5.14.2

Project justifications for sub-transmission cable replacements

Ausgrid

Content

1 INTRODUCTION

1.1 What is the purpose of this document

This document is to provide a summary of the need, options, timing and costs for each of the subtransmission cables that we have identified in our proposed standard control services (SCS) capital expenditure (capex) for the 2019-24 regulatory period including our 33kV, and 132kV assets.

The purpose is to provide the Australian Energy Regulator (AER), its consultants, and our stakeholders with a high level view of the need for each individual cable project, and to show that our analysis of timing, options and cost estimates are efficient and prudent as required by the National Electricity Rules (the Rules).

1.2 Where does this document fit with other material in our regulatory proposal

The underlying strategy and planning context for developing the subtransmission cable replacement program has been described in Attachment 5.01 (Ausgrid's proposed capital expenditure). This information is critical to understanding how Ausgrid has developed its program within the context of its total forecast capex. The key elements of Attachment 5.01 that should be read alongside this document include:

- Section 2 which explains the capital planning process
- Section 3 which explains how our total capex meets the requirements of clause 6.5.7 of the Rules
- Section 4 which explains Ausgrid's total replacement program, including an overall description of the subtransmission cable replacement program.

Attachment 5.01 also identifies a list of supporting attachments where further information on our capital planning process, key inputs and results of the AER's replacement expenditure (repex) model can be found.

1.3 Structure and contents

The document provides a list of significant subtransmission cable projects where we forecast to incur a capital cost in the 2019-24 regulatory period. We have then provided a description of each of these projects including identifying the need, options, timing and costs. Our project justifications are grouped by voltage type for ease of reconciling to the AER's repex model. Underpinning documentation, including methodologies, area plans, cost benefit analysis (CBA) and planning studies, is available on request.

2 PORTFOLIO OF PROJECTS

Table 1 below identifies the most significant subtransmission cable replacement projects where we expect to incur forecast SCS capex in the 2019-24 regulatory period. The table provides the name of the project, expected start and end date, the forecast capex on SCS in the 2019-24 period and the total project cost.

Table 1. Project list for Subtransmission cable replacements

Project name		Cost ($m, real FY19)		Start	End
		2019-24	Total		
132kV cable replacements					
1.	Beaconsfield to Zetland	39.4	40.5	2020	2025
2.	Castle Cove to Mosman	36.4	37.5	2018	2022
3.	Beaconsfield to Campbell St & Belmore Park	21.7	27.7	2018	2025
4.	Sydney South to Revesby	19.2	21.6	2019	2022
5.	Zetland to Clovelly	19.2	21.1	2018	2022
6.	Bunnerong to Maroubra	17.5	19.9	2021	2025
7.	Beaconsfield to Millpond	15.5	15.7	2019	2025
8.	Mason Park to Burwood	9.2	9.2	2020	2024
9.	Beaconsfield to Green Square	6.7	6.7	2020	2024
10.	Beaconsfield to Kingsford	3.7	26.0	2022	2026
11.	Double Bay to Clovelly	1.6	11.0	2023	2027
12.	Kingsford to Maroubra	1.0	7.0	2023	2027
13.	Mason Park to Homebush	0.6	1.8	2017	2019
14.	Mason Park-Drummoyne & Drummoyne-Rozelle	0.5	47.2	2024	2029
15.	Haymarket to Pyrmont	17.0	33.9	2022	2026
	Haymarket to Pyrmont (after DM*)	0.0	37.2	2025	2029
33 kV cable replacements					
16.	Homebush to Auburn and Lidcombe	11.4	26.8	2017	2022
17.	Bunnerong to Sydney Airport	15.5	15.6	2018	2021
18.	Surry Hills to Paddington	7.4	10.0	2022	2026

*This project is part of a targeted demand management (DM) program consisting of six significant projects associated with the replacement/retirement of aged assets. Consistent with customer feedback, our opex forecast includes expenditure to further develop our demand management capabilities in the face of uncertainty over future technologies and energy demand and consumption patterns. We are proceeding with these projects, where the benefits of implementing a demand management solution (i.e. the benefits from deferring replacement capex) outweigh its costs. The solution will help us defer investments related to the replacement or retirement of aged assets and offer customers incentives to invest in energy efficiency solutions that will lower their energy use and their bills.

3 PART A – 132 KV CABLE REPLACEMENT STRATEGY OVERVIEW

Figure 1. Typical 132kV single phase fluid filled cable

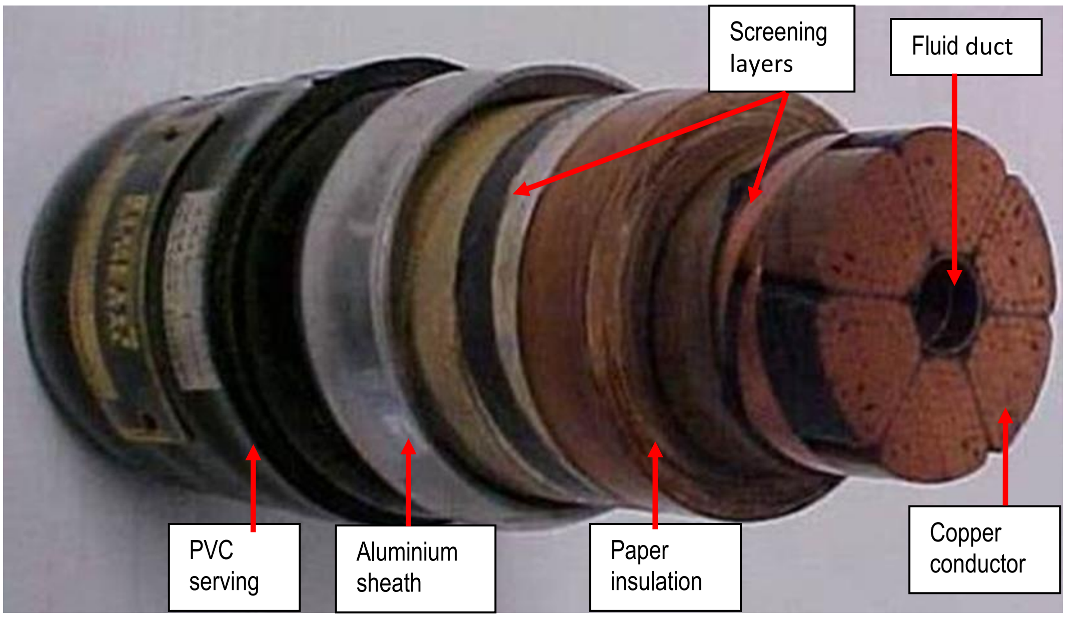


Figure 2. Typical 33kV three phase fluid filled cable

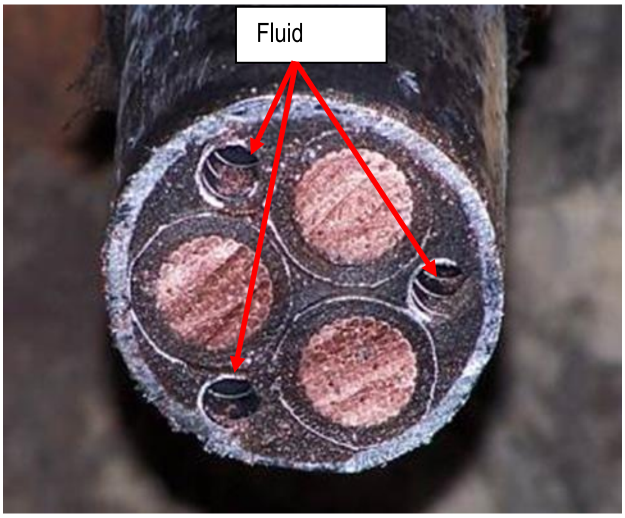


Figure 3. Leaking fluid filled cable

3.1 Summary

Part A summarises Ausgrid's strategy for addressing condition and performance issues related to Fluid-Filled Subtransmission 132kV cables in the Ausgrid network that will, over time, require the retirement of all these cables.

Subtransmission feeders comprising Fluid-filled cables (FFC)[1] operating at voltages between 33kV and 132kV have been used extensively in Ausgrid's network from the early 1960s to the mid-1980s, when this technology was superseded. They form the backbone of Sydney's Inner Metropolitan Subtransmission network and their operation is essential to provide our customers with reliable electricity supply.

Over the last 20 years increasing numbers of these cables have been affected by a fault that causes leaks to develop, allowing insulating fluid that is under pressure to escape from the cable into the surrounding environment. Such leaks pose a danger to the environment as they enter the water table, and to the integrity of the cables, which depend on the fluid to prevent a catastrophic internal flashover.

Consequently a leaking cable must be repaired. This requires that it is removed from service, so that the source of the leak can be identified, often requiring extensive excavation in heavily-trafficked roads. The leak must be repaired, the cable oil pressure restored, the cable trench back-filled, the road surface replaced, and the road returned to service. Such repairs can take a long time: much longer than applies to any other piece of equipment on Ausgrid's network. After the leak is repaired the remainder of the cable remains in its original, leak prone, condition.

The condition risk assessment has revealed that there are a number of risks associated with these cables continuing to operate in the network. Some of these risks are:

1. Multiple overlapping feeder failures leading to network risk (increased unserved energy)
2. Environmental risk from the leaking fluid, particularly in areas that are in catchment areas and near waterways
3. Access restrictions to excavate to repair cables laid in busy roadways, causing extremely difficult repairs
4. Significantly longer repair time than for any other feeder type
5. The loss of manufacturer support for superseded technology and availability of equipment for emergency repairs
6. The decline of engineering and specialist trades expertise for FFC technology.

The overlapping outage of multiple feeders can have significant reliability of supply impacts upon our customers, particularly in the Sydney CBD and surrounding urban areas. Ausgrid operates subject to a licence issued by the relevant NSW Minister that specifies reliability targets in terms of frequency and duration of supply interruption outcomes. Performance reports against these targets are required annually.

Leaking cables are also subject to oversight by the NSW Environment Protection Authority (EPA) under the *Protection of the Environment Operations Act (NSW) 1997*. Ausgrid has given the EPA an undertaking to reduce the environmental risk of leaking cables by at least 50% in each regulatory period and to replace all fluid cables with known leaks by 2034.

Ausgrid has developed a model to quantify the failure parameters (probabilistic distribution of outage frequency and duration) of each cable, relative to its observable condition. The failure model is applied to a probabilistic model of the network and the demand it is supplying, so as to estimate the long term average amount of annual energy that is beyond the technical capability of the depleted network and therefore cannot be supplied. This

[1] Both names, fluid filled cables and oil filled cables were used interchangeably in this document.

energy is then valued according to an estimate of the value of customer reliability (VCR) determined in accordance with methodology developed by the Australian Energy Market Operator (AEMO).

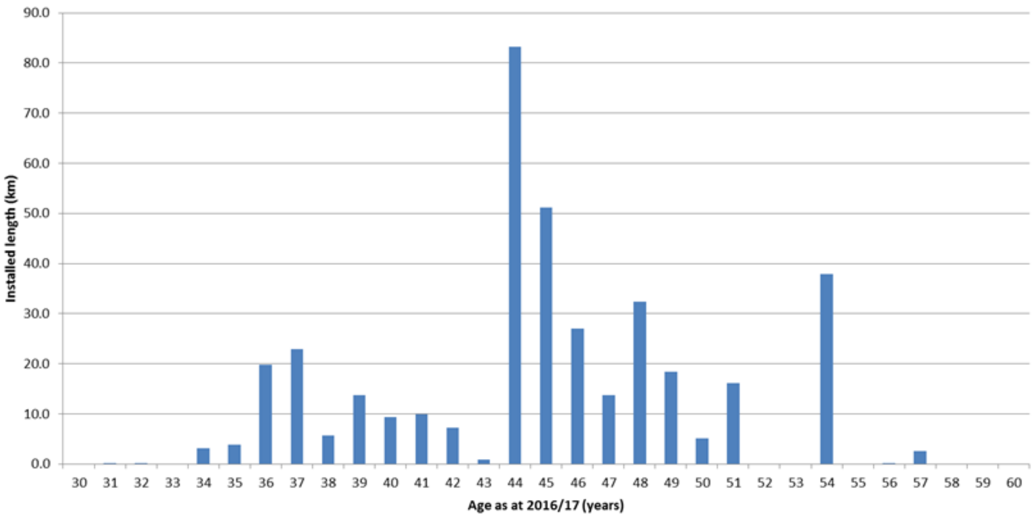
The methodology for ranking cables for retirement, and the construction of equivalent capacity to replace them, is based on separate consideration of the avoided network risk valuation (reduced cost of unserved energy) and the reduced environmental risk of each cable, or pair of cables, per dollar of the required replacement expenditure. The aim is to address both impacts, by selecting the portfolio of projects that offers the most efficient reduction in unserved energy and environmental risk per dollar of expenditure.

It should be noted that replacement of these cables requires a significant undertaking such as major road closures with disruption to customers and proactive planning and management.

3.2 Overview of Ausgrid's use of Fluid-filled cables (FFC)

Fluid filled cable technology allowed the use of underground AC cables at 132 kV and above, providing efficient and unobtrusive electricity supply to urban areas where the construction of overhead transmission lines was not feasible. They were installed by the then named Electricity Commission of NSW and electricity distribution councils such as Sydney County Council to transfer energy to urban loads that were growing at high rates. 132kV fluid filled cables in the Sydney urban areas now supplied by Ausgrid were installed in the period between 1963 and 1986. The age distribution for this population is shown in Figure 4.

Figure 4. 132kV Fluid-filled underground cables over 30 years old



Each cable comprises a large number of conducting wires that are surrounded by fluid impregnated paper layers that have excellent electrical insulating properties. The cable structure contains insulating fluid under pressure that fills all voids within the cable and paper insulation structure, enabling the cable to withstand the electrical stresses imposed at the highest operating voltage of the cable. Ducts allow the fluid to fill the entire length of cable between joint bays. The conductors and insulating materials are all contained within a metal sheath with a protective covering. The conducting sheath forms part of the electrical circuit, but most importantly must also confine the fluid to within the cable.

132kV FFC's are typically single core/single phase cables grouped together to form a three phase circuit. Each FFC circuit comprises three cables that are installed in either a flat or triangular pattern in deep trenches, mostly in roads. Usually two cable circuits (six cables) are installed in each cable trench. They are laid in a special stabilised backfill material designed to efficiently transfer heat from the cables into the surrounding earth.

At the time of their installation it was generally believed that these cables would require little maintenance and that they would have long lives, with excellent reliability, being not subject to environmental factors. Hence the decision to install them in deep trenches, sometimes in major roads, was considered reasonable because it was never contemplated that they would ever have to be dug up to enable repairs.

FFC technology has been obsolete for more than 30 years, as new technologies that reduce or remove reliability-related problems have been introduced. The specialist skills required to manage FFC assets are also becoming scarce.

The factor that is driving the need to retire this class of cable is that over a considerable time period cable sheaths degrade, allowing fluid to escape into the surrounding environment. As there is no barrier that surrounds direct-buried cables the fluid enters the ground water system. The presence of a leak is detected by a change in the fluid pressure, and the need to pump additional oil into the cable to restore this pressure. Detected leakage alarms are immediately apparent in Ausgrid's control room.

Cables that leak significantly are disconnected to remove the risk of catastrophic failure. There are two immediate and related impacts:

1. The leak must be reported to the NSW Environment Protection Authority (EPA) under the Protection of the Environment Operations Act (NSW) 1997, and corrective action undertaken.
2. The leak must be located and repaired or controlled before the cable is returned to service. This can be a difficult and time consuming task, due to the fact that the cable is buried in a road with special backfill material, and there is a need to minimise the amount of fluid that enters the environment. Further the repair of a cable requires particular skills and, due to the strategic nature of many of these cable circuits, careful management of other outages is required to reduce the network risk to an acceptable level.

From an operational viewpoint the second impact: that a leaking cable may not be able to be returned to service for a long period: days, weeks or months, is the most important. During this period of disconnection there is a high risk that a second network event will cause the capability of the network to be exceeded, requiring load disconnection, either under a Demand Management agreement or involuntarily. Taken over the whole population of these cables the expected frequency and duration of events that result in unserved energy is significant compared with Ausgrid's Licence obligations.

The identified need for replacement of the FFC's therefore includes the management of reliability risk, as measured by the reduction in unserved energy to the level implied by its Licence Conditions, in addition to meeting the requirements of the environmental risk abatement Strategy it has lodged with the NSW EPA.

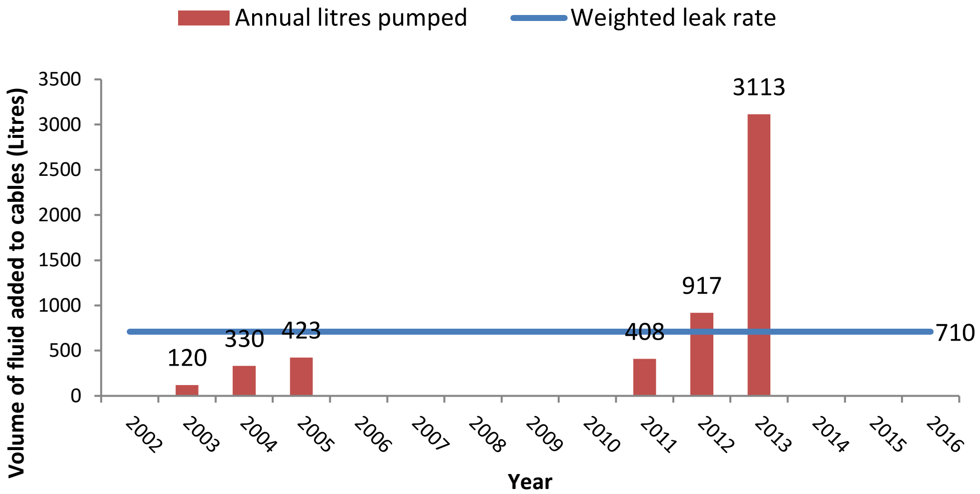
Ausgrid aims to maximise the net economic benefit by first selecting those projects that provide the highest overall economic benefit per dollar of expenditure, consistent with meeting the environmental risk reduction target.

3.3 Environmental Risk Analysis

A significant problem associated with FFC circuits is the leaking of cable dielectric fluid into the surrounding environment.

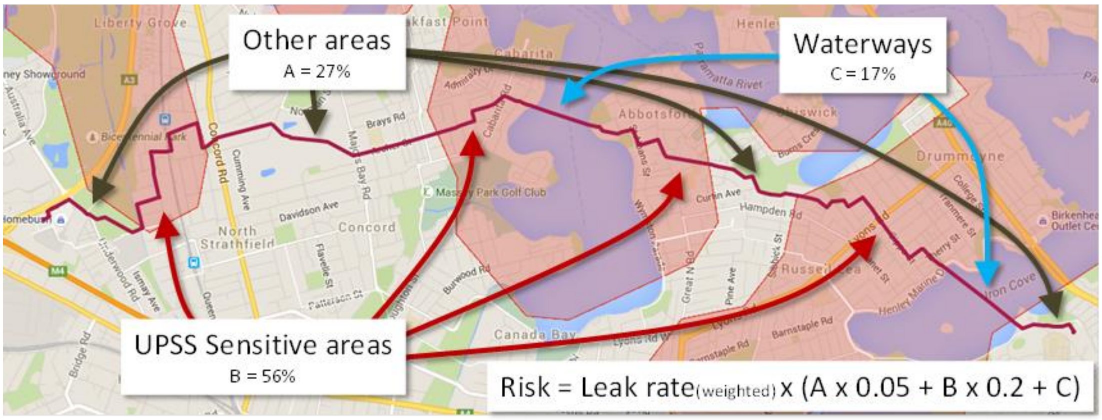
Environmental risk for each cable is quantified based on historical cable fluid leak volume records and knowledge of environmental sensitivity along the cable route. For example, one 132kV feeder experienced a cable fluid leak in 2013 that required over 3000 litres of cable fluid to be pumped into the cable in order to restore it to normal operation. This incident was preceded by a number of smaller leaks as shown in Figure 2. The calculation of a weighted annual leak rate that gives a greater weighting to incidents in the last 5 years is shown below in Figure 5.

Figure 5. Cable fluid pumped for a typical 132kV feeder



The weighted annual leak rate[2] from Figure 5 is combined with the lengths of the cable that are located within areas of different environmental sensitivity as shown in Figure 6.

Figure 6. Calculation of the environmental sensitivity of a typical cable



The environmental model of Figure 6 was developed in consultation with the EPA and uses consequence assumptions similar to those applied to underground petroleum storage systems ('UPSS') as these present a pollution threat similar to FFC's. Each FFC has been risk assessed according to its circuit length within water catchment area, UPSS sensitive areas and other less sensitive areas to quantify an environmental risk 'cost' per annum for FFC leakage into the ground, ground water and waterways.

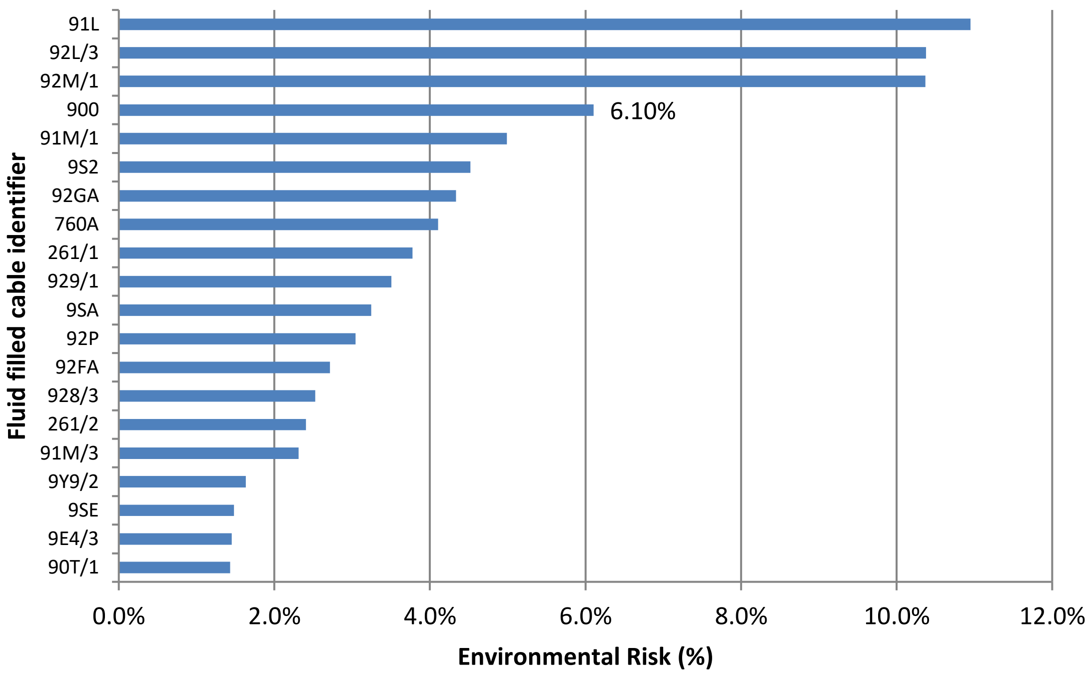
[2] This will be influenced by how quickly the leak was detected and what measures were able to be taken to mitigate and repair the leak.

An environmental risk score was calculated to be 210[3] for this cable. This equates to 6.1% of the sum of the environmental risk scores of all of Ausgrid's fluid filled cables that have experienced leaks.

A more comprehensive description of the environmental risk model can be found in Ausgrid's Environmental Management Strategy for Fluid Filled Cables.

The top 20 fluid filled cables ranked by their relative environmental risk scores are shown in Figure 7.

Figure 7. Top 20 fluid filled cables by environmental risk



In consultation with staff of the EPA, Ausgrid has developed an Environmental Management Strategy for these cables. This has been formally lodged with the EPA. This Strategy involves the reduction of the total environmental risk due to the continued operation of these cables by at least 50% of the starting level for each successive regulatory period, and the replacement of all cables that have experienced leaks by 2034. It was not expected that the EPA would either accept or reject this Strategy as this would imply its acceptance that Ausgrid will continue to operate assets that may pollute the environment. Ausgrid accepts that its actions will be judged against this document, but this does not preclude the possibility that the EPA may institute additional measures in accordance with the Act in response to some new leakage event.

Ausgrid has determined that it must continue to show good faith by abiding strictly by the replacement Strategy, as it has done since its inception.

3.4 Supply / Network Risk

Supply or Network risk is assigned for each cable based on the network configuration, available capacity under defined contingency conditions, demand forecasts and historical

[3] The scale of this score is essentially arbitrary. The scores are subsequently normalised, allowing the risks for all cables to be compared with the cable that was given the highest score.

asset management records. A key component to this assessment is the cable failure model[4] which forecasts the frequency of future cable failures. This model is developed from historical failure records, shown in Figure 8, and then modified by cable condition indicators including Insulation Resistance (IR) tests of the cable serving.

An example of the cable failure model forecast for a typical 132kV fluid filled cable is also shown in Figure 8. The forecast cable failure frequency and duration is combined with a model of the electricity network, including the forecast pattern of demand, to determine the expected[5] unserved energy. The cable failures are assumed to be random but their impact depends on the load level at that time.

Minor cable outages, usually requested to carry out some form of maintenance, are scheduled at times when there will be no impact on supply, assuming there is not another coincident failure. Maintenance outages occur more frequently than major failures, but are usually of short duration. They are included separately in the model because of the possibility that an unscheduled major failure may occur during a scheduled outage. On the other hand maintenance would normally not be scheduled while another major failure was being dealt with, so this occurrence is not entirely random.

A cable that is on scheduled maintenance will usually be given a “recall time”, which is an estimate of the time it will take to complete any work and to restore the cable to a serviceable condition. For FF cables this time can be long, and meanwhile unserved energy is possible if the demand is high. This situation differs from outages for overhead lines, for example, where recall will usually be quite short.

Unserved energy arises when Ausgrid is unable to maintain full supply to customers, usually as a result of equipment failures either while there is a prior scheduled maintenance outage, or while there is a prior outage due to equipment failure. Because equipment failures are random in nature, it is necessary to use the cable failure model to forecast the frequency of multiple cable failures in the future in order to estimate the expected unserved energy.

