Appendix 4.3: Molonglo Zone Substation PJR

Revised regulatory proposal for the ACT electricity distribution network 2019–24

November 2018

evoenergy

Project Justification Report

Project name	**Molonglo Zone Substation**
Expenditure type	Capital Expenditure
Business Group	Asset Strategy
Regulatory Period	1 July 2019 to 30 June 2024
Total Project Cost Estimate	$16,652,600 excluding corporate overheads, excluding contingency, and excluding GST
Five year total spend 2019-24	$6,178,600 excluding corporate overheads, excluding contingency, and excluding GST
CAPEX category	ENAA Zone Substations
Primary driver	Load growth in Molonglo Valley - Greenfield
Project Number	17519206

Contents

1. Executive Summary

This Project Justification Report addresses the growth of electricity demand in the Molonglo Valley and evaluates options into how Evoenergy can meet these needs. The maximum demand in the Molonglo Valley is forecast to increase steadily to 50 MVA over the next 20 years as load grows in the new and developing suburbs of Weston, Coombs, Wright, Denman Prospect and Whitlam. The development of this area will include 21,000 residential dwellings, plus commercial and community facilities.

Existing 11 kV feeders to the area have insufficient thermal capacity to meet the forecast load beyond winter 2021. The selected option to meet this increasing load demand is the construction of a new 132/11 kV zone substation in the Molonglo Valley with associated 11 kV feeders from the zone substation to serve the residential suburbs as they develop.

It is proposed that the new zone substation will be equipped initially with Evoenergy's 132/11 kV 15 MVA mobile substation (MOSS) ex Angle Crossing by June 2021. 132 kV supply will be provided by a loop-in-loop-out connection to the proposed Stockdill–Woden (currently Canberra–Woden) 132 kV transmission line. The new zone substation site will be established and developed complete with all earthworks, earthing, fencing, communications, and 132 kV structure and busbar, to enable the MOSS to be connected and commissioned and be able to operate continuously until the permanent zone substation infrastructure is constructed and commissioned.

Stage 2 of the project will involve the establishment of the permanent zone substation with the installation of one 132/11 kV 30/55 MVA transformer and one 11 kV switchboard, with space provided for a future two additional transformers and two additional 11 kV switchboards. Timing of Stage 2 will depend on the rate of load growth in the Molonglo Valley but is tentatively scheduled for 2025-26. Stage 3 of the project will involve installation of a second 132/11 kV 30/55 MVA transformer and a second 11 kV switchboard, and removal of the MOSS, around 2029-30.

Other options have been considered and evaluated including the installation of 11 kV feeders from existing zone substations, a two-stage development of the permanent zone substation, demand management, and a grid battery. The proposed installation of the MOSS with associated 11 kV feeders is the preferred option as it has the highest (ie least negative) net present cost of the credible options considered.

Demand management is not considered to be a credible option due to the insufficient capacity of existing infrastructure and the requirement for greater than 40% of new demand to be offset. The grid battery option is not preferred due to its lower net present cost and the relative certainty of the demand increase (noting grid batteries and other modular solutions deliver a higher options value in the context of uncertain demand).

A preliminary cost estimate for the selected option is $16,652,600 excluding corporate overheads, contingency and GST. Stage 1 comprising development of the substation site and relocation of the MOSS from Angle Crossing is estimated to cost $6,178,600 and is proposed to be completed by the end of the 2020-21 financial year to provide the capacity required by developments in the Molonglo Valley. Stage 2 comprising installation of one 132/11 kV 30/55 MVA transformer and one 11 kV switchboard is estimated to cost $6,961,000 and is proposed to be completed by the end of the 2025-26 financial year though this will depend on the actual rate of load growth. Stage 3 comprising installation of a second 132/11 kV 30/55 MVA transformer and second 11 kV switchboard is estimated to cost $3,513,000 and is proposed to be completed by the end of the 2029-30 financial year though this will depend on the actual rate of load growth. These estimates are based on construction of the substation at the William Hovell Drive site. A staged approach to this project is selected to minimise the initial capital expenditure and construct only what is required to meet the forecasted load.

