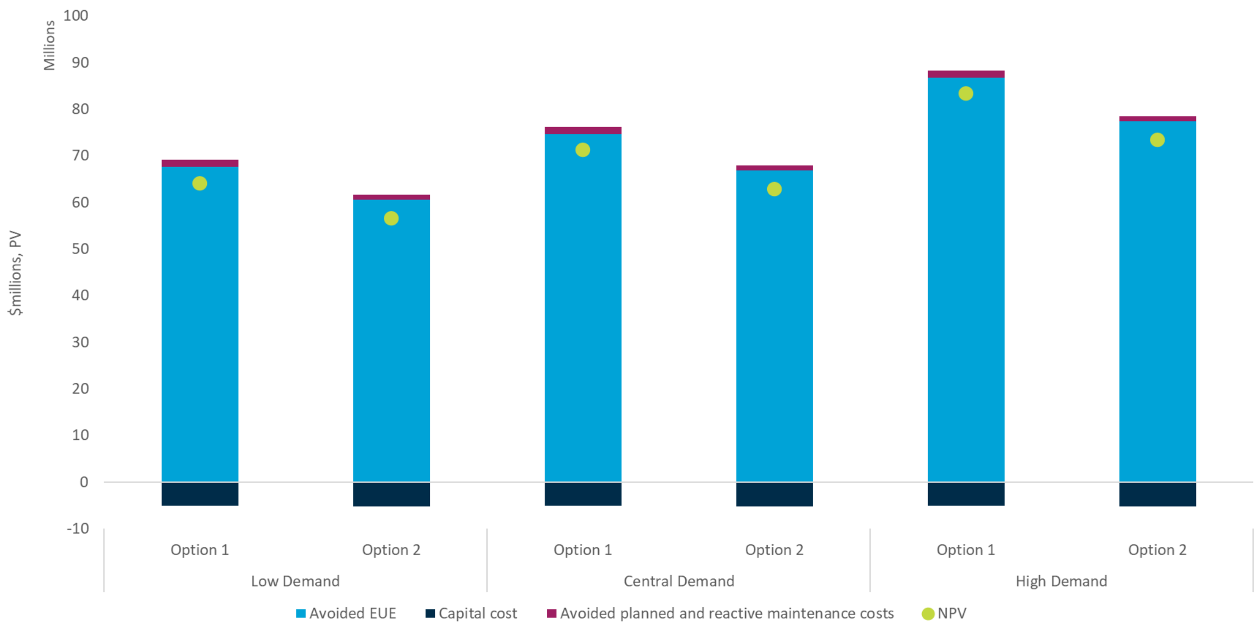
Option 1 has the greatest estimated net market benefits of the two options in each of the scenarios investigated (and therefore also on a weighted basis). The differences in net market benefits are primarily driven by the cost and timing differences between the options.

Table 5.3 – Present value of net benefits relative to the base case by scenario and weighted, NPV $m

Option / scenario	Central demand	High demand	Low demand	Weighted	Rank
Scenario weighting	1/3	1/3	1/3		
Option 1	**71.3**	**83.3**	**64.1**	**72.9**	**1**
Option 2	62.9	73.4	56.6	64.3	2

Figure 5.2 provides a breakdown of the net present value assessment by costs and benefits.

Figure 5.2 – Breakdown of net present value assessment



5.4 Sensitivity analysis results

Ausgrid has undertaken a 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. While this is the date at which the reliability standards are expected to be breached for Option 1, we consider that they are likely to be breached before the date determined for Option 2 (and we have included a sensitivity in Step 2 to show that an assumed earlier timing for Option 2 would not affect the ranking of the options).

Having assumed to have committed to the project by the dates determined in Step 1, Ausgrid has also looked at whether the ranking of the options changes when key assumptions are varied under Step 2 of the sensitivity testing.

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 options

Ausgrid has estimated the optimal timing for each option according to when the expected annual benefit from the proposed option exceeds its annualised cost, consistent with the AER guidance on how to determine the economically prudent and efficient timing for asset retirement.[10] This process was undertaken for both the central set of assumptions (i.e., the central scenario) as well as a range of alternative assumptions for key variables.