It is important to appreciate that in many cases two fluid filled cables provide the only network supply to an extensive area of Ausgrid’s network. In the event that both cables are disconnected the entire energy of that area will be “unserved” until either one cable is restored to service, or full or limited supply is able to be restored by switching from an adjacent area. This is an “n-1” supply where n, the number of circuits, is 2. This is more than adequate when both circuits are reliable, but involves a high, and increasing, risk when the probability of cable failure, and the duration of failures increases over time.

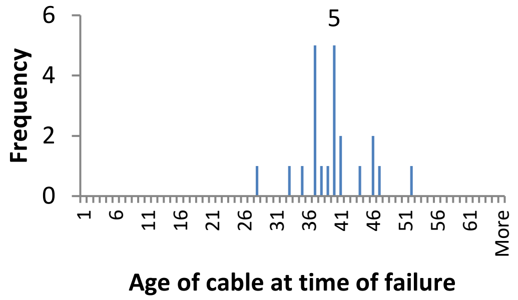
In those cases where there is another source of supply available after two circuits are disconnected the equipment failures would frequently lead to overloading the remaining healthy components of the network which results in more unserved energy when the overload is corrected by shedding load.

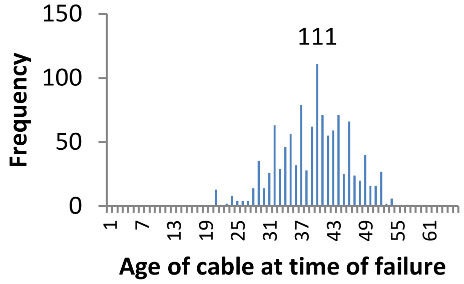
[4] Further information on the cable failure model can be found in the “Asset Risk Report – Fluid Filled Cables” and the Oil filled cable failure model independent validation report.

[5] The word ‘expected’ is used in the mathematical sense of the word i.e. a probability weighted value of a random variable.

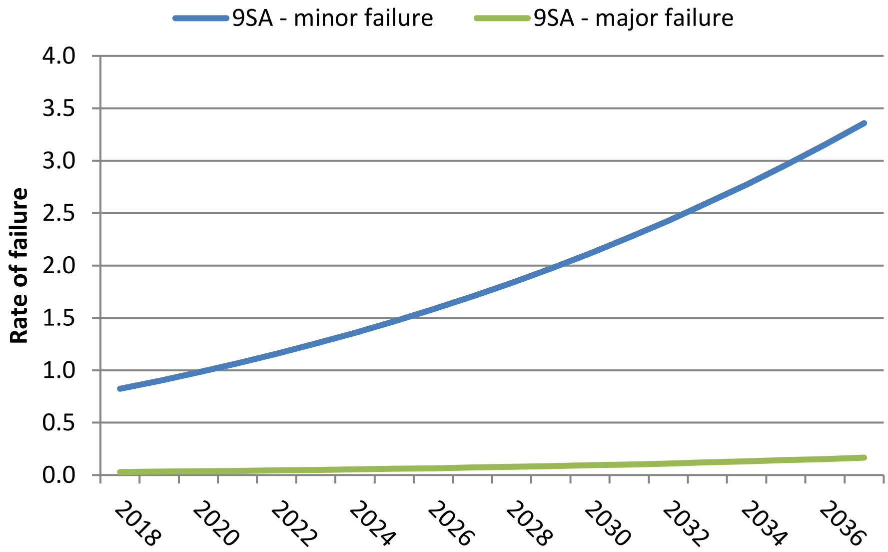
Figure 8. Cable failure data

- Historical Breakdown (Major) and Corrective (Minor) Failures[6]





- Forecast of corrective action (minor) and breakdown (major) failure rates for 132 kV cable 9SA

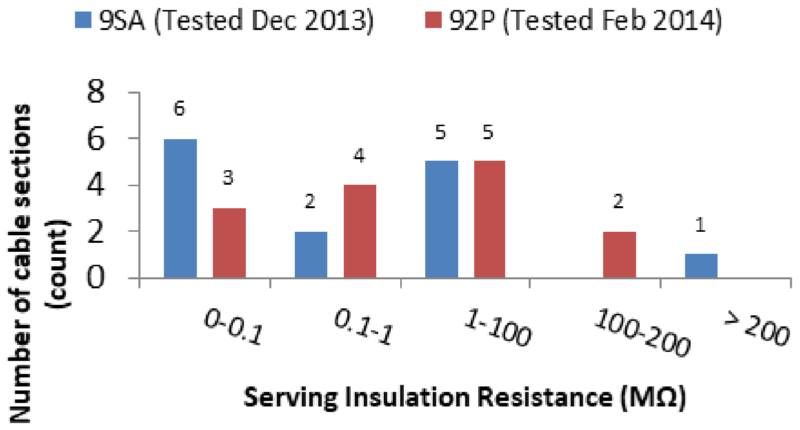


Expected unserved energy is used to represent the impact on customers because it is a function of both the frequency of outages and their duration. The calculation of Expected Unserved Energy and the formulation of a business case for replacement of equipment are detailed in Ausgrid's "Cost-Benefit Analysis for Planning" document.

Electrical Tests are used to assess the condition of a cable that is not currently leaking. As an example the cable serving Insulation Resistance (IR) test results for 9SA & 92P are shown in Figure 9.

[6] Major (left graph) and minor (right graph) failure data for Ausgrid's fluid filled cables over the period between 2009 and 2016.

Figure 9. Serving insulation resistance



The above serving insulation resistance test results show that 15 out of 28 cable sections have a serving Insulation Resistance (IR) of less than 1 MΩ, which is treated as the lower band of acceptable results. However these tests, carried out at a location where the cable is accessible, such as at a joint bay, are not definitive as to the location or timing of the potential fault.

These results may be symptomatic of numerous failures of the outer serving insulation which exposes the cable sheath to the environment and increases the likelihood of oil leaks developing. Alternatively the test results may be due to low IR at the cable link boxes and not symptomatic of a problem with the cable itself. The first case is clearly more serious than the second, but there is no means of distinguishing between them.

So the test gives a strong indication that further failures should be anticipated, but it gives no information that is useful for planning pre-emptive repairs.

The condition information is, however, included in the cable failure model.

3.5 Strategy Assessment Method

The cable prioritisation program has been developed with the key objective of maximising the net positive economic benefit to the community. The benefits that can be realised through network and non-network options are reduced expected unserved energy, reduced likelihood of cable repair and maintenance costs and reduced environment risk.

The following two step process is employed in order to select the most economically beneficial option.

- The timing of each option is identified based on the first year in which the total benefit exceeds the benefit from deferring the capital investment. Then, the Net Present Value (NPV) of net economic benefit is calculated using the total benefit and the total capital expenditure. The option that provides the highest net economic benefit is chosen as the preferred option. These studies are undertaken during Ausgrid's area plan[7] strategy review.
- Each year, as part of the annual review of the investment portfolio, the timing of the preferred option is evaluated. The CBA used in this report forms the basis for the optimal timing.

[7] The options analysis used in the previous area plans is based on the lowest Net Present Cost (NPC) criteria.

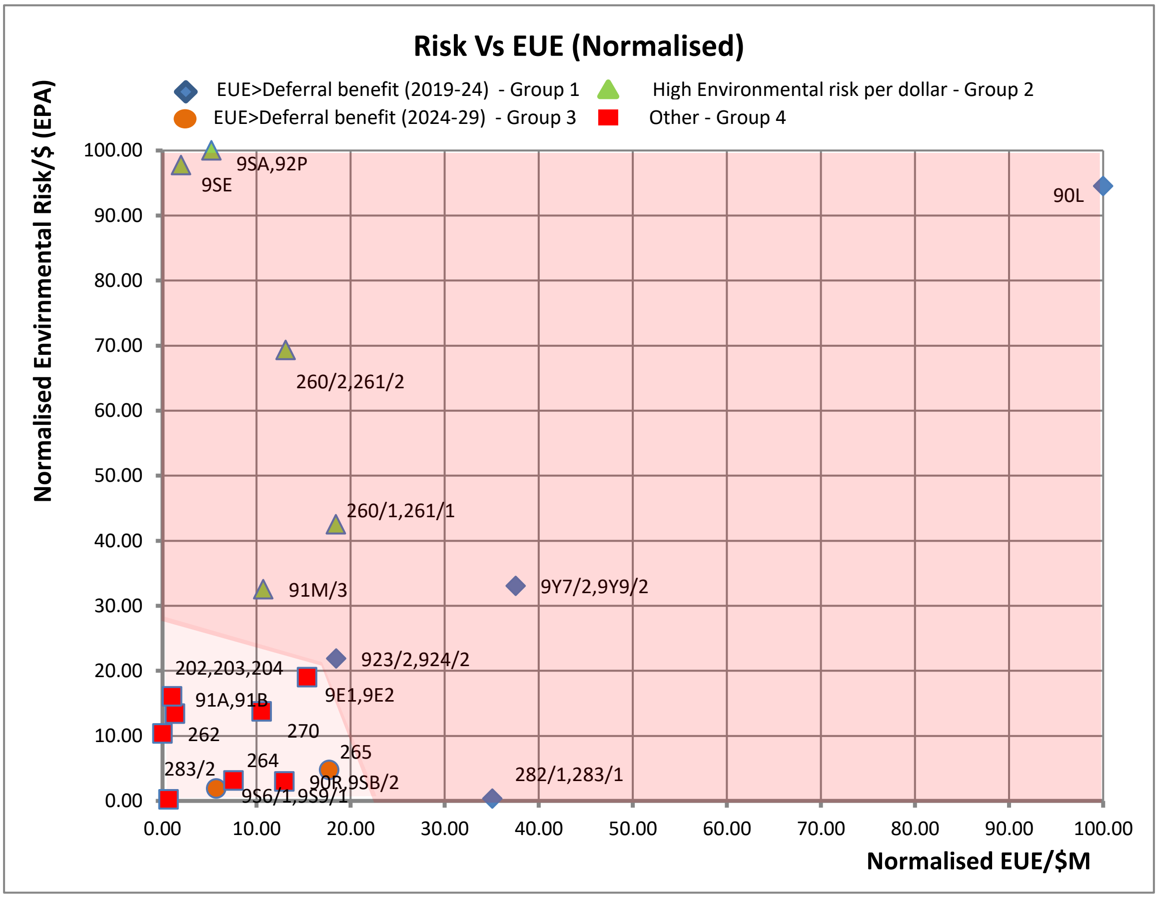
The suite of projects is ranked according to the economic evaluation analysis described above. In addition, Ausgrid must comply with various non-economic objectives such as safety issues, compliance issues or environmental issues. In regard to oil filled cables, oil leaks pose a significant risk to the environment, and hence Ausgrid has developed an environmental management strategy in consultation with the requirement of NSW Environmental Protection Authority. The strategy was discussed briefly under the heading 'Environmental Risk Analysis' in this section and further details can be found in Ausgrid's Environmental Management Strategy – EMS300.

In order to successfully implement the environmental management strategy it is necessary to distribute the cable replacement expenditure across the three regulatory periods between now and 2034, such that the net present cost is minimised while all leaking cables are retired.

Broadly, the 132kV Fluid Filled cable replacement strategy aims to achieve the least cost of investment in replacement cable assets by using a prioritised and a targeted project selection criterion that manages the expected decline in network reliability while meeting environmental obligations.

The relative environmental risk and supply risk per dollar of expenditure is calculated and compared for each cable or pair of related cables in Figure 10. The expenditure in each case is the estimated capital cost of the preferred option to retire and replace the capacity of the fluid filled cable. Each axis of the figure has been normalised such that the highest environmental risk and the highest supply risk per dollar of expenditure has been assigned a value of 100.

Figure 10. Normalised environmental risk and supply per dollar



The cables or cable pairs have been prioritised using the following criteria:

1. Those cables for which the value of the avoided estimated annual unserved energy (EUE) is greater than the annualised cable replacement cost are assigned the highest priority. These cable replacement projects produce a greater net economic benefit (based on avoided unserved energy) compared to maintaining the cables in service beyond the 2019-24 regulatory period. Some of these projects provide a secondary benefit in terms of contributing to meeting the environmental risk reduction target.
2. Those cables that will achieve the greatest environmental risk reduction per dollar of expenditure are assigned the second highest priority. These are the most cost effective projects to reduce the environmental risk.
3. The third priority is assigned to cable replacements that are expected to provide a net economic benefit if replacement is deferred until the 2024-29 regulatory control period. These feeders will also contribute to achieving the environment risk reduction target for the 2024-29 regulatory control period.
4. The fourth priority is assigned to cables that do not have a net positive benefit but which, when considered with other unreliable cables, will contribute most efficiently to reaching the target reduction in environmental risk prior to 2034 (all cables of this group are not shown in the above diagram).

The replacement of some of the selected cables may also have a strategic benefit. For example, the replacement of cables 9SA & 92P at this time coincides with the proposed construction of a new Zone Substation, Alexandria North, which will obtain supply from either 9SA or 92P.

Figure 11 shows the contribution of each of the recommended cable replacements to meeting Ausgrid's environmental risk reduction obligations in the 2019-24 regulatory period.

Figure 11. Environmental Risk Reduction Contributions

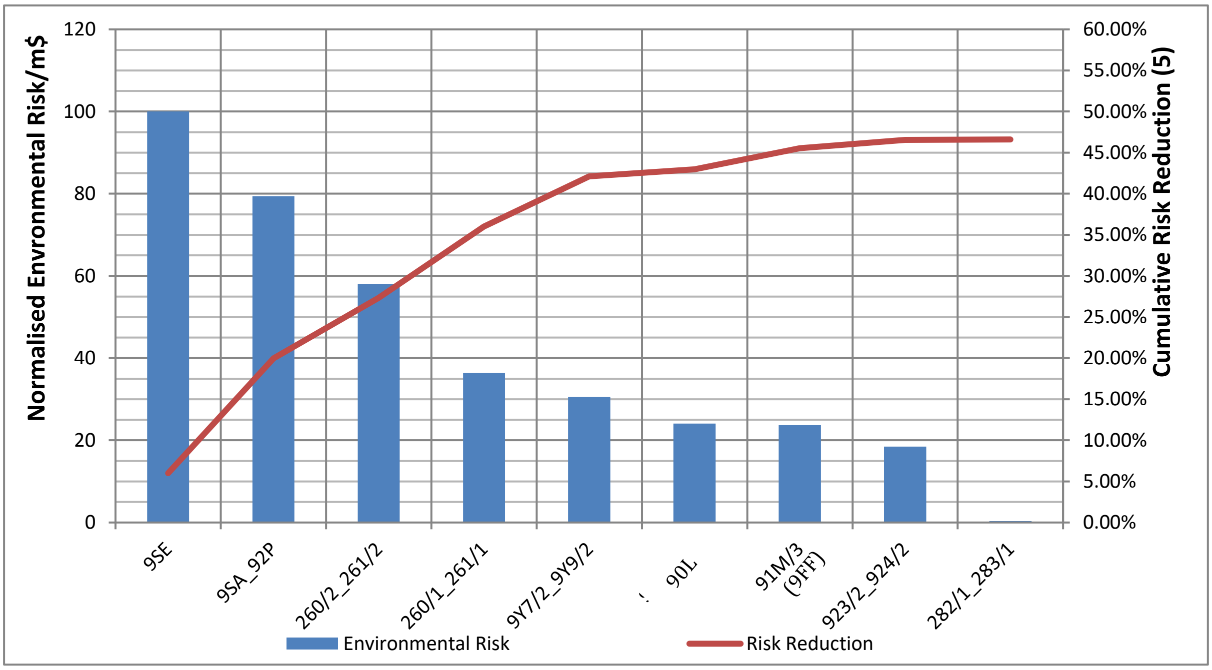


Table 2 lists all the feeders that Ausgrid has planned for replacement and decommission in the 2019-24 regulatory period to maximize the net economic benefit as well as to achieve the required 50% reduction in environmental risk.

Table 2. Feeder projects to be completed in the 2019-24 regulatory period

Feeder	Project Type	Need Date	Environment Risk	Project Number
90L	Replacement	September 2019	0.39	13
260/2 & 261/2	Replacement	June 2021	3.31	5
9P7	Decommission	September 2021	0.00	2
9Y7/2 & 9Y9/2	Replacement	September 2021	2.75	2
282/1 & 283/1	Replacement	September 2021	0.02	4
9FF ex 91M/3	Replacement	September 2021	2.31	7
9SE	Replacement	September 2023	1.48	9
9SA & 92P	Replacement	March 2024	6.29	3
260/1 & 261/1	Decommission	March 2024	3.89	1
265	Replacement	September 2024	0.21	6
291 & 292	Decommission	2021 (committed)	1.21	-
H773 & H775	Decommission	2021 (committed)	0.04	-

3.6 Associated 132kV cables related to Powering Sydney's Future

In addition to the cables listed in Table 2, a number of other cables supplying Inner Sydney area are approaching the end of their serviceable lives. TransGrid and Ausgrid have jointly worked to identify the most economically viable solution to ensure a reliable supply. Joint planning between TransGrid and Ausgrid has developed a solution to address issues related to the Sydney Inner Metropolitan network. This project is known as "Powering Sydney's Future" and has two stages in TransGrid's revised regulatory submission.

Stage 1 (in the 2019-24 regulatory control period):

- Installation of one 330kV feeder from Rookwood Rd to Beaconsfield
- Operation of 330kV cable 41 between Sydney South and Beaconsfield at 132kV
- Partial decommissioning of Ausgrid's 132kV feeders.

Stage 2 (in the 2024-29 regulatory control period):

- Installation of the second 330kV feeder from Rookwood Rd to Beaconsfield
- Conversion of 132kV feeder 9S4 between Beaconsfield and Haymarket to 330kV operation
- Decommissioning of remaining Ausgrid's 132kV feeders.

The Ausgrid's 132kV cables scheduled for decommissioning as part of Powering Sydney's Future project are given in the table below. The decommissioning expenditure will be mostly incurred by Ausgrid.

Table 3. The list of feeders to be decommissioned as part of the "Powering Sydney's Future" project

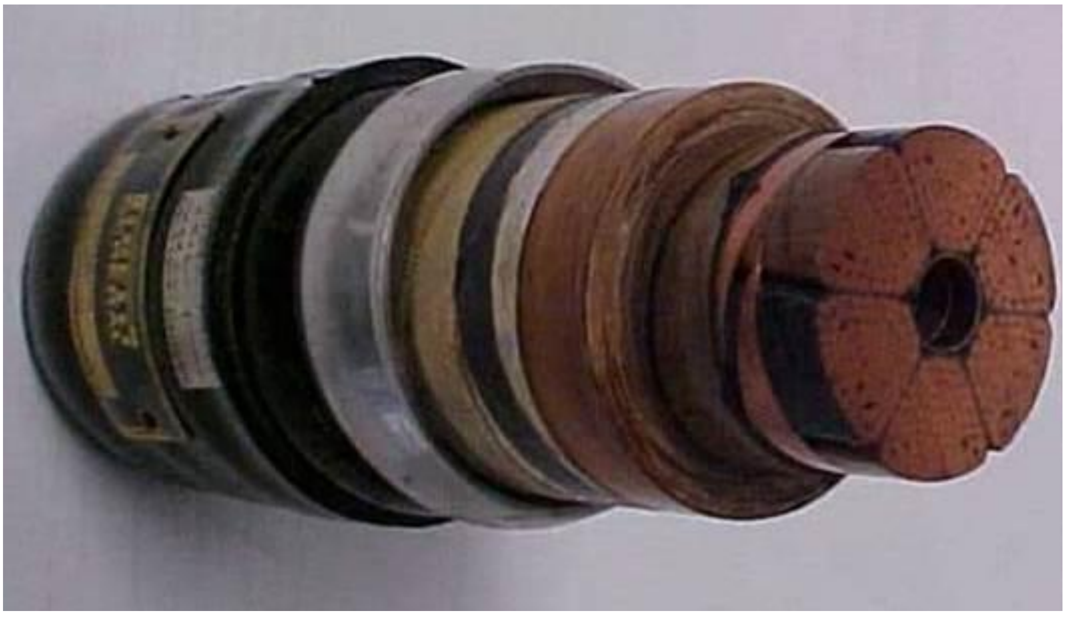
Feeder	Need Date	Environmental Risk (%)	Cost ($m, real FY19, 19-24)	Cost ($m, real FY19, Total)
928/3	2023	2.53	1.7	1.7
929/1	2023	3.51	1.7	1.7
9RT (ex91M/1)	2023	4.99	0.1	1.6
929/2	2024	0.00	0.4	0.4
92L/1	2024	0.52	0.4	0.4
928/1	2024	0.00	0.4	0.4
92M/2	2024	0.22	0.4	0.4
92C	2027	0.32	-	2.5
92X	2027	0.47	-	2.5
91X/2	2027	0.16	-	2.0
91Y/2	2027	0.37	-	2.0
9S2	2027	4.52	-	0.7
90T/1	2027	1.43	-	0.5

3.7 Delivery of Fluid Filled cables replacement projects

Delivery of a new subtransmission cable typically takes around five years from project initiation to commissioning. Route options are assessed, considering total route length as well as crossings of significant obstacles such as rail lines, waterways and major roads. Where practical, route alignments are selected to follow public roadways, but in many cases crossings are required across property that is owned by private or government entities and these property crossings require negotiation and acquisition of easements. A process of community consultation and environmental impact assessment is also required prior to commencing installation work. When the route alignment is confirmed and environmental approvals are in place, excavation can commence (timing subject to RMS road access restrictions) for the installation of ducts, through which cables are installed. The construction schedule of each project described in Part B is on the basis of above consideration.

4 PART B – 132KV CABLE REPLACEMENT PROJECTS

Figure 12. Typical 132KV single phase fluid filled cable



5 PROJECT 1 – BEACONSFIELD TO ZETLAND

5.1 Project description

The project is to replace 132kV oil filled cables 260/1 and 261/1 between Beaconsfield and Zetland in the Eastern Suburbs area of Ausgrid's network. It is shown in Figure 13. These cables have experienced significant oil leaks in the past. Having regard for this and the condition of the equipment at the Zetland Zone Substation, the preferred project is to decommission Zetland Zone Substation and establish a new Alexandria North Zone Substation on Ausgrid owned land, by looping 132kV feeder 9SA or 92P through the new substation. The need for a high capacity zone substation is also aligned with growth concentrated in the 'Central to Eveleigh Precinct' area that is being managed by Urban Growth, a NSW government agency. The target completion date is June 2024. The 260/1 and 261/1 feeder decommissioning is consistent with Ausgrid's fluid filled cable replacement strategy for the Eastern Suburbs area and the environmental management strategy for fluid filled cables. The project cost estimate to retire the 132kV oil-filled cable circuits over the length of 4.5km is $40.5 million, $39.4 million of which is forecast to be incurred in the 2019-24 period.

Figure 13. Beaconsfield to Zetland

5.2 Need

The existing 260/1 and 261/1 132kV feeders consist of oil filled cables, and supply Zetland and Clovelly Zone Substations from Beaconsfield Bulk Supply Point. After the decommissioning of feeders 260/2 and 261/2 supplying Clovelly Zone Substation (Project 5), the feeders would only supply Zetland Zone Substation. The existing feeders are single core 426mm^2 oil-filled cables. The length of 132kV feeders 260/1 and 261/1 is approximately 2.4km and 2.7km respectively. They will be 50 years old when replaced in 2024.

The concurrent outage of these feeders would result in the loss of supply to Zetland Zone Substation. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Essentially there is a low, but increasing, probability that a significant portion of the customers in this area will experience a very long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 130MWh in 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars expenditure (normalised x-axis). These cables are ranked fourth on this basis.

Cables 260/1 and 261/1 have experienced significant oil leaks over the past 15 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 260/1 and 261/1 as contributing 0.12% and 3.77% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation resistance testing indicates that there are potential problems with the outer serving of the cables which could lead to oil leaks in the future.

The cable failure model forecasts that the reliability of these cables will deteriorate into the future if they are not replaced. A history of cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace these aged fluid filled cables.

The current planning approach provides for the decommissioning of Zetland Zone Substation, and its replacement by a new Zone Substation at Alexandria North. This plan addresses the need to retire the ageing switchgear at Zetland and to decommission the 132kV oil filled cables that supply it from Beaconsfield BSP. Consequently supplying Clovelly from a different source is required, and Kingsford is the strategic solution.

5.3 Options

We examined the following options as part of the Ausgrid's network planning process:

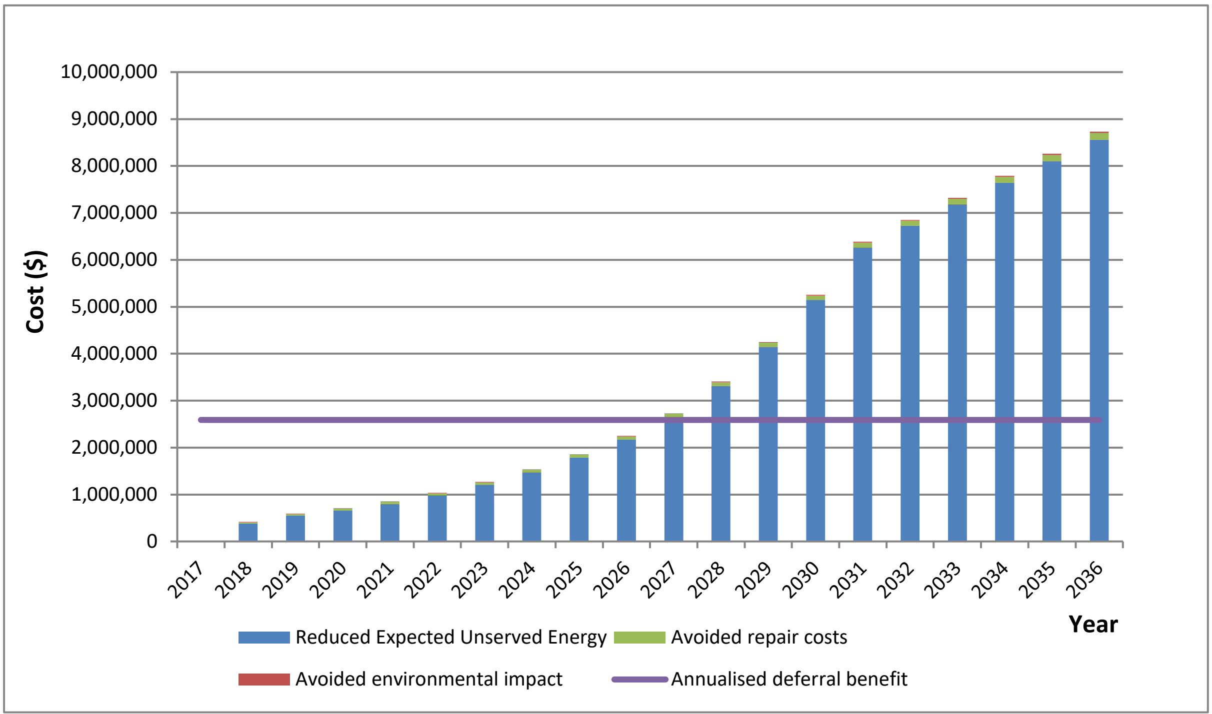
1. Replacement of 132kV feeders 260/1 and 261/1 like-for-like
2. Decommission 132kV feeders 260/1 and 261/1 by transferring Zetland loads to existing adjacent zone substations
3. Decommission 132kV feeders 260/1 and 261/1 by installing a new Alexandria North Zone Substation looped into a 132kV feeder between Beaconsfield and Campbell St (9SA)
4. Consideration of demand management.