This project is coupled with the proposed Molonglo Valley 11 kV Feeders project, reference PN 20001374 which is estimated to cost $4,694,000 excluding corporate overheads, contingency and GST during the 2019-24 Regulatory Control Period.

The proposed expenditure for the 2019-24 Regulatory Control Period is:

PN 17519206 (Molonglo Zone Substation) = $6,178,600 excluding corporate overheads, contingency and GST; plus
PN 20001374 (Molonglo Valley 11 kV Feeders = $4,694,000 excluding corporate overheads, contingency and GST.

The capital expenditure will add to Evoenergy's regulated asset base and is expected to accrue returns in Evoenergy's regulated income.

2. Strategic Context and Expenditure Need

2.1. Strategic context

The Molonglo Valley District is situated in Canberra's west, approximately 10 km from the Canberra Central Business District (CBD). It lies to the north of the urban area of Weston Creek and south of Belconnen. Land servicing has commenced for the initial developments and when fully developed over the next 30 years, the Molonglo Valley District including the new suburbs of North Weston, Coombs, Wright, Denman Prospect and Whitlam will support an estimated 21,000 dwellings plus shopping centres, schools and community facilities. Development is proceeding rapidly and in some cases, ie Whitlam suburb, the development program has recently been accelerated (refer to Developer's program attached as Appendix C).

Coombs and Wright suburbs are mostly developed and are continuing to fill at a steady rate. North Wright and North Coombs will comprise approximately 400 dwellings each and are due to commence construction in late 2018.

North Weston suburb is mostly developed and is continuing to fill at a steady rate.

Denman Prospect suburb is being developed in five stages. Denman Prospect Stage 1A has been completed recently with 390 dwellings currently under construction. Stage 1B is under construction and will comprise 2,530 dwellings. Stages 2A, 2B and 3 will follow in the next three years and will include dwellings, a commercial centre (supermarkets, shops and service buildings), schools and community facilities.

Whitlam suburb is being developed in four stages. Whitlam Stage 1 is due to commence construction in November 2018 and will comprise 619 dwellings. Stages 2, 3 and 4 will each comprise approximately 620 dwellings and be developed by the end of 2021.

Mt Stromlo recreation area is being developed and will include a new aquatic centre plus holiday accommodation, scheduled to be completed by 2023.

A population of approximately 55,000 people is expected to ultimately live in the Molonglo Valley. Maximum demand of the Molonglo Valley is expected to grow steadily to approximately 50 MVA over the next 30 years.

Rooftop solar PV generation is installed on approximately 10% of all dwellings in Coombs, Wright and North Weston suburbs to date, whereas battery storage penetration to date is minimal (< 0.5%). This is typical for residential areas in the ACT where PV is not mandatory. The developer of Denman Prospect has mandated the installation of 3 kW rooftop PV generation systems on all detached dwellings in Stage 1A (390 dwellings), but has not mandated rooftop PV for multi-unit or commercial buildings. Battery storage systems are voluntary. It is unlikely that multi-unit developments (apartment buildings) will have rooftop PV or battery storage installed. Modern apartment buildings tend to be all-electric with no gas connected. Detached dwellings comprise approximately 30% of all dwellings in Denman Prospect, so this is the maximum likely penetration rate.

On its own rooftop PV will decrease summer maximum demand but without associated battery storage will have no impact on winter maximum demand which occurs in the evening after the sun has set. However as prices of batteries are anticipated to fall over coming years, it is expected that the rate of uptake will increase and ultimately many customers who have a rooftop PV installation may opt to install a battery storage system also. Thus a penetration rate of 30% has been assumed for rooftop PV and 20% for associated residential level battery storage systems throughout the Molonglo Valley. This is based on 100% rooftop PV on all detached or terraced dwellings, but minimal rooftop PV on apartment buildings. Fewer residential customers are connecting to gas, and coupled with the likely uptake of electric vehicles and instantaneous hot water heating systems, it is anticipated that future after diversity maximum demand (ADMD) levels will be approximately 2.5 kVA per dwelling.