The optimal timing of Option 1 is found to be invariant to the assumptions of:

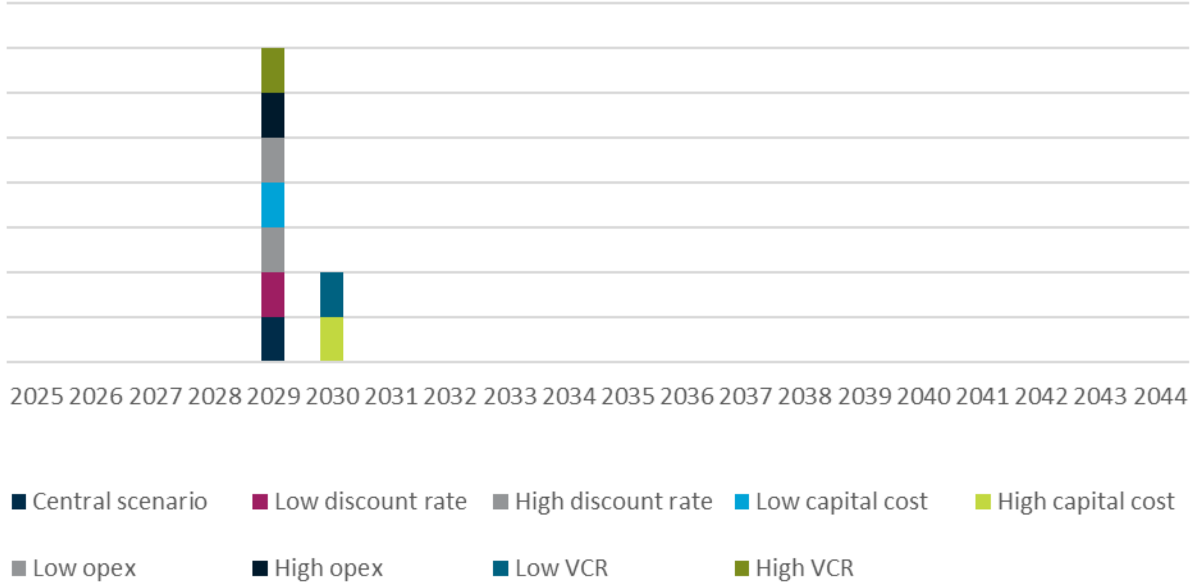
- a 10% decrease in the assumed network capital costs;
- a 30% increase/decrease in the unplanned corrective maintenance costs;
- a 30% increase/decrease in the assumed planned maintenance costs;
- a higher VCR ($47.32/kWh); and
- a lower and higher discount rate assumption (3.69% and 10%, respectively).

Overall, the optimal commissioning date for Option 1 under the majority of sensitivities is 2028/29, which is the timing that has been assumed in the core net benefits assessment.

The optimal timing of Option 1 is only found to be later (in 2029/30) under the assumptions of:

- a 30% increase in the assumed network capital costs; and
- a 30% lower VCR ($25.48/kWh)

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



[10] AER, *Industry practice application note – Asset replacement planning*, January 2019, pp 36-37.

Similarly, the optimal timing of Option 2 is found to be invariant to the assumptions of:

