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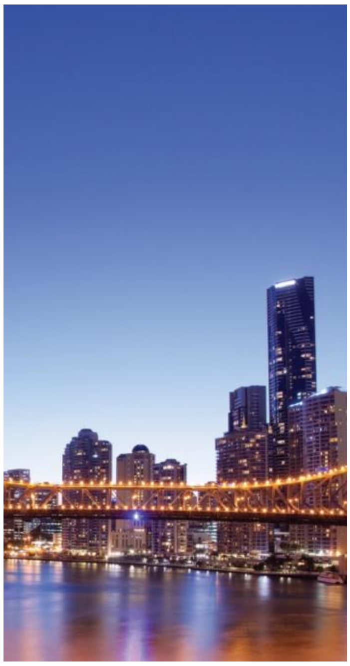


Strategic Options Evaluation – Port Melbourne Area

CitiPower

21 December 2018

Contents

Overview

The Port Melbourne area of CitiPower's network is supplied by Fisherman's Bend Terminal Substation (FBTS). FBTS is located to the west to the Melbourne central business district (CBD) and supplies ten Zone Substations (ZS) which then distribute power through the local area.

CitiPower concerns relating to two of the ZSs in the area, Port Melbourne (PM) and Fisherman's Bend (E), have triggered a strategic options evaluation for the entire Port Melbourne area. The PM and E ZSs have ageing assets and present an increasing risk to the operation of the network as well as safety of workers and the community.

The identified need is to efficiently meet forecast consumer demand for electrical power throughout the Port Melbourne area. The key issues for the Port Melbourne area are summarised as follows:

- **Ageing assets:** Both primary plant and general site infrastructure at ZS PM and E are ageing and have high probability-of-failure (PoF) that will continue to increase.
- **Disruptive failures:** A disruptive failure of any of these assets presents a significant risk to supply availability to inner suburbs of Melbourne city.
- **Catastrophic failures:** Of particular concern, is that assets of this vintage are relatively susceptible to catastrophic failure. A catastrophic failure of any of the assets can result in loss of supply to the inner suburbs of the Port Melbourne area. The assets, being oil-filled plant items, are relatively susceptible to failing explosively compared with modern equivalents, which increases the safety risks associated with them. The increased maintenance burden associated with these sites further increases the exposure of maintenance personnel to safety risks associated with catastrophic failures.
- **Construction constraints:** The PM and E substations were constructed prior to the development of contemporary design standards, and the civil infrastructure on site is also deteriorating in condition. These sites are located in Melbourne's inner suburbs and are space constrained, both internally and in relation to access surrounding the sites. This constrains the ability for piecemeal construction or rebuilding the sites whilst they remain in operation; and attract relatively higher costs, and safety and operational risks.
- **Good electricity industry practice:** The PM and E substations operate using a 6.6 kV distribution voltage, which is an outdated and sub-optimal industry practice. Piecemeal renewal of assets at end-of-life (if viable) would extend these issues over the service life of the new assets (over 50 years).

Seven options have been evaluated:

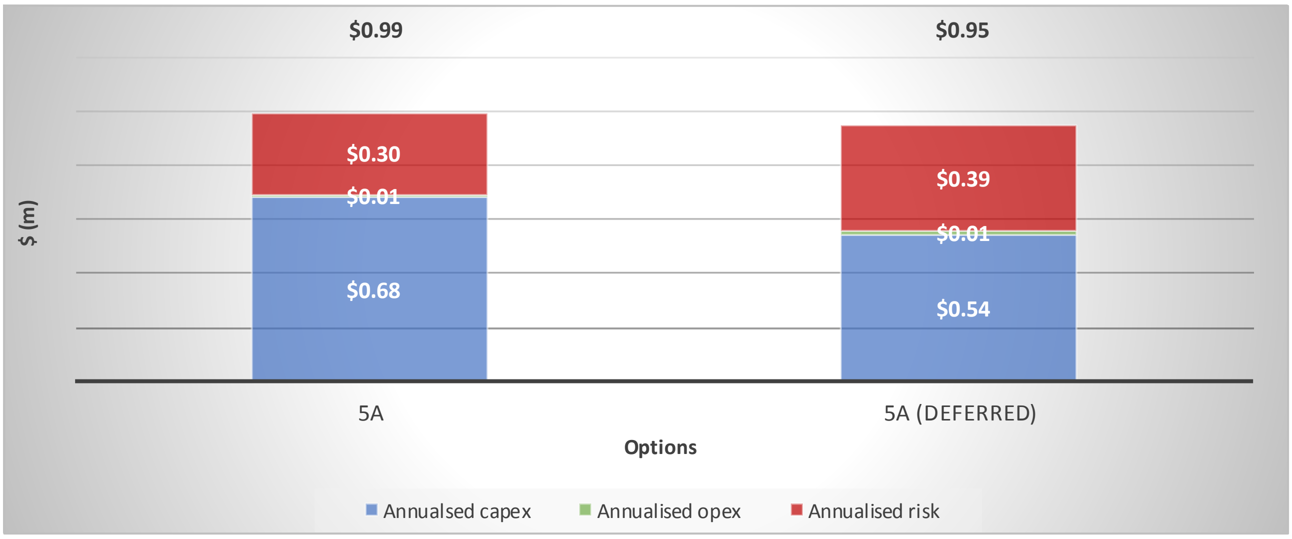
- Option 1: Continued maintenance and monitoring
- Option 2: Non-network solutions
- Option 3: Life extension of existing assets (refurbishment)
- Option 4: Replacement of existing assets (in-situ)
- Option 5a to 5c: Retirement of existing assets (and transfer of load to nearby substations)

The evaluation demonstrates that Option 5a (Offload ZS PM and ZS E to ZS WG at 11 kV) is the most prudent and efficient solution to manage the issues summarised above. This assessment is based on the evaluation of Direct Cost (capital expenditure (capex) + operating expenditure (opex)) and risk cost, and comparative advantages and disadvantages. The implementation plan for the preferred option shows that the optimal Net Present Value (NPV) occurs when implementation of the preferred option is deferred to 2024.

Option 5a Advantages	
✓	It is the lowest capex solution.
✓	It addresses the risk profile associated with Option 1 (following implementation in 2024).
✓	It has a lower capex than Option 5c (which is a similar solution but retains the 6.6 kV distribution voltage) due to less assets required at 11 kV compared to 6.6 kV.
✓	The option reduces network security, but this risk is partially mitigated at 11 kV due to the ability to reconfigure the network to restore power.
✓	The option overcomes identified issues in relation to good electricity industry practice.

The figure below compares the annualised costs for the preferred option if implemented immediately and if deferred to an optimal implementation timing of 2024.

Deferring the investment discounts the annualised capex spend for Option 5a from \$0.68m to \$0.54m based on a real discount rate of 3.06%, equivalent to CitiPower's real weighted average cost of capital (WACC). This requires continuing with Option 1 (continued maintenance and monitoring) and accumulating associated risk through to 2024. The total annualised cost for implementing the optimal solution in 2024 is \$0.95m, versus \$0.99m for implementing the option in 2018.



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1. Background

1.1 Purpose

The Port Melbourne area of CitiPower's network is supplied by Fisherman's Bend Terminal Substation (FBTS). FBTS is located to the west to the Melbourne CBD and supplies ten Zone Substations (ZS) which then distribute power through the local areas of Port Melbourne, South Melbourne, South Bank, Albert Park and part of St Kilda Road.

Concerns relating to two of the ZSs in the area, Fisherman's Bend (E) and Port Melbourne (PM), have triggered a strategic options evaluation for the Port Melbourne area. These two ZSs have ageing assets that which present an increasing risk to the operation of the network as well as safety of workers and the community. The increasing risk profile warrants an investigation to identify and evaluate options for the management of these assets.

The purpose of this document is to summarise the strategic options evaluation that has been undertaken, and outline the preferred option to meet forecast consumer demand for electrical power throughout the Port Melbourne area.

1.2 Background

GHD has been engaged by CitiPower to undertake this strategic options evaluation for the Port Melbourne area. The report has been developed collaboratively with relevant personnel from CitiPower.

GHD personnel worked closely with personnel from CitiPower's Network Planning group, to understand issues relevant to the evaluation. GHD met with personnel from Network Planning, Asset Management, Network Operations and Network Services to gain a stronger understanding of the issues.

Two workshops were held with relevant representatives participating from each of the above groups:

- Issues Workshop: The first workshop focussed on understanding the issues associated with the assets of concern. Workshop participants produced a collective definition of why the risk profile of the assets warrants a detailed investigation and options evaluation.
- Options Workshop: The second workshop focussed on identifying the full range of potential options to meet forecast consumer demand for electrical power throughout the Port Melbourne area. Workshop participants produced a collective definition of the credible options that should be investigated in detail.

Following the on-site explorative activities GHD sourced information from CitiPower required to undertake detailed investigation and analysis, and develop the strategic options evaluation.

1.3 Scope

The scope of this report relates to ZSs E and PM, and includes:

- Background (Section 1): Description of the historical development and current status of the Port Melbourne area in general, and how this compares to "good electricity industry practice".
- Identified need (Section 2): Detailed articulation of the issues and risk profile associated with the assets of concern (initially defined through the Issues Workshop outlined in Section 1.2).

- Options (Section 3): Detailed investigation into the credible options to meet forecast consumer demand for electrical power throughout the Port Melbourne area. These were initially established through the Options Workshop outlined in Section 1.2 as follows:
    - Continued maintenance and monitoring (Section 3.1)
    - Non-network solutions (Section 3.2)
    - Life extension of existing assets (Section 3.3)
    - Replacement of existing assets (in-situ) (Section 3.4)
    - Retirement of existing assets (Section 3.5)
- Preferred Option (Section 4): Comparative evaluation of options to identify the preferred option.

1.4 Assumptions

The following assumptions have been applied in developing the strategic options evaluation (based on the collaborative process described in Section 1.2):

- ZS E supplies relatively small load of 4 MVA and the maximum demand is forecast to decrease. The ZS E site is located adjacent to ZS WG site and can easily be electrically connected allowing ZS WG to take up ZS E load. Subsequently, our economic benefits / risk analyses has excludes probabilities of failure of ZS E assets; because the risk profile is relatively low, set to decrease, and can be readily transferred. This means that all risk analyses can be considered as conservative.
- The distribution networks downstream of ZSs E and PM operate at 6.6 kV. We have assumed that these assets are 11 kV rated and will not need to be replaced in the options where the operating voltage is increased to 11 kV.
- Distribution Substations (DS) are an exception to the above assumption. We understand that a portion of the DSs operating at 6.6 kV are “dual-wound” meaning they are “11 kV ready”, whereas a portion that are not dual-wound will need to be replaced where the operating voltage is increased to 11 kV. A survey has been undertaken on a sample of the DS population, and the survey identified a percentage of 11 kV ready DSs.

  We have assumed that the percentage of 11 kV ready DSs within the survey sample is representative of the 11 kV DSs across CitiPower’s 6.6 kV network assets i.e. in the options where the operating voltage is increased to 11 kV we have applied the 11 kV ready percentage from the survey sample to ascertain the number of DSs that would need to be replaced.
- The economic analysis for the options evaluation assumes a 50 year service life for all network options (30 years for non-network – Option 2) and applies a real Weighted Average Cost of Capital (WACC) of 3.06%. This is consistent with the regulated WACC.