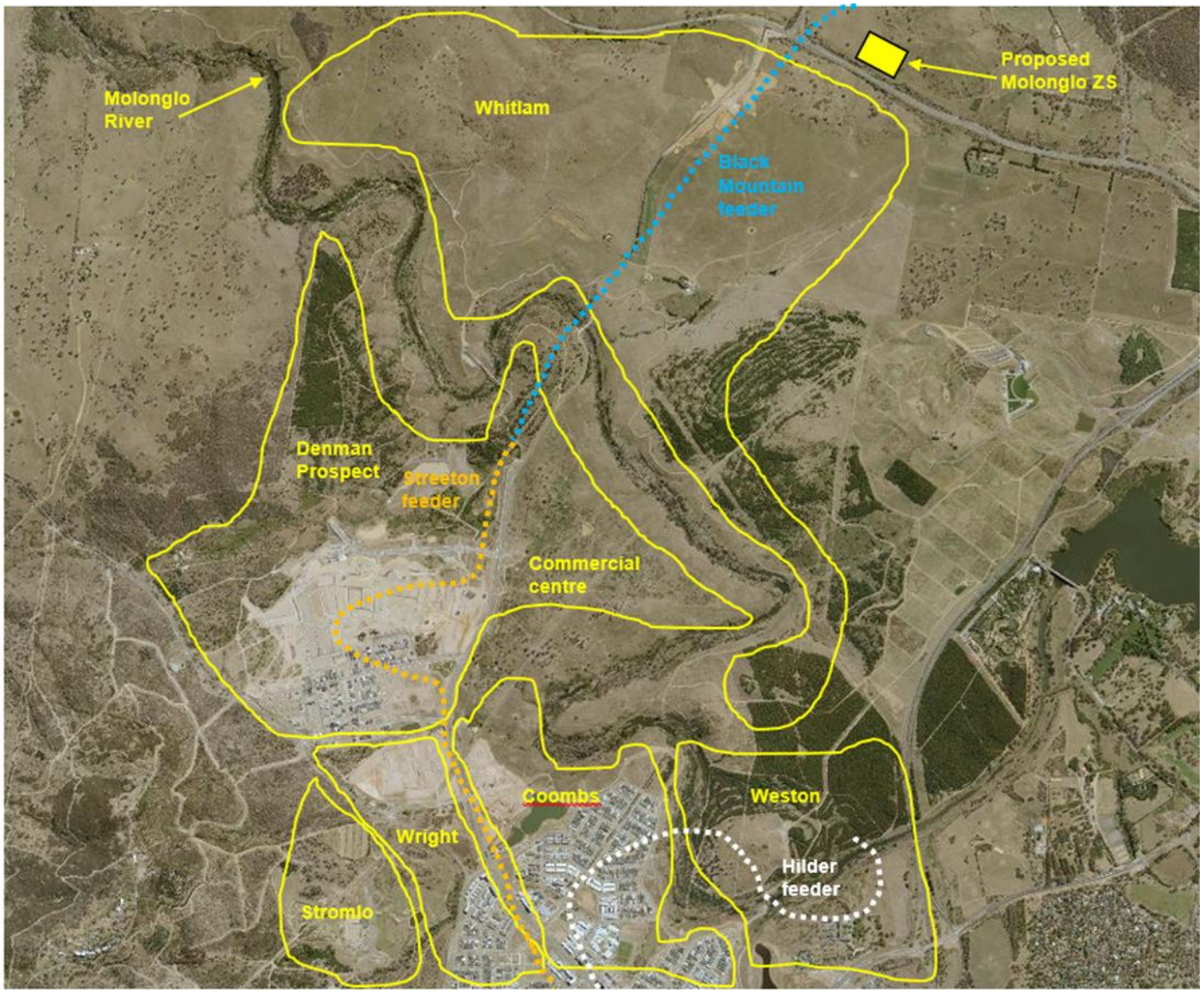
Supply is being provided to Wright and Denman Prospect through one 11 kV feeder from Woden Zone Substation (Streeton feeder), with an inter-tie connection to one 11 kV feeder from Civic Zone Substation (Black Mountain feeder).