Based on the future strategic solution to address the need for retirement of other cables in the Eastern Suburbs area, the preferred network option is to undertake the decommissioning of feeders 260/1 and 261/1 by installing a new Alexandria North Zone Substation looped into an existing 132kV feeder from Beaconsfield and Campbell St (9SA) along with the proposed replacement of 132kV feeders 9SA and 92P (Project 3).

5.4 Timing

CBA was used to determine the optimal timing of feeder replacements. This includes the estimated benefit in terms of avoided unserved energy as a result of cable failure. On the basis of network risk, the optimal timing for commissioning the project is likely to be beyond the 2019-24 regulatory control period, as illustrated in Figure 14.

Figure 14. Total risk cost versus project deferral benefit - Beaconsfield to Zetland



Ausgrid is also committed to reducing the environmental risk associated with the operation, maintenance and repair of oil-filled cables, and aims to reduce the overall environmental risk by at least 50% for each regulatory period.

Figure 11 in Part A shows the ranking of cables based on the environmental risk per million dollars of expenditure (maximum risk per dollar being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the replacement of feeders 260/1 and 261/1 during 2019-24 regulatory period provides a substantial cost-effective contribution towards achieving this environmental target, being ranked fifth. Taking this into consideration, its timing was advanced.

The timing analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability and cash flow smoothing are other factors that define the optimum timing to complete the project. In consideration of these factors, **the optimum timing for completion of this project is recommended as March 2024**.

We forecast that construction work will start in 2020 and end in 2025.

5.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by environmental risk and other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective.

Further analysis considered whether the estimated unserved energy at risk could be cost effectively reduced using non-network options. The analysis used the same unserved energy model developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. This analysis determined that using non-network options to reduce the estimated unserved energy at risk is not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a Regulatory Investment Test for Distributors (RIT-D) will be conducted on this project, and a Non-Network Options Report (NNOR) will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

5.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the Business Planning and Consolidation (BPC) tool outlined in Attachment 5.03.

The proposed solution involves the construction of the New Alexandria North Zone Substation at a location that facilitates 132kV connections to feeders proposed for replacement in the area. The proposed scope also includes the decommissioning of Zetland Zone Substation and the existing oil filled cables supplying the site.

The total cost of the project is $40.5 million. The cash flow for the project is outlined in Table 4.

Table 4. Beaconsfield to Zetland project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Decommission 132kV Feeders 260/1 & 261/1	-	-	-	0.0	0.1	0.7	-
Decommission Zetland Zone Substation	-	-	-	-	-		1.8
New Alexandria North Zone Substation	-	0.6	2.0	10.7	16.9	4.5	0.0
New Alexandria North 132kV supply connections	-	-	-	-	1.6	1.7	-
Total Costs	-	**0.6**	**2.0**	**10.7**	**18.6**	**6.9**	**1.8**

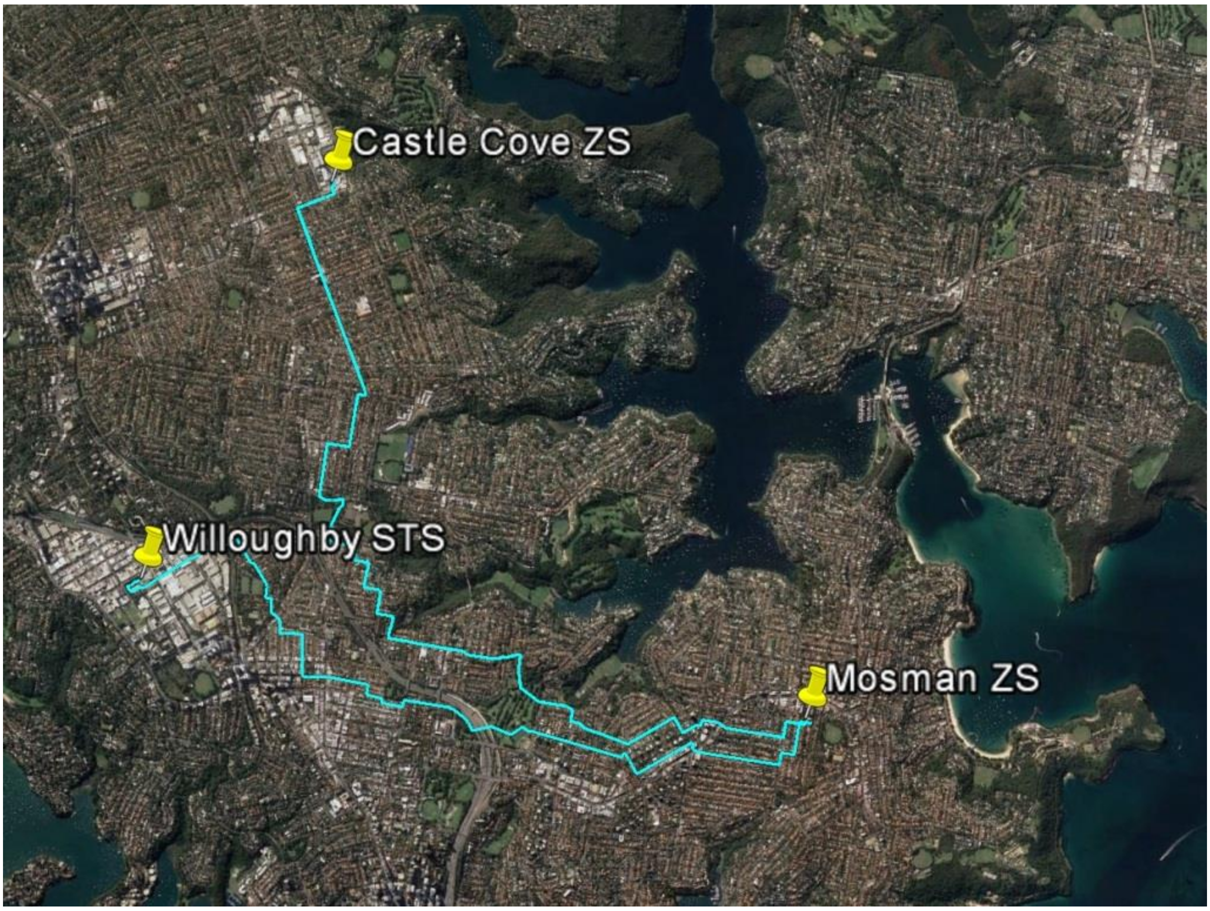
NOTE: Numbers may not sum due to rounding.

6 PROJECT 2 – CASTLE COVE TO MOSMAN

6.1 Project description

The project is to replace 132kV oil filled cables 9Y7/2 and 9Y9/2 between Castle Cove and Mosman Zone Substations in the Lower North Shore Area of Ausgrid's network. It is shown below in Figure 15. These cables have experienced oil leaks, and have been prioritised for replacement in 2019-24. Based on an assessment of cost-benefit and environmental risk, and the need to coordinate this work with other replacement projects we plan to replace these cables by summer 2022. The replacement capacity will be provided by installing two new 132kV cable feeders between Willoughby Subtransmission Substation (STS) and Mosman Zone Substation. The feeders will consist of XLPE cables, and will be installed on a route that will pass near an Ausgrid-owned property at Cremorne Junction to enable construction of a new zone substation there in the future. The total project cost is $37.5 million, of which $36.4 million is expected to be incurred in the 2019-24 period.

Figure 15. Castle Cove to Mosman



6.2 Need

The 132kV cable feeders 9Y7 and 9Y9 supply Castle Cove and Mosman Zone Substations from Lindfield STS. The cable section between Castle Cove and Mosman (9Y7/2 and 9Y9/2) is oil-filled. The simultaneous outage of feeders 9Y7/2 and 9Y9/2 would take both Castle Cove and Mosman Zone Substations out of service as there are no 132kV feeder circuit breakers at each substation. A third, normally out of service, oil filled feeder (9P7) from Willoughby to Mosman Zone Substation could be energised to supply Mosman substation by disconnecting bonds on feeders 9Y7/2 and 9Y9/2, and would have to be reversed to restore normal supply. The length of 132kV oil-filled cable feeders 9Y7/2 and 9Y9/2 is 8.6km. These cables will be 51 years old when replaced in 2022.

The concurrent outage of these feeders would result in the loss of supply to Castle Cove and Mosman Zone Substations. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Essentially there is a low, but increasing, probability that a significant portion of the customers in this area will experience a very long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 240MWh in 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). These cables are ranked second on this basis.

Cables 9Y7/2 and 9Y9/2 have experienced moderate oil leaks over the past 15 years. Based on leakage data, along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 9Y7/2 and 9Y9/2 as contributing 1.63% and 1.12% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation resistance testing indicates that there may be problems with the outer serving of the cables, which could lead to oil leaks in the future. Our cable failure model forecasts that the reliability of these cables will deteriorate into the future if they are not replaced.

The cables supply Castle Cove and Mosman Zone Substations in the Lower North Shore area and their integrity are essential to ensure reliable supply for customers in these areas. The potential for further cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace the remaining sections of aged fluid filled cables.

6.3 Options

We examined the following options as part of the Ausgrid's network planning process:

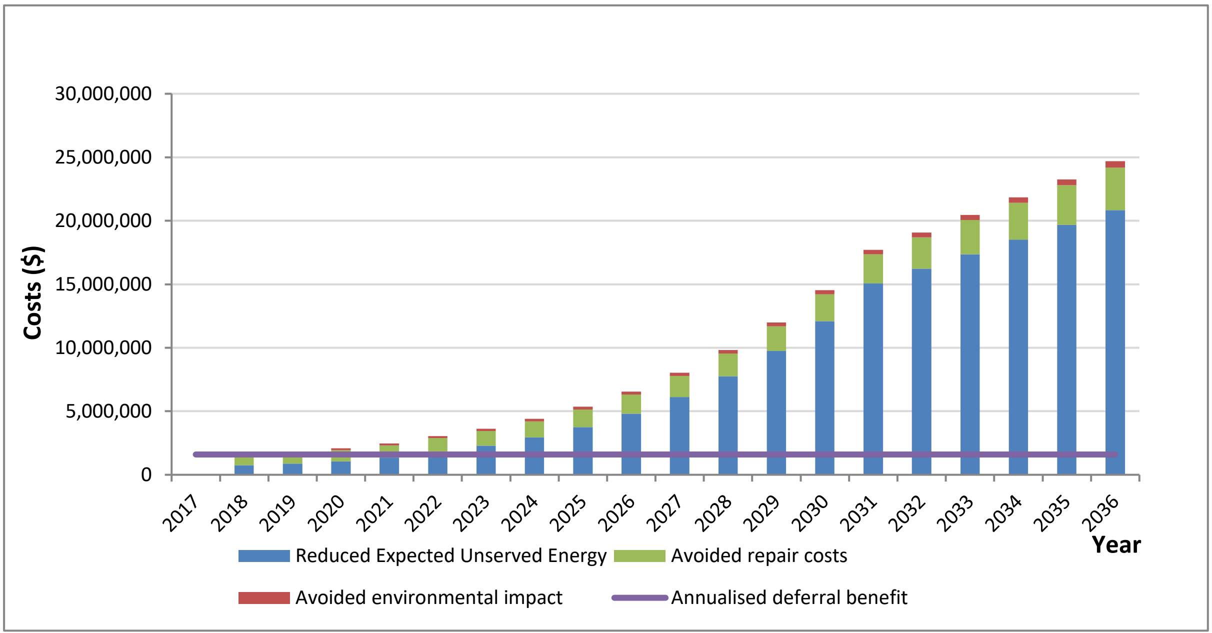
1. Installation of two new 132kV feeders from Willoughby STS to Mosman via Cremorne Junction to replace existing feeders 9Y7/2 and 9Y9/2 from Castle Cove to Mosman Zone Substation. This would also require that oil filled feeder 9P7 be decommissioned to allow connection of the new feeders at Willoughby. This is an additional benefit
2. Replacement of feeders 9Y7/2 & 9Y9/2 like for like from Castle Cove to Mosman Zone Substation
3. Consideration of demand management.

The preferred network option is Option 1, using modern XLPE cable on a route that would allow establishment of a new Zone Substation at Cremorne Junction as it provides a future strategic solution to the Lower North Shore area.

6.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify the optimum replacement date. To achieve positive net economic benefits, the optimal timing for commissioning the project is as early as possible in the 2019-24 regulatory control period, as illustrated in Figure 16.

Figure 16. *Total risk cost versus project deferral benefit - Cast Cove to Mosman*



The replacement of these feeders also contributes significantly to achievement of Ausgrid's 50% environmental risk reduction target (Refer to the Figure 10 and Figure 11 in Part A).

This timing also considers the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Other factors, such as, deliverability, resource availability and cash flow smoothing define the optimum timing to complete the project. **The optimum timing for completing this project is recommended as September 2021**.

We forecast that construction work will start in 2018 and end in 2022.

6.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives would not be cost effective due to the magnitude of the load reduction required.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

6.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution includes the installation of two 7.5km high capacity cables and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in Table 5.

Table 5. Castle Cove to Mosman project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Replace 132kV Feeders 9Y7/2 and 9Y9/2	1.0	7.8	14.6	13.2	-	-	-
Decommission 132kV Feeder 9P7	0.1	0.6	0.1	-	-	-	-
Total cost	**1.1**	**8.4**	**14.7**	**13.2**	**-**	**-**	**-**

NOTE: Numbers may not sum due to rounding.

7 PROJECT 3 – BEACONSFIELD TO CAMPBELL STREET AND BELMORE PARK

7.1 Project description

The project is to complete the replacement of oil filled cables 9SA from Beaconsfield to Campbell St and 92P from Beaconsfield to Belmore Park with new XLPE cables between the same terminals. It is shown below in Figure 17. These cables are laid in one trench over most of their route. The construction of the road infrastructure project WestConnex and associated road widening work requires replacement of 2.6km of the existing oil filled cables with new XLPE cables, leaving 3.1km of the existing oil filled cables in service on the network. These cables have both experienced oil leaks, 9SA being worse than 92P. As a pair they have been identified as posing a very high environmental risk, but they have also been identified as the highest-ranked cable pair in cost-effectiveness in reducing environmental risk (i.e. the reduction of environmental risk per dollar of replacement expenditure). Both cables have also been assigned a lower rating to avoid over-heating, and their replacement will avoid costly and difficult remediation works to restore capacity. The cables have been considered together because the least cost solution is for them to be laid at the same time in new adjacent ducts over most of their length. Their replacement by March 2024 is consistent with Ausgrid's environmental risk management strategy for fluid filled cables. The project cost estimate to replace the two 132kV cable circuits over the remaining length of 3.1km is $27.7 million, of which $21.7 million is forecast to be incurred in the 2019-24 period.

Figure 17. Beaconsfield to Campbell Street and Belmore Park

7.2 Need

132kV oil filled cables 9SA and 92P run from Beaconsfield to Campbell St and Belmore Park Zone Substations respectively, and they supply the southern CBD. The existing feeders are single core 1200mm2 oil-filled cables. These cables will be 51 years old when replaced in 2024.

The concurrent outage of these feeders would result in the load curtailment on a number of zone substations in Eastern Suburbs area due to the capacity constraint in the transmission corridor 2 in Sydney's Inner Metropolitan network. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Essentially there is a low probability that many of the customers in this area will experience a very long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 25MWh in 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars expenditure (normalised x-axis). These cables have a low ranking on this basis, but the greater concern is to cost-effectively remove their potential environmental impact, as outlined below, for which they have the highest ranking.

Cable 9SA has experienced significant oil leaks over the past 15 years, while cable 92P has more severe leaks in more recent years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 9SA and 92P as contributing 3.25% and 3.04% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Both cables have been significantly de-rated because problems with the backfill that surrounds the cables prevent heat from dissipating in accordance with the original design intention. It has been determined that the thermal resistivity of the cable bedding and backfill increases dramatically as the moisture content reduces. As a result the recurrent cyclic summer rating of these cables has been reduced from 250 MVA to 135 MVA in order to protect them from overload and failure.

Insulation resistance testing indicates that there may be further problems with the outer serving of the cables which could lead to oil leaks in the future. There are no practical actions that can be taken to reduce this risk before the leaks become apparent.

Our failure model forecasts that the reliability of these cables will deteriorate rapidly if they are not replaced. This means that there will be increased expenditure on corrective work.

The cables are a critical component of the network that transfers power from Beaconsfield to the CBD / Eastern Suburbs load area, and their integrity is essential to ensure reliable supply for customers in these areas. The high environmental risk reduction per dollar of replacement expenditure, reduced cable capacity, a history of cable fluid leaks, poor test results that indicate that more leaks are likely and increased rates of corrective work for these cables support the case to replace the remaining sections of aged fluid filled cables.

7.3 Options

We examined the following options as part of the Ausgrid's network planning process:

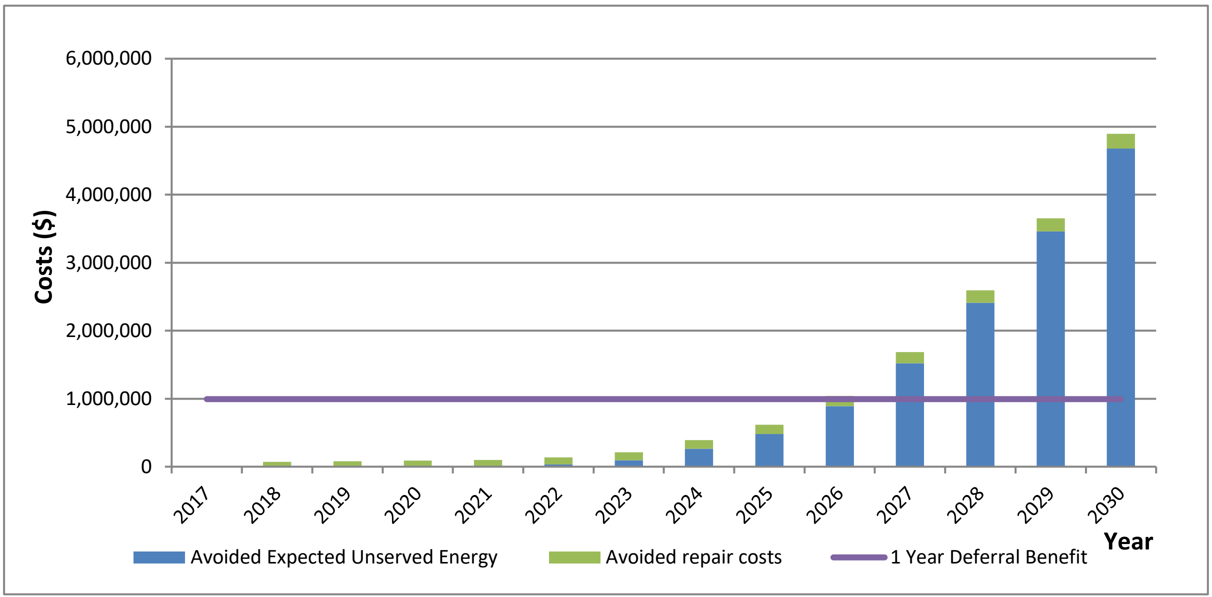
1. Like-for-like replacement of the remaining section (Wellington St – Surry Hills STS) for these cables
2. Remediation of the cable section Wellington St – Redfern initially and replacement of the entire remaining section (Wellington St – Surry Hills STS) at a later date
3. Consideration of demand management.

The preferred network option is to undertake like for like replacement of the entire remaining section of feeders 9SA and 92P as it provides a future strategic and the most cost effective solution to the area.

7.4 Timing

A CBA, which includes the estimated cost of unserved energy due to unreliability attributable to the assets to be replaced, was used to identify a break-even replacement date. If we were considering only the achievement of a positive net economic benefit, the timing for the project is likely to be just beyond the 2019-24 regulatory control period, as illustrated in Figure 18.

Figure 18. Total risk cost versus project deferral benefit, Beaconsfield to Campbell Street and Belmore Park



However Ausgrid is also committed to reducing the environmental risk associated with the operation, maintenance and repair of oil-filled cables and it aims to reduce the overall environmental risk by at least 50% during each regulatory period.

Figure 11 in Part A shows the ranking of cables based on the environmental risk per million dollars of expenditure (maximum risk being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the replacement of feeders 9SA and 92P during the 2019-24 regulatory period will make a highly cost effective contribution towards achieving this environmental target.

Replacement of these cables is also the first step in a coordinated strategy to progressively replace oil filled cables that serve the northern part of the Eastern Suburbs.

The timing also considers the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability, sensitivity analysis and cash flow smoothing are also considered.

The timing selected to replace 9SA and 92P also coincides with the proposed establishment of Alexandria North[8] Zone Substation by connecting one of these two cables to the new site. It is also consistent with the retirement / replacement strategy for 132kV fluid filled cables to

[8] Due to the proposed retirement of Zetland Zone Substation and emerging new customer loads in Waterloo area.

meet the EPA's commitment. In consideration of these factors, **the optimum timing for completion of this project is recommended as March 2024**.

We forecast that construction work will start in 2018 and end in 2025.

7.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by environmental risk and other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeders. A preliminary deferral analysis determined that this is not cost effective due to the magnitude of the load reduction required.

A further analysis considered whether the estimated unserved energy at risk could be cost effectively reduced using non-network options. The analysis used the same unserved energy model developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. This analysis determined that using non-network options to reduce the estimated unserved energy at risk is not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

7.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution includes the installation of 3.1km of high capacity cables, including six joint bays, and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in Table 6 below.

Table 6. Beaconsfield to Campbell and Belmore Park project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	5.1	0.2	0.5	1.0	10.8	9.1	1.0

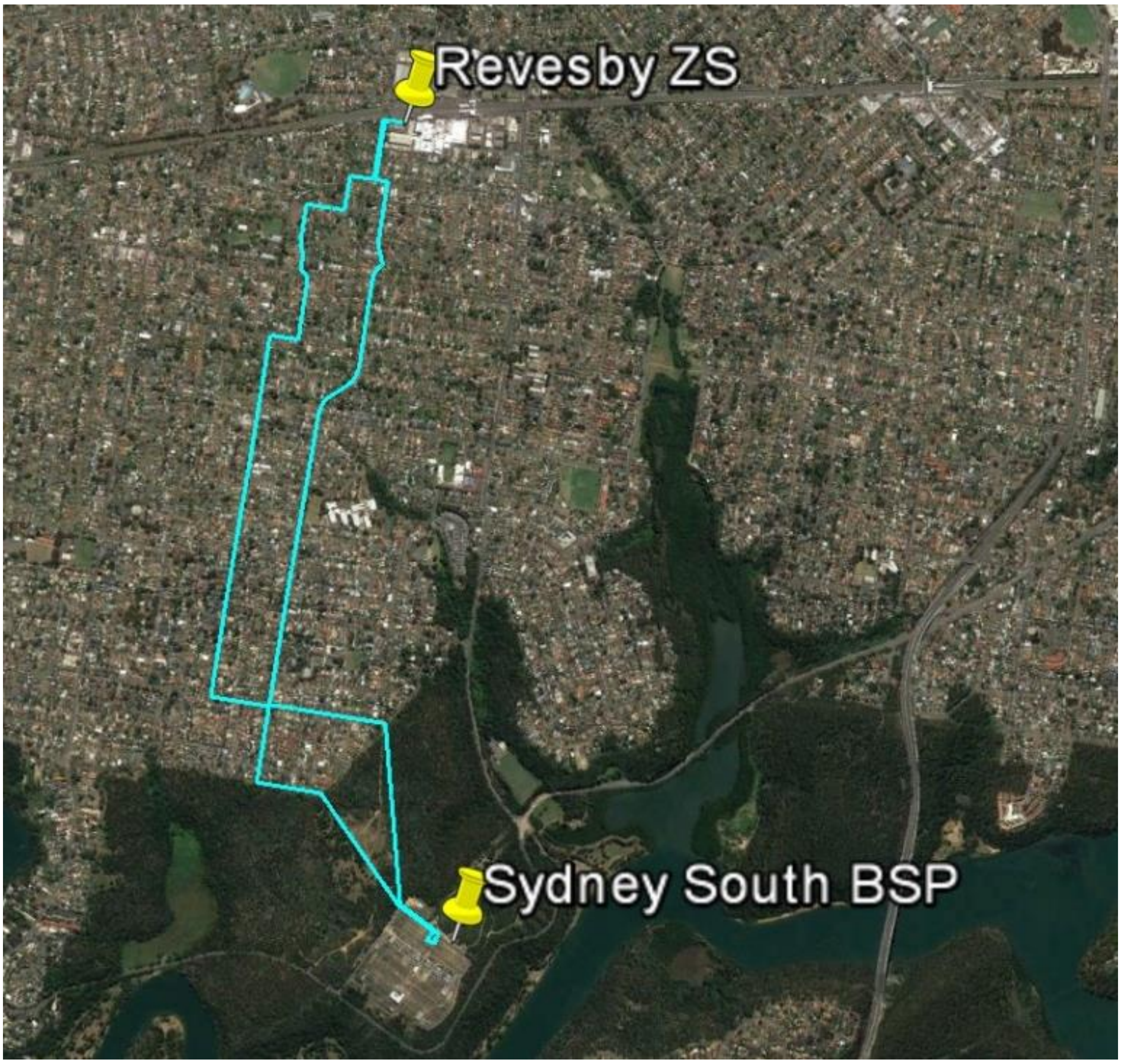
8 PROJECT 4 – SYDNEY SOUTH TO REVESBY

8.1 Project description

The project is to replace 132kV oil filled cables 282/1 and 283/1 between TransGrid's Sydney South BSP and Revesby Zone Substation in the Canterbury Bankstown area of Ausgrid's network. It is shown in Figure 19 below. These cables have experienced oil leaks. The Canterbury Bankstown Area Plan review in 2012 indicated their replacement due to condition by 2016 for 283/1 and by 2023 for 282/1. The main consideration driving the replacement of these cables is their potential contribution to unserved energy.