1.5 Port Melbourne electricity distribution network

1.5.1 Development of the Port Melbourne / Fisherman’s Bend area

The Port Melbourne / Fisherman’s Bend area has historically been supplied by a combination of two operating voltages: 66 kV sub-transmission and 6.6 kV distribution; and 66 kV sub-transmission and 11 kV distribution.

The different operating voltages are a result of evolving industry practice; where 6.6 kV is a historic approach. The higher operating voltage at 11 kV has been adopted as the modern industry approach as it provides for a more efficient supply of power to a greater population density (and associated electrical demand density). The Port Melbourne / Fisherman's Bend area is now mostly operating at 11 kV distribution; however, pockets of 6.6 kV remain which are supplied by ZS PM and E.

The Port Melbourne / Fisherman's Bend area has been gentrifying from industrial and low density residential (suburban) to commercial and high density residential (apartment buildings), and the outlook for the area is for this trend to continue. The Australian Energy Market Operator's (AEMO) "Transmission Connection Point Forecasts" show Fisherman's Bend amongst the highest growth area in Victoria, with annual winter growth rates of around 3%[1]. This trend suggests that a 66 kV / 11 kV operating voltage is better suited for the area than a 66 kV / 6.6 kV operating voltage philosophy.

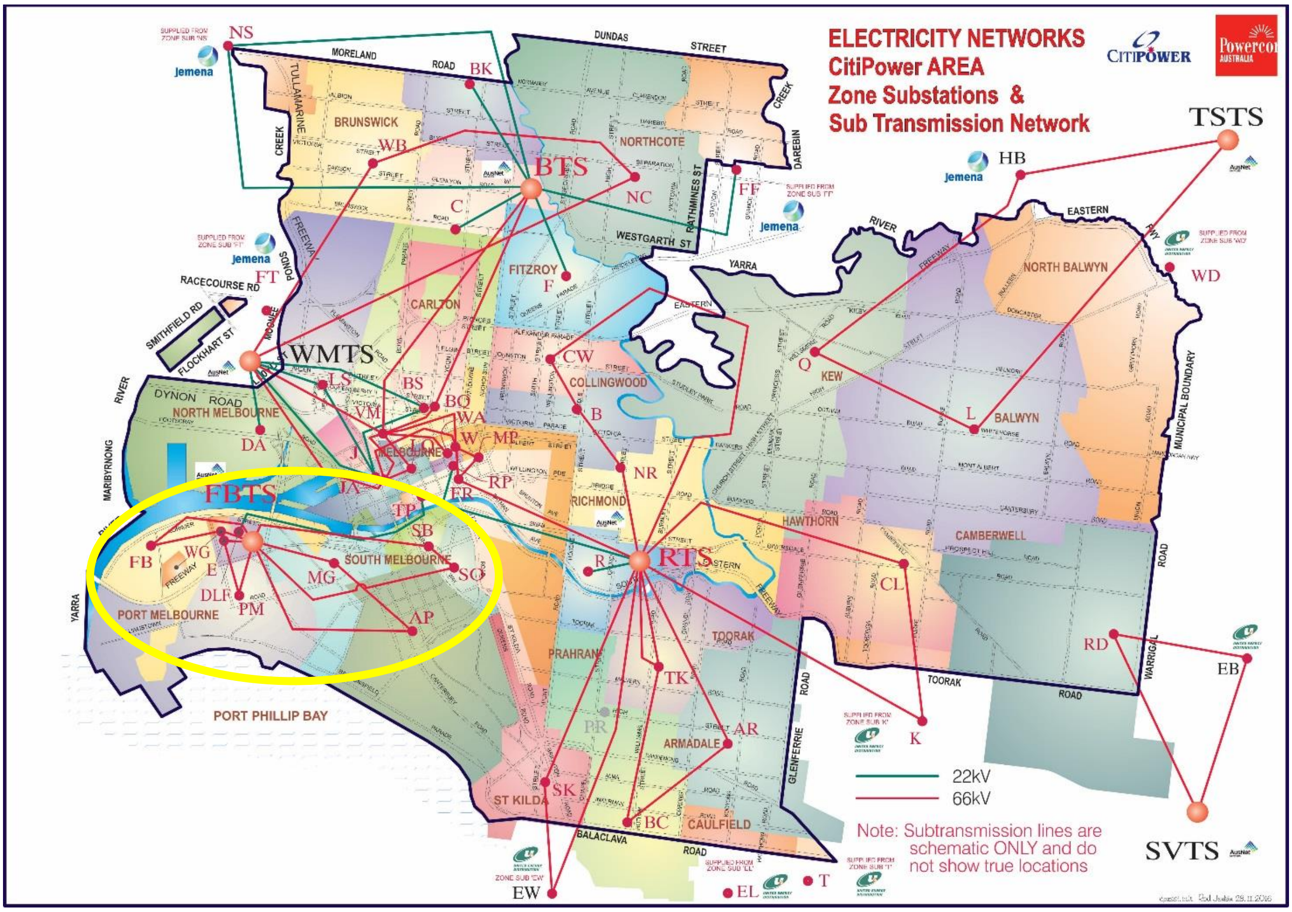
Another consequence of having two different operating voltages is that the area is supplied by "islanded" networks which can't be operationally interconnected. This constrains the ability to reconfigure the network to restore supply during power outages (i.e. customers on the 6.6 kV network cannot be supplied by adjacent 11 kV feeders during outage events).

Practices relating to the use of 6.6 kV distribution within the National Electricity Market (NEM) is discussed in further detail in Section 1.5.3.

The sub-transmission network for the Port Melbourne / Fisherman's Bend area is encircled in yellow in the below map. It is noted that Docklands (DLF) substation operates at 66/22 kV and supplies 22 kV sub-transmission to ZS TP and distribution to a few commercial and high-voltage (HV) customers.

[1] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Transmission-Connection-Point-Forecasting/Victoria

Figure 1: Map of CitiPower sub-transmission network with Port Melbourne encircled in yellow



1.5.2 Overview of assets in Port Melbourne (PM) Fisherman's Bend (E) substations

Table 1 provides an overview of assets in ZS PM and E substations. Condition issues associated with these assets are discussed in Section 1.5.3, and the associated risk profile is discussed throughout Section 2.

Table 1: Overview of ZS PM and E assets

Items	Port Melbourne (PM)	Fisherman's Bend (E)
Voltage	66 kV / 6.6 kV	66 kV / 6.6 kV
Capacity / Max. Demand (MVA)	30 / 18	34 / 4 (limited by TX cables)
Transformers	3 x 10 MVA	2 x 10 MVA 1 x 20 MVA
Sub-transmission feeders	2	2
2ndary feeders	12	9
11 kV ready DSs	30%	30%
Capacity comments	• Demand is below firm rating (N-1).	• Load at E is only 4 MVA and forecast to decrease.

1.5.3 Summary of asset condition issues in Port Melbourne (PM) Fisherman's Bend (E) substations

The Port Melbourne (PM) Fisherman's Bend (E) Zone Substations were constructed nearly sixty years ago, prior to the development of contemporary design standards. In addition to the deteriorating condition of the electrical infrastructure, the civil infrastructure on site is deteriorating in condition. Primary plant at ZS PM and E are also approaching end-of-life and have high probability-of-failure (PoF) that will continue to increase (including transformers and secondary switchboards equipped with around ten individual circuit breakers).

Transformers:

- Port Melbourne (PM): Port Melbourne has three transformers – all three have exceeded their nominal lifespan (55, 57 and 58 years old). One of the transformers has now been decommissioned and the other two have deteriorated in condition and are approaching end-of-life.
- Fisherman's Bend (E): Fisherman's Bend has two transformers – both have exceeded their nominal lifespan (54 and 58 years old). Both have deteriorated in condition and are approaching end-of-life.

Switchboards:

- Port Melbourne (PM): Port Melbourne has an Email HQ and an Email LC switchboard (both are 56 years old).

  Switchboards of this vintage do not meet modern design standards and are not arc fault contained or vented. This means that an arc-fault is more likely to result in explosive failure than would be the case with modern arc suppressed switchboards. As such, in addition to operational risks, the deteriorating condition presents a significant safety risk to personnel entering the substation.

  In addition to the above:

  – The Email LC switchboard has asbestos filled secondary cable trunks. Deterioration in the mechanical protection has exposed the asbestos, which has been temporarily secured by taping over the flexible cable trunks.
  – The SECV HQ compound filled switched board has reported compound leaks. There is no agreed effective maintenance for this type of defect (leaking pitch).

  Maintenance personnel enter the substation more often than is typical for such substations due the general deterioration of site infrastructure and ongoing testing and monitoring of the switchboard.

- Fisherman's Bend (E): Fisherman's Bend has an Email J18 that is 53 years old. The switchboard has deteriorated in condition and is approaching end-of-life.

General site infrastructure:

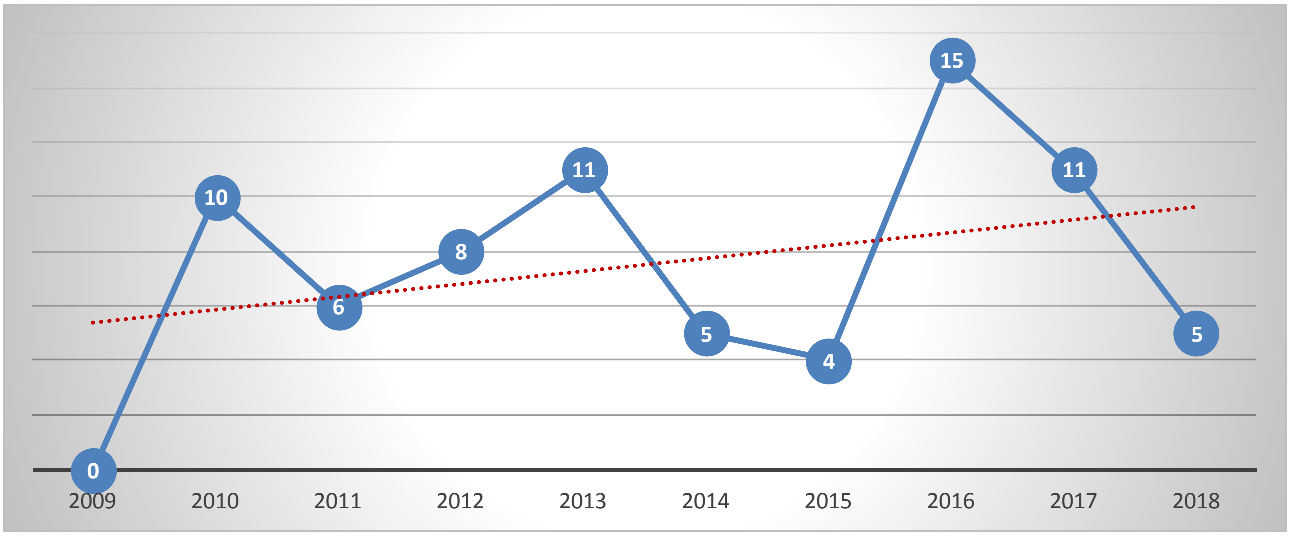
The observable condition issues are also apparent in defect rates for equipment at ZS PM and ZS E. For example:

- The two 66 kV circuit breakers at ZS PM have reached end-of-life and currently scheduled for piecemeal replacement. These circuit breakers have known failure issues and are the only two remaining on CitiPower's network.
- Both capacitor banks are out of service due to deteriorated conditions and cable ratings.