Supply is being provided to Coombs and Weston through one 11 kV feeder from Woden Zone Substation (Hilder feeder). Hilder feeder has a limited backup connection to the Streeton feeder.

Initial supply to Whitlam will be provided via connection to the Black Mountain feeder, with backup supply from the Streeton feeder.

Figure 1 shows the proposed areas of development of the Molonglo Valley and the routes of existing 11 kV feeders. It also shows the site of the proposed Molonglo Zone Substation.

Figure 1: Development of Molonglo Valley



2.2. Existing infrastructure in Molonglo Valley

The Molonglo Valley load centre is approximately 7 km from Evoenergy's nearest existing zone substations, Woden and Civic. Both of these zone substations have three 132/11 kV transformers each and would require major extensions to accommodate additional transformers. Civic has a firm capacity of 110 MVA and is forecast to rise to approximately 75 MVA over the next 10 years. Woden has a firm capacity of 100 MVA and is forecast to rise to approximately 105 MVA over the next 10 years, with proposed new developments in the Yarralumla, Weston and Woden areas.

There are two existing feeders that cross the Molonglo Valley – Streeton feeder from the south and Black Mountain feeder from the north. There is one other feeder in the vicinity that could be extended to the Molonglo Valley – Hilder feeder

Supply is being provided to Wright and Denman Prospect through by the Streeton and Black Mountain feeders. Supply is being provided to Coombs and Weston through the Hilder feeder.

Initial supply will be provided to Whitlam through a cable connection to the Black Mountain feeder.

The existing feeders in the Molonglo Valley vicinity have the following attributes:
Streeton – firm rating 5.5 MVA, thermal rating 7.3 MVA, 2018 demand 3.6 MVA.
Black Mountain – firm rating 5.0 MVA, thermal rating 6.5 MVA, 2018 demand 3.2 MVA.
Hilder – firm rating 5.2 MVA, thermal rating 7.0 MVA, 2018 demand 5.6 MVA.

2.3. Driving need for infrastructure investment

At an expected fill rate of approximately 1,000 dwellings pa, the Molonglo Valley load is forecast to grow steadily at approximately 3.0 MVA pa on average. The majority of demand of Molonglo Valley developments will be residential dwellings with some commercial facilities (proposed Denman Prospect group shopping centre) and community facilities (schools, churches, streetlights, and the proposed Stromlo Forest Park Aquatic Centre and Leisure Centre).

Table 1 shows a summary of the forecast load growth in the Molonglo Valley for the next 10 years. These forecast loads make allowance for predicted penetration of rooftop solar PV and battery storage systems.

Table 1: Forecast Load Growth for Molonglo Valley

Molonglo Valley Development - Load Forecast @ 29.8.18									
Year	2018	2019	2020	2021	2022	2023	2024	2025	2026
Residential Loads (MVA)									
Coombs	0.5	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Wright	0.4	0.7	0.5	0.5	0.2	0.1	0.1	0.1	0.1
Weston	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Denman Prospect	1.8	0.6	1.0	1.0	1.0	1.0	0.5	0.4	0.5
Whitlam		1.9	1.5	1.5	1.5	0.2	0.2	0.2	
Additional Residential Load (MVA) @ 2.5 kVA ADMD	2.9	3.7	3.3	3.3	3.0	1.5	1.0	0.9	0.8
Block Loads (MVA)									
Wright - hotel etc				0.5	0.7				
Denman Prospect Commercial centre						0.5	0.5	0.5	0.5
Stromlo Aquatic Park				0.5					
Stromlo Leisure Centre					1.0	1.0			
North Wright School				0.2					
Additional Non-residential Load (MVA) ADMD	0.0	0.0	0.0	1.2	1.7	1.5	0.5	0.5	0.5
Total Additional Load (MVA) ADMD	2.9	3.7	3.3	4.5	4.7	3.0	1.5	1.4	1.3
Cumulative Additional Load (MVA) ADMD	2.9	6.6	9.9	14.4	19.1	22.1	23.6	25.0	26.3

Load growth forecasts for the Molonglo Valley are **very dynamic** as development is proceeding at a rapid pace and the size of developments is increasing due to intense mixed use developments (eg apartment buildings coupled with commercial development) becoming commonplace.