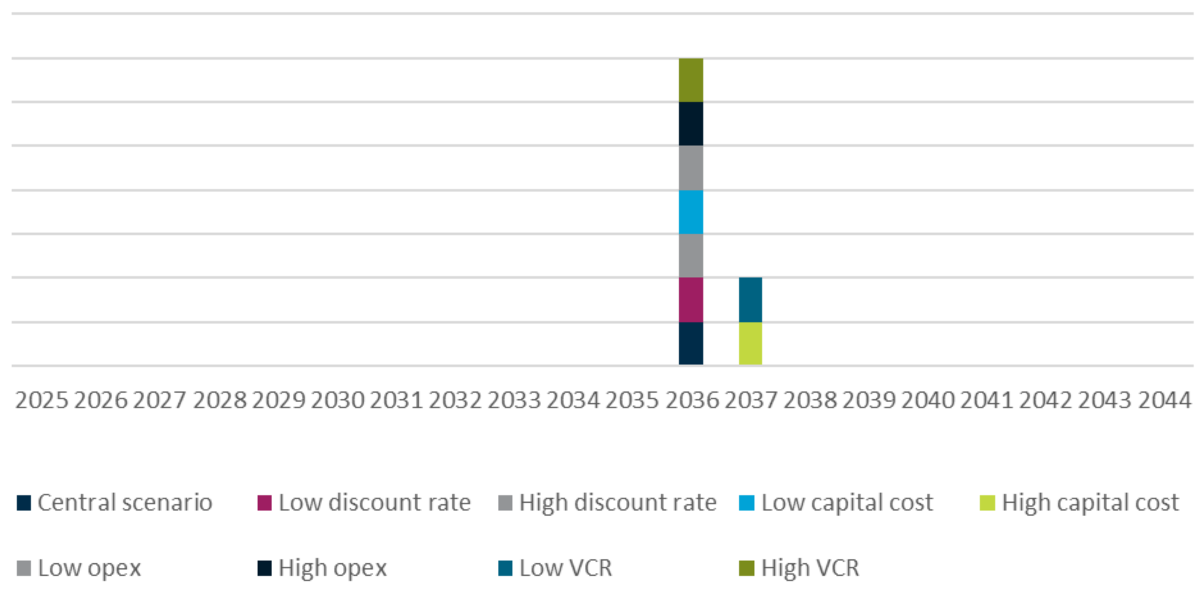
- a 10% decrease in the assumed network capital costs;
- a 30% increase/decrease in the unplanned corrective maintenance costs;
- a 30% increase/decrease in the assumed planned maintenance costs;
- a higher VCR ($47.32/kWh); and
- a lower and higher discount rate assumption (3.69% and 10%, respectively).

Overall, the optimal commissioning date for Option 2 under the majority of sensitivities is 2035/36, which is the timing that has been assumed in the core net benefits assessment.

The optimal timing of Option 2 is only found to be later (in 2036/37) under the assumptions of:

- a 30% increase in the assumed network capital costs; and
- a 30% lower VCR ($25.48/kWh)

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 overall net market benefits, based on the assumed 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 30% increase and a 10% decrease in the assumed network capital costs;
- a 30% increase/decrease in the unplanned corrective maintenance costs;
- a 30% increase/decrease in the assumed planned maintenance costs;
- a 30% lower VCR ($25.48/kWh) and a higher VCR ($47.32/kWh); and
- a lower and higher discount rate assumption (3.69% and 10%, respectively).

In addition:

- as mentioned in section 3.1, we have also considered the impact of including the replacement of the existing air-insulated 11 kV switchgear in the scope of works for Option 1 in order to enable a 'like-for-like' comparison with Option 2 (i.e., since that option also decommissions these assets):

> while these works are not currently forecast to be replaced over the twenty-year assessment period for this RIT-D, we have assumed for the purpose of this sensitivity that they are commissioned in 2043/44 with works commencing in 2039/40 and involving $17.8 million in capital costs (in 2024/25 dollars); and

- as mentioned in section 3.2, we have also investigated a sensitivity that brings forward the assumed timing of Option 2 to align with that of Option 1.

The results of the sensitivity tests are presented in the table below and show that Option 1 remains the top-ranked option across all the general sensitivities modelled. Furthermore:

- when including the estimated cost of the 11 kV switchgear replacement Option 1 remains the top-ranked option compared to Option 2; and
- when bringing forward the assumed timing of Option 2 (to align with Option 1), the estimated net benefits of Option 2 remain below those for Option 1 (and Option 1 including the 11 kV switchgear).