Based on an assessment of cost-benefit and environmental risk, we now plan to replace both cables like-for-like by summer 2022. The total project cost is $21.6 million, of which $19.2 million is forecast to be incurred in the 2019-24 period.

Figure 19. Sydney South to Revesby



8.2 Need

The 132kV cable feeders 282/1 and 283/1 supply Revesby Zone Substation and then two feeders 282/2 & 283/2 from Revesby supply Milperra Zone Substation. The lengths of

132kV oil filled cable feeders 282/1 and 283/1 are 3.3km and 3.7km respectively. Cables 282/1 and 283/1 will be 41 years old when replaced in 2022.

The concurrent outage of these feeders would result in the loss of supply to both Revesby and Milperra Zone Substations. There is a very limited supply restoration via 11kV connections to other nearby zone substations. Hence, only partial loads would be recovered via 11kV load transfers to nearby zone substations using existing connections after a time delay (switching time). Essentially there is a low, but increasing, probability that a significant portion of the customers in this area will experience a very long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 130MWh in the 2019-24 regulatory period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). These cables are ranked third on this basis. The value of this unserved energy exceeds the one year deferral benefit and hence their replacement is economically justified.

Cables 282/1 and 283/1 have experienced oil leaks over the past 15 years[9]. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 282/1 and 283/1 as contributing only very small proportion (0.01%) of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation resistance testing indicates potential problems with the outer serving of the cables which could lead to oil leaks requiring outage for repair in the future. Our cable failure model forecasts that these cables will deteriorate if they are not replaced.

The cables are the sole supply to Milperra and Revesby Zone Substations in the Canterbury Bankstown area and their integrity are essential to ensure reliable supply for customers in these areas. The potential that cable fluid leaks will cause decreasing reliability, poor test results and increased rates of corrective work for these cables support the case to replace these aged fluid filled cables.

8.3 Options

We examined the following options as part of the Ausgrid's network planning process:

1. Replacement of feeders 282/1 and 283/1 like-for-like
2. Replacement of feeders 282/1 and 283/1 with new overhead feeders
3. Replacement of feeders 282/1 and 283/1 with new feeders from Bankstown STS
4. Consideration of demand management.

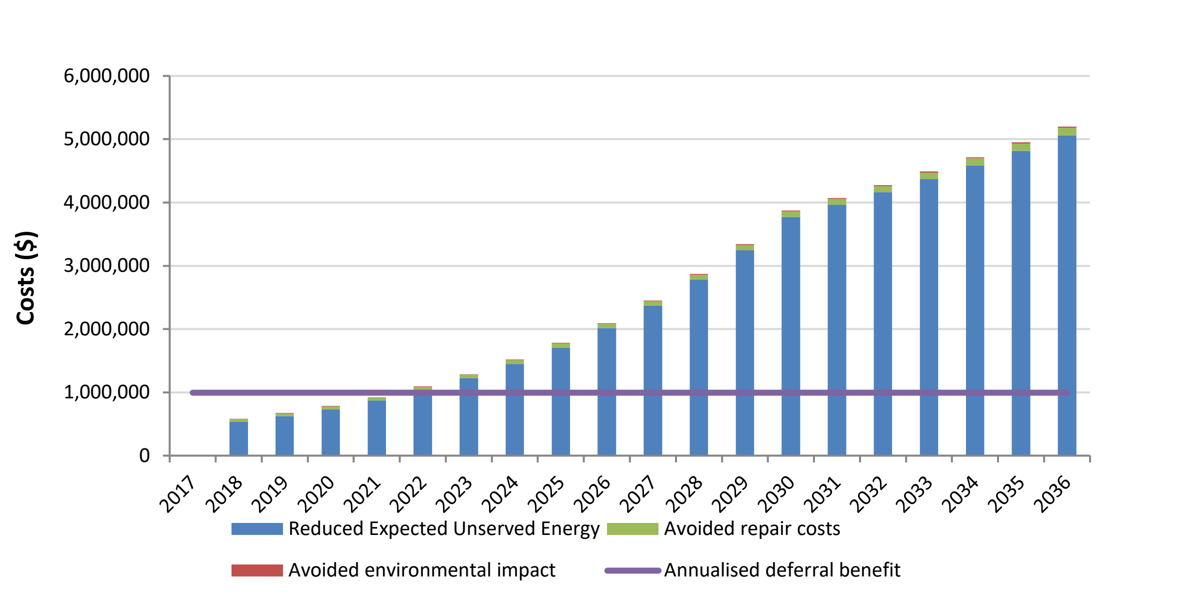
The preferred network option is to undertake like for like replacement with modern XLPE cables on a different but similar route as it provides a future strategic and the most cost effective solution to the area.

8.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to both the assets to be replaced, was used to identify the optimum replacement date. To achieve a positive net economic benefit, the optimal timing for commissioning the project is early in the 2019-24 regulatory control period, as illustrated in Figure 20 below.

[9] On 15 February 2018, an external contractor doing an under-bore damaged feeder 283/1, causing an outage to both feeders supplying Revesby and Milperra zones. This resulted in a supply interruption to customers in Revesby and Milperra area until the supply was restored. This also resulted in environmental pollution from significant oil leaking from the damaged feeder.

Figure 20. Total risk cost versus project deferral benefit - Sydney South to Revesby



The timing analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers, together with deliverability, resource availability and cash flow smoothing. In consideration of these factors, **the optimum timing for this project is recommended as September 2021**.

We expect that construction work will start in 2019 and end in 2022.

8.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives were not found to be cost effective due to the magnitude of the load reduction required.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

8.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution includes the installation of two 3.8km 800mm^2 XLPE cables and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in Table 7 below.

Table 7. Sydney South to Revesby project cash flows ($m, real FY19)

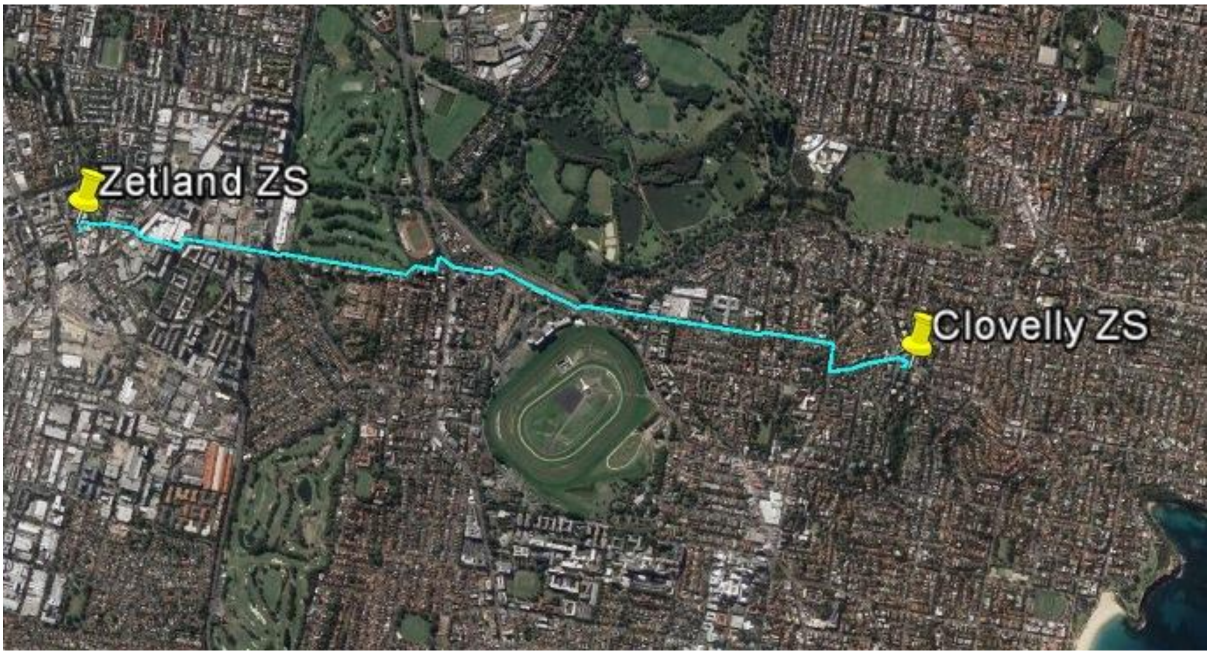
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	2.4	4.9	9.6	4.7	-	-	-

9 PROJECT 5 – ZETLAND TO CLOVELLY

9.1 Project description

The project is to replace 132kV oil filled cables 260/2 and 261/2 between Zetland and Clovelly Zone Substations in the Eastern Suburbs area of Ausgrid's network. These cables have experienced significant oil leaks. The preferred project is to replace the cable capacity by laying a single cable from Kingsford to Clovelly, with provision of a spare duct, so deferring a second cable while avoiding the community impact and cost of excavating in roads for a second time. The target completion date is summer 2022. The 260/2 and 261/2 feeder replacement is consistent with Ausgrid's fluid filled cable replacement strategy for the Eastern Suburbs area and the environmental management strategy for fluid filled cables. The project cost estimate to replace 132kV oil-filled cable circuit over the length of 4.0km is $21.1 million of which $19.2 million is forecast to be incurred in the 2019-24 period.

Figure 21. Zetland to Clovelly



9.2 Need

The existing 260/2 and 261/2 132kV oil filled cable feeders supply Clovelly Zone Substation from Beaconsfield Bulk Supply Point via Zetland Zone Substation. Another cable, 262, provides a normally-open connection between Double Bay and Clovelly. These feeders form part of the major supply to the Eastern Suburbs area. The existing feeders are single core 387mm2 oil-filled cables. The length of 132kV feeders 260/2 and 261/2 is approximately 4.5km. They will be 53 years old when replaced in 2022.

The concurrent outage of these feeders would result in the loss of supply to Clovelly Zone Substation. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated which is approximately 50MWh in the 2019-24 regulatory control period. Figure 10 in Part A shows the ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). These cables have a relatively low ranking on this basis.

Cables 260/2 and 261/2 have experienced significant oil leaks over the past 15 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 260/2 and 261/2 as contributing 0.9% and 2.41% of the total environmental risk associated with Ausgrid's fluid filled cable population. Figure 10 in Part A shows that these cables have the third highest ranking in terms of environmental risk reduction per million dollars of expenditure.

The Eastern Suburbs Area Plan provides for the decommissioning of Zetland Zone Substation, and its replacement by a new zone substation at Alexandria North. This plan addresses the need to retire the ageing 11kV switchgear at Zetland and to decommission the 132kV oil filled cables that supply Zetland from Beaconsfield BSP. Consequently supplying Clovelly from a different source is required, and Kingsford is the strategic solution.

Insulation resistance testing indicates that there are potential problems with the outer serving of the cables which could lead to oil leaks in the future.

Our cable failure model forecasts that the reliability of these cables will deteriorate into the future if they are not replaced.

Reduced cable capacity, a history of cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace these aged fluid filled cables.

9.3 Options

We examined the following options as part of the Ausgrid's network planning process:

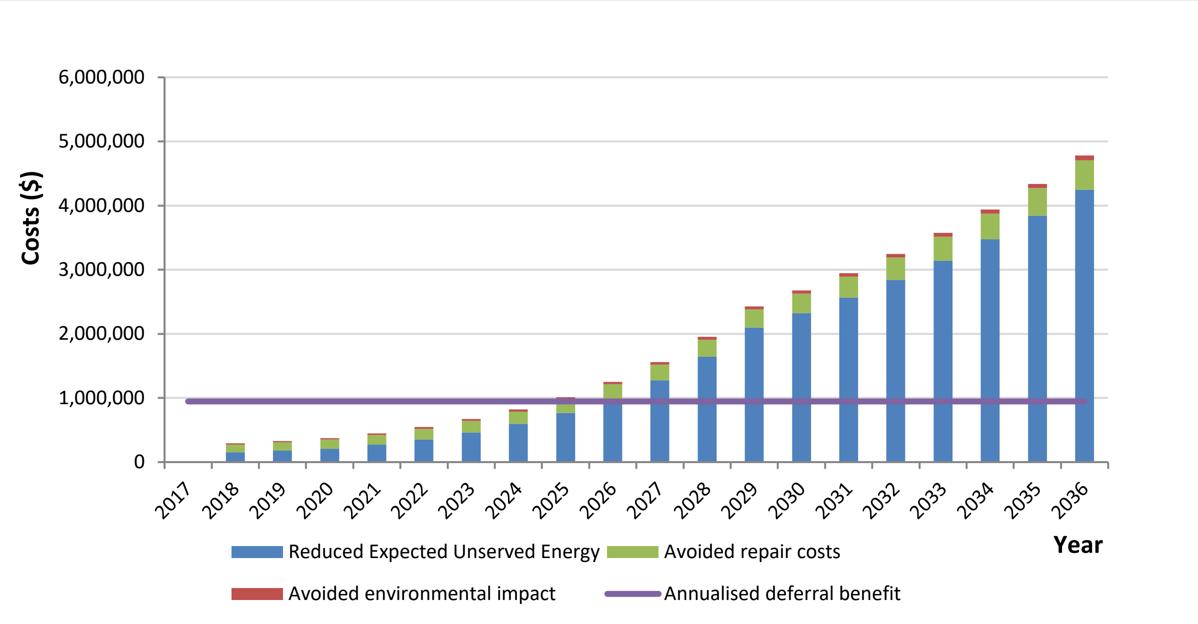
1. Replacement of 132kV feeders 260/2 and 261/2 like-for-like
2. Decommission 132kV feeders 260/2 and 261/2 by transferring Clovelly loads to adjacent zone substations
3. Decommission 132kV feeders 260/2 and 261/2 by installing a new 132kV feeder from Kingsford to Clovelly Zone Substation with a spare duct
4. Consideration of demand management.

Based on the future strategic solution to address number of issues in the area, the preferred network option is to decommission feeders 260/2 and 261/2 by installing a new 132kV feeder from Kingsford to Clovelly with a spare duct, using modern XLPE cable on a suitable route. The existing cable 262 from Double Bay will provide the second supply to Clovelly.

9.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to the assets to be replaced, was used to identify the optimum replacement date. To achieve a positive net economic benefit, the optimal timing for commissioning the project is just beyond the 2019-24 regulatory period, as illustrated in Figure 22 below.

Figure 22. Total risk cost versus project deferral benefit, Zetland to Clovelly



Ausgrid is also committed to reducing the environmental risk associated with the operation, maintenance and repair of oil-filled cables, and aims to reduce the overall environmental risk by at least 50% for each regulatory period (Refer to Figure 10 and Figure 11 in Part A).

Figure 11 in Part A shows the ranking of cables based on the environmental risk per million dollars of expenditure (maximum risk per dollar being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the replacement of feeders 260/2 and 261/2 during 2019-24 regulatory period provides a substantial cost-effective contribution towards achieving this environmental target, being ranked fourth. It has therefore been determined that the timing of this project should be advanced.

The timing analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability, cash flow smoothing and demand management initiatives are other factors that define the optimum timing to complete the project. In consideration of these factors, **the optimum timing for completing this project is recommended as September 2021**.

We forecast that construction work will start in 2018 and end in 2022.

9.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by environmental risk and other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective due to the magnitude of the load reduction required.

A further analysis considered whether the estimated unserved energy at risk could be cost effectively reduced using non-network options. The analysis used the same unserved energy model developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. This analysis determined that using non-network options to reduce the estimated unserved energy at risk is not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

9.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of a 4.0km of 800mm^2 XLPE cable in congested roads, including the installation of a spare duct and the decommissioning of the existing oil filled cable.

The cash flow for the project is outlined in Table 8 below.

Table 8. Zetland to Clovelly project cash flows ($m, real FY19)

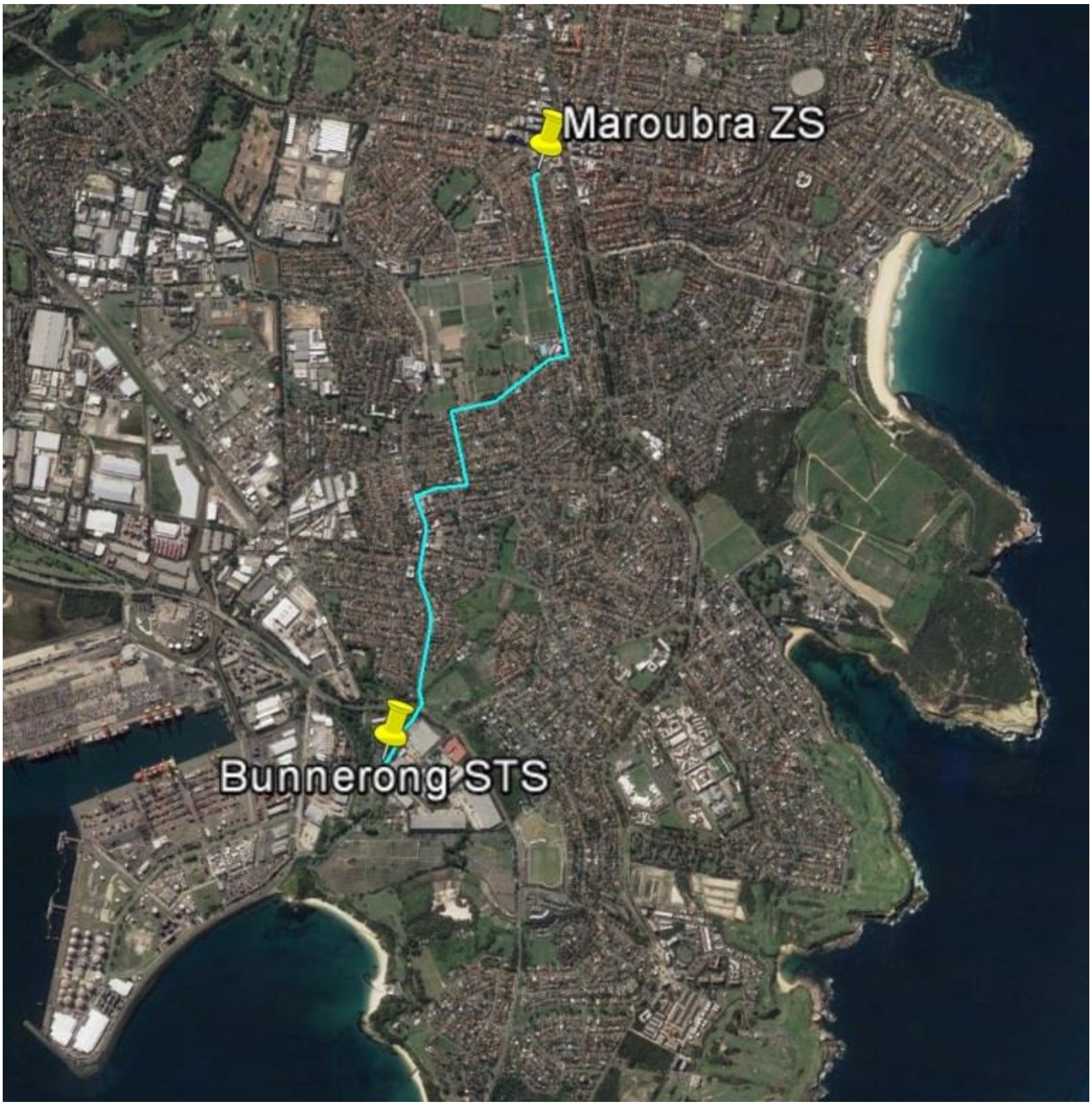
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	1.9	4.6	13.0	1.7	-	-	-

10 PROJECT 6 – BUNNERONG TO MAROUBRA

10.1 Project description

The project is to replace 132kV oil filled cable 265 between Bunnerong STS and Maroubra Zone Substation in the Eastern Suburbs area of Ausgrid's network. It is shown in Figure 23 below. Based on an assessment of cost-benefit and environmental risk, we plan to replace the asset by summer 2025 using an XLPE cable, with a spare duct installed at the same time. The total project cost is $19.9 million of which $17.5 million is forecast to be incurred in the 2019-24 period.

Figure 23. Bunnerong to Maroubra



10.2 Need

The 132kV oil filled cable 265 connects Maroubra Zone Substation to Bunnerong STS. This cable is part of a ring network that joins together Beaconsfield BSP, Kingsford Zone, Maroubra Zone and Bunnerong STS. Currently, the ring is normally open on feeder 265 at the Bunnerong STS end. The length of 132kV oil filled cable feeder 265 is approximately 4.0km. This cable will be 46 years old when replaced in 2025.

The cable is filled with oil, is energised, and subject to leaks despite not transferring energy. Its availability is necessary to supply other zones in the ring in the event of the opening of any one of several other cables. The outage of this feeder together with another feeder in the ring would result in the loss of supply to Kingsford and Maroubra Zone Substations. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 60MWh in the 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). It is ranked equal fourth, being similar to two other cable pairs.

Cable 265 has experienced oil leaks over the past 15 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cable 265 as contributing 0.21% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation resistance testing indicates that there are potential problems with the outer serving of the cables which could lead to further oil leaks in the future. Our cable failure model forecasts that reliability of this cable will deteriorate if it is not replaced.

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

10.3 Options

We examined the following options as part of the Ausgrid's network planning process:

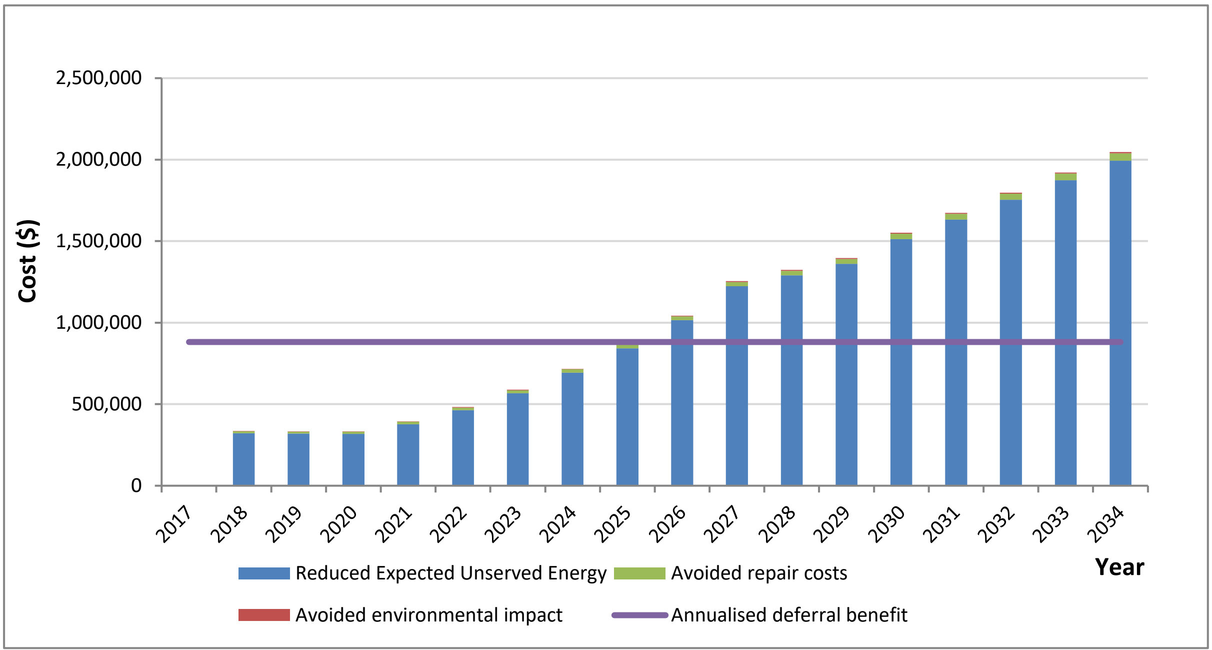
1. Replacement of feeder 265 like-for-like
2. Replacement of feeder 265, with inclusion of a spare duct to reduce the cost of installing a future feeder between Bunnerong STS and Kingsford zone or to another zone beyond there
3. Consideration of demand management.

Based on the future strategic solution to address a number of issues in the area, the preferred network option is to replace feeder 265 with a spare duct using a modern XLPE cable on a different but similar route. The inclusion of a spare duct is a strategic decision that recognises that there is capacity to serve additional loads in the eastern suburbs from TransGrid's Sydney South BSP via Bunnerong STS, without placing additional load on the Beaconsfield and Haymarket BSPs.

10.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to the asset to be replaced, was used to identify a break-even replacement date. To achieve a positive net economic benefit, the optimal timing for commissioning the project is just beyond the 2019-24 regulatory control period, as illustrated in Figure 24 below.

Figure 24. Total risk cost versus project deferral benefit - Bunnerong to Maroubra



Our analysis has shown that, while there is an environmental risk associated with cable 265, it is not sufficiently high to justify a substantial advancement of the project.

The timing analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers as well as, deliverability, resource availability and cash flow smoothing. In consideration of all these factors, **the optimum timing for completing this project is recommended as September 2024**. However substantial expenditure will be required in the 2019/2024 regulatory period.

We forecast that construction work will start in 2021 and end in 2025.

10.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives were not cost effective due to the magnitude of the load reduction required.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

10.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of one 3.9km 1200mm2 XLPE cable in congested roads, including the installation of a spare duct and the decommissioning of the existing oil filled cable.

The cash flow for the project is outlined in Table 9 below.