The Load Forecasting Process:

- Evoenergy's original load forecasts for the Molonglo Valley were based on the ACT Government's Indicative Land Development Program. This document is updated every year by the ACT Govt.
- As individual estates/suburbs are developed, Evoenergy then receives an Estate Development Plan which includes "Dwelling Yield" figures (refer to Appendix D for Whitlam Stage 1 as an example). Evoenergy updates its load forecast using 2.5 kVA ADMD per dwelling based on the expected uptake of rooftop solar PV generation and residential battery storage systems, coupled with the expected uptake of electric vehicles and the current trend away from gas. ADMD figures for commercial building and community facilities are calculated using typical VA rates per m^2 of building space being developed.
- As individual multi-use blocks are sold to individual developers, the expected number of units/apartments often changes. For example, the number of apartments to be constructed at two blocks in Wright have doubled from the original EDP, and one block also includes a hotel and restaurant and will also be all-electric. Evoenergy updates its load forecast accordingly.
- Evoenergy bases its load forecasts on hard facts and does not speculate re unknowns such as possible larger buildings, hotels, all-electric developments etc. Thus load forecasts require constant revision and updating.

The *Electricity Distribution (Supply Standards) Code* issued by the ACT Independent Competition and Regulatory Commission (ICRC) sets out certain performance standards for the distribution network in the ACT. A Distribution Network Service Provider (DNSP) is required to "take all reasonable steps to ensure that its Electricity Network will have sufficient capacity to make an agreed level of supply available". The processes defined in these criteria serve to limit network augmentation expenditure to instances where the increase in demand is clear and above the secure or firm capacity.

Evoenergy's Demand Management Strategy states: "Evoenergy is working to reduce peak demand relative to average demand as this will lead to reduce capital expenditure and better asset utilisation".

Evoenergy's Asset Management Strategy states: "The strategic intent for asset management is to ensure that all assets must be of sufficient capacity to meet expected peak demands. For the electricity network, this means that zone substations, transmission and distribution networks must, at all times, be adequately rated to ensure customers are not interrupted because of peak demand requirements".

The key business and regulatory compliance drivers for this expenditure are to provide new and existing customers in the Molonglo Valley with a safe, secure, reliable, quality and cost effective electricity service.

Evoenergy (formerly ActewAGL Distribution) originally proposed to construct the Molonglo Zone Substation in its 2014-19 Regulatory Submission with proposed construction by late 2015. This proposal was not approved by the AER so Evoenergy had to uprate its Black Mountain 11 kV feeder (by reconductoring) in 2017 to meet the growing demand and connect new customers.

3. Objectives

3.1. Corporate, asset management and key project objectives

The corporate, asset management and related key project objectives are shown in Table 2 below. These objectives are used to assess the relative risk of options.