Table 5.4 – NPV results from sensitivity tests, weighted across demand scenarios ($2024/25, million)

Sensitivity	Option 1	Option 1 (with 11 kV switchgear)	Option 2	Option 2 (2028/29)
Core weighted results	**72.92**	72.00	64.28	69.00
High capital costs (+30%)	**71.43**	70.24	62.74	65.70
Low capital costs (-10%)	**73.42**	72.59	64.79	70.10
High unplanned maintenance costs (+30%)	**73.35**	72.44	64.60	69.45
Low unplanned maintenance costs (-30%)	**72.49**	71.57	63.96	68.55
High planned maintenance costs (+30%)	**72.94**	72.03	64.28	69.00
Low planned maintenance costs (-30%)	**72.90**	71.98	64.28	68.99
High VCR ($47.32/kWh)	**95.84**	94.92	84.78	92.55
Low VCR ($25.48/kWh)	**50.01**	49.09	43.78	45.45
High discount rate (10%)	**26.72**	25.99	20.02	17.14
Low discount rate (3.69%)	**73.04**	72.12	64.40	69.13

We do not find any realistic boundary values for the above key variables that would make Option 2 preferred over Option 1.

6 Proposed preferred option

Ausgrid considers that Option 1 is the preferred option that satisfies the RIT-D. It involves two new 33 kV feeder cables between the Surry Hills STS and the Darlinghurst ZS to replace the existing, ageing 33 kV gas pressured feeder cables.

The scope of this option includes the:

- works at Surry Hills STS and Darlinghurst ZS to facilitate the 33 kV connections;
- construction of a cable shaft in Yurong Street in Darlinghurst to form a connection to the existing CECT;
- construction of a new 33 kV ductline along Liverpool Street in Darlinghurst;
- installation of two 33 kV XLPE feeder cables of approximately 1 km through the CECT shaft and Liverpool Street ductline;
- communication upgrades at both ends; and
- decommissioning of the existing, ageing gas pressured cables between the Surry Hills STS and the Darlinghurst ZS.

The estimated capital cost of this option is approximately $8.2 million, comprising:

- $6.8 million for commissioning two new 33 kV feeder cables;
- $1.2 million for the construction of a cable shaft in Yurong Street; and
- $0.2 million for the decommissioning of the old 33 kV feeder cables.

Planned routine network operating costs under this option are expected to be around $14,000/year once commissioned, which is approximately 30% lower than the current annual routine maintenance costs for the two ageing cables at the Darlinghurst ZS.

Overall, Option 1 is the lowest cost of the two credible options assessed in this FPAR and delivers the greatest net benefits.

Ausgrid expects that the necessary construction would commence as soon as practicable after this RIT-D and end in 2027/28, with commissioning occurring at the beginning of 2028/29.

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.

Appendix A – Checklist of compliance clauses

This table below sets out a compliance checklist that demonstrates the compliance of this FPAR with the requirements of clause 5.17.4(r) of the NER version 243.