Figure 2 demonstrates an increasing trend in defect rates. This trend is expected to continue despite a major maintenance intervention in 2016. The defects are spread across all site infrastructure. The increasing trend in defect rates illustrates the increasing risk profile for ZS PM and ZSE, which is not confined to the advanced deterioration of the transformers and switchboards.

The deterioration of site infrastructure presents operational risks and maintenance costs. Of particular concern is that the increased maintenance burden exposes personnel to safety risks associated with being in the vicinity of the transformers and switchboards which are at heightened risk of catastrophic failure (and do not meet modern design standards to safeguard against explosive failure).

Figure 2: Number of defects at ZS PM and ZS E



1.6 Overview of 6.6 kV distribution trends in the NEM

The NEM operates using a power systems model of bulk base-load generation (coal fired), peak demand generation (gas fired), and distributed renewable generation. All of these generation sources are developed remote from urban areas, with power then transmitted and distributed to consumers. High voltages are used to transmit and distribute electricity as this is more efficient, both in terms of reduced losses and a lower quantum of assets required to transfer power.

A notable exception to the above is embedded rooftop solar photovoltaic (SPV) panels. Rooftop SPV reduces the demand seen by the network, but does not (and will not in the foreseeable future) negate the need for electricity transmission and distribution. Hence, transmission and distribution will continue to be required as the NEM transitions away from bulk coal fired generation to distributed renewable generation and storage.

The NEM model described above is substantially different to when Australia's electricity networks were first established. Historically, electricity was supplied by local small-scale fossil-fuel fired generators, which was then distributed throughout local council areas. Demand density at this time was incomparably lower than it is today, and therefore, lower distribution voltages were an efficient means of power distribution.

Hence, CitiPower's distribution network was established at 6.6 kV, which was standard practice at the time of development. As generation sources were removed from urban centres, 22 kV sub-transmission was installed to transfer power to local areas.

As maximum demand and demand density increased, transmission and distribution voltages have also increased throughout the NEM to facilitate more efficient electricity supply. Throughout this period, the majority of CitiPower's network has been converted from 22/6.6 kV to 66/11 kV, which is standard practice across the NEM for central city areas.

CitiPower's Brunswick and Port Melbourne areas are the last remaining localities continuing to operate using the 6.6 kV distribution voltage. A large proportion of these assets were installed over 80 years ago or more, have exceeded their nominal lifespan, and are deteriorating in condition.

The 6.6 kV assets are comprised of outdated technologies and installation practices that are more prone to failure than modern equivalent assets e.g. paper insulated cables and directly buried underground. The increased risk of failure is compounded by the 6.6.kV networks being "islanded" from the adjacent 11 kV network. The islanding means that customers on the 6.6 kV network cannot be supplied by adjacent 11 kV feeders during outage events.

The issues described above are not unique to CitiPower. Distribution Network Service Providers (DNSP) throughout the NEM have been replacing their 6.6 kV networks with modern equivalent networks as they reach end-of-life (e.g. 11 kV XLPE insulation cable installed conduit and overlayed with protection tape). Figure 3 shows the progressive retirement of 6.6 kV assets at DNSPs throughout the NEM.

Figure 3 Progressive retirement of 6.6 kV (or 5 kV) distribution assets across the NEM

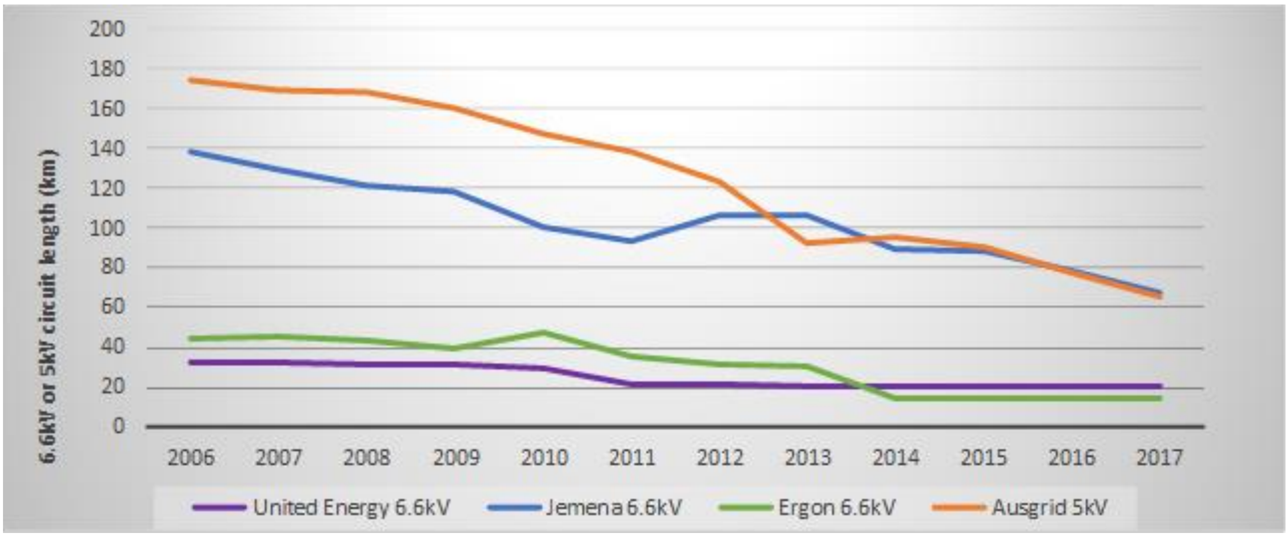
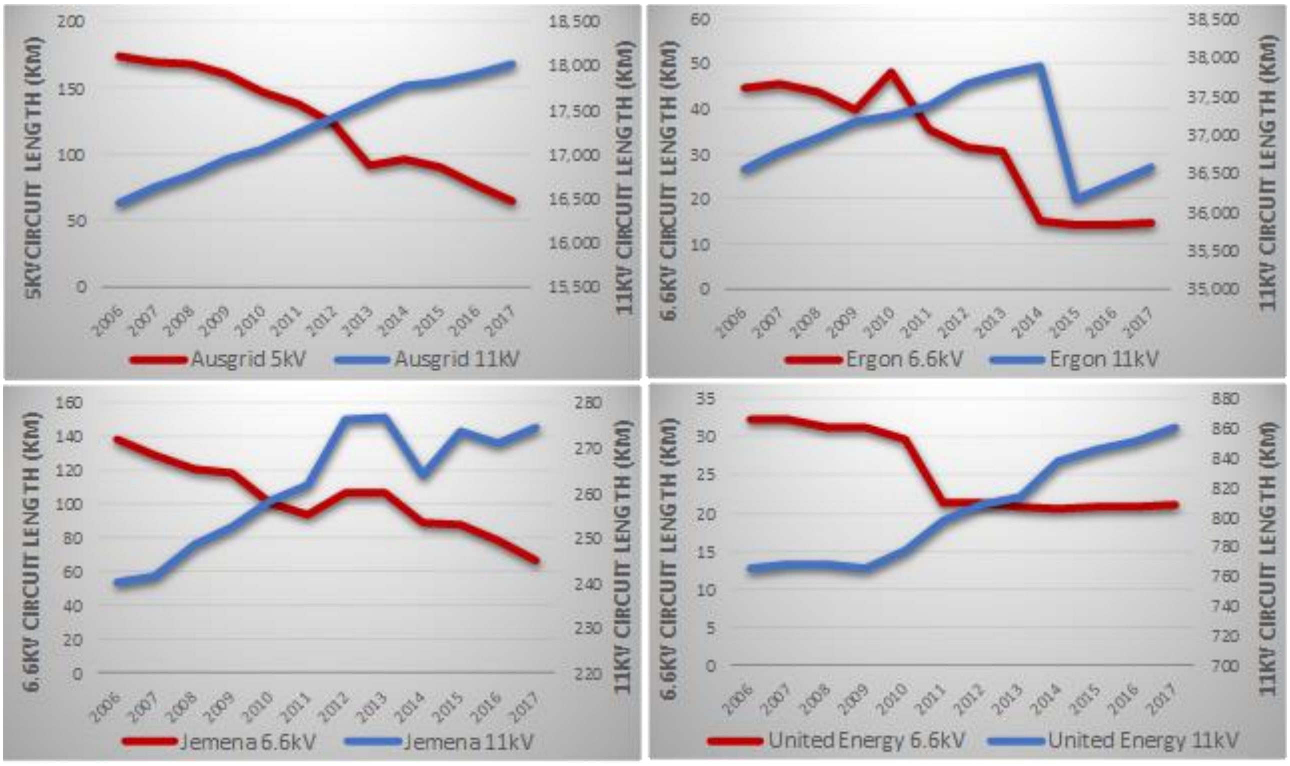


Figure 4 compares quantities of 6.6 kV versus 11 kV assets. It indicates that DNSPs are generally retiring their 6.6 kV assets and replacing them with modern equivalent 11 kV assets.

Figure 4: Volumes of 6.6 kV (or 5 kV) vs. 11 kV distribution assets across the NEM



1.7 "Good Electricity Industry Practice"

The National Electricity Rules (NER) define 'Good Electricity Industry Practice' as shown below. In effect, the definition suggests that CitiPower can look to peer Network Service Provider (NSP) practices as a baseline indicator for good practice.

> ***good electricity industry practice***
>
> The exercise of that degree of skill, diligence, prudence and foresight that reasonably would be expected from a significant proportion of operators of *facilities* forming part of the *power system* for the *generation*, *transmission* or *supply* of electricity under conditions comparable to those applicable to the relevant *facility* consistent with *applicable regulatory instruments*, *reliability*, safety and environmental protection. The determination of comparable conditions is to take into account factors such as the relative size, duty, age and technological status of the relevant *facility* and the *applicable regulatory instruments*.

(Source: National Electricity Rules Version 111)

In the context of a strategic options evaluation for the Port Melbourne area, good practice can be interpreted as follows:

- An asset's likelihood of failure increases as it deteriorates with age. These assets present an increasing risk to the operation of the network, and safety of workers and the community. An NSP would be expected to exercise skill, diligence, prudence and foresight to:

- Progressively retire such assets in view of the risk that they present;
- Where appropriate, replace non-standard and obsolete assets with modern equivalent assets of standard specifications; and
- In doing so, seek an enhanced operational and safety risk profile than originally existed through the application of efficiency frontier asset management practice.

- Specific issues in the Port Melbourne area relating to outdated or obsolete industry practices include:
  - As discussed in Sections 1.5.1 and 1.5.3, the use of 6.6 kV assets is a non-standard practice. When these networks were first established each council area used local diesel generation to supply the area; where 6.6 kV networks were established based on the diesel generator output voltage. 11 kV has since been established as standard distribution voltage as it distributes power more efficiently, using similar size assets but requiring less assets to perform the same task. CitiPower's comparable peers have been observed to be retiring their 6.6 kV assets.

    This suggests that, when the risk profile warrants retirement of 6.6 kV assets, good electricity industry practice would preference transitioning to 11 kV distribution approach rather than continuing with the legacy 6.6 kV distribution.

    It is understood that current project underway will leave the Port Melbourne area as one of only two remaining pockets of 6.6 kV network on CitiPower's network (the other being the Brunswick area).
  - Bitumen-compound insulated secondary switchboards that house bulk-oil circuit breakers are obsolete, and manufacturers no longer produce or support them. Modern equivalents use vacuum or SF6 CB panels installed indoor in switch rooms at distribution voltage levels. Modern panels are designed with "arc fault" containment systems, which makes them inherently are safer. They are also more efficient (cost and space), with advanced communication and measurement capabilities.