Table 2: Corporate, asset management and key project objectives

Corporate objectives	Asset management objectives	Key project objectives
Responsible	• Achieve zero deaths or injuries to employees or the public. • Maintain a good reputation within the community. • Minimise environmental impacts, for example bushfire mitigation. • Meet all requirements of regulatory authorities, such as the AER as outlined in the NER, and the ACT Utilities (Technical Regulations) Act 2014.	The selected option must ensure environment and safety standards will be met.
Reliable	• Tailor maintenance and renewal programs for each asset class based on real time modelling of asset health and risk. • Meet network SAIDI and SAIFI KPIs. • Record failure modes of the most common asset failures in the network. • Successfully deliver the asset class Program of Work (PoW) to ensure that the protection operates correctly to disconnect faulty sections in accordance with the NER.	Options evaluations to consider the value of customer reliability (VCR). In accordance with regulated requirements, the selected option must ensure access to an electricity supply.
Sustainable	• Enhance asset condition and risk modelling to optimise and implement maintenance and renewal programs tailored to the assets' needs. • Make prudent commercial investment decisions to manage assets at the lowest lifecycle cost. • Integrate primary assets with protection and automation systems in accordance with current and future best practice industry standards • Deliver the asset class PoW within budget.	Options evaluations to consider the cost effectiveness of the solution. In accordance with regulated requirements, the selected option must be the most prudent and efficient. Non-network options will be evaluated on equal merit with network solutions.
People	• Proactively seek continual improvement in asset management capability and competencies of maintenance personnel.	A post implementation review to incorporate learnings through the asset management system.

The project objectives are consistent with Evoenergy's regulatory requirements described below.

3.2. Regulatory Compliance

3.2.1. National Electricity Law and National Electricity Rules

Evoenergy is subject to the National Electricity Law (NEL) and the National Electricity Rules (NER) which regulate the National Electricity Market (NEM). Evoenergy operates in the NEM as both a Transmission Network Service Provider (TNSP) and a Distribution Network Service Provider (DNSP).

The National Electricity Objective (NEO), as stated in the NEL is to:

> *"…promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:*
>
> *a) price, quality, safety, reliability and security of supply of electricity; and*
> *b) the reliability, safety and security of the national electricity system."*

This objective requires Registered NEM participants to balance the costs and risks associated with electricity supply.

The planning and development process for distribution and transmission networks is carried out in accordance with the National Electricity Rules (NER) Chapter 5 Part B Network Planning and Expansion.

The primary objective of planning is to ensure that customers are able to receive a sufficient and reliable supply of electricity now and into the future.

3.2.2. Capital Expenditure Objectives and Criteria

The NER provides further guidance in terms of allowable capital expenditure via the capital expenditure objectives and criteria for standard control services. These capital expenditure objectives, specified in clause 6.5.6(a) and 6.5.7(a) of the NER describe the outcomes or outputs to be achieved by the expenditure. The objectives include:

1) *Meet or manage the expected demand for standard control services*
2) *Comply with all applicable regulatory obligations or requirements associated with the provision of standard control services*
3) *To the extent that there is no applicable regulatory obligation or requirement in relation to the quality, reliability or security of supply of standard control services; or the reliability or security of the distribution system through the supply of standard control services, to the relevant extent:*
    a) *Maintain the quality, reliability and security of supply of standard control services*
    b) *Maintain the reliability and security of the distribution system through the supply of standard control services*
4) *Maintain the safety of the distribution system through the supply of standard control services.*

The expenditure criteria, set out in Section 6.5.6(c) and Section 6.5.7(c) of the NER, further outline requirements for the way in which expenditure must be set to achieve the objectives above. These include:

1) *The efficient costs of achieving the expenditure objectives*
2) *The costs that a prudent operator would require to achieve the expenditure objectives; and*
3) *A realistic expectation of the demand forecast and cost inputs required to achieve the expenditure objectives.*

The above criteria therefore imply that the capital expenditure, determined in line with the expenditure objectives, must be met via prudent and efficient expenditure, is to be achieved at least cost.

3.2.3. Regulatory Investment Test

Section 5.16 of the NER describes the Regulatory Investment Test for Transmission (RIT-T) and Section 5.17 describes the Regulatory Investment Test for Distribution (RIT-D). These tests must be carried out for any proposed investment where the augmentation or replacement cost of the most expensive credible option exceeds $5 million.

The regulatory investment tests provide the opportunity for external parties to submit alternative proposals to the Network Service Provider, who is obliged to consider any credible proposal objectively.