Table 9. Bunnerong to Maroubra project cash flows ($m, real FY19)

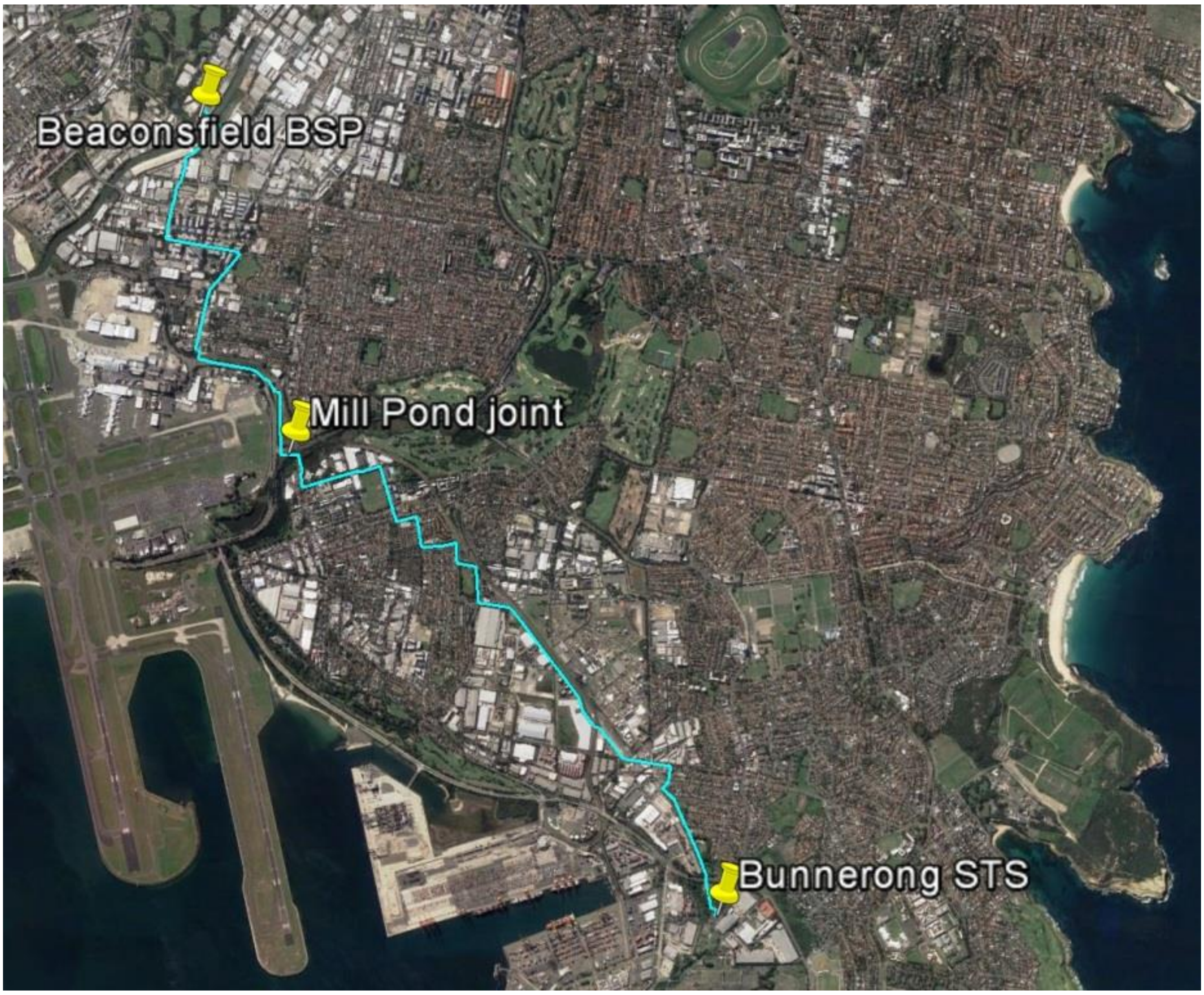
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	-	0.0	1.0	2.2	14.4	2.5

11 PROJECT 7 – BEACONSFIELD TO MILLPOND

11.1 Project description

The project is to replace a section of oil-filled 132kV cable 9FF (previously named 91M/3) in the Eastern Suburbs area of Ausgrid's network between a joint bay in the vicinity of Millpond Rd, on the edge of Sydney Airport, and Beaconsfield. It is shown in Figure 25 below. The remainder of cable 9FF between Bunnerong and Millpond Rd has already been replaced by an XLPE cable. The condition of the cable that was replaced was very poor. The portion that is the subject of this project was laid by a different manufacturer. It has performed better and was prioritised for replacement by 2026 in accordance with a previous condition assessment. Based on an assessment of cost-benefit and environmental risk, and in support of the strategy to establish a future new Mascot 132/11kV Zone Substation we plan to replace the asset by summer 2024. The total project cost is $15.7 million of which $15.5 million is forecast to be incurred in the 2019-24 period.

Figure 25. Beaconsfield to Millpond



11.2 Need

The existing 9FF 132kV cable feeder runs from Beaconsfield to Bunnerong. It forms part of the major transmission supply to the Eastern Suburbs area. The existing feeder comprises

7.0km of new 1200mm^2 XLPE cable and 3.7km of 1200mm^2 oil-filled cable. The oil-filled cable section will be 47 years old when replaced in 2024.

Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 30MWh[10] in the 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). This cable has a moderate ranking on this basis.

Cable 9FF has experienced some oil leaks over the past 15 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cable 9FF as contributing 2.31% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation Resistance testing indicates that there are potential problems with the outer serving of the cable which could lead to oil leaks in the future. Our cable failure model forecasts that reliability of this cable will deteriorate if they are not replaced.

The cable is an element of the network transferring power between Beaconsfield and Bunnerong in the Eastern Suburbs load area and its integrity is essential to ensure reliable supply for customers in these areas. The potential for further cable fluid leaks, poor test results and increased rates of corrective work for this cable type support the case to replace this cable.

It is also necessary to consider the interaction between this project and the future project to replace the existing Mascot 33/11kV Zone substation with a new 132/11kV Zone substation on a new site, by looping in the replacement cable to the new site. This requires that the replacement 9FF cable should be routed close to the future Mascot site to minimise the total cost.

11.3 Options

We examined the following options as part of the Ausgrid's network planning process:

1. The replacement of 132kV feeder 9FF like for like with new Mascot Zone Substation looped in
2. Decommission 132kV feeder 9FF
3. Consideration of demand management.

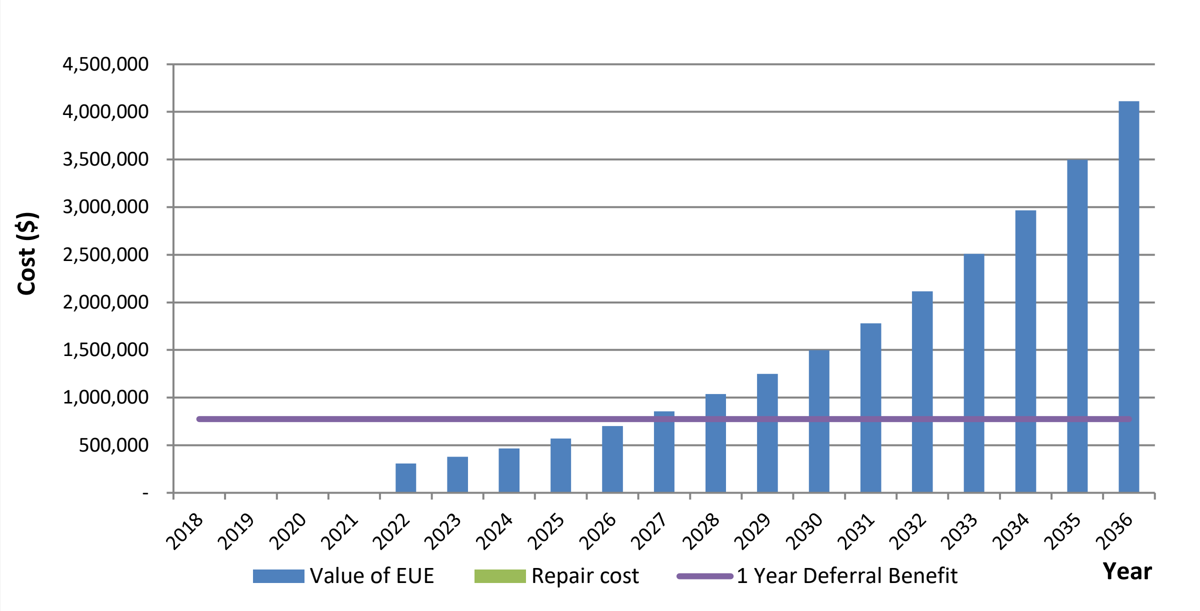
On the basis of technical feasibility, the decommissioning feeder 9FF is considered to be not viable. Hence, the preferred network strategy is the replacement of 132kV feeder section between Beaconsfield and Mill Pond Road, routed so that the overall cost of replacement of cable 9FF and the future establishment of the new Mascot 132/11kV Zone Substation is minimised.

11.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to the assets to be replaced, was first used to identify a break-even replacement date. The study has taken into consideration the looping of a new Mascot Zone Substation into feeder 9FF. To achieve a positive net economic benefit, the optimal timing for commissioning the project is beyond the 2019-24 regulatory control period, as shown in Figure 26 below.

[10] The expected unserved energy is calculated on the basis that future Mascot Zone Substation is looped in to the feeder 9FF.

Figure 26. Total risk cost versus project deferral benefit - Beaconsfield to Millpond



Ausgrid is also committed to reducing the environmental risk associated with the operation, maintenance and repair of oil-filled cables and aims to reduce the overall environmental risk by at least 50% for each regulatory period.

Figure 11 in Part A shows the ranking of cables based on the environmental risk per million dollars of expenditure (maximum risk being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the environmental risk of this cable is moderate but the replacement of feeder 9FF is proposed in the 2019/24 regulatory period to help achieve the environmental risk reduction targets. It is also cost-effective to undertake the replacement of this feeder at the same as the proposed new Mascot Zone Substation is being established so as to minimise the cost of installing the looped connection.

The timing also considered the requirement to meet the EPA target and the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability, sensitivity analysis and cash flow smoothing are other factors that define a new timing to complete the project. In consideration of these factors, **the optimum timing for completing this project is recommended as September 2023.**

We forecast that construction work will start in 2019 and end in 2024.

11.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by environmental risk and other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective.

A further analysis considered whether the estimated unserved energy at risk could be cost effectively reduced using non-network options. The analysis used the same unserved energy model developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. This analysis determined that using non-network options to reduce the estimated unserved energy at risk is not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

11.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution includes the installation of a high capacity cable 4km long and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in the Table 10 below.

Table 10. Beaconsfield to Millpond project cash flows ($m, real FY19)

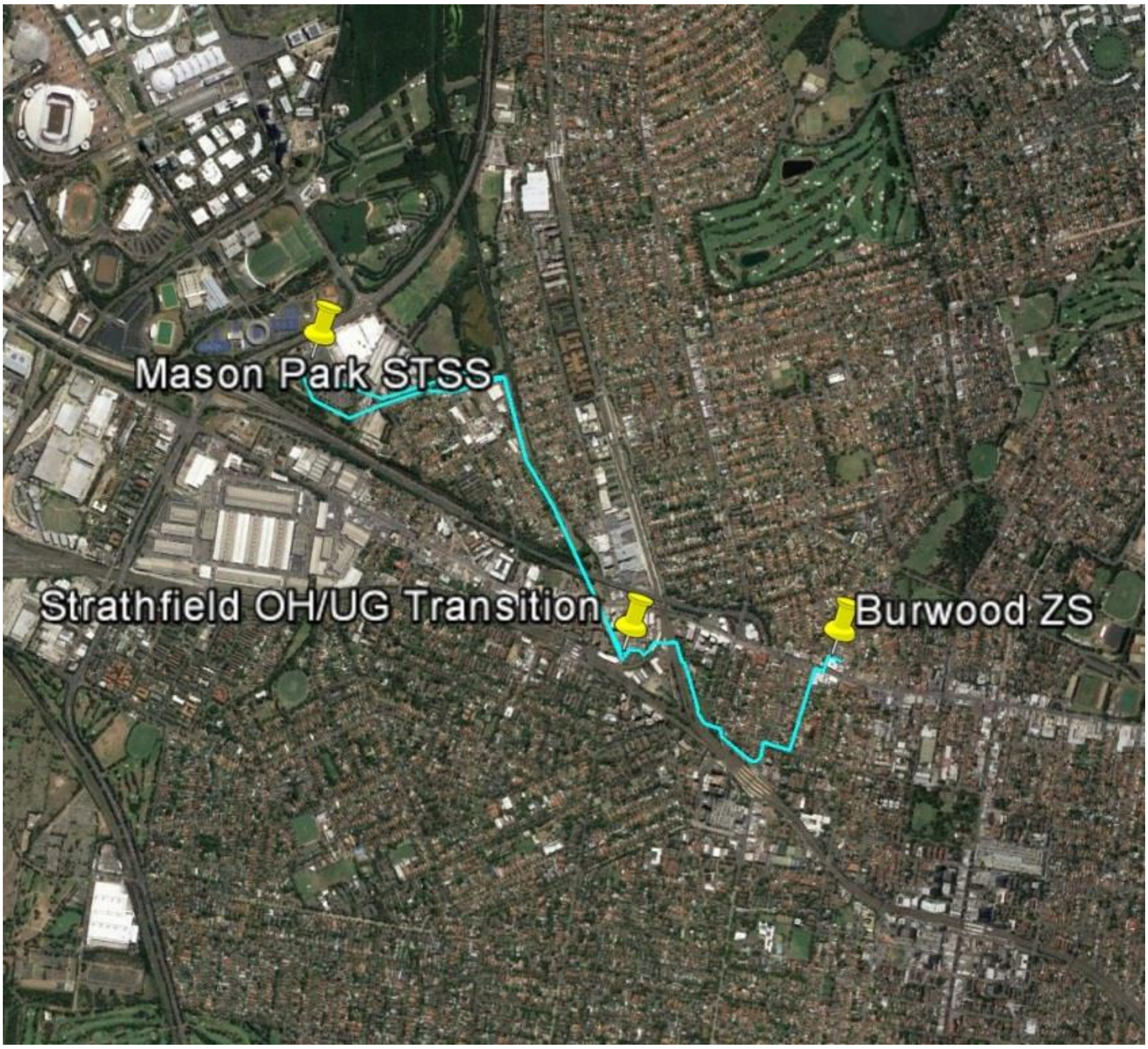
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	0.0	0.6	0.9	2.3	9.4	2.2	0.2

12 PROJECT 8 – MASON PARK TO BURWOOD

12.1 Project description

The project is to replace 132kV oil filled cables 923/2 and 924/2 that form part of combined overhead and underground connection between Mason Park and Burwood, the other part being overhead lines 923/1 and 924/1 from Mason Park to a transition point near Strathfield. It is shown in Figure 27 below. These cables are located in the Inner West area of Ausgrid's network. These cables have recorded moderate oil leaks over the last 15 years. There are stormwater canals in their vicinity which increase the environmental risk. Based on an assessment of cost-benefit and environmental risk, we propose to replace these cables by summer 2024. The total project cost is $9.2 million all of which is forecast to be incurred in the 2019-24 period.

Figure 27. Mason Park to Burwood



12.2 Need

The 132kV cable feeders 923/2 and 924/2 supply Burwood Zone Substation from Mason Park STS via Strathfield STS. Strathfield STS has been planned for retirement, after which the feeders will directly supply Burwood Zone Substation. The length of 132kV oil filled cable feeders 923/2 and 924/2 is approximately 1.6km. These cables will be 52 years old when replaced in 2024.

The concurrent outage of these two feeders would result in the loss of supply to Burwood Zone Substation. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Essentially there is a low, but increasing, probability that some customers in this area will experience a very long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 30MWh in 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). On this basis they are ranked equal fourth, along with two other cables.

Cable 923/2 has experienced significant oil leaks over the past 15 years. Cable 924/2 was installed beside 923/2 at the same time but has suffered fewer leaks so far. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 923/2 and 924/2 as contributing 0.41% and 0.04% of the total environmental risk assigned to Ausgrid's fluid filled cable population. Together they are ranked eighth on the basis of environmental risk per million dollars of expenditure.

Insulation resistance testing indicates that there are potential problems with the outer serving of both cables which could lead to oil leaks in the future. The cable failure model forecasts that reliability of these cables will deteriorate if they are not replaced.

These cables will supply Burwood Zone Substation in the Inner West area and their integrity is essential to ensure reliable supply for customers in the area. A history of cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace the remaining aged fluid filled cables.

12.3 Options

We examined the following options as part of the Ausgrid's network planning process:

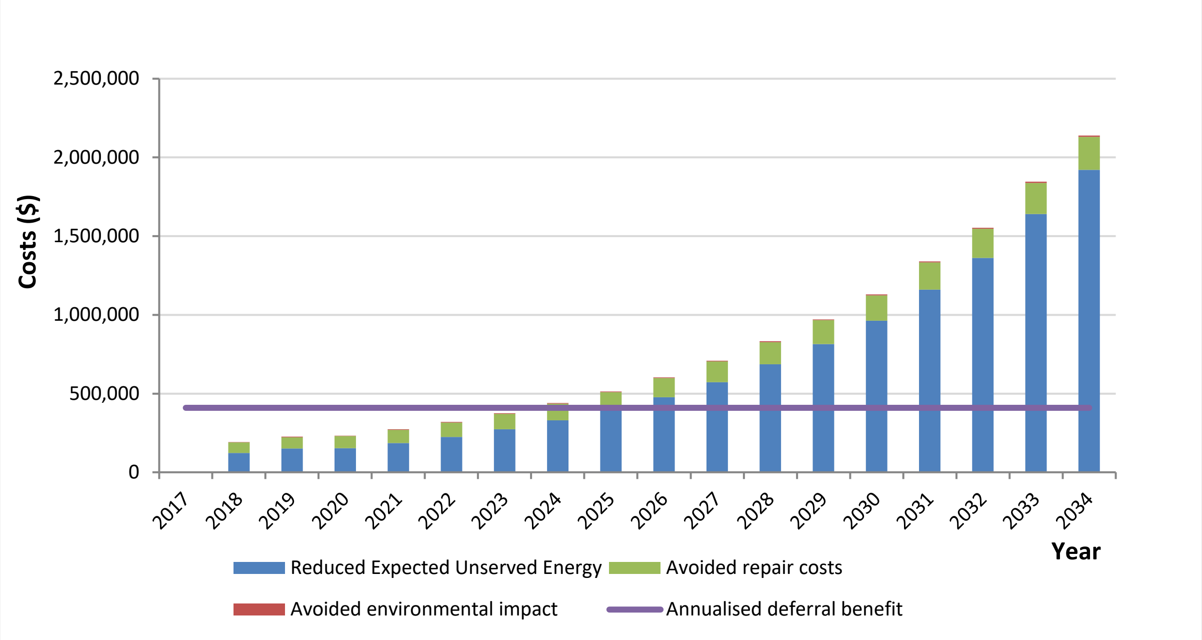
1. Replacement of feeders 923/2 and 924/2 like-for-like
2. Replacement of feeders 923/2 and 924/2 like-for-like with a spare duct
3. Decommissioning of 132kV feeders by retiring Burwood Zone Substation
4. Consideration of demand management.

Based on the future strategic solution to address number of issues in the area, the preferred network option is to undertake the replacement of feeders 923/2 and 924/2 like for like with a spare duct using modern XLPE cables on a different but similar route.

12.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date. To achieve positive net economic benefits, the optimal timing for commissioning the project is towards the end of 2019-24 regulatory control period, as illustrated in Figure 28 below.

Figure 28. Total risk cost versus project deferral benefit - Mason Park to Burwood



The replacement of these feeders also contributes significantly to achievement of Ausgrid's 50% environmental target (Refer to the Figure 10 and Figure 11 in Part A).

The timing analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers, together with deliverability, resource availability and cash flow smoothing. In consideration of these factors, **the optimum timing for completing this project is recommended as September 2023**.

We forecast that construction work will start in 2020 and end in 2024.

12.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives were found to be not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

12.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of two 1.6km 800mm2 XLPE cables, including an underbore required to cross rail lines and a stormwater drain near Strathfield STS, and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in the Table 11 below.

Table 11. Mason Park to Burwood project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	0.2	1.0	1.2	5.3	1.5	-

13 PROJECT 9 – BEACONSFIELD TO GREEN SQUARE

13.1 Project description

The project is to replace oil filled cable 9SE from TransGrid's Beaconsfield Bulk Supply Point to Green Square Zone Substation in the Inner Metropolitan Area of Ausgrid's network with a new XLPE cable. It is shown in Figure 29 below. The existing 132kV cable experienced oil leaks in 2011. Replacement by summer 2024 is consistent with Ausgrid's environmental management strategy for fluid filled cables, since cable 9SE is the second highest ranked in the reduction of environmental risk achieved per dollar of expenditure. The project cost estimate to replace 132kV oil-filled cable 9SE over the length of 1.0km is $6.7 million, all of which is forecast to be incurred in the 2019-24 period.

Figure 29. Beaconsfield to Green Square

13.2 Need

The existing 132kV cable feeder 9SE supplies Green Square Zone Substation from TransGrid's Beaconsfield Bulk Supply Point. This feeder forms part of the Subtransmission supply to the Green Square Zone Substation which also supplies the Alexandria area. The existing feeder is a single core 1000mm^2 oil-filled cable. The aerial view above shows that it is in the watershed of the Alexandria canal and that it crosses this canal. It has high environmental sensitivity. This cable will be 36 years old when replaced in 2024.

The outage of this feeder together with another feeder would result in the loss of supply to Green Square Zone Substation. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 2MWh in the 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). On this basis it is among the lowest ranked cables.

Cable 9SE experienced moderate oil leaks in the year 2011. No oil leaks have been recorded in more recent years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2016 review of fluid filled 132kV cable environmental risk assessed cables 9SE as contributing 1.48% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation resistance testing indicates that there are potential problems with the outer serving of the cables which could lead to oil leaks in the future.

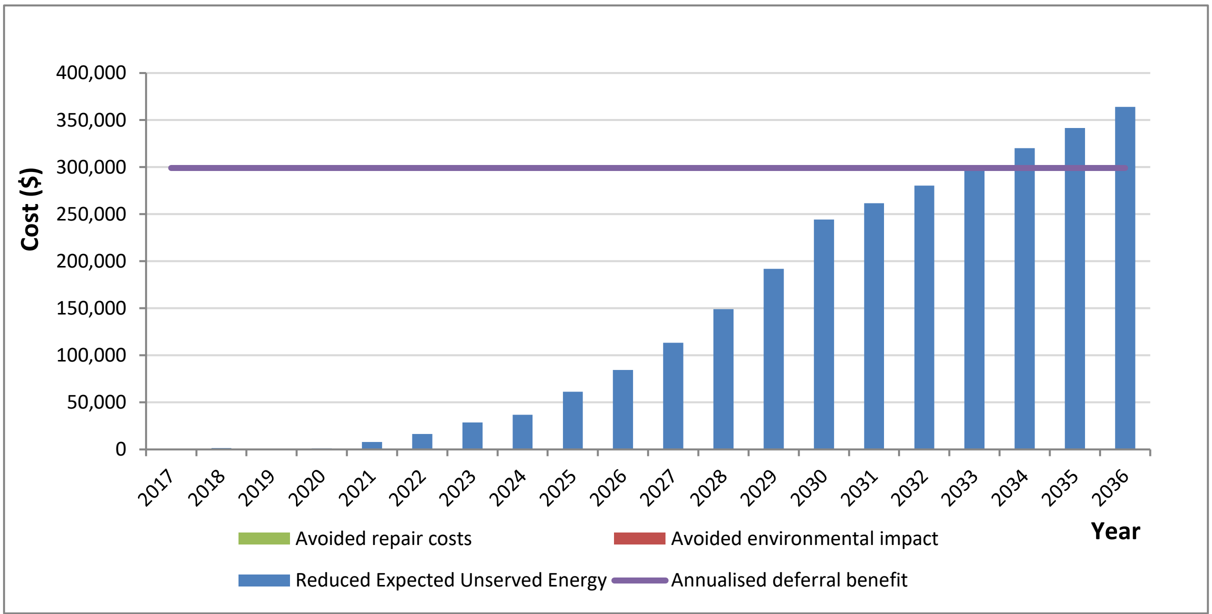
The cable failure model forecasts that reliability of this cable will deteriorate if it is not replaced.

The cable forms part of the network transferring power from Beaconsfield to the Eastern Suburbs load area and its integrity is essential to ensure reliable supply for customers in this area. A history of cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace the remaining aged fluid filled cables.

13.3 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date. The expected unserved energy for this cable is relatively low because the alternative 132kV cable that supplies Green Square (90T) is newer and more reliable. If the only criterion was achieving a positive net economic benefit, the optimal timing for commissioning the project would be beyond the 2019-24 regulatory control period, as illustrated in Figure 30 below.

Figure 30. Total risk cost versus project deferral benefit - Beaconsfield to Green Square



However Ausgrid is committed to reducing the environmental risk associated with the operation, maintenance and repair of oil-filled cables, and aims to reduce the overall environmental risk by at least 50% in each regulatory period to 2034.

Figure 11 in Part A of this document shows the ranking of cables based on the environmental risk per million dollars of expenditure (the maximum risk reduction per dollar of expenditure being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the replacement of feeder 9SE during 2019-24 regulatory period is the second most cost effective of all cable replacement projects and it is therefore an essential part of the strategy to achieve this environmental target.

This timing is also influenced by factors such as the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability and cash flow smoothing are other factors that define a new optimum timing. In consideration of these factors, **the optimum timing for completing this project is recommended as September 2023**.

We forecast that construction work will start in 2020 and end in 2024.

13.4 Options

We examined the following options as part of the Ausgrid's network planning process:

1. Replacement of feeder 9SE like-for-like
2. Consideration of demand management.

Based on the future strategic solution to address a number of issues in the area, the preferred option is to undertake the replacement of feeder 9SE with a spare duct, using XLPE cable on a different but similar route.

13.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by environmental risk issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

13.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of a 1.2km of 1200mm^2 XLPE cable in congested roads, including the installation of a spare duct and the decommissioning of the existing oil filled cable.

The cash flow for the project is outlined in Table 12 below.