    This suggests that, when the risk profile warrants retirement of bitumen-compound and oil-filled assets, good electricity industry practice would preference transitioning to modern equivalent assets (e.g. vacuum or SF6 insulated).

2. Identified need

The identified need is to efficiently meet forecast consumer demand for electrical power throughout the Port Melbourne area. The issues and risks associated with meeting this need are discussed in Sections 2.1 and 2.2.

2.1 Issues summary

The key issues for the Port Melbourne area are summarised as follows:

- **Ageing assets:** Primary plant at ZS PM and E are ageing[2] and have high probability-of-failure (PoF) that will continue to increase (including transformers and secondary switchboards equipped with around ten individual circuit breakers). General site infrastructure is also deteriorating in condition.
- **Disruptive failures:** A disruptive failure of any of these assets presents a significant risk to supply availability to inner suburbs of Melbourne city.
- **Catastrophic failures:** Of particular concern, is that assets of this vintage are relatively susceptible to catastrophic failure:
  - A catastrophic failure of any of the assets can result in complete loss of supply to the inner suburbs of Melbourne that are supplied by these substations. Emergency diesel generators would be required for up to three months to restore power.
  - Upon catastrophic failure, bulk-oil and bitumen-compound insulated assets are purported to be relatively susceptible to failing explosively compared with modern equivalents, which increases the safety risks associated with them.
  - A catastrophic failure of bulk-oil insulated assets will cause it to release its tank of oil, which will contaminate the land if containment systems fail (which would likely be damaged by an explosive failure).

  The increased maintenance burden associated with these sites increases the exposure of maintenance personnel to safety risks associated with catastrophic failures.
- **Construction constraints:** The PM and E substations were constructed prior to the development of contemporary design standards. Further, the civil infrastructure on site is deteriorating in condition. These sites are located in Melbourne's inner suburbs and are space constrained, both internally and in relation to access surrounding the sites. This constrains the ability for piecemeal construction or rebuilding the sites whilst they remain in operation; and attract relatively higher costs, and safety and operational risks.
- **Good electricity industry practice:** The PM and E substations operate using a 6.6 kV distribution voltage, which is an outdated and sub-optimal industry practice (Refer to Section 1.5.3). Piecemeal renewal of assets at end-of-life would extend outdated business practices over the service life of the new assets (over 50 years).

2.2 Risk profile

There are varying consequences for each asset failure mode across different types of assets. CitiPower broadly categorises consequences as "Minor", "Disruptive" or "Catastrophic", and assigns an associated PoF for each category.

Minor failures result in a higher level of defect rectification. CitiPower reports that substations containing assets with a low rate of minor failures cost $4,000 per annum in routine maintenance, whereas those housing assets of deteriorating condition with high minor failure rates cost around $12,000 per annum.

The average cost when an asset failure occurs at ZS PM[3] is shown in Table 2. The table includes Consequence of Failure (CoF) applied in the economic analysis for the different options. It captures the

[2] Primary plant at ZS PM and E is approaching 60 years in service.

[3] Note that a conservative assumption has been made to exclude ZS E from the risk profiling analysis due to its low and decreasing demand profile (refer to assumptions in Section 1.4)

quantifiable consequences for credible failure modes associated with the power and voltage transformers, circuit breakers, and sub-transmission supply. It does not capture a comprehensive build of all possible consequences for all assets and failure modes.

Table 2: Average cost when an asset failure occurs at ZS PM (Consequence of Failure – CoF)

Items	Disruptive	Catastrophic	Comments
Reliability	$0.03m	$22m	• Applies the Value of Customer Reliability (VCR) as per the Australian Energy Market Operator (AEMO), using the average for CitiPower's network. • Disruptive failures assume that power will be lost to a single feeder for a period for 2 hours (for feeder CBs only). • Catastrophic failure assumes entire substation load will be lost for three days until it can be restored using emergency diesel generators.
Safety	-	$0.1m	• Assumes a fatality occurs for 1% of catastrophic failures, based on substation entry analysis.
Environment	$0.3m	$1.2m	• Assumes soil contamination rectification costs for bulk-oil assets.
Opex	-	$28m	• Assumes diesel generator running costs. • Assumes diesel generators required for a period of four weeks for a catastrophic transformer failure and a period for ten weeks for a catastrophic switchboard failure.
Capex	$2.3m	$4.2m	• Costs of unplanned asset replacement applies regular asset unit rates, as well emergency substation construction and fire damage costs.
TOTAL	**$2.6m**	**$55m**	

CitiPower has developed Condition Based Risk Management (CBRM) modelling for its transformer (TX) and circuit-breaker switchboard (SB) populations. The aggregate PoFs shows that, based on CitiPower's network data, over the next 12 months:

- There is a 6.6% likelihood of incurring a $2.6m cost based on the average consequence of a disruptive failure; and
- There is a 0.2% likelihood of incurring a $55m cost based on the average consequence of a consequence of failure.

3. Options

The issues relating to construction constraints and good electricity industry practice (discussed in Sections 1.5, 1.6 and 1.7, and unpacked in further detail throughout Sections 2) have given rise to an options evaluation for the Port Melbourne area that is broader than business-as-usual piecemeal replacement of these assets.

These credible options that have been evaluated in detail include:

- Option 1: Continued maintenance and monitoring (Section 3.1)
- Option 2: Non-network solutions (Section 3.2)
- Option 3: Life extension of existing assets (refurbishment) (Section 3.3)
- Option 4: Replacement of existing assets (in-situ) (Section 3.4)
- Option 5a to 5c: Retirement of existing assets (and transfer of load to nearby substations) (Section 3.5)

3.1 Option 1: Continued maintenance and monitoring

This option involves continuing the business-as-usual annual inspection and routine maintenance practices in ZS PM and ZS E.

The option has been analysed based on its associated direct costs (capex + opex) and risk costs (PoF × CoF); each of these are discussed in Table 3.

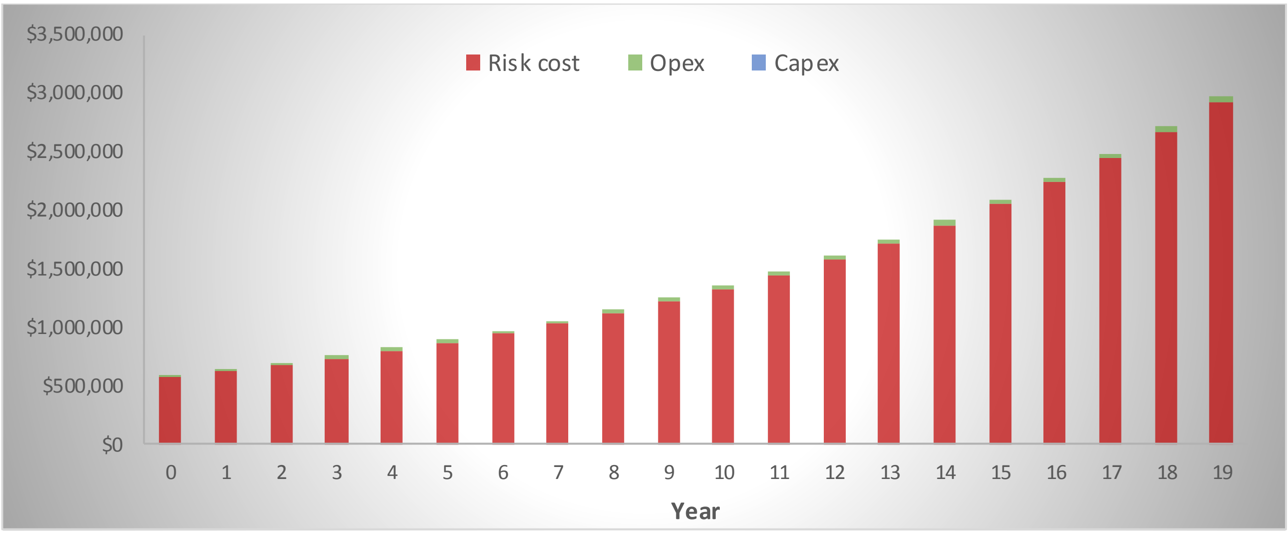
Table 3: Cost breakdown summary for Option 1

Cost category	Description
Capex	There is no planned capital expenditure (capex) associated with this option.
Opex	Due to the ageing assets and civil infrastructure, the cost for undertaking these activities at ZS PM and E is relatively high compared to CitiPower's other substations. The operational expenditure (opex) costs are around \$24k combined for ZS PM and ZS E each year, versus an average of around \$4k each year for other CitiPower substations. These opex costs continue increasing as the substation assets and civil infrastructure continue to deteriorate.
Risk costs	The increasing opex costs for defect maintenance are immaterial in relation to the costs that would be incurred should a disruptive or catastrophic asset failure occur (as discussed in Section 2.2). The total risk cost is calculated by applying the individual PoFs to the individual CoFs and summating the total. Presently, the annual risk cost carried by CitiPower by continuing the business-as-usual annual inspection and routine maintenance practices in ZS BK and ZS F is \$571k. These risk costs continue increasing as the substation assets and civil infrastructure continue to deteriorate (and the associated PoFs continue increasing).

Figure 5 shows the real cash flows for the option over the next 20 years. It illustrates the impact of the increasing risk profile for the option. As discussed in Section 2.2, the risk cost considers quantifiable consequences for credible failure modes and does not capture a comprehensive build of all possible consequences for all assets and failure modes.

Notably, only the PoFs are escalated over time, and the CoFs are not escalated. The reliability and opex items make up the greatest contribution to consequence of failure costs. The CoFs have not been escalated as this would require a range of potentially speculative economic analyses. However, it is noted that the impact of these categories would be expected to increase with demand profiles and increases in the cost of diesel, neither of which not factored into the analysis. As such, the assessment of risk costs is considered conservative.

Figure 5: Real cost cash flows for Option 1



3.2 Option 2: Non-network solutions

This option involves solutions that do not require investment in network assets to meet consumer demand for electrical power throughout the Port Melbourne area going forwards.[4]

The non-network solution considered includes retiring ZS PM and ZS E, and supplying their remaining loads using a portfolio of different technologies. The option has considered:

- **Operational initiatives** (i.e. transfer of demand to alternate network assets): We have assumed that the network can be reconfigured such that 20% of the load can be transferred to adjacent feeders supplied from neighbouring Zone Substations.
- **Demand management** (i.e. measures to reduce demand and consumption): We have assumed that demand management initiatives can be implemented such that peak demand can be reduced by 10%.
- **Embedded generation and storage** (i.e. alternate means of electricity supply to using network assets): We have assumed that embedded generation and storage will cater for the remaining 70% of demand.

The option has been analysed based on its associated direct costs (capex + opex) and risk costs (PoF × CoF); each of these are discussed in Table 4. Note the cost estimates do not include any costs associated with network reconfiguration or demand management initiatives.