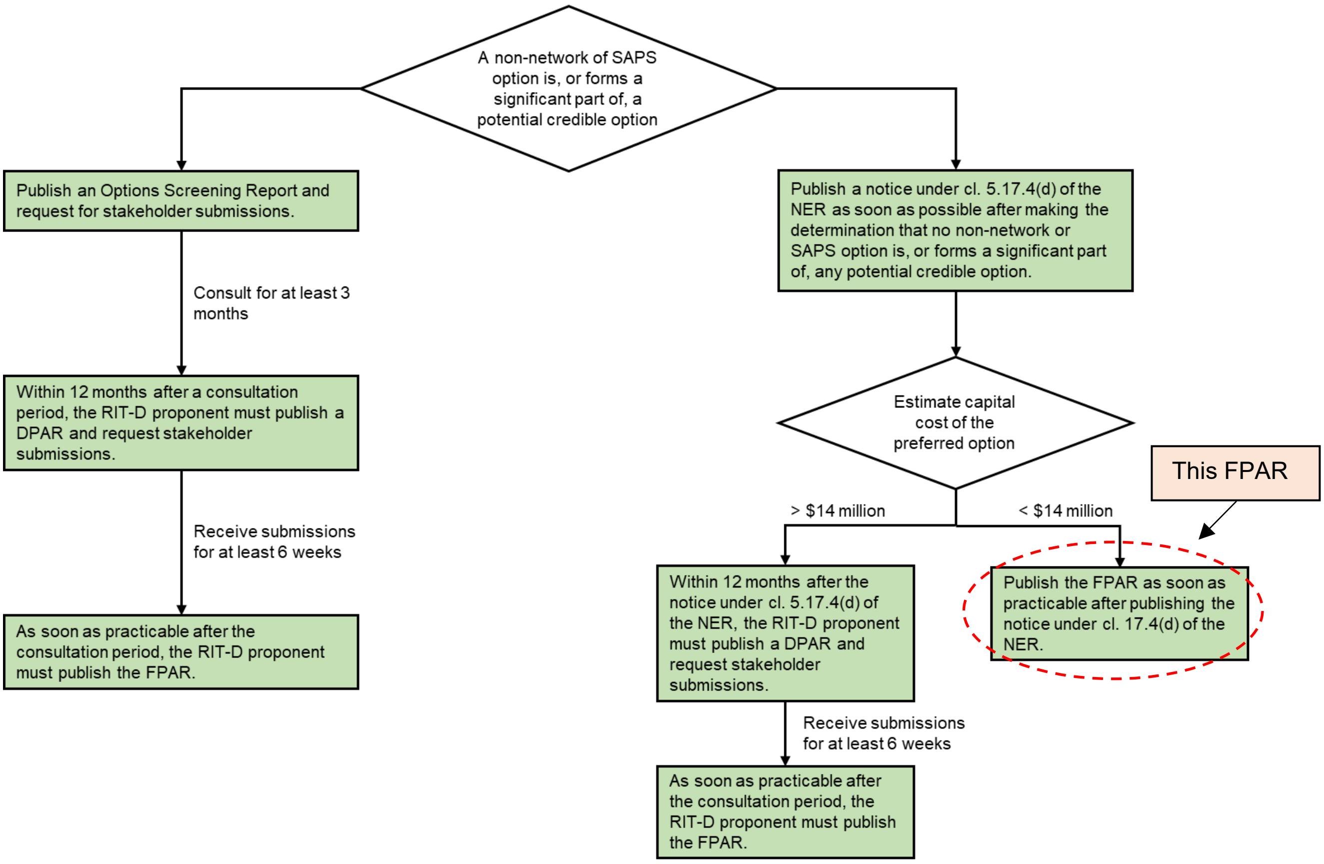
Clause	Summary of requirements	Section in the FPAR
5.17.4(r)	The matters specified as requirements for the DPAR, as outlined below in clause 5.17.4(j).	See below
	A summary of any submissions received on the DPAR and the RIT-D proponent's response to each such submission	NA
5.17.4(j)	(1) a description 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 RIT-D; 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
	(13) if the estimated capital cost of the proposed preferred option is greater than $100 million (as varied in accordance with a cost threshold determination), include the RIT reopening triggers applying to the RIT-D project.	NA

In addition, the table below outlines a separate compliance checklist demonstrating compliance with the binding guidance in the latest AER RIT-D guidelines relating to cost estimation (i.e., the new requirements added from the AER's review of the guidelines following the MCC Rule change).

Guidelines section	Summary of requirements	Section in the FPAR
3.5A.1	Where the estimated capital costs of the preferred option exceeds $100 million (as varied in accordance with a cost threshold determination), a RIT–D proponent must, in a RIT-D application: • outline the process it has applied, or intends to apply, to ensure that the estimated costs are accurate to the extent practicable having regard to the purpose of that stage of the RIT-D • for all credible options (including the preferred option), either o apply the cost estimate classification system published by the AACE, or o if it does not apply the AACE cost estimate classification system, identify the alternative cost estimation system or cost estimation arrangements it intends to apply, and provide reasons to explain why applying that alternative system or arrangements is more appropriate or suitable than applying the AACE cost estimate classification system in producing an accurate cost estimate	NA
3.5A.2	For each credible option, a RIT-D proponent must specify, to the extent practicable and in a manner which is fit for purpose for that stage of the RIT-D: • all key inputs and assumptions adopted in deriving the cost estimate • a breakdown of the main components of the cost estimate • the methodologies and processes applied in deriving the cost estimate (e.g. market testing, unit costs from recent projects, and engineering-based cost estimates) • the reasons in support of the key inputs and assumptions adopted and methodologies and processes applied • the level of any contingency allowance that have been included in the cost estimate, and the reasons for that level of contingency allowance	3 & 4.3
3.8.1	Where the estimated capital cost of the preferred option exceeds $100 million (as varied in accordance with an applicable cost threshold determination), a RIT-D proponent must undertake sensitivity analysis on all credible options, by varying one or more inputs and/or assumptions.	NA
3.9.4	If a contingency allowance is included in a cost estimate for a credible option, the RIT-D proponent must explain: • the reasons and basis for the contingency allowance, including the particular costs that the contingency allowance may relate to, and • how the level or quantum of the contingency allowance was determined.	NA

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 material

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;
- option value;
- changes in electrical energy losses; and
- changes in Australia's greenhouse gas emissions.