Table 12. Beaconsfield to Green Square project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	0.1	0.8	0.4	4.4	0.9	-

14 PROJECT 10 – BEACONSFIELD TO KINGSFORD

14.1 Project description

The project is to replace 132kV oil filled cable 264 between Beaconsfield and Kingsford in the Eastern Suburbs Area of Ausgrid's network. It is shown in Figure 31 below. This cable has experienced oil leaks, and has been prioritised for replacement in 2024-29. Based on an assessment of cost-benefit and environmental risk, and the need to coordinate this work with other replacement projects we currently propose to replace cable 264 by summer 2026. The total project cost is $26.0 million of which $3.7 million is expected to be incurred in the 2019-24 period.

Figure 31. Beaconsfield to Kingsford

14.2 Need

The cable 264 route between Beaconsfield and Kingsford is via heavily used suburban streets in the Eastern Suburbs of Sydney. It is part of a cable loop that goes via Kingsford and Maroubra to Bunnerong. The length of 132kV feeder 264 is about 5.5km, and it is an oil-filled cable. It will be 47 years old when replaced in 2026.

If the Bunnerong to Maroubra cable is out of service cable 264 is the only supply to this area, so its integrity is vital. The Bunnerong to Maroubra cable is in a similar condition and is planned to be replaced earlier (see Project 6 in this Attachment). The concurrent outage of these two feeders would result in the loss of supply to Kingsford and Maroubra Zone Substations. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 30MWh in 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per a million dollar expenditure (normalised x-axis). Its ranking is twelfth on this basis.

Cable 264 has experienced moderate oil leaks over the past 10 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 264 as contributing 0.17% of the total environmental risk assigned to Ausgrid's fluid filled cable population. Its ranking is fourth last on this basis.

Insulation Resistance tests indicate that there are potential problems with the outer serving of the cables which could lead to oil leaks in the future.

The cable failure model forecasts that reliability of this cable will deteriorate if it is not replaced.

The cable transfers power from Beaconsfield to the Eastern Suburbs load area (Maroubra and Kingsford) and its integrity is essential to ensure reliable supply for customers in these areas. A history of cable fluid leaks, poor test results and forecast increased rates of corrective work for these cables support the case to replace this aged fluid filled cable.

14.3 Options

We examined the following options as part of the Ausgrid's network planning process:

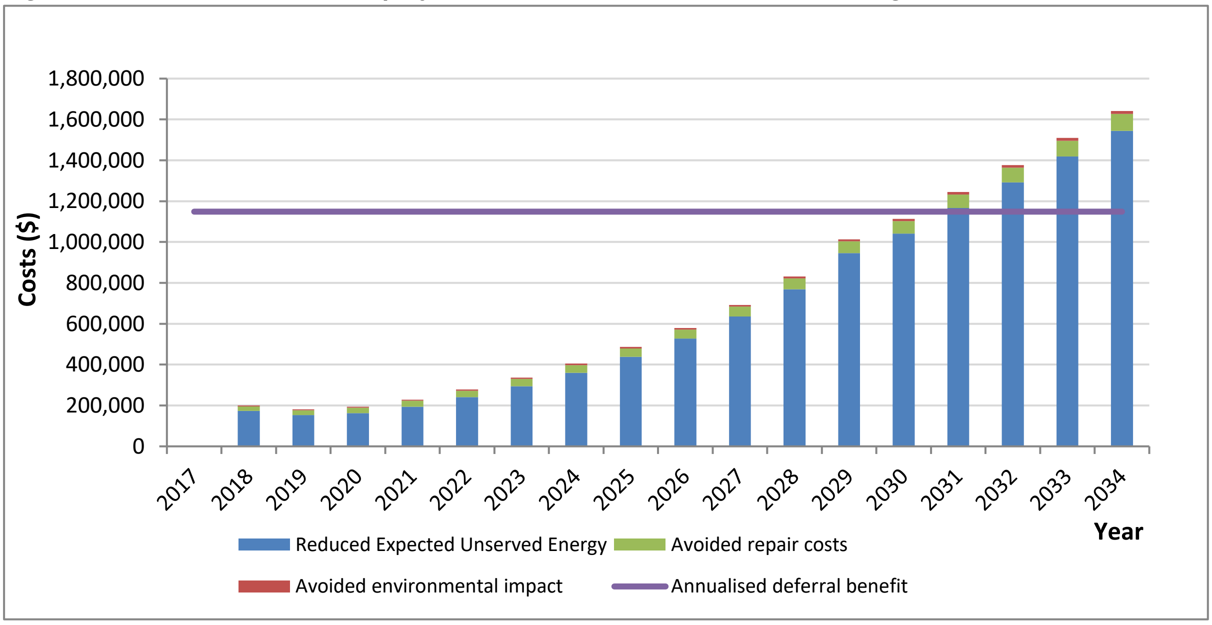
1. The replacement of 132kV feeder 264 like for like
2. Decommission 132kV feeder 264
3. Consideration of demand management.

On the basis of technical feasibility, the decommissioning of feeder 264 is considered to be not viable. Hence, the preferred network strategy is the replacement of 132kV feeder between Beaconsfield BSP and Kingsford Zone Substation.

14.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date. To achieve a positive net economic benefit, the timing the project is well beyond the 2019-24 regulatory control period, as shown in Figure 32 below.

Figure 32. Total risk cost versus project deferral benefit - Beaconsfield to Kingsford



The environmental risk of these cables is relatively minor and therefore the replacement of this feeder is being proposed in 2025-29 regulatory control period, in consideration of the long term Eastern Suburbs area plan strategy.

The timing has considered factors including the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers, deliverability, resource availability, sensitivity analysis, cash flow smoothing and demand management. These factors define the optimum timing to initiate the project In consideration of these factors, **the optimum timing for this project is recommended as September 2025**.

We forecast that construction work will start in 2022 and end in 2026.

14.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective.

A further analysis considered whether the estimated unserved energy at risk could be cost effectively reduced using non-network options. The analysis used the same unserved energy model developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. This analysis determined that using non-network options to reduce the estimated unserved energy at risk is not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

14.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, based on the methodology for major projects outlined in Attachment 5.03.

The proposed solution includes the installation of a high capacity cable 5.5km long in congested roads, including an underbore under a Golf Club, and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in Table 13 below.

Table 13. Beaconsfield to Kingsford project cash flows ($m, real FY19)

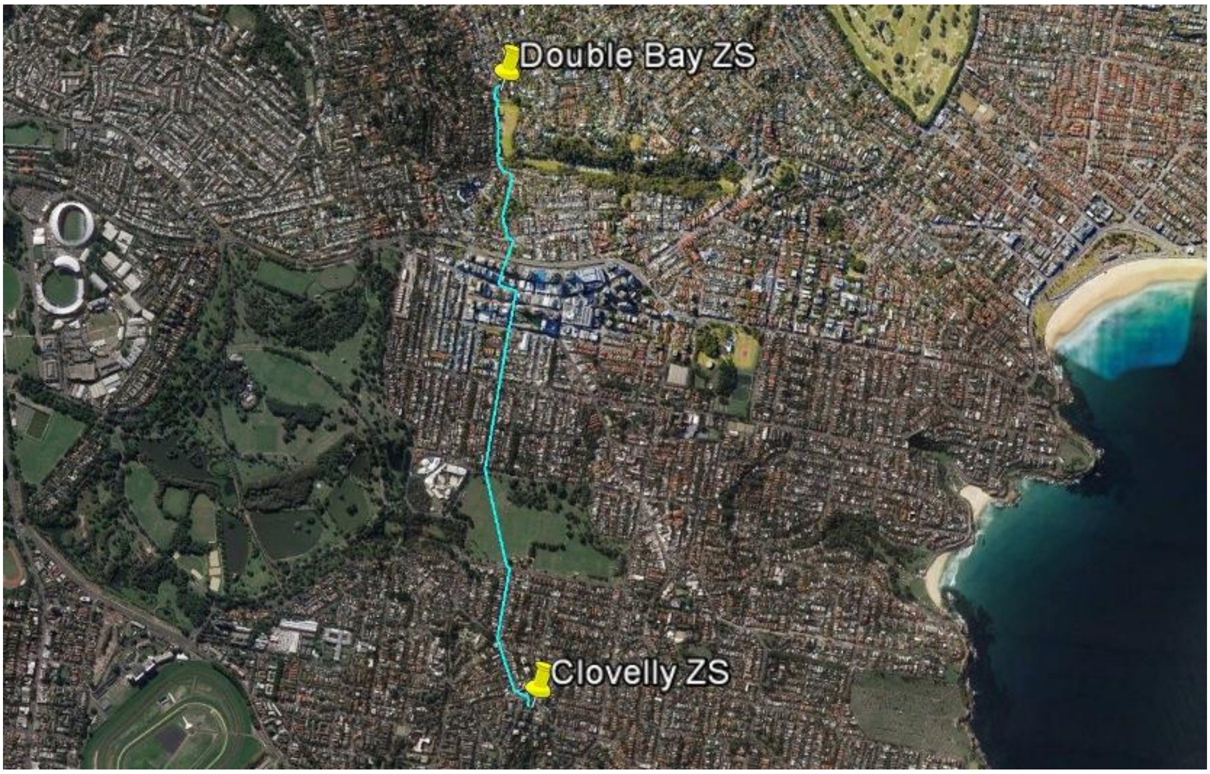
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	-	-	0.0	1.0	2.7	22.3

15 PROJECT 11 – DOUBLE BAY TO CLOVELLY

15.1 Project description

The project is to replace 132kV oil filled cable 262 between Double Bay and Clovelly in the Eastern Suburbs Area of Ausgrid's network. It is shown in Figure 33 below. This cable has experienced oil leaks, and has been prioritised for replacement in 2024-29. Based on an assessment of cost-benefit and environmental risk, and the need to coordinate this work with other replacement projects, we currently propose to replace cable 262 by summer 2026. The total project cost is $11.0 million of which $1.6 million is expected to be incurred in the 2019-24 period.

Figure 33. Double Bay to Clovelly



15.2 Need

The cable 262 route between Double Bay and Clovelly is via heavily used suburban streets in the Eastern Suburbs of Sydney. It supplies half of the Clovelly Zone Substation load under normal condition and full Clovelly Zone Substation load under emergency condition. The length of 132kV feeder 262 is about 3.1km, and it is an oil-filled cable. It will be 53 years old when replaced in 2026.

Cable 262 has experienced moderate oil leaks over the past 10 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 262 as contributing 0.21% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

The Eastern Suburbs Area Plan provides for the decommissioning of Zetland Zone Substation, and its replacement with a new zone substation at Alexandria North. This plan addresses the need to retire the ageing 11kV switchgear at Zetland and to decommission the 132kV oil filled cables that supply Zetland from Beaconsfield BSP. There is already a project in progress to replace the existing feeders 260/2 and 261/2 from Zetland to Clovelly with one feeder from Kingsford to Clovelly and decommissioning of half of Clovelly Zone Substation due to condition issues with the 11kV compound switchgear.

Insulation resistance testing indicates that there are potential problems with the outer serving of the cables which could lead to oil leaks in the future.

Our cable failure model forecasts that the reliability of these cables will deteriorate into the future if they are not replaced.

Reduced cable capacity, a history of cable fluid leaks, poor test results and increased rates of corrective work for these cables support the case to replace these aged fluid filled cables.

15.3 Options

We examined the following options as part of the Ausgrid's network planning process:

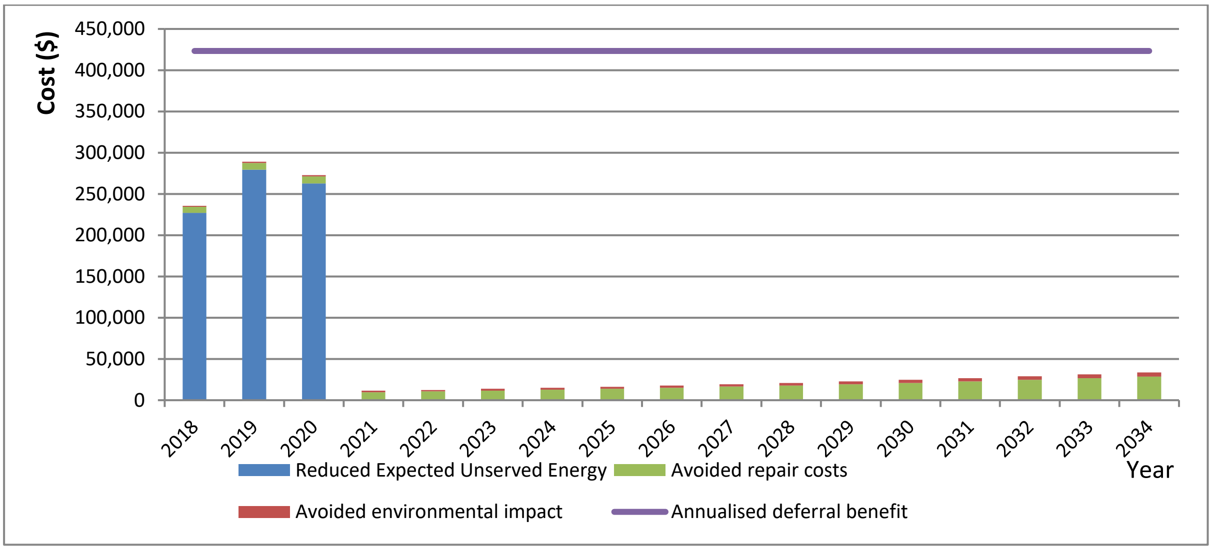
1. The replacement of 132kV feeder 262 like for like.
2. Decommission 132kV feeder 262 by installing a new 132kV feeder from Kingsford to Clovelly Zone Substation utilising the spare duct installed as part of Project 5.
3. Decommission 132kV feeder 262 by installing a new 132kV feeder from Clovelly to Maroubra Zone Substation utilising the spare duct installed as part of Project 5 & a new feeder with a spare duct from Kingsford to Maroubra Zone Substation.
4. Consideration of demand management.

Based on the future strategic solution to address number of issues in the Eastern Suburbs area, the preferred network option is Option 3, namely decommission 132kV feeder 262 by installing a new 132kV feeder from Clovelly to Maroubra Zone Substation utilising the spare duct installed as part of Project 5 and a new feeder with spare duct from Kingsford to Maroubra Zone Substation.

15.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date. To achieve a positive net economic benefit, the timing of the project is well beyond the 2019-24 regulatory control period, as shown in Figure 34 below.

Figure 34. Total risk cost versus project deferral benefit – Double Bay to Clovelly



The environmental risk of these cables is relatively minor and therefore the replacement of this feeder is being proposed in 2025-29 regulatory control period, in consideration of the long term Eastern Suburbs area plan strategy.

The timing has considered factors including the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers, deliverability, resource availability, sensitivity analysis, cash flow smoothing and demand management. These factors define the optimum timing to initiate the project In consideration of these factors, **the optimum timing for this project is recommended as December 2025**.

We forecast that construction work will start in 2023 and end in 2027.

15.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective.

Further analysis considered whether the estimated unserved energy at risk could be cost effectively reduced using non-network options. The analysis used the same unserved energy model developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. This analysis determined that using non-network options to reduce the estimated unserved energy at risk is not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

15.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, based on the methodology for major projects outlined in Attachment 5.03.

The proposed solution includes the installation of a high capacity cable 5.5km long in congested roads, including an underbore under a golf club, and the decommissioning of the existing oil filled cables.

The cash flow for the project is outlined in Table 14 below.

Table 14. Double Bay to Clovelly project cash flows ($m, real FY19)

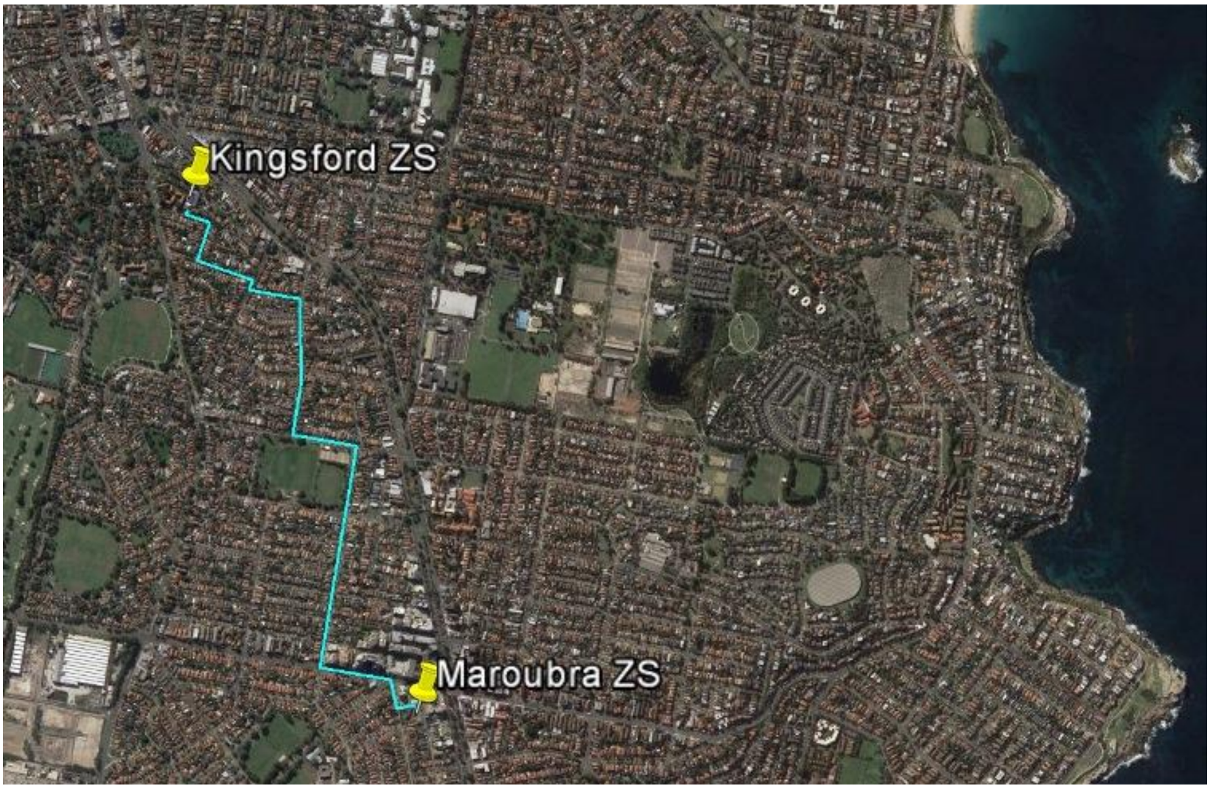
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	-	-	-	0.5	1.1	9.4

16 PROJECT 12 – KINGSFORD TO MAROUBRA

16.1 Project description

The project is to replace 132kV oil filled cable 270 between Kingsford and Maroubra Zone Substation in the Eastern Suburbs area of Ausgrid's network. It is shown in Figure 35 below. Based on an assessment of cost-benefit and environmental risk, we plan to replace the asset by summer 2026 using an XLPE cable, installed on a spare duct. The total project cost is $7.0 million of which $1.0 million is forecast to be incurred in the 2019-24 period.

Figure 35. Kingsford to Maroubra



16.2 Need

The 132kV oil filled cable 270 connects Kingsford Zone Substation to Maroubra Zone Substation. This cable is part of a ring network that joins together Beaconsfield BSP, Kingsford Zone Substation, Maroubra Zone Substation and Bunnerong STS. Currently, the ring is normally open on feeder 265 at the Bunnerong STS end. The length of 132kV oil filled cable feeder 270 is approximately 2.4km. This cable will be 49 years old when replaced in 2026.

Availability of feeder 270 is necessary to supply other zone substations in the ring in the event of a cable outage on any one of several other cables. The outage of this feeder together with another feeder in the ring would result in the loss of supply to either Kingsford or Maroubra Zone Substation. Partial loads would be recovered via 11kV load transfers to nearby zone substations using existing connections after a time delay (switching time). Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis).

Cable 270 has experienced oil leaks over the past 15 years. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cable 270 as contributing 0.2% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Insulation resistance testing indicates that there are potential problems with the outer serving of the cables which could lead to further oil leaks in the future. Our cable failure model forecasts that reliability of this cable will deteriorate if it is not replaced.

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

16.3 Options

We examined the following options as part of the Ausgrid's network planning process:

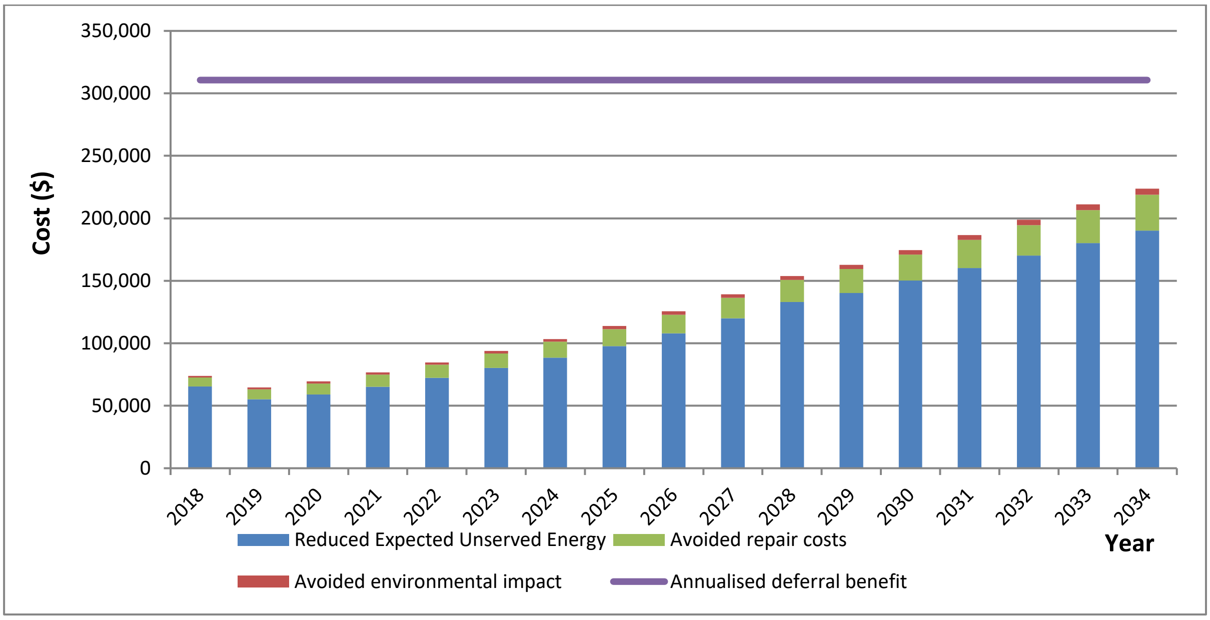
1. Replacement of feeder 270 like-for-like
2. Replacement of feeder 270, with new cables in spare ducts installed on as part of the replacement of feeders 262 and 265.
3. Consideration of demand management.

Based on the future strategic solution to address a number of issues in the area, the preferred network option is to replace feeder 270 using a modern XLPE cable on a spare duct. The inclusion of a spare duct as part of the replacement of feeders 262 (Project 11) and 265 (Project 6) is a strategic decision that recognises that there is capacity to serve additional loads in the Eastern Suburbs from TransGrid's Sydney South BSP via Bunnerong STS, without placing additional load on the Beaconsfield and Haymarket BSPs.

16.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to the asset to be replaced, was used to identify a break-even replacement date. To achieve a positive net economic benefit, the optimal timing for commissioning the project is just beyond the 2019-24 regulatory control period, as illustrated in Figure 36 below.

Figure 36. Total risk cost versus project deferral benefit - Kingsford to Maroubra



The environmental risk of these cables is relatively minor and therefore the replacement of this feeder is being proposed in 2025-29 regulatory control period, in consideration of the long term Eastern Suburbs area plan strategy.

The timing has considered factors including the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers, deliverability, resource availability, sensitivity analysis, cash flow smoothing and demand management. These factors define the optimum timing to initiate the project In consideration of these factors, **the optimum timing for this project is recommended as December 2025**.

We forecast that construction work will start in 2023 and end in 2026.

16.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives were not cost effective due to the magnitude of the load reduction required.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

16.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of one 5.0km 1200mm^2 XLPE cable in a spare duct and the decommissioning of the existing oil filled cable.

The cash flow for the project is outlined in Table 15 below.

Table 15. Kingsford to Maroubra project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	-	-	-	0.3	0.7	6.0

17 PROJECT 13 – MASON PARK TO HOMEBUSH

17.1 Project description

The project is to replace 132kV oil-filled cables 90A and 90L between Mason Park and Homebush in Ausgrid's Inner West Area. It is shown in Figure 37 below. It is proposed to replace these cables in two stages, because the history of cable 90L indicates that it poses a greater risk due to leaks than does 90A. The replacement of cable 90L only is considered and it is intended that an overhead connection to a nearby 132kV overhead line will be constructed by 2019 to replace its capacity. The primary need for this replacement is the reduction of expected unserved energy, whose value has been assessed as exceeding the project deferral benefit at an early date.

The condition of cable 90A will be reassessed periodically, but at this time it is unlikely that it will be replaced in the 2019-24 period. For the purpose of assessing the least cost solution it was assumed that it would be replaced using XLPE cable.

Based on an assessment of cost-benefit and environmental risk, we are proposed to replacing cable 90L in 2019. The second stage has been deferred and its timing will be decided based on further analysis. The total stage 1 project cost is $1.8 million of which $0.6 million is forecast to be incurred in the 2019-24 period.

Figure 37. Mason Park to Homebush

17.2 Need

The 132kV oil filled cable feeders 90A and 90L supply Homebush STS from Mason Park STS. The length of 132kV feeders 90A and 90L is approximately 1.0km. Cable 90L will be 56 years old when replaced in 2019.

The concurrent outage of feeders 90A and 90L would result in the loss of supply to Homebush STS. Partial loads would be recovered via 11kV load transfer to nearby zone substations that are not supplied from Homebush, using existing connections after a time delay (switching time). Essentially there is a low, but increasing, probability that some customers in this area will experience a very long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated which is approximately 30MWh in 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per a million dollar expenditure (normalised x-axis). This cable has the highest ranking of all cables on this basis, because of the availability of a low replacement cost.