Table 4: Cost breakdown summary for Option 2

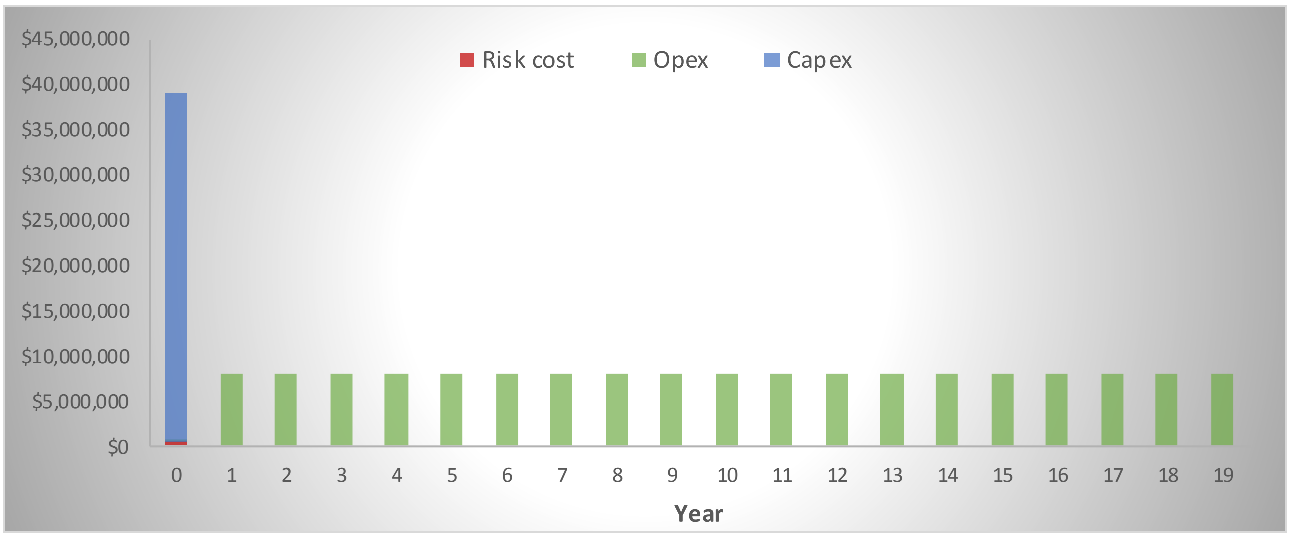
Cost category	Description
Capex	The solution includes a combination of local diesel generation complimented with local Solar Photovoltaic (SPV) generation and battery storage. The capex cost estimate includes the cost

[4] We note that CitiPower will be required to seek proposals from the market in relation to non-network solutions as part of the RIT-D process. Notwithstanding, the costs for the provision of non-network solution in full have been estimated for option analysis in this area plan. This should allow CitiPower to appreciate the scope of non-network solution required and the associated costs.

Cost category	Description
	of diesel generators, solar panels, batteries and inverters. No other related infrastructure is included. The total cost of installing this infrastructure is estimated at $39m (based on a unit price build of $2.5m per MVA and a requirement for 15.4MVA of remaining maximum demand for both ZS PM and ZS E). The capex assumes that the existing substation sites would house the equipment and hence does not include any costs to decommission the existing substations and remediate the sites. As a price check, large scale solar projects supported by the Australian Renewable Energy Agency (ARENA) show total project costs of around $45m for a 20 MW solar farm[5]. Similar scale developments within Melbourne's inner suburbs would be expected to incur higher costs.
Opex	Operational costs have been estimated for running the diesel generation at $8 m per annum. This allows for diesel generators supplying 35% of the total energy and running for 12 hours each day at $1.5 per litre of diesel. As per Option 1, increasing demand profiles have not been factored into the analysis.
Risk costs	Risk costs have not been estimated for the non-network solution. The risk cost for Option 1 ($571 k) applies in year zero only (until the non-network solution can be implemented). No value for risk is captured once the non-network solution is implemented.

Figure 6 shows the real cash flows for the option over the next 20 years.

Figure 6: Real cost cash flows for Option 2



3.3 Option 3: Life extension of existing assets

This option involves undertaking refurbishment projects to extend the life of ZS PM and ZS E. This would target high risk assets and seek to reduce the probability or consequence of asset failures. For example,

[5] https://arena.gov.au/funding/programs/advancing-renewables-program/large-scale-solar-photovoltaics-competitive-round/

targeted renewals of asset items (e.g. transformer oil, tap changers or cooling systems) to reduce the associated risk and defer the retirement of the assets.

CitiPower has advised that it has already exhausted all possible options to extend the life of ZS PM and ZS E. Based on this advice the option is considered not credible and has not been investigated further. Piecemeal replacement options are considered in Option 4 (Section 3.4).

This option would perpetuate the issues relating to sub-standard construction and non-conformance with good electricity industry practice discussed in Section 2.1.

3.4 Option 4: Replacement of existing assets (in-situ)

This option involves in-situ rebuild of the ZS PM and WG (in place of ZS E as it is an adjacent site), including the replacement of primary plant and secondary systems. The existing 6.6 kV distribution network would remain in service. This would require the temporary offload of ZS PM and E while the works are completed.

This option was originally considered as a piecemeal replacement of end-of-life assets. However, upon developing this option it became apparent that piecemeal replacement would be unfeasible. This is because a significant proportion of assets approaching end-of-life. Consequently, offloading and significant construction works would be required to replace assets. Retaining ageing assets on-site that are approaching end-of-life would mean that subsequent offloading and significant construction projects would be required again in the near future to replace these assets. Hence, a piecemeal replacement approach would result in substantially higher overall costs to manage the site and also attract a significantly higher risk profile.

Given both ZS PM and ZS E are situated in highly populated areas with restrictive space for construction activities, heavy vehicle traffic, and certain requirements and expectations from the local council and community (for e.g. working hours), the actual delivery of this option is challenging. This involves complex construction method, logistics planning, project organisation and switch-over scheduling. Due to space constraints at ZS PM, the only in situ rebuild option involves offload first to allow the rebuild to happen while supplying the existing load. This difficulty has been captured in the capital cost estimate.

This option would perpetuate the issues relating to sub-standard construction and non-conformance with good electricity industry practice discussed in Section 2.1.

The option has been analysed based on its associated direct costs (capex + opex) and risk costs (PoF × CoF). The following considerations with respect to capex, opex and risk costs have been applied:

- **Capex:** The total capex for this option is estimated at $31m. The scope of capital works required is provided in Table 5.

  This option involves in-situ replacement of primary plant and secondary systems in ZS PM and ZS WG (in place of ZS E as it is an adjacent site), 66 kV feeders from ZS WG to cut into ZS E 66 kV system, and the 6.6 kV reticulation originating from ZS PM and ZS E with modern equivalent assets where required. It is noted that the load in ZS E is small, forecast to decrease and in the future ZS WG is fully capable of picking up the entire load of ZS E. Due to space constraints at ZS PM, the only in situ rebuild option involves offload first to allow the rebuild to happen while supplying the existing load.

Table 5: Scope of capital works for Option 4

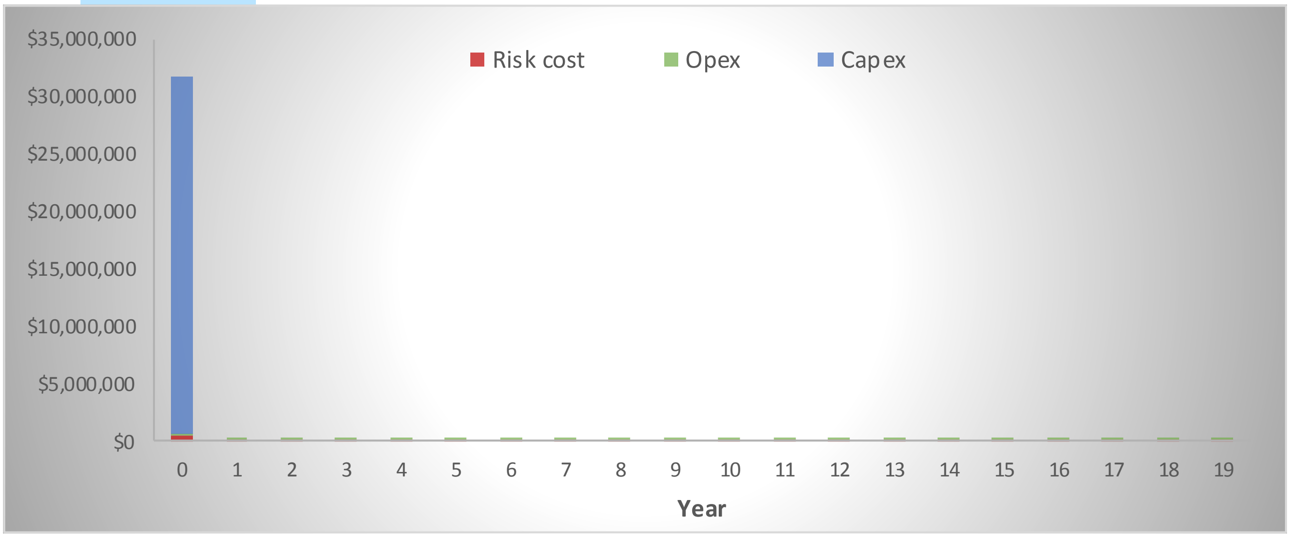
Categories	Asset items	Port Melbourne (PM)	Fisherman's Bend (E)	Westgate (WG)	Comments
Sub-transmission	66 kV overhead lines	-	-	-	Once E is decommissioned, it is expected WG will be cut into E 66 kV system. Overhead infrastructure in WG is not required as E already has 66 kV in site.
Zone substation	Zone substation decommissioning and site remediation (civil works)		1		
	66 kV overhead lines terminations and AIS switch-bay	2			
	66/6.6 kV 10 MVA transformer and associated civil works and secondary systems	3			
	Aux/station transformer	1			
	6.6 kV indoor panels	19			Transformer protection, bus section and feeder protection.
	6.6 kV underground cable terminations	12			
	Civil works for new switch room and control room to house the indoor panels and secondary systems	1			
	Demountable switch room			1	Set up to facilitate temporary offload during replacement.
	Demountable control room			1	Set up to facilitate temporary offload during replacement.
	66 kV AIS complete switch-bay			-	This infrastructure already exists in WG. Therefore using it during the temporary offload duration.
	11 kV indoor panels			15	PM has 19 × 6.6 kV CB panels. Assuming when offloaded to WG it will be 15 × 11 kV CB panels Transformer protection, bus section and feeder protection.
	11 kV underground termination			8	
Distribution	11 kV underground cable			4.0 km	8 new feeders, 500 m each to provide temporary offload solution during the replacement project duration.
	11/0.4 kV step-down distribution transformer			38	60 distribution txs. Assuming same proportion are dual wound as in Brunswick. This is to provide temporary offload solution during the replacement project duration.

Categories	Asset items	Port Melbourne (PM)	Fisherman's Bend (E)	Westgate (WG)	Comments
	11 kV RMUs			8	Assuming RMU has to be provided if distribution transformers are required for the temporary offload solution during the replacement project duration.
	6.6 kV underground cable	2.4km	0.6km		12 feeders at ZS PM. Allowing 200 m each to connect new switchboard. 2 feeders from existing 11 kV ZS WG spare breakers (note: E and WG are in adjacent sites)
	6.6 kV step-down distribution transformers		4		6 distribution transformers connected to E feeders. Assuming same proportion are dual wound as in Brunswick area.
	6.6 kV ring main units (RMU)		1		Assuming RMU has to be replaced if distribution transformers are replaced.

- **Opex:** This option would decrease CitiPower's annual costs for routine inspection and maintenance from $24k to $4k combined for ZS PM and ZS E each year. This increases as the assets deteriorate over their projected 50 year lifespan.
- **Risk costs:** Renewing the assets results in a substantial reduction in risk costs. This reduces from $571k in year zero (prior to implementation) to $88k in year one. This difference rapidly increases compared to Option 1 (continued maintenance and monitoring) where the PoFs for deteriorating assets approaching end of life increase exponentially; whereas the PoFs for the renewed assets under this option increase gradually over their 50 year service life.