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	The options are not expected to affect the timing or amount of any other expenditure for unrelated needs.
Changes in voluntary load curtailment	The level of voluntary load curtailment currently present in the National Electricity Market 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. None of the options in this RIT-D are not 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. The options in this RIT-D will not 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. The options under consideration do not affect high voltage feeders and therefore are unlikely to materially change load transfer capacity. 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 sufficiently flexible to respond to that change. The credible options assessed do not involve stages or any other flexibility and so we do not consider that option value is relevant.
Changes in electrical energy losses	Ausgrid does not expect that the credible options considered will lead to significant changes in network losses and so have not estimated this category of market benefits.
Changes in Australia's greenhouse gas emissions	None of the options are expected to result in materially different levels of greenhouse gas emissions (including sulphur hexafluoride (SF_6) emissions), as they do not affect either the pattern of generator dispatch in the wholesale market or the level of expected SF_6 leakages from network assets.

Appendix D – Additional detail on the assessment methodology

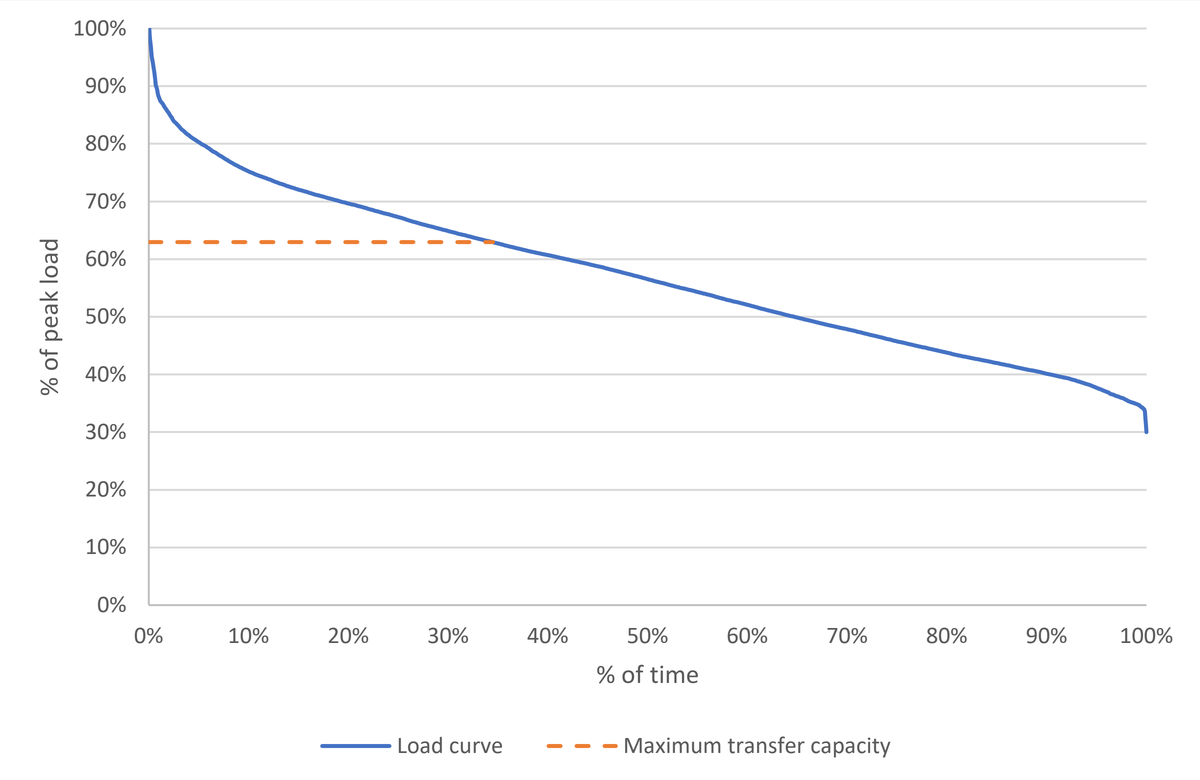
This appendix presents additional detail on the supply restoration assumptions and probability of failure assumptions made by Ausgrid.