Since the required investment is greater than $5million the project is subject to the RIT-D. Evoenergy (ActewAGL Distribution) commenced the RIT-D process in 2014 with publication of a Project Specification Consultation Report, but has yet to complete the RIT-D process (ie publication of Draft Project Assessment Report and Final Project Assessment Report). These reports will need to be prepared as part of the development of this project. The initial RIT- D consultation paper published in 2014 recommended establishing a new zone substation at the Arboretum site (comprising two transformers and two switchboards) by 2017-18, but lower load growth rate has enabled this to be deferred to 2020-21.

3.2.4. Utilities Act 2000 (ACT)

Evoenergy has an obligation to comply with the Utilities Act 2000 (ACT) which imposes specific technical, safety and reliability obligations via the Management of Electricity Network Assets Code and the Electricity Distribution Supply Standards Code.

The Electricity Distribution Supply Standards Code (August 2013) sets out performance standards for Evoenergy's distribution network. Evoenergy is required to take all reasonable steps to ensure that its Electricity Network will have sufficient capacity to make an agreed level of supply available.

This local jurisdictional code specifies reliability standards that Evoenergy must endeavour to meet when planning, operating and maintaining the distribution network. It also specifies power quality parameters that must be met including limits on voltage flicker, voltage dips, switching transients, earth potential rise voltage unbalance, harmonics and direct current content.

The Management of Electricity Network Assets Code requires electricity distributors to protect the integrity and reliability of the electricity network and to ensure the safe management of the electricity network without injury to any person or damage to property and the environment.

3.2.5. Evoenergy's Distribution Network Augmentation Standards

Evoenergy's distribution network augmentation standards are set to ensure compliance with the relevant regulatory instruments as described above. System planning studies are undertaken to assess the adequacy of the distribution network to meet current and forecast demands whilst meeting the quality of supply criteria stipulated in the NER. The key performance criteria that are addressed are: thermal overloading, voltage performance, supply security, and supply reliability. Studies are conducted using Evoenergy's medium growth, 50% PoE demand forecast, coupled with known customer-initiated point load requests and applications.

As a **first step,** Evoenergy applies deterministic planning criteria to identify where existing or emerging constraints exist on the network. The deterministic approach can lead to uneconomic outcomes. For that reason further analysis is performed to confirm whether the investment proposal is justified economically.

Therefore, as a **second step,** Evoenergy applies probabilistic assessment of risk to determine whether network investment is justified. The value of avoided risk is estimated using probabilistic methodology.

Thus, benefit is expressed as avoided risk. The risk may include other components, but typically unserved energy is the dominant risk component for augmentation projects. If avoided risk exceeds the cost of the proposed augmentation, the investment is considered economic. The assessment of risk is based on the probability of a credible contingency event occurring sufficiently frequently, and with such consequences as to justify Evoenergy to take prudent action to mitigate against it. The probability of a credible contingency event occurring at a time when load exceeds firm capacity, is used to calculate unserved energy.

The value of unserved energy compared with the cost of the investment, determines the prudency of the augmentation.

The value of Unserved Energy identified in this PJR (refer Appendix B2) is high due to the fact that forecast demand exceeds the thermal capacity of the existing network.

To meet the forecast demand under the Do Nothing option (ie connecting all new loads to existing feeders only), would require operating some feeders above their thermal ratings. Operating an 11 kV distribution feeder at or above its thermal rating is extremely risky as overheating can lead to conductor annealing and failure, or cause failure of jumpers, clamps, connectors, conductor joints, or other hardware. On overhead lines the conductors may sag below their statutory ground clearance (resulting from a combination of ambient and conductor temperature).

In addition, non-network solutions and demand side management solutions are considered when evaluating project options. To inform Evoenergy's position, as part of this assessment, Evoenergy models various load forecast outcomes using Monte Carlo methodology to select the preferred option. This modelling allows Evoenergy to consider whether a demand side solution is a viable option and should be explored further.

The proposed new Molonglo Zone Substation has been selected as the preferred option taking into account the available capacity (Table 1), forecast load (Table 2) and the corresponding reduction of risk. It is considered to be a prudent investment, because the avoided risk is higher than the cost of investment. Furthermore, at the time of investment the risk value exceeds the annualized cost of investment.