Figure 7 shows the real cash flows for the option over the next 20 years.

Figure 7: Real cost cash flows for Option 4



3.5 Option 5: Retirement of existing assets

This section considers four separate options for retiring existing assets:

- Option 5a: Offload ZS PM and ZS E to ZS WG at 11 kV
- Option 5b: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 6.6 kV
- Option 5c: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 11 kV

The overview of Port Melbourne area and its electricity distribution system is described in Section 1.5. All the zone substations under consideration in this area plan are supplied by AusNet's FBTS at 66 kV (the 66 kV assets are not approaching end-of-life). ZS PM and ZS E distribute electricity at 6.6 kV and their assets in general are ageing. For example, all the transformers and switchgear in ZS PM are more than 55 years old.

In this evaluation, ZS E is optimised in all options because it supplies very small load which is forecast to decrease. It is also adjacent and connected to ZS WG which can readily take up and accommodate ZS E load.

Although the Docklands (DLF) substation is reasonably suited geographically to accept loads from ZS PM or E it operates using a 22 kV distribution voltage, and operational and space constraints are prohibitive. Subsequently, offloading loads from ZS PM or E to ZS DLF is not considered a credible option and has not been evaluated.

Likewise, although the Montague (MG) substation is a similar distance from ZS PM as ZS FB, geographic obstacles along the route are considered prohibitive. Subsequently, offloading loads from ZS PM or E to ZS MG is not considered a credible option and has not been evaluated.

3.5.1 Option 5a: Offload ZS PM and ZS E to ZS WG at 11 kV

This option involves retiring ZS PM and ZS E from service and transferring both loads to ZS WG, and operating at 66/11 kV voltage levels. This option would address all issues identified in Section 2.

The option enables ZS WG to supply loads of ZS PM and ZS E over an assumed 50 year service life.

Consolidating and optimising the two sites to one will result in a reduced overall asset quantum; however, it also reduces network security i.e. in the event that a catastrophic failure occurs the combined loads of ZS PM, ZS E and ZS WG will be lost.

The option has been analysed based on its associated direct costs (capex + opex) and risk costs (PoF × CoF). The following considerations with respect to capex, opex and risk costs have been applied:

- **Capex:** The total capex for this option is estimated at $17m. This will include decommissioning assets at ZS PM and ZS E, and building a new switch-room in ZS WG to house new assets (the existing ZS WG switch-room has no space to extend and accommodate additional assets). It also involves extending the 66 kV overhead lines from ZS WG to cut in to the supply of ZS PM, and upgrading and extending the 11 kV distribution network from ZS WG to connect to existing feeders supplying the ZS PM loads. The scope of work in this option includes the following assets as shown in Table 6.

Table 6: Scope of capital works for Option 5a

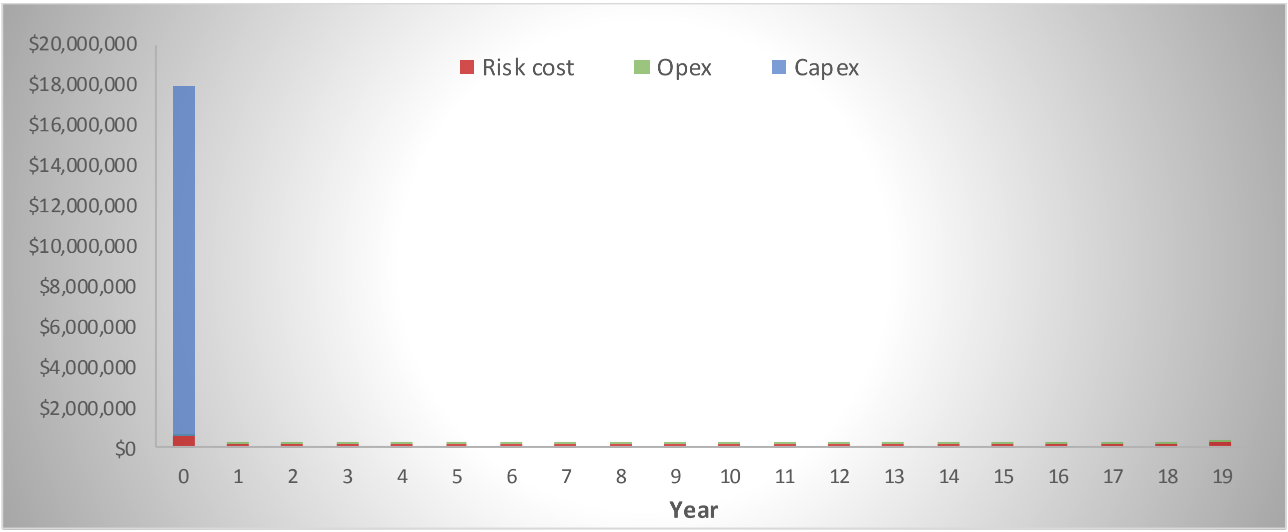
Categories	Asset items	Port Melbourne (PM)	Fisherman's Bend (E)	Westgate (WG)	Comments
Sub-transmission	66 kV overhead lines	-		-	Once E is decommissioned, it is expected WG will be cut into E 66 kV system. Not required as E already has 66 kV in site.
Zone substation	Zone substation decommissioning and site remediation (civil works)	1	1		Note that no remediation is required as ZS E as it is within ZS WG compound.
	In-situ retrofit of existing ZS E (inside ZS WG site) switch room to accommodate new indoor panels and secondary systems (civil works)			1	Using the existing ZS E switch room
	66 kV overhead lines terminations and AIS switchbay			-	This already exists in this site
	66/11 kV 27MVA transformer and associated civil works and secondary systems			1	
	11 kV indoor panels			15	PM presently has 19 × 6.6 kV CB panels. Assuming when offloaded to WG it will be 15 × 11 kV CB panels Transformer protection, bus section and feeder protection.
	11 kV underground cable terminations			8	PM presently has 12 × 6.6 kV feeders. Assuming when offloaded to WG it will be 8 × 11 kV feeders
	11 kV cap bank			2	
Distribution	11 kV underground cable			4 km	8 new feeders - around 500m
	11 kV step-down distribution transformers			38	60 distribution txs. Assuming same proportion are dual wound as in Brunswick
	11 kV RMUs			8	Assuming RMU has to be replaced if distribution transformers are replaced.

- **Opex:** This option would decrease CitiPower's annual costs for routine inspection and maintenance from $24k to $4k combined for ZS PM and ZS E each year. This increases as the assets deteriorate over their projected 50 year lifespan.

- **Risk costs:** Renewing the ZS PM and ZS E assets results in a substantial reduction in asset failure risks but an increase network security risk in the event of a catastrophic failure (with three substation sites being amalgamated into a single site), where the combined load of ZS PM, E and WG will be at risk. However, the reliability risks are reduced by the upgrade to 11 kV, which will allow network reconfigurations to restore supply to faulted feeders. This has a net effect of reducing risk costs from $571k in year zero (prior to implementation) to $158k in year one. This difference rapidly increases compared to Option 1 (continued maintenance and monitoring) where the PoFs for deteriorating assets approaching end of life increase exponentially; whereas the PoFs for the renewed assets under this option increase gradually over their 50 year service life.

Figure 8 shows the real cash flows for the option over the next 20 years.

Figure 8: Real cost cash flows for Option 5a



3.5.2 Option 5b: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 6.6 kV

This option involves retiring ZS PM and ZS E from service and transferring ZS PM to ZS FB and ZS E to ZS WG. The ZS PM loads would continue to be supplied at 6.6 kV whilst ZS E would be supplied at 11 kV.

The option enables ZS FB and ZS WG to supply loads of ZS PM and ZS E over an assumed 50 year service life.

Consolidating and optimising the two sites to one will result in a reduced overall asset quantum; however, it also reduces network security i.e. in the event that a catastrophic failure occurs the combined loads of ZS PM with ZS FB, or ZS E and ZS WG, will be lost.

This option would perpetuate the issues relating to construction and good electricity industry practice discussed in Section 2.1.

The option has been analysed based on its associated direct costs (capex + opex) and risk costs (PoF × CoF). The following considerations with respect to capex, opex and risk costs have been applied:

- **Capex:** The total capex for this option is estimated at $34 m. The option will include decommissioning assets at ZS PM and ZS E and augmenting ZS FB and ZS WG sites to accommodate new modern equivalent assets to supply ZS PM and ZS E loads. This will involve extending the 66 kV overhead lines from ZS WG to cut in to ZS E 66 kV system. This will also involve extending the 6.6 kV distribution network from ZS FB and ZS WG to connect to existing feeders supplying ZS PM and ZS E loads, and if necessary installation of 11/6.6 kV auto transformers downstream of ZS FB and ZS WG. The scope of work in this option includes the following assets as shown in Table 7.

Table 7: Scope of capital works for Option 5b

Categories	Asset items	PM	FB	E	WG	Comments
Sub-transmission	66 kV overhead lines		-		-	Once E is decommissioned, it is expected WG will be cut into E 66 kV system. Not required as E already has 66 kV in site.
Zone substation	Zone substation decommissioning and site remediation (civil works)	1		1		Note that no remediation is required as ZS E as it is within ZS WG compound.
	In-situ extension of existing switch rooms and control rooms in to accommodate new indoor panels and secondary systems (civil works)		1		-	Not required in WG as it can accommodate E load presently.
	66 kV overhead lines terminations and AIS switch-bay		-		-	No need for additional 66 kV switch-bay as explained below.
	66/11 kV 30 MVA transformer and associated civil works and secondary systems		-			FB max demand is 33 MVA. PM max demand is 18 MVA. Assuming they do not have demand diversity, the total will be about 51 MVA. N-1 can be achieved with the existing 3×30 MVA Tx at FB.
	66/11 kV 27 MVA transformer and associated civil works and secondary systems				-	Optimising the transformers when offloading E to WG as it has very small load with decreasing max demand forecast, but still maintaining at N-1 collectively.
	11 kV indoor panels		15		13	Transformer protection, bus section and feeder protection. PM presently has 19×6.6 kV CB panels. Assuming when offloaded to FB it will be 15×11 kV CB panels. E presently has 17×6.6 kV CB panels. Assuming when offloaded to WG it will be 13×11 kV CB panels.
	11 V underground cable terminations		8		4	PM presently has 12×6.6 kV feeders. Assuming when offloaded to FB it will be 8×11 kV feeders. E presently has 10×6.6 kV feeders. Assuming when offloaded to FB it will be 4×11 kV feeders.
	11/6.6 kV auto transformer distribution feeder		8		4	FB has existing 16 outgoing feeders + new ones offloaded from PM. WG has existing 19 outgoing feeders + new ones offloaded from E.