D.1 Characteric load duration curve

The load duration curve used in the analysis is presented in Figure D.1 below.

It is assumed that the load types supplied will not change substantially into the future and therefore the load duration curve will maintain its characteristic shape.

Figure D.1 – Load duration curve



D.2 Load transfer capacity and supply restoration

Darlinghurst zone substation load area is classified as urban and has 11kV interconnections with Campbell St and Paddington ZSs. In the event of a total loss of supply to Darlinghurst zone substation, approximately 63 per cent of peak load can be recovered within days via the load transfer capacity of the existing network.

In the event of an equipment outage, the network may be returned to a normal configuration by one of the following actions:

- repairing the failed equipment
- initiating a contingency plan
- replacing the failed equipment with spares.

The assumed supply restoration actions and the time taken to implement the action are detailed in the table below. These actions are the most likely actions for the contingencies considered in this planning study.

Table D.1 – Supply restoration assumptions

Equipment outage	Action	Time
Switchboard failure	Restore – supply is restored to customers by deploying the 11 kV mobile switch room	17 days
Gas cable failure	Repair – the cable is repaired on site. Extensive time is required to de-gas and re-gas the cable	24.5 days
Gas cable third party damage	Repair – the cable is repaired on site. Extensive time is required to de-gas and re-gas the cable. Additional time is typically required to repair third party damage	28 days

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
Switchboards	Weibull analysis	Age of switchboard Age of functional failure of failed switchboard Age of retirement for switchboard that were retired before the point of failure

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 3.

Equation 3

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

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 4 shows the modelled Crow-AMSAA parameters for each cable type.

Table D.3 – Underground cable parameters

Feeder type	Type	Β factor	Λ factor	MTTR[11] (weeks)
Gas insulated	Corrective action	7.994	1.93E-14	0
Gas insulated	Breakdowns	9.8456	3.29E-18	3.5
Gas insulated	Third party damage	1	2.799E-03	4

The frequency of corrective action, failure or third party damage can then be determined by applying Equation 4 to each cable section.

Equation 4

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

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 resulting in a MTTR of 0. Equation 5 shows how the frequency is used to calculate unavailability for failures or third party damage.

Equation 5

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

The total cable section unavailability is calculated taking the union of the failure and third-party damage unavailabilities as shown in Equation 6. If a feeder consists of multiple cable sections, the feeder unavailability is calculated by taking the union of all the respective section unavailabilities

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[11] Mean Time To Repair

Equation 6

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

Figure 2.2 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.

Switchboards

For the purposes of this analysis, failures of 11 kV switchboards are assumed to be non-repairable because typically the board is no longer functional following a failure (and hence is replaced or removed from service). Weibull analysis is used to derive a probability distribution function for the asset's age at time of failure. This function is denoted as f(t), where 't' is expressed in years. The parameters of the function are derived by considering the following information:

- the age of Ausgrid's in service 11 kV switchboards;
- the age of functional failure for Ausgrid's failed switchboards; and
- the age of retirement for Ausgrid's switchboards that were retired before the point of functional failure.

The model has been created to distinguish between 11 kV switchboards that are of differing condition. This assessment was performed using a group of Ausgrid subject matter experts based upon their specialist knowledge of the asset(s) and a review of the available conditional information (i.e. test results). This review assigned switchboards into three specific condition bands: 'Good', 'Average' and Poor'. The Darlinghurst zone substation 11 kV air insulated switchboard is assigned a condition band of Average.

The resultant Weibull parameters are given in the table below.