Cable 90L has experienced several oil leaks over the past 15 years, whereas cable 90A has not yet leaked. Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cable 90L as contributing 0.39% of the total environmental risk assigned to Ausgrid's fluid filled cable population.

The cable failure model forecasts that the condition of this cable will deteriorate if it is not replaced. However cable 90A is expected to perform at an acceptable level for a sufficient time to make it economic to defer its replacement.

17.3 Options

The following options were considered as part of the Ausgrid's network planning process:

1. Do nothing – maintain existing feeders 90A and 90L in service

   This option is not feasible since the identified risks cannot be mitigated with conventional maintenance activities.

2. Replacement of 132kV feeders 90A and 90L with equivalent underground cables

   This option also requires the commissioning of the third transformer at Homebush STS to facilitate staging replacement of the feeders. It also considers the installation of a set of spare ducts to enable the installation of a future third 132kV feeder in 2028 to address demand growth requirements.

3. Replacement of 132kV feeder 90L now using overhead cables and feeder 90A later using underground cables

   This option considers the initial installation of an overhead tee connection off feeder 203 to enable the retirement of feeder 90L. In the future, this option considers the installation of two underground cables in 2028 to replace feeder 90A and to install an additional feeder to address expected demand growth requirements.

4. Replacement of 132kV feeders 90A and 90L with underground cables and install a third feeder later using overhead cables

   This option involves the replacement of feeders 90A and 90L with no spare ductline. The third feeder will be installed in 2028 by means of a tee connection off feeder 923 or 924.

5. Replacement of 132kV feeders 90A and 90L with staged overhead connections and install third feeder later using overhead cables

   This option considers the initial installation of an overhead tee connection off feeder 203 to enable the retirement of feeder 90L. In the future, it considers the installation of additional overhead connections to replace feeder 90A and to install an additional feeder to address expected demand growth requirements.

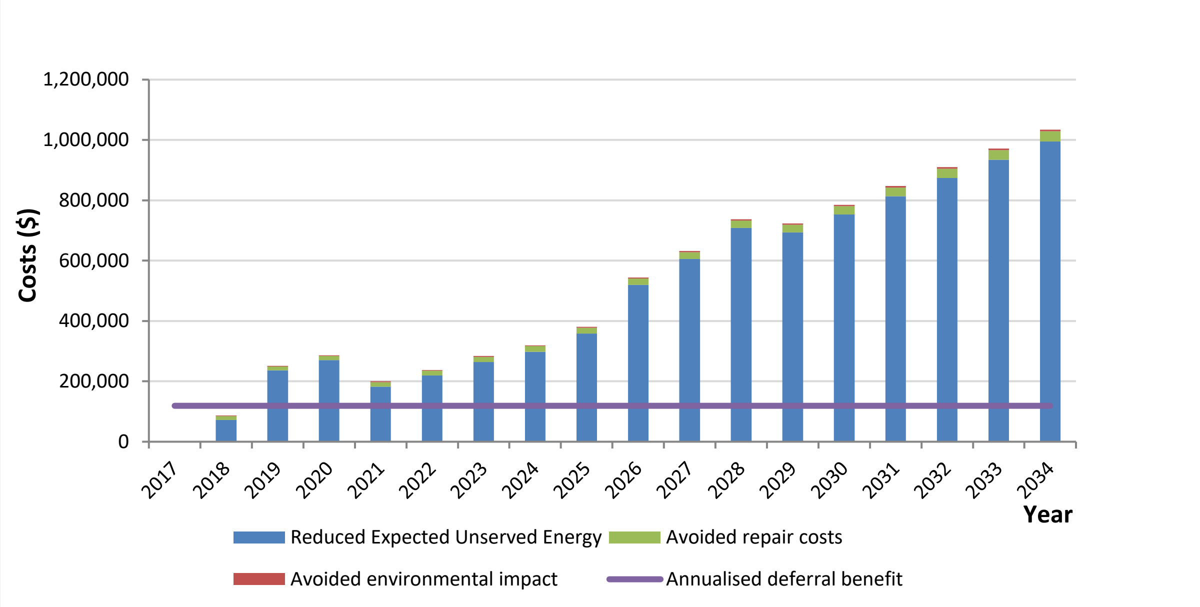
6. Consideration of demand management

Option 5 is the preferred network solution, as it as it provides a future strategic and the most cost effective solution to the area.

17.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date for the first stage of the project. A positive net economic benefit will be achieved early in the 2019-24 regulatory control period, as illustrated in Figure 38 below. This is the result of using low-cost overhead construction for the replacement feeder, and deferring the replacement of the second cable.

Figure 38. Total risk cost versus project deferral benefit - Mason Park to Homebush



Ausgrid is also committed to minimising the environmental risk associated with the operation, maintenance and repair of oil-filled cables and it aims to reduce the overall environmental risk by at least 50% during each regulatory period.

Figure 11 in Part A shows the ranking of cables based on the environmental risk per a million dollars of expenditure (maximum risk being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the replacement of feeder 90L during 2019-24 regulatory period is the third least expensive contribution to achieving this environmental risk reduction target.

This timing is also driven by the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability and cash flow smoothing define 2019 as the optimum timing to complete the stage 1 project.

We forecast that construction work will start in 2018 and end in 2019.

17.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives were not found to be cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

17.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of a 0.1km of overhead connection to feeder 203 from tower RP23011 within Ausgrid's Homebush depot, including a landing structure and approximately 20m of underground connections to the transformer, as well as the decommissioning of the existing oil filled cable 90L.

The cash flow for the project is outlined in Table 16 below.

Table 16. Mason Park to Homebush project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	0.6	1.2	-	-	-	-	-

18 PROJECT 14 – MASON PARK TO DRUMMOYNE TO ROZELLE

18.1 Project description

The project is to replace 132kV cables 203 and 204 between Mason Park and Drummoyne and cable 202 between Drummoyne and Rozelle by summer 2028. It is shown in Figure 39 These cables are oil-filled, and cable 202 includes a submarine crossing of Iron Cove. Cables 203 and 204 pass close to Canada Bay, on the southern bank of the Parramatta River. They all pose a serious environmental risk. The proposed replacement for cables 203 and 204 is a single high capacity XLPE cable between Mason Park and Drummoyne using an unused cable duct, and for cable 202 it is a single XLPE cable between Drummoyne and Rozelle. The total project cost is $47.2 million of which $0.5 million is forecast to be incurred in the 2019-24 period.

Figure 39. Mason Park to Drummoyne to Rozelle

18.2 Need

The existing 203 and 204 feeders run from Mason Park to Drummoyne and feeder 202 runs from Drummoyne to Rozelle. These circuits operate as a meshed network predominantly supplying local distribution loads while also providing the ability to transfer the load from City South, City Central and Pyrmont substations. They form part of the major transmission supply to the Inner West Transmission area. The existing feeders 203 and 204 consist of single core 800mm2 oil-filled cables. The existing feeder 202 consists of various sizes of single core (400/800/1150mm2) oil-filled cables. The 202 oil filled cable will be 48 years old if replaced in 2028. Cables 203 and 204 will be aged 50.

The outage of two or all three of these feeders would result in the loss of supply to Drummoyne Zone Substation. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 10MWh in the 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). These cables have a very low ranking on this basis.

Based on the history of leaks, along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 202, 203 and 204 as contributing 1.01%, 0.13% and 0.58% of the total environmental risk assigned to Ausgrid's fluid filled cable population. These cables are ranked tenth in terms of environmental risk per million dollars of expenditure.

Insulation Resistance tests indicate that there are potential problems with the outer serving of the cables which could lead to oil leaks in the future. The cable failure model forecasts that the reliability of these cables will deteriorate if they are not replaced.

The cables are an important part of the network that transfers power from Mason Park to the Drummoyne and the Rozelle areas and they also enable switching of CBD load to the northern network under certain outage scenarios. Therefore their integrity is essential to ensure reliable supply for customers in these areas. A history of cable fluid leaks over an environmentally sensitive route, poor test results and increased rates of corrective work for these cables support the case to replace these aged fluid filled cables.

18.3 Options

We examined the following options as part of the Ausgrid's network planning process, in conjunction with a number of related options for replacement of feeders 923/2, 924/2 (see project 12) and 900 (replaced by 9P2, 9P8, and 9P9):

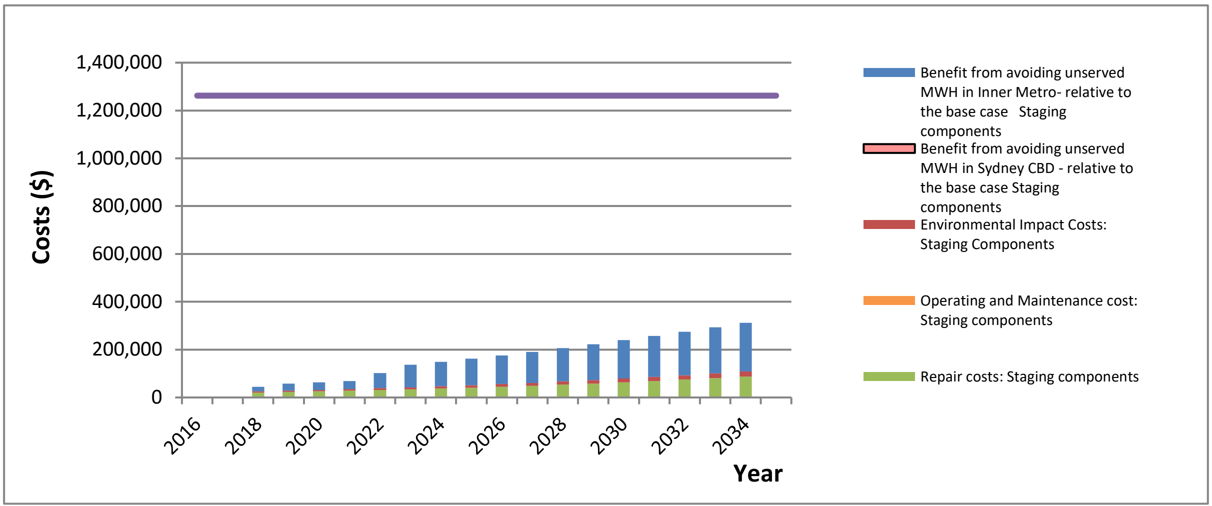
1. Like-for-like replacement of feeder 202 followed by like for like replacement of feeders 203, 204
2. Installing a new feeder in the spare duct from Mason Park to Rozelle to replace feeder 202. Feeders 203 and 204 would be replaced like-for-like
3. Like-for-like replacement of feeder 202 followed by replacement of feeders 203 and 204 with a single feeder
4. Like-for-like replacement of 202 and 203 followed by replacement of feeder 204 via Burwood zone and a new feeder between Burwood and Croydon
5. The replacement of feeder 202 with a new feeder using the spare duct from Mason Park to Rozelle followed the like for like replacement of 203 and 204
6. Installing a new feeder between Mason Park and Rozelle using a spare duct, with the feeder teed in to Drummoyne
7. An interim solution to run a single feeder from the existing feeder 900 to Croydon and Leichhardt Zone Substations. Feeders 202, 203, and 204 would still need to be replaced
8. Consideration of demand management.

The preferred network strategy for the inner west transmission area is Option 1. This option is a low cost, low risk strategy that maximises utilisation of existing overhead assets and provides synergies with a number of other distribution constraints in the area. Details of this investigation are included in the Feasibility Report.

18.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date. In terms of maximising positive net economic benefits, the optimal timing for commissioning the project is well beyond the 2019-24 regulatory control period, as illustrated in Figure 40 below.

Figure 40. Total risk cost versus project deferral benefit - Mason Park to Drummoyne to Rozelle



Ausgrid is also committed to the community, safety and meeting the needs of the energy market by effectively maintaining reliability of our assets. Ausgrid considers that minimising the environmental risk associated with the operation, maintenance and repair of oil-filled cables in such an environmentally sensitive area is an important priority.

Figure 11 in part A shows the ranking of cables based on the environmental risk per million dollar of expenditure (maximum risk being normalised to 100%) and the percentage cumulative risk reduction. It can be seen that the environmental risk of these cables is moderate, being ranked tenth, and the replacement of feeders 202, 203 and 204 will only be required beyond the 2019/24 regulatory period to achieve subsequent environmental risk reduction targets.

This timing is also driven by the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Also, deliverability, resource availability, sensitivity analysis and cash flow smoothing are other factors that would define a new optimum timing to initiate the project. In accordance with the EPA requirement, the cable is scheduled for replacement in 2024-29 regulatory period. In consideration of these factors, **the optimum timing for completing this project is recommended by September 2027.**

We forecast that construction work will start in 2022 and end in 2027.

18.5 Demand Management

The timing for this project is not driven by the result of a CBA (CBA), but principally by environmental risk issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeder. A preliminary deferral analysis determined that this is not cost effective.

Analysis to consider whether the estimated unserved energy at risk could be cost effectively reduced using non-network options has not been completed at this early stage but will be assessed closer to the need date.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

18.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves:

- The installation of a 7.2km long high capacity cable between Mason Park STSS and Drummoyne ZS, including the underbore of Powells Creek (100m), the underbore of the rail line near North Strathfield station (100m) as well as two bridge crossings
- The installation of a 3.8km long high capacity cable between Drummoyne Zone Substation and Rozelle STS, including a 400m underbore of the Parramatta River at Rodd Point
- The decommissioning of the existing oil filled cables 202, 203 and 204.

The cash flow for the project is outlined in Table 17 below.

Table 17. Mason park to Drummoyne to Rozelle project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Replace 132kV Feeder 202	-	-	-	-	-	0.2	15.4
Replace 132kV Feeder 203 and 204	-	-	-	-	-	0.2	31.3
Total Cost						0.5	46.7

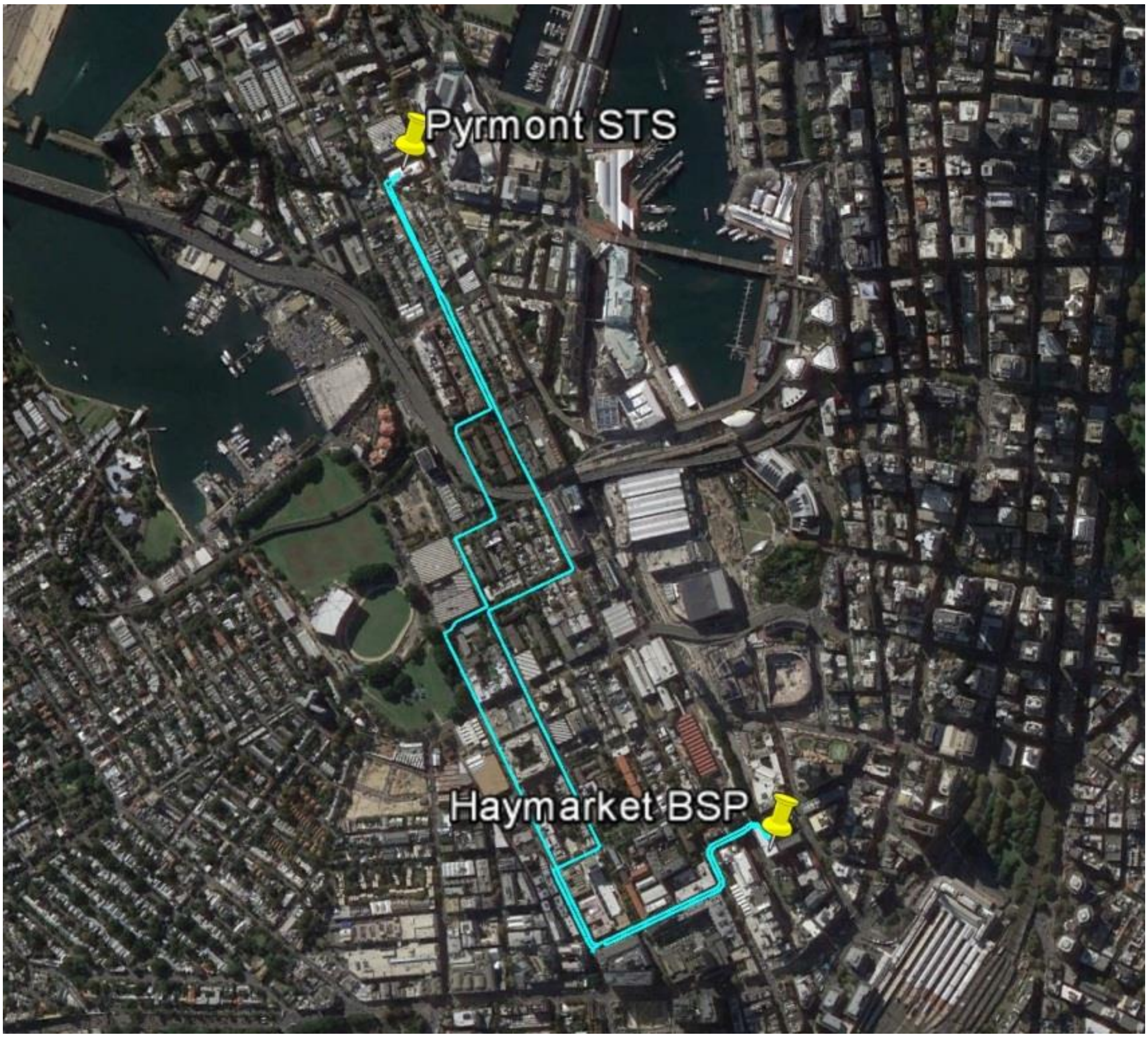
NOTE:	Numbers may not sum due to rounding.

19 PROJECT 15 – HAYMARKET TO PYRMONT

19.1 Project description

The project is to replace 132kV cable 9S6/1 and cable 9S9/1 between TransGrid's Haymarket BSP and Pyrmont STS with XLPE cables between the same terminals by summer 2026. It is shown in Figure 41 below. The present 132kV cables are oil-filled, and 9S6/1 has experienced moderate oil leaks. The cable route is close to Darling Harbour and Pyrmont Bay, posing an environmental risk. The cables have been considered together because the least cost solution is for them to be laid at the same time in new adjacent ducts over most of their length. The total project cost is $37.2 million.

Figure 41. Haymarket to Pyrmont



19.2 Need

The existing 9S6/1 and 9S9/1 feeders run from Haymarket to Pyrmont. These feeders form part of the major subtransmission supply to the Pyrmont and Darling Harbour area at the edge of the Sydney CBD. The existing feeders are single core 1000mm^2 oil-filled cables. Cables 9S6/1 and 9S9/1 will be 38 and 46 years old respectively when replaced in 2026.

The concurrent outage of these two feeders would result in the loss of supply to Darling Harbour Zone Substation. Partial loads would be recovered via 11kV load transfer to nearby zone substations using existing connections after a time delay (switching time). Essentially there is a low, but increasing, probability that some customers in this area will experience a long blackout. Based on the cable failure model, the aggregated expected unserved energy associated with these feeders has been calculated to be approximately 35MWh in the 2019-24 regulatory control period. Figure 10 in Part A shows the relative ranking of feeder projects based on the EUE per million dollars of expenditure (normalised x-axis). These cables have a low ranking on this basis.

Cable 9S6/1 has experienced moderate oil leaks over the past 15 years, while cable 9S9/1 has so far been leak free. It cannot be assured that cable 9S9/1 will not leak, as it is identical to 9S6/1. Recent insulation resistance testing of both cables indicates that there are potential problems with the outer serving of cable 9S6/1 or the cable link boxes, which could lead to oil leaks in the future.

Based on this history of leaks along with an assessment of the environmental sensitivity along the cable route, the 2017 review of fluid filled 132kV cable environmental risk assessed cables 9S6/1 and 9S9/1 as contributing very small proportion (0.15% and 0.00%) of the total environmental risk assigned to Ausgrid's fluid filled cable population.

Our cable failure model forecasts that the reliability of these cables, particularly cable 9S6/1 will deteriorate if they are not replaced.

The cables are an essential part of the network transferring power from Haymarket to the Pyrmont and Darling Harbour load area and their integrity is essential to ensure reliable supply for customers in these areas.

19.3 Options

We examined the following options as part of the Ausgrid's network planning process:

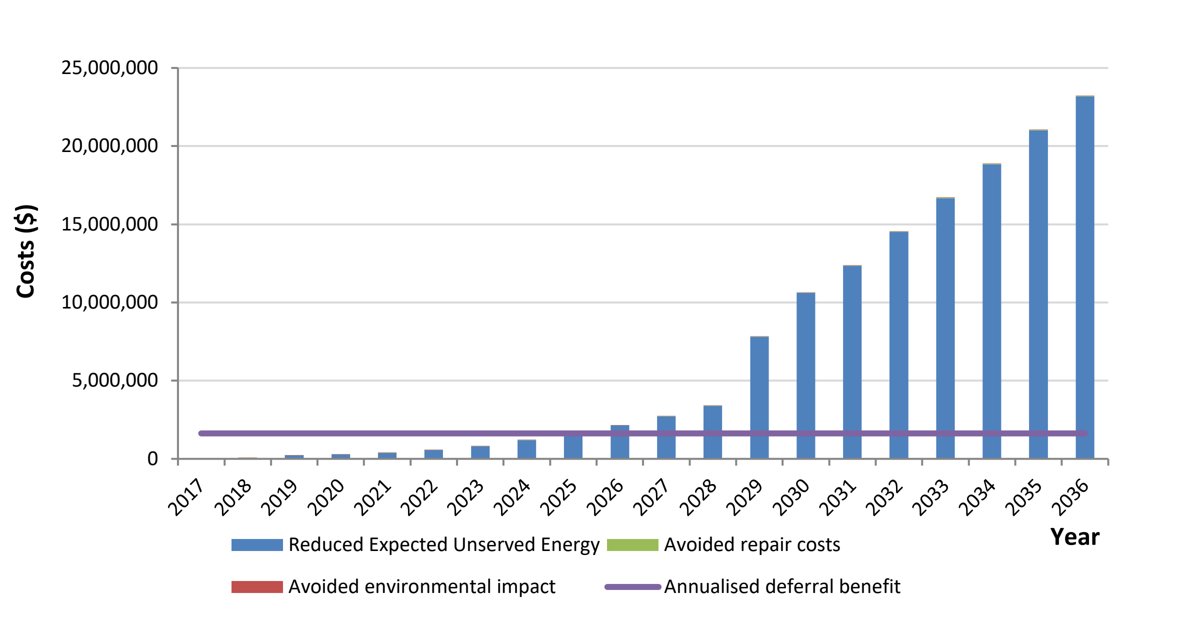
1. Like-for-like replacement – Haymarket BSP to Pyrmont STS using horizontal directional drilling (HDD) from near Wentworth Park to Pyrmont STS
2. Like-for-like replacement – Haymarket BSP to Pyrmont STS using a trench (two circuits in the same trench)
3. Like-for-like replacement – Haymarket to Pyrmont STS two single circuits in separate trenches
4. Replacement of feeders 9S6/1 and 9S9/1 by installing new 132kV feeders from Lane Cove STS to Pyrmont STS
5. Consideration of demand management.

The preferred network option is to undertake like for like replacement using HDD on a part of route between Haymarket BSP and Pyrmont STS as it provides a future strategic and the most cost effective solution to the area.

19.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to the assets to be replaced, was first used to identify a break-even replacement date. In terms of achieving a positive net economic benefit, the timing for commissioning the project is just beyond the 2019-24 regulatory control period, as illustrated in Figure 42 below.

Figure 42. Total risk cost versus project deferral benefit - Haymarket to Pyrmont



Ausgrid is also committed to reducing the environmental risk associated with the operation, maintenance and repair of oil-filled cables, and aims to reduce the overall environmental risk by at least 50% for each regulatory period. The environmental risk of these cables per dollar of expenditure is low and therefore the replacement of these feeders is proposed to remain in the 2024-29 regulatory period.

The timing also considers the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. The need to address the EPA's requirement, deliverability, resource availability, sensitivity analysis and cash flow smoothing are other factors that affect the timing to initiate the project.

19.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative.

The cost benefit assessment has shown that the non-network option is able to efficiently reduce the estimated unserved energy at risk in advance of the completion date and a deferral of the preferred network option by three years from 2025/26 to 2028/29. As such, this option is the preferred option. Details on the capital and operating expenditure impacts are found in Chapter 5 (Capital expenditure) and Chapter 6 (Operating expenditure) of the Regulatory Proposal.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

19.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution includes the installation of 2.5km of high capacity cables, approximately 600m of Horizontal Directional Drilling (HDD) between Wentworth Park and Pyrmont STS, the construction of cable shafts at Haymarket BSP, Wentworth Park and Pyrmont STS, and the decommissioning of the existing oil filled cables.

The cash flow for the project, including both the network option and the preferred option including demand management, are outlined in Table 18 below.