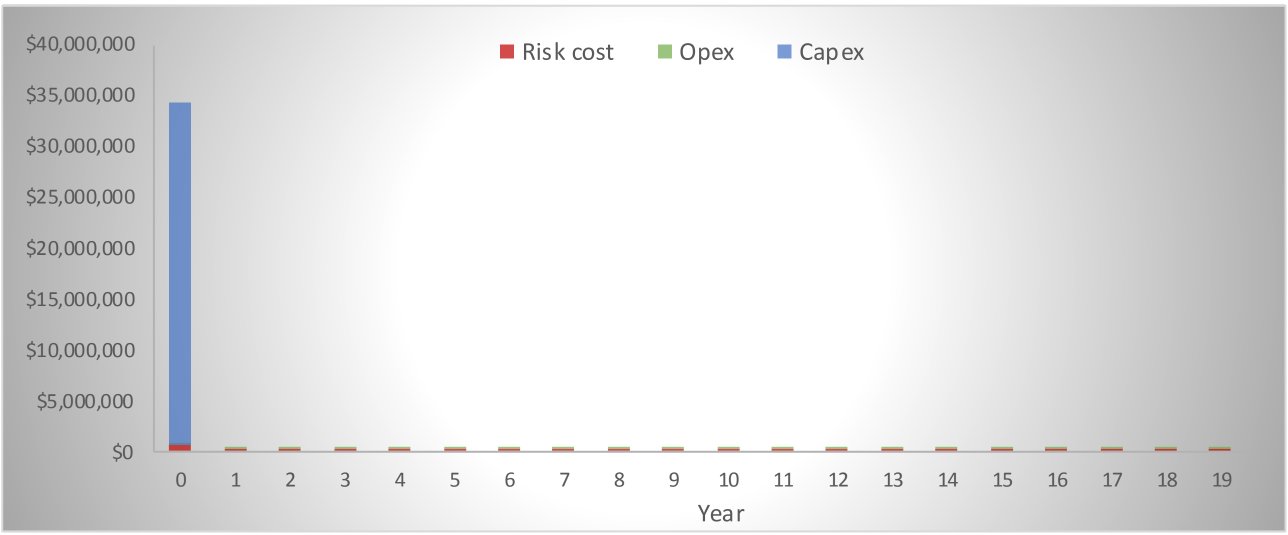
Categories	Asset items	PM	FB	E	WG	Comments
						New ones will distribute at 6.6 kV to PM and E loads.
	6.6/11 kV cap bank		-		2	FB has sufficient cap banks at present.
Distribution	6.6 kV underground cable		12 km		0.6 km	
	6.6 kV step-down distribution transformers and RMUs		-		-	Continue using the existing assets.

- **Opex:** This option would decrease CitiPower's annual costs for routine inspection and maintenance from $24k to $8k combined for ZS PM and ZS E each year. This increases as the assets deteriorate over their projected 50 year lifespan.

- **Risk costs:** Renewing the ZS PM and ZS E assets results in a substantial reduction in risk costs. However, there is an increased network security risk in the event of a catastrophic failure (with two substation sites being amalgamated into a single site), where the combined loads of ZS PM and ZS FB, or ZS E and ZS WG, will be at risk. This has a net effect of reducing risk costs from $571k in year zero (prior to implementation) to $194k in year one. This difference rapidly increases compared to Option 1 (continued maintenance and monitoring) where the PoFs for deteriorating assets approaching end of life increase exponentially; whereas the PoFs for the renewed assets under this option increase gradually over their 50 year service life.

Figure 9 shows the real cash flows for the option over the next 20 years.

Figure 9: Real cost cash flows for Option 5b



3.5.3 Option 5c: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 11 kV

This option involves retiring ZS PM and ZS E from service and transferring ZS PM to ZS FB and ZS E to ZS WG. The ZS PM loads would then both be supplied at 11 kV. This option would address all issues identified in Section 2.

The option enables ZS FB and ZS WG to supply loads of ZS PM and ZS E over an assumed 50 year service life.

Consolidating and optimising the two sites to one will result in a reduced overall asset quantum; however, it also reduces network security i.e. in the event that a catastrophic failure occurs the combined loads of ZS PM with ZS FB, or ZS E and ZS WG, will be lost. This risk is partially mitigated (as compared to Option 5b) through the ability to reconfigure the network to restore supply at 11 kV.

The option has been analysed based on its associated direct costs (capex + opex) and risk costs (PoF × CoF). The following considerations with respect to capex, opex and risk costs have been applied:

- **Capex:** The total capex for this option is estimated at $26m. This will include decommissioning assets at ZS PM and ZS E and augmenting ZS FB and ZS WG sites to accommodate new modern equivalent assets to supply ZS PM and ZS E loads. This will involve extending the 66 kV overhead lines from ZS WG to cut in to ZS E 66 kV system. This will also involve extending the 11 kV distribution network from ZS FB and ZS WG to supply ZS PM and ZS E loads. The scope of work in this option includes the following assets as shown in Table 8.

Table 8: Scope of capital works for Option 5c

Categories	Asset items	PM	FB	E	WG	Comments
Sub-transmission	66 kV overhead lines		-		-	Once E is decommissioned, it is expected WG will be cut into E 66 kV system. Not required as E already has 66 kV in site.
Zone substation	Zone substation decommissioning and site remediation (civil works)	1		1		Note that no remediation is required as ZS E as it is within ZS WG compound.
	In-situ extension of existing switch rooms and control rooms in to accommodate new indoor panels and secondary systems (civil works)		1		-	Not required in WG as it can accommodate E load presently.
	66 kV overhead lines terminations and AIS switch-bay		-		-	No need for additional 66 kV switch-bay as explained below.
	66/11 kV 30 MVA transformer and associated civil works and secondary systems		-			FB max demand is 33 MVA. PM max demand is 18 MVA. Assuming they do not have demand diversity, the total will be about 51 MVA. N-1 can be achieved with the existing 3×30 MVA Tx at FB.
	66/11 kV 27 MVA transformer and associated civil works and secondary systems				-	Optimising the transformers when offloading E to WG as it has very small load with decreasing max demand forecast, but still maintaining at N-1 collectively.
	11 kV indoor panels		12		8	Transformer protection, bus section and feeder protection. PM presently has 19×6.6 kV CB panels. Assuming when offloaded to FB it will be 12×11 kV CB panels. E presently has 17×6.6 kV CB panels. Assuming when offloaded to WG it will be 8×11 kV CB panels.
	11 kV underground cable terminations		6		3	PM presently has 12×6.6 kV feeders. Assuming when offloaded to FB it will be 6×11 kV feeders. E presently

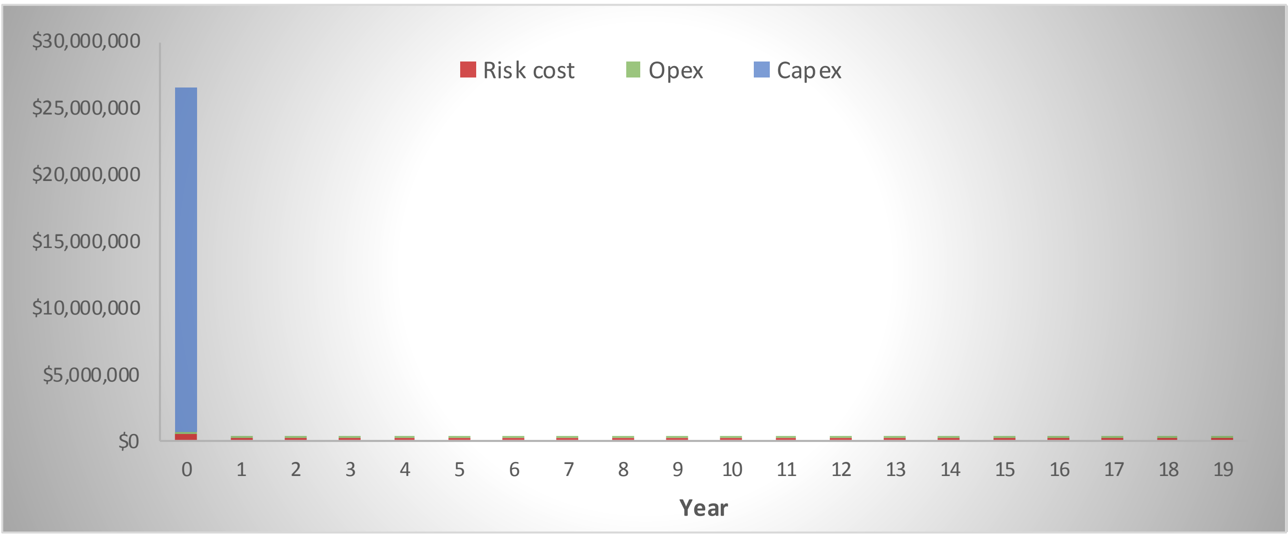
Categories	Asset items	PM	FB	E	WG	Comments
						has 10×6.6 kV feeders. Assuming when offloaded to FB it will be 3×11 kV feeders.
	11 kV cap bank		-		2	FB has sufficient cap banks at present.
Distribution	11 kV underground cable		6 km		0.6 km	6 feeders × 1 km each adequate for supplying PM loads
	11 kV step-down distribution transformers		38		4	60 distribution TXs. Assuming same proportion as Brunswick are dual wound.
	11 kV RMUs		38		1	Assuming 20% of distribution TXs as RMUs for E loads as they are pole top TXs.

- **Opex:** This option would decrease CitiPower's annual costs for routine inspection and maintenance from $24k to $8k combined for ZS PM and ZS E each year. This increases as the assets deteriorate over their projected 50 year lifespan.

- **Risk costs:** Renewing the ZS PM and ZS E assets results in a substantial reduction in risk costs. However, there is an increased network security risk in the event of a catastrophic failure (with two substation sites being amalgamated into a single site), where the combined loads of ZS PM and ZS FB, or ZS E and ZS WG, will be lost. This risk is partially mitigated (as compared to Option 5b) through the ability to reconfigure the network to restore supply at 11 kV. This has a net effect of reducing risk costs from $571k in year zero (prior to implementation) to $130k in year one. This difference rapidly increases compared to Option 1 (continued maintenance and monitoring) where the PoFs for deteriorating assets approaching end of life increase exponentially; whereas the PoFs for the renewed assets under this option increase gradually over their 50 year service life.

Figure 10 shows the real cash flows for the option over the next 20 years.

Figure 10: Real cost cash flows for Option 5c



4. Preferred option

4.1 Options evaluation

4.1.1 Annualised cost comparison

Table 9 provides a comparison of capex and annualised cost for each option; where the annualised cost is the sum of Direct Costs (capex + opex) and Risk Costs over the service life discounted to a NPV using CitiPower's Real WACC discount rate.

Table 9: Annualised costs comparison and ranking of all considered options

Options	Capex	Annualised cost	Rank
Option 1: Continued maintenance and monitoring	$0	$7.5m	**5**
Option 2: Non-network solutions	$39m	$10.0m	**6**
Option 3: Life extension of existing assets	~ Option Not Credible ~		
Option 4: Replacement of existing assets (in-situ)	$31m	$1.4m	**3**
Option 5a: Offload ZS PM and ZS E to ZS WG at 11 kV	$17m	$1.0m	**1**
Option 5b: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 6.6 kV	$34m	$1.7m	**4**
Option 5c: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 11 kV	$26m	$1.3m	**2**

** Note that Option 3 (Life extension of existing assets) was considered not credible based on advice from CitiPower and supported by the analysis of historical trend of defective events.*

4.1.2 Comparative advantages and disadvantages

Figure 11 provides a comparison of the annualised costs for the options considered. It illustrates the comparative breakdown of capex, opex and risk costs comprising the total cost for each option.