Table D.4: Switchboard parameters for the Weibull analysis

Equipment	Condition	Shape	Scale
Air insulated 11 kV switchboard	Average	3.6	203.5

The concept of conditional probability is used to evaluate the probability of failure (Pf) for each year in the planning period. The probability a switchboard failure occurring each year, given that the board has survived to the current age (T) is calculated by applying the Equation 1:

$$P_f = \frac{\int_t^{t+1} f(t)dt}{\int_T^{\infty} f(t)dt} \qquad (1)$$

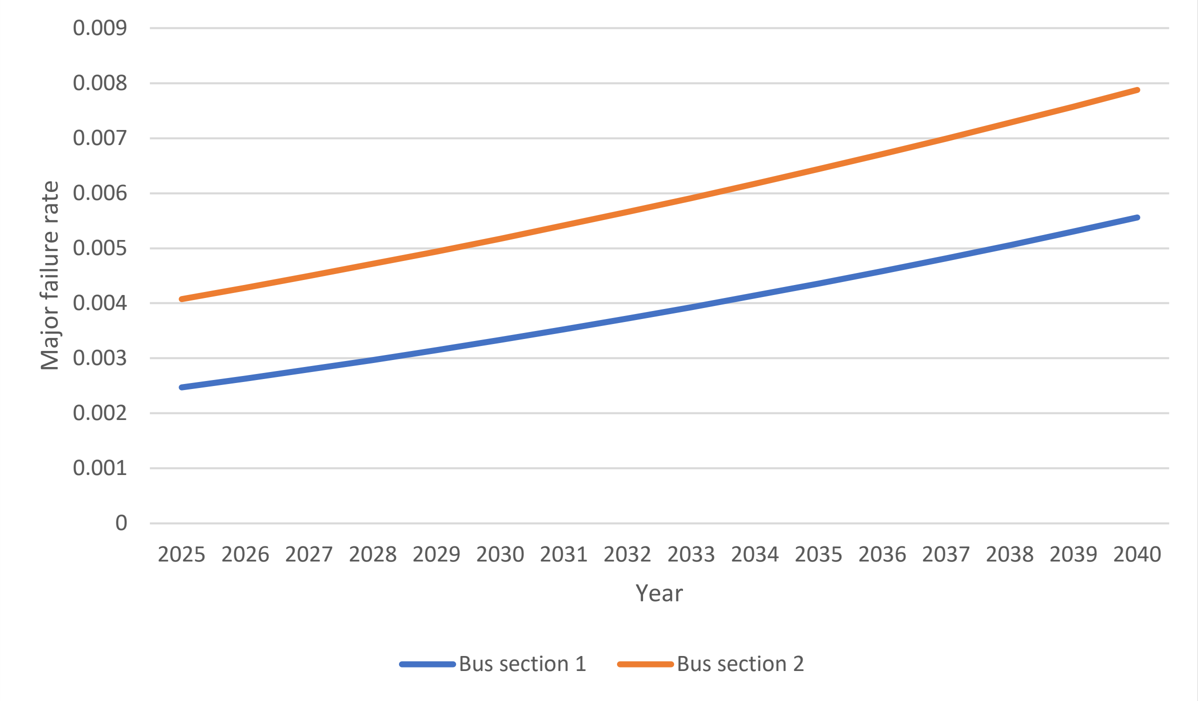
Unavailability is calculated by using a restore time, so the unavailability represents the percentage of time that a particular busbar is not available to supply load. The unavailability (U) of a switchboard is calculated for each year by applying Equation 2:

$$U = \frac{P_f\,.\,Outage\ Duration}{365} \qquad (2)$$

This model is based on the assumption that the condition of a switchboard is dependent upon its age. In order to explore the possibility that each board is in better or worse condition than the population average, lower and upper bounds for U are calculated by either adding or subtracting ten years from the age of each board.

Figure D.2 shows cumulative probability of failure for the 11 kV switchboards at Darlinghurst ZS.

Figure D.2: Cumulative probability of failure – 11 kV switchboards



D.5 Direct costs of equipment failures

In the event of a serious failure of a gas pressure cable, repairs would need to be done to return the cable into service.

In the event of a serious failure of an 11kV busbar which would require the equipment to be replaced, temporary repairs would need to be done to maintain supply until the replacement busbar is commissioned.

As these costs are avoided if the equipment 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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