Table 18. Haymarket to Pyrmont project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Network Option	-	-	-	0.5	1.7	14.8	16.9
DM Option (preferred)	-	-	-	-	-	-	37.2

20 PART C – 33KV CABLE REPLACEMENTS

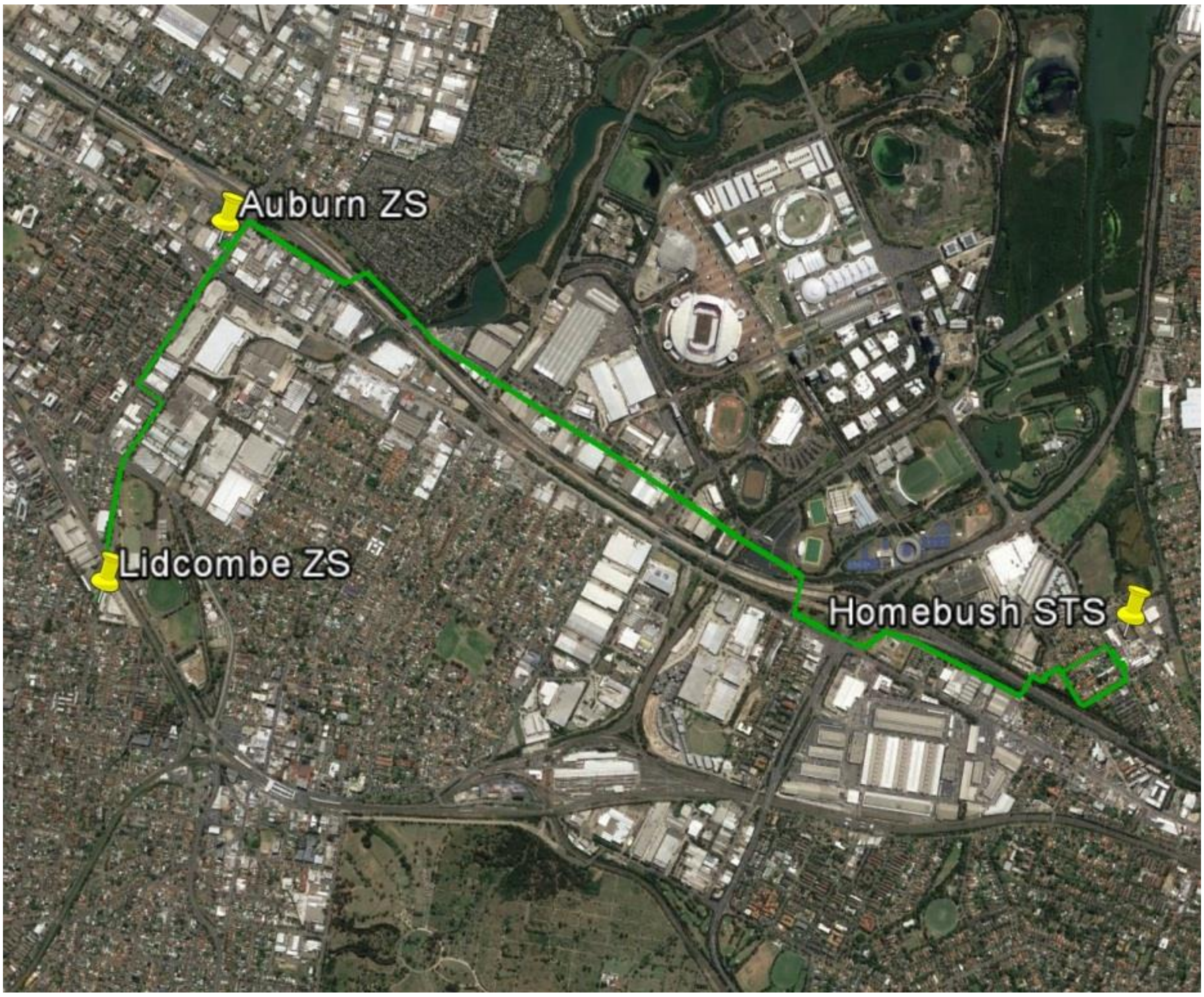
Figure 43. Typical 33kV three phase HSL cable

21 PROJECT 16 – HOMEBUSH TO AUBURN AND LIDCOME

21.1 Project description

The project is to replace 33kV cables 601, 614 and 615 between Homebush STS and Auburn Zone Substation, and 33kV cables 602, 604 and 605 between Homebush and Lidcombe Zone Substation in the Inner West area of Ausgrid's network. It is shown in Figure 44. Cable 601 uses HSL cable, cable 614 is gas pressure cable, while the remainder contain sections of both of these technologies. The plan is to replace the 33kV feeders supplying Auburn and Lidcombe Zone Substations by installing new XLPE cables from the Endeavour Energy-owned Camellia STS. Based on an assessment of cost-benefit we plan to replace these cable assets by summer 2020. The total project cost is $26.8 million of which $11.4 million is forecast to be incurred in the 2019-24 period.

Figure 44. Homebush to Auburn and Lidcome



21.2 Need

Auburn and Lidcombe are 33/11kV Zone Substations supplied from Homebush STS: three 33kV feeders to Auburn and three to Lidcombe Zone Substation. These six cables are directly connected to 33/11kV transformers at Auburn and Lidcombe Zone Substations.

The 33kV feeders supplying Auburn and Lidcombe Zone Substations are comprised of a mixture of Paper Insulated Lead Covered (PILC) cables and Gas Pressure insulated cables. The gas-pressure cables have been prioritised for replacement on the basis of their age and condition (mostly the occurrence of gas leaks). The HSL cables were installed in the period 1949 to 1953. These have not been formally prioritised, but these cables will be aged 66 to 70 years in 2019. This type of cable is also known as Solid/HSL cable, and generally has a life expectancy of sixty years. The 33kV cables supplying Auburn and Lidcombe Zone Substations are approaching the end of their service lives. In accordance with the asset replacement prioritisation program performed in 2012, these feeders were scheduled for replacement between 2016 and 2023.

21.3 Options

We examined the following options as part of the Ausgrid's network planning process:

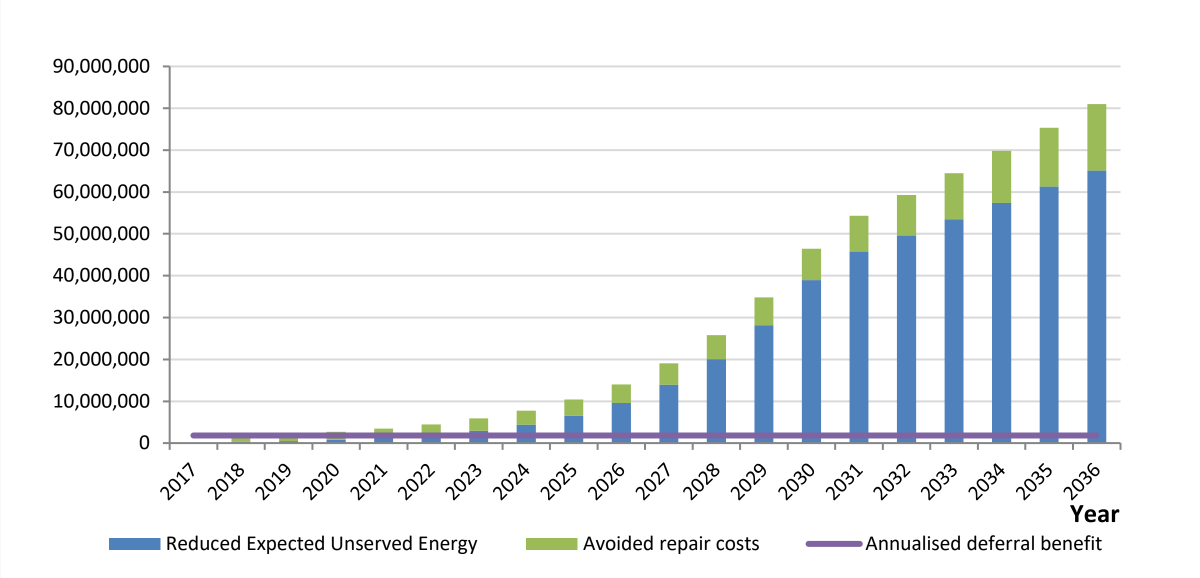
1. Replacement of Auburn and Lidcombe zones with a new 132/11kV Zone Substation with decommissioning of the 33kV feeders
2. Replacement of 33kV feeders like-for-like from Homebush STS to Auburn and Lidcombe zones
3. Retirement of Lidcombe Zone Substation and decommissioning of its 33kV feeders, replace Auburn 33kV feeders like-for-like
4. Installation of 33kV feeders from the Endeavour Energy owned Camellia STS and decommission Auburn and Lidcombe 33kV feeders
5. Consideration of demand management.

The preferred network option is to replace the 33kV feeders supplying Auburn and Lidcombe Zone Substations by installing new XLPE cables from the Endeavour Energy-owned Camellia STS as it provides a future strategic and the most cost effective solution to the area.

21.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date of 2017/18 as illustrated in Figure 45 below.

Figure 45. Total risk cost versus project deferral benefit - Homebush to Auburn and Lidcome



The timing analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers. Deliverability, resource availability and cash flow smoothing are other factors that define the optimum timing to initiate the project. In consideration of these factors, **the optimum timing for completing this project is recommended as September 2019**.

Construction work started in 2017 and end in 2020.

21.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives would not be cost effective due to the magnitude of the load reduction required.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solutions providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

21.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves:

- The installation of new 33kV feeder protection at Endeavour's Camellia STS
- The installation of four new feeders, which will mainly be constructed as overhead lines, comprising two pole lines with 3.5km overhead circuits, each originated from Endeavour's Camellia STS to Adderley Street near Auburn Zone Substation
- The installation of one overhead circuit that will continue for 1.8km from Adderley Street to Lidcombe Zone Substation
- The installation of three UGOH poles to enable underground connections to reach Auburn Zone Substation
- The connection of one overhead feeder through a UGOH pole to be joined to existing paper insulated lead covered feeders 602 and 605 to complete supply to Lidcombe Zone Substation
- The decommissioning of approximately 11km of existing gas pressure cables and 14km of paper insulated lead covered cables supplying Auburn and Lidcombe Zone Substations from Homebush STS.

The cash flow for the project is outlined in Table 19 below.

Table 19. Homebush to Auburn and Lidcombe project cash flows ($m, real FY19)

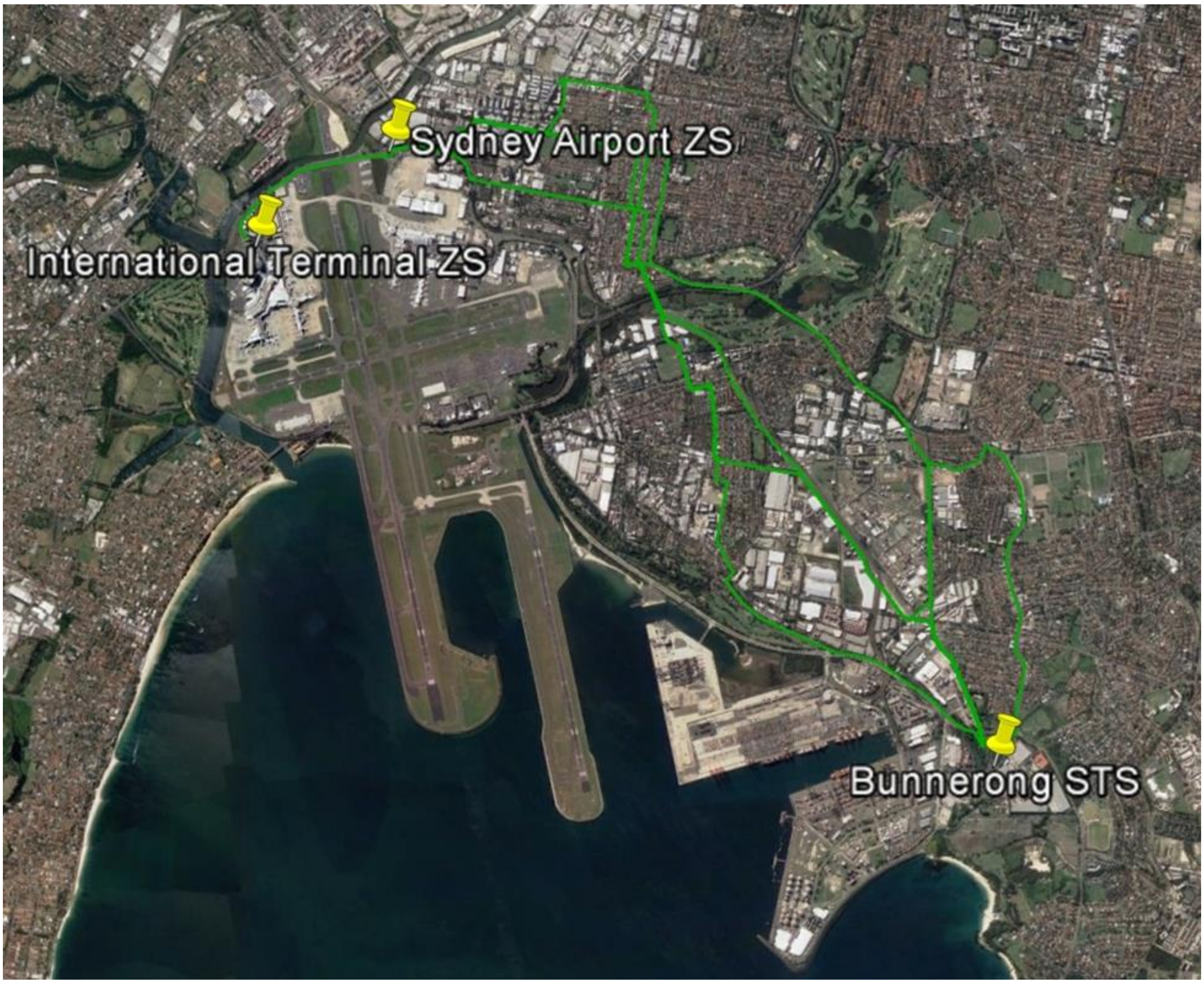
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	15.4	8.0	2.4	1.1	-	-	-

22 PROJECT 17 – BUNNERONG TO AIRPORT

22.1 Project description

The project is to replace 33kV cables 331, 345, 352, 356 and 359 between Bunnerong STS and the Sydney Domestic Airport Zone Substation in the Eastern Suburbs area of Ausgrid's network. It is shown in Figure 46. The driver is the age and condition of these cables and the condition of equipment at the Airport Zone Substation. Alexandria 132/33kV Sub-transmission Station is being established within a short distance of the airport, and the replacement 33kV cables are to be laid between Alexandria and the Airport. The target completion date is summer 2020. The total project cost is $15.6 million of which $15.5 million is forecast to be incurred in the 2019-24 period.

Figure 46. Bunnerong to Airport



22.2 Need

Sydney Airport and International Terminal are two 33/11kV Zone Substations that are supplied through five 33kV cables from Bunnerong North STS. Three of the 33kV feeders supply Sydney Airport Zone Substation and remaining two 33kV feeders supply the International Terminal Zone Substation. There is also an interconnecting 33kV feeder between these two substations. Sydney Airport and International Terminal Zone Substations were commissioned in 1946.

The 33kV feeders supplying Sydney Airport and International Terminal Zone Substations comprise of combination of XLPE and Paper Insulated Lead Covered (PILC) cables. The present age of the PILC 33kV feeders, mostly installed during the 1940's and 1950's, is about 70-75 years. It should be noted that the condition is deteriorating and significant failures can be expected in the future. Also, it has been identified that there are condition issues with the 33kV switchgear assets at these two substations which will be addressed along with feeder replacement.

These cables have experienced failures and the risk of continuing to rely on such old cables for supply to Sydney Airport has been determined to be high enough to justify retirement.

22.3 Options

We examined the following options as part of the Ausgrid's network planning process and subsequent joint planning discussions with Sydney Airport Corporation Limited:

1. Retain existing cables in service
2. Replace cables with like-for-like new cables from Bunnerong
3. Install new cables from new Alexandria 132/33kV STS (tail ended arrangement)
4. Install new cables from new Alexandria 132/33kV STS (tail ended arrangement with 33kV circuit breakers at Sydney Airport)
5. Install new cables from new Alexandria 132/33kV STS (Ring Main arrangement at Sydney Airport)
6. Consideration of demand management.

Options 3, 4 and 5 are similar, differing only in the arrangement of 33kV circuit breakers, which is beyond the scope of the cable replacement portion of the project. Installation of new cables from the new Alexandria 132/33kV STS helps to optimally solve multiple needs as it also facilitates the retirement of the existing 33kV switchgear at Sydney Airport which is approaching the end of its service life.

The preferred network option is to undertake replacement with modern XLPE cables from the new Alexandria 132/3kV STS which is approximately 2km away from Sydney Airport Zone Substation. Details of a new 33kV connection arrangement are being determined with the Sydney Airport Corporation. Achieving a cost-effective level of reliability is the prime consideration.

22.4 Timing

The timing analysis for this project is decided in consideration of increasing the reliability of supply to the Sydney Airport, being a critical customer. The feeders are considered to be very old and have experienced a number of outages over the past years causing concern for the operation of Sydney airport. The prime consideration is the reliable supply to the customer and hence the replacement of these feeders is justified. Further, analysis also considered the need to coordinate the work with the replacement of other assets while maintaining the required levels of reliability to customers, together with deliverability and resource availability. In consideration of these factors, **the optimum timing for completing this project is recommended as September 2019**.

Construction work will start in 2018 and end in 2021.

22.5 Demand Management

The timing for this project is not driven by the result of a CBA, but principally by other issues. Consequently, the demand reduction required to change the timing of this investment is the entire load to allow the retirement of the feeders.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. Where the RIT-D process or any consequent tender for non-network solutions indicates that a modified non-network scope of work offers an improved cost benefit outcome, the selected solution to the need will be modified accordingly.

22.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of four 2.0km 500mm2 XLPE 33kV cables originating from Alexandria STS, and the decommissioning of approximately 44km of existing paper insulated lead covered cables supplying Sydney Airport from Bunnerong North STS.

The cash flow for the project is outlined in Table 20 below.

Table 20. Bunnerong to Airport project cash flows ($m, real FY19)

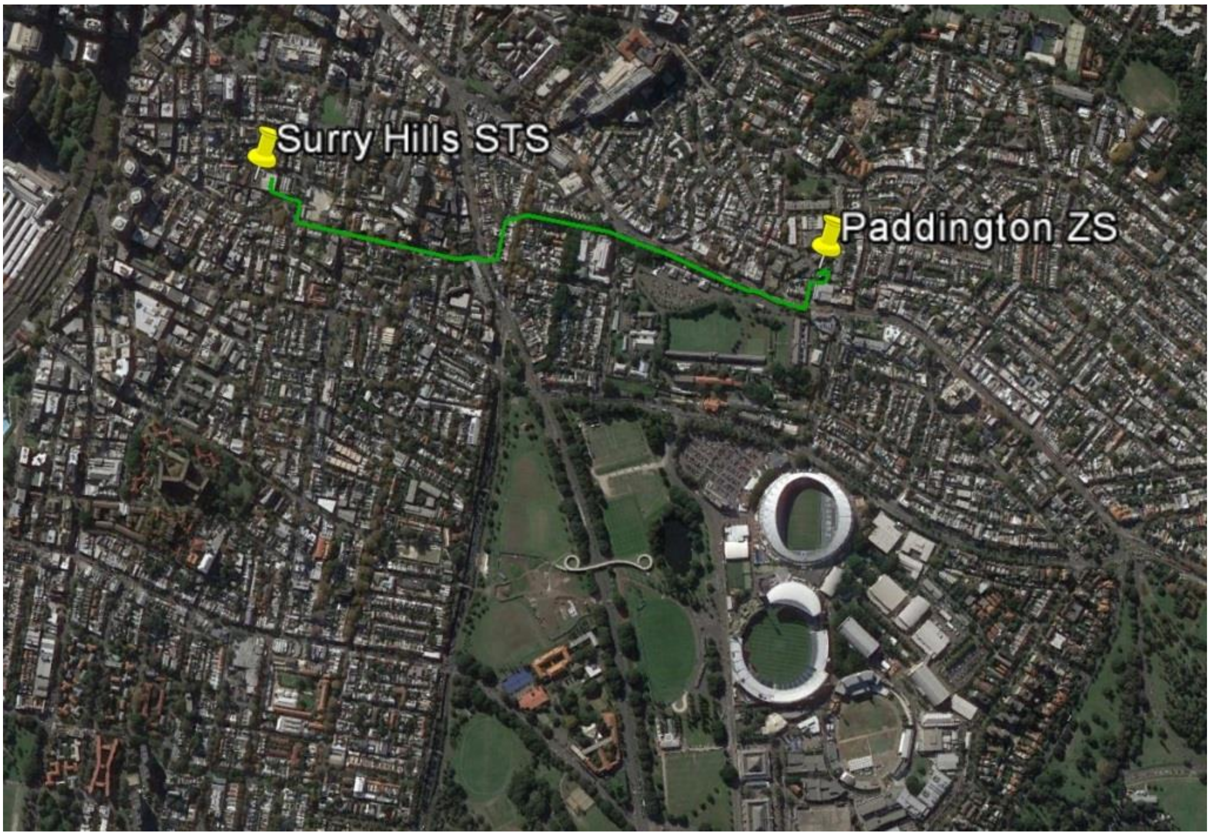
	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	0.1	9.7	5.8	-	-	-	-

23 PROJECT 18 – SURRY HILLS TO PADDINGTON

23.1 Project description

The project is to retire gas pressure 33kV cables 380, 381 and 382 between Surry Hills and Paddington Zone Substation. It is shown in Figure 47 below. There is no record of gas leakage for these cables prior to 2012, but cable 380 was prioritised for replacement in 2016, and 381 and 382 in 2018. Based on an assessment of cost-benefit, we forecast to replace the cables like-for-like by summer 2025. The total project cost is $10.0 million of which $7.4 million is forecast to be incurred in the 2019-24 period.

Figure 47. Surry Hills to Paddington



23.2 Need

Paddington is a 33/11kV Zone Substation that is supplied through three 33kV cables from Surry Hills STS. These three cables are directly connected to three 33/11kV transformers. Paddington Zone Substation and the 33kV feeders were commissioned in 1940.

The 33kV feeders supplying Paddington Zone Substation are Gas Pressure (GP) insulated cables. Gas pressure cables are considered to be prone to leaks due to their higher operating temperatures. Minor leaks are particularly difficult to locate. The GP cables take considerable time for the gas to diffuse through the cable and displace any air introduced during defects and associated repair works. It can take between 2 and 10 days before the cable can be safely returned to service. The present age of Paddington 33kV feeders is 77 years. These Paddington 33kV feeders have not experienced significant gas leaks historically, and are beyond the 40 worst feeders in terms of gas leakage reported in Strategic Asset Prioritisation Sub-transmission cables.

23.3 Options

We examined the following options as part of the Ausgrid's network planning process:

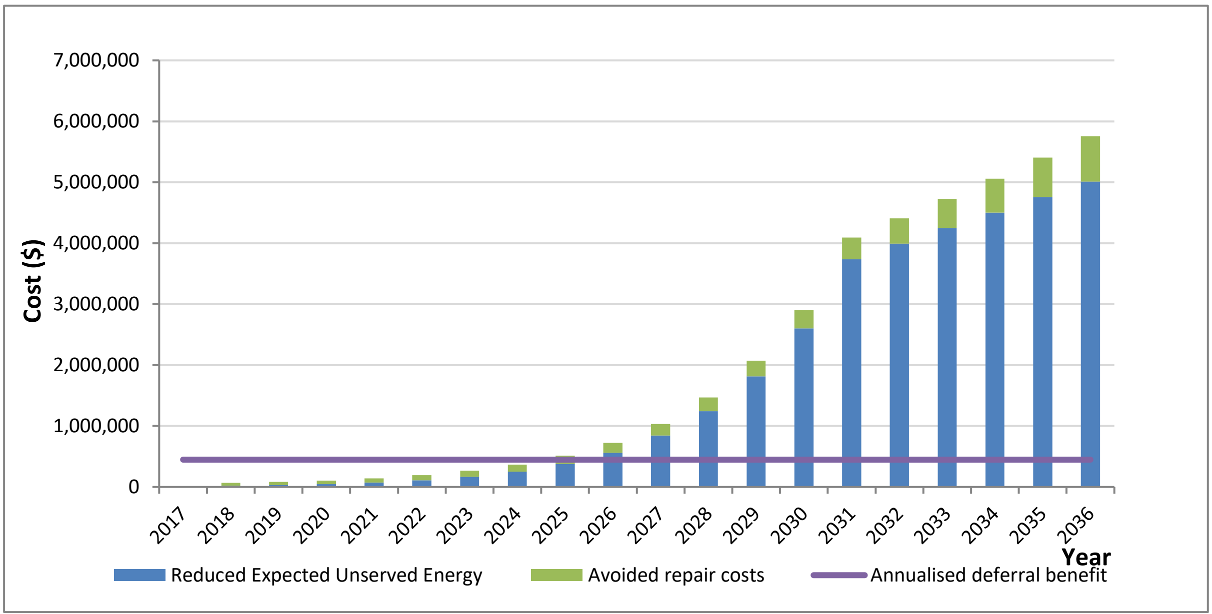
1. Replacement of 33kV feeders like-for-like
2. Retirement of Paddington zone via a new zone enabling the decommissioning of the 33kV feeders
3. The retirement of Paddington Zone Substation via transferring loads to surrounding zones. This option was considered not feasible as there is insufficient capacity at neighbouring zones to accept 11kV load transfers
4. Consideration of demand management.

The preferred network option is to replace the 33kV feeders supplying Paddington Zone Substation by new XLPE cables on an alternative but similar route.

23.4 Timing

CBA, which includes the estimated cost of unserved energy due to unreliability attributable to all the assets to be replaced, was used to identify a break-even replacement date of 2024/25 as illustrated in Figure 48 below.

Figure 48. Total risk cost versus project deferral benefit - Surry Hills to Paddington



The timing analysis also considered the need to coordinate the work with the retirement of other assets including Darlinghurst Zone Substation, while maintaining the required levels of reliability to customers. Deliverability, resource availability and cash flow smoothing are other factors that define the optimum timing to complete the project. In consideration of these factors, **the optimum timing for completing this project is recommended as December 2024**.

We forecast that construction work will start in 2022 and end in 2025.

23.5 Demand Management

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. The analysis used the same unserved energy model and cost benefit assessment developed to assess network options to compare the NPV of the preferred network option against the non-network alternative. The cost benefit assessment has shown that non-network alternatives were found to be not cost effective.

Note that at this early stage there is little or no specific information known about actual non-network options available in the area, so assumptions are made about the likely scale of demand reductions possible and the estimated costs. These assumptions are based upon previous experience with delivery of demand management projects, submissions to non-network options reports from non-network solution providers and lessons learned from demand management trials by Ausgrid and others.

As part of the Rules requirements, a RIT-D will be conducted on this project, and a NNOR will be published as part of the demand management engagement process. This will inform interested parties of the opportunity identified, and invite submissions from non-network proponents. If during the consultation process a non-network option is found to offer a cost effective alternative to the preferred network option, the selected solution to the need will be modified accordingly.

23.6 Costing

We undertook a site specific estimate of the costs of the preferred solution, using the BPC tool outlined in Attachment 5.03.

The proposed solution involves the installation of three 1.50km 630mm^2 XLPE 33kV cables originating from Surry Hills STS, and the decommissioning of approximately 4.6km of existing gas pressure cables.

The cash flow for the project is outlined in Table 21 below.

Table 21. Surry Hills to Paddington project cash flows ($m, real FY19)

	Previous years	2019-20	2020-21	2021-22	2022-23	2023-24	Later years
Preferred option	-	-	-	0.4	1.1	5.8	2.6