Figure 11: Annualised costs – of all options ($m)

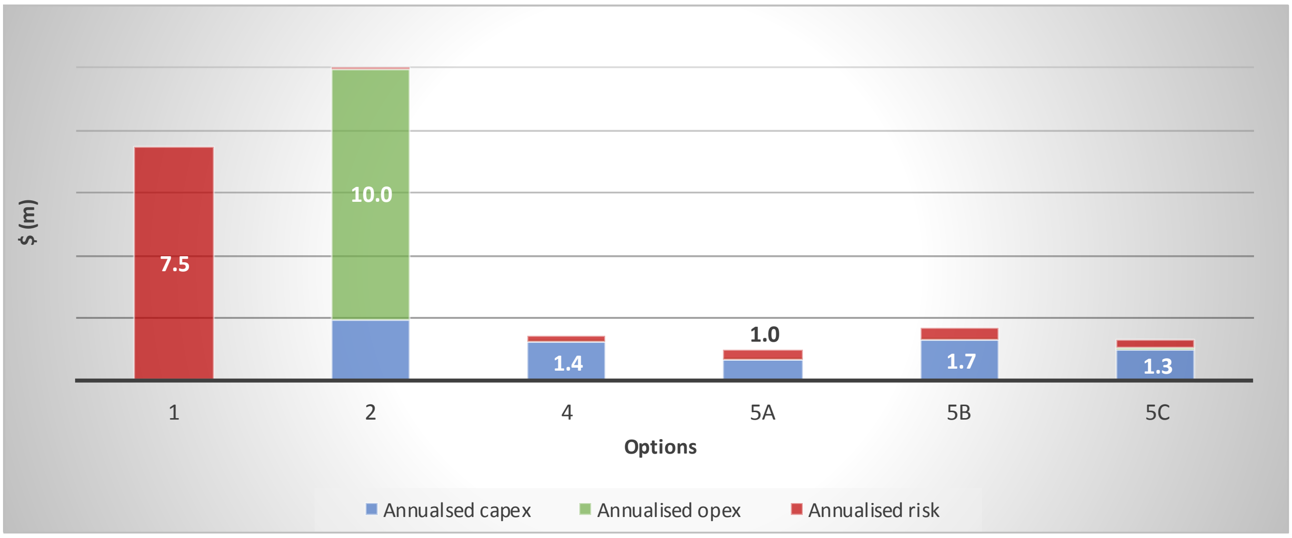


Table 10 provides a qualitative discussion of the comparative advantages and disadvantages of each option.

Table 10: Qualitative discussion of comparative advantages and disadvantages

Options	Advantages	Disadvantages
Option 1: Continued maintenance and monitoring	• No capital investment required.	• Option has an exponentially increasing risk profile that will ultimately result in disruptive and catastrophic failures. • It does not overcome issues relating to non-conformance with good electricity industry practice.
Option 2: Non-network solutions	• Does not require network investment.	• Very high ongoing operational investment is required • This is the highest cost option • Risk costs have not been evaluated
Option 3: Life extension of existing assets	N/A – CitiPower advises it has already exhausted all possible options to extend the life of ZS PM and ZS E. Option not credible and not evaluated.	
Option 4: Replacement of existing assets (in-situ)	• None identified.	• Option attracts a higher capital cost than other network solutions due to on-site construction difficulties. • It does not overcome issues relating to non-conformance with good electricity industry practice.
Option 5a: Offload ZS PM and ZS E to ZS WG at 11 kV	• This is the lowest capex solution • It addresses issues in relation to non-conformance with good electricity industry practice. • Redevelopment and future use of two offloaded sites. • Reduced risk profile compared to Option 1. • Reduction in network security is partially mitigated by supplying at 11 kV (which allows network to be reconfigured to restore power).	• Option reduces network security.
Option 5b: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 6.6 kV	• Redevelopment and future use of two offloaded sites. • Reduced risk profile compared to Option 1.	• Option reduces network security. • Option does not address issues relating to non-conformance with good electricity industry practice. • Capital works required at an additional substation site (FB).
Option 5c: Offload ZS E to ZS WG at 11 kV and ZS PM to ZS FB at 11 kV	• Redevelopment and future use of two offloaded sites. • Reduced risk profile compared to Option 1. • Option addresses issues relating to non-conformance with good electricity industry practice. • Reduction in network security is partially mitigated by supplying at 11 kV (which allows network to be reconfigured to restore power).	• Option reduces network security. • Capital works required at an additional substation site (FB).

4.1.3 Preferred option

The evaluation demonstrates that Option 5a (Offload ZS PM and ZS E to ZS WG at 11 kV) is the most prudent and efficient solution to manage the issues highlighted in Section 2. This assessment is based on the evaluation of Direct Cost (capex + opex) and Risk Cost, and comparative advantages and disadvantages.

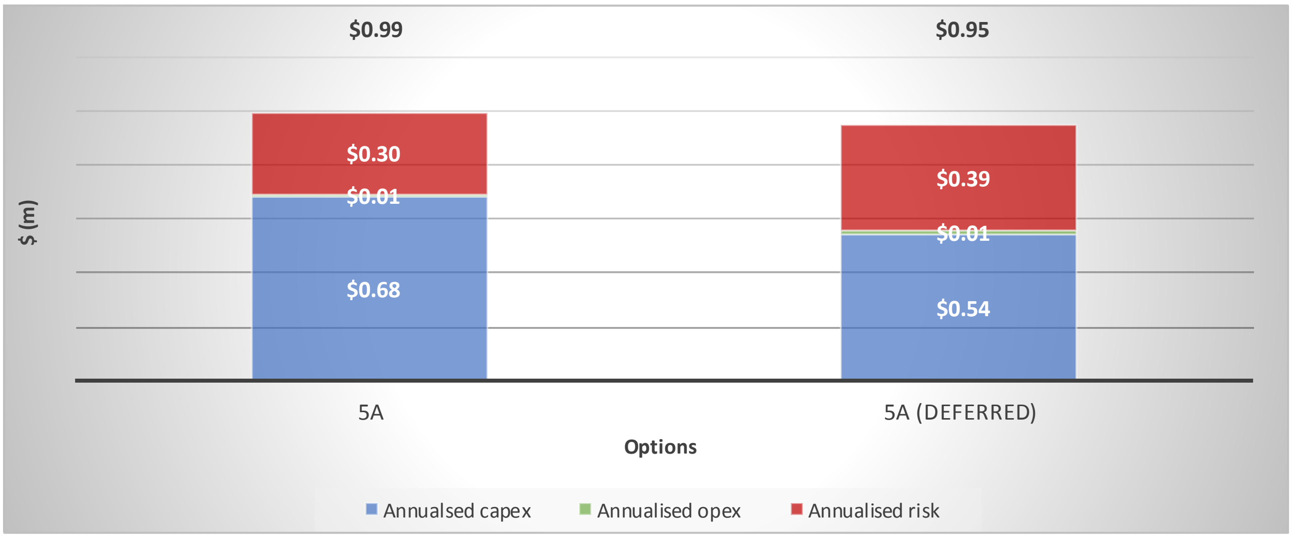
4.2 Preferred option implementation plan

Figure 12 compares the annualised costs for the preferred option if implemented immediately and if deferred to an optimal implementation timing. The optimal solution is to defer the implementation of the preferred option to 2024.

Deferring the investment discounts the annualised capex spend for Option 5a from $0.68m to $0.54m. This requires continuing with Option 1 (continued maintenance and monitoring) and accumulating associated risk through to 2024.

The total annualised cost for implementing the optimal solution in 2024 is $0.95m, versus $0.99m for implementing the option in 2018.

Figure 12: Annualised costs ($m) for option 5A (immediate and deferred to 2024)



4.3 Preferred option sensitivity analysis

Sensitivity analysis was conducted on key assumptions that could affect the final cost, optimal timing and preferred option. This analysis consisted of looking at changes of ±10% and ±20% in the direct and risk costs individually and in combination (16 sensitivities in total). None of the sensitivity scenarios presented another option as potentially preferable.

Figure 11 illustrates the spread of the optimal timing of Option 5a under the various sensitivity scenarios. The optimal year of implementation of 2024 is the most common result. The average optimal year of implementation is 2024. The sensitivity analyses do not present a strong case for either expediting or delaying the project.

Figure 13: Optimal timing of Option 5a under various sensitivity scenarios

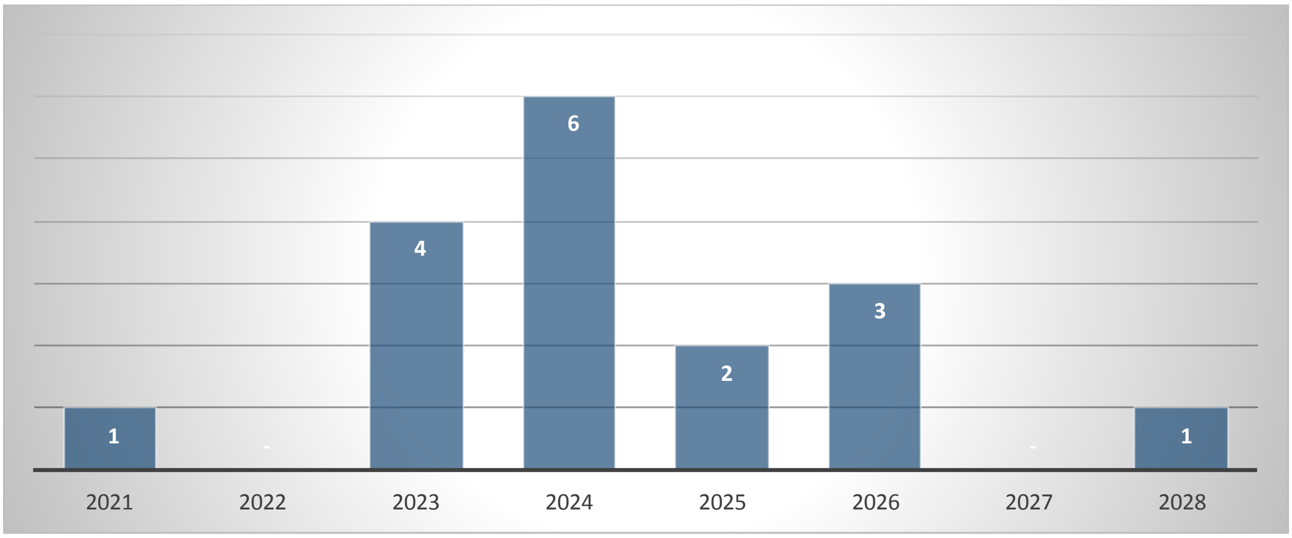


Table 11 provides a breakdown of optimal timing for each sensitivity scenario considered (as shown in Figure 13). The sensitivity analyses independently toggled direct costs and risk costs up and down, and then toggled both together in the same direction and also in opposite directions.

Table 11: Optimal year of implementation for the preferred option

Scenarios variables		Optimal year of implementation
Cost Category	Sensitivities	
Direct costs	+10%	2024
	+20%	2025
	-10%	2026
	-20%	2023
Risk costs	+10%	2023
	+20%	2024
	-10%	2023
	-20%	2025
Direct and risk costs (same direction)	+10%	2026
	+20%	2024
	-10%	2024
	-20%	2024
Direct and risk costs (opposite directions)	±10%	2024
	±20%	2026
	-+10%	2028
	-+20%	2023
BASE SCENARIO		2022
AVERAGE OF ALL SCENARIOS		**2024**

Level 15 133 Castlereagh Street Sydney NSW 2000 Australia

61 2 9239 7100
advisory@ghd.com

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Rev.No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
v1-0	Anuraag Malla	Adam Homan			Stephen Hinchliffe	20/12/2018

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