3.2.6. Cost compliance

Cost compliance is achieved by proactively pursuing the philosophy of compliance with the National Electricity Objective by fully exploring and evaluating all options technically and commercially so as to seek approval for a solution that provides sound grounds for an efficient investment while meeting the long term interests of consumers.

The investment value has been determined using 2016-17 market prices. The methodology and estimated costs used for this project are developed through the application of industry knowledge and Good Engineering Operating Practices based on historical similar projects. This approach complies with paragraphs 6 & 7 of the National Electricity Law (NEL).

It is noted that the National Electricity Law, Rules, Objectives, Criteria, and the ACT Distribution Code, do not require an assessment of unserved energy to be included in the cost evaluation of major augmentation projects.

4. Options Assessment

Table 3 lists the options that Evoenergy has considered to provide 11 kV supply capacity to the Molonglo Valley District.

Table 3: Options considered for supply to Molonglo Valley District

Option	Option type	Description
0	Network	Do nothing – connect all new loads to existing Streeton and Black Mountain feeders and operate to their thermal ratings
1	Network	Extend Hilder 11 kV feeder and operate Streeton, Black Mountain and Hilder feeders to their thermal ratings
2	Network	Construct new 11 kV feeders from existing zone substations in stages: Five feeders from Latham Zone Substation and Five feeders from Civic Zone Substation
3	Network	Construct new Molonglo Zone Substation in two stages with a 55 MVA transformer at each stage. This is part of the overall project: Construct new Molonglo Zone Substation (PN17519206); and Construct 11 kV feeders from Molonglo Zone Substation (PN20001374)
4	**Network**	**Construct new Molonglo Zone Substation in three stages with the mobile substation at Stage 1 followed by two stages with a 55 MVA transformer at each stage. This is part of the overall project:** **Construct new Molonglo Zone Substation (PN17519206); and** **Construct 11 kV feeders from Molonglo Zone Substation (PN20001374)**
5	Non-network	Demand side management and embedded generation
6	Mixed - Option 4 plus batteries	Delayed preferred network option using non-network options
7	Non-network	Grid battery

4.1. Options Description

4.1.1. Do Nothing Option

The ‘Do Nothing’ option requires connecting all new loads to existing feeders in the Molonglo Valley and operating these feeders up to their thermal limits. The Streeton and Black Mountain feeders are the only feeders adjacent to proposed new developments.

The ‘Do Nothing’ option would result in insufficient network capacity in the area and thus would result in Evoenergy breaching its obligations to provide a reliable and secure power supply. This option is not a prudent or acceptable solution and would place considerable load at risk in the event of a feeder contingency.

4.1.2. Option 1: Extend Hilder feeder and operate Streeton, Black Mountain and Hilder feeders to thermal limits

Option 1 considers extending the 11 kV Hilder feeder to the Molonglo Valley load centre, and operating the extended Hilder feeder, Streeton feeder and Black Mountain feeders up to their thermal limits.

The Hilder feeder is the only existing feeder near Molonglo Valley other than Streeton and Black Mountain feeders. Hilder feeder emanates from Woden Zone Substation and currently supplies part of Coombs and Weston (refer Figure 1).

The works required to extend the Hilder feeder would include directional drilling beneath the Molonglo River. Removal of the overhead Black Mountain feeder section between William Hovell Drive and Molonglo River is currently timed to coincide with the development of Whitlam Estate (and proposed new Molonglo Valley feeders). Under this option it would be necessary to underground the Black Mountain feeder as a separate exercise prior to the estate development works.

A preliminary cost estimate for this option is $4,055,000 excluding corporate overheads, contingency and GST. Refer to Appendix A1.

The effectiveness of this option is similar to the Do Nothing Option in that it would defer construction of the Molonglo Zone Substation and associated 11 kV feeders until winter 2021 only. This option would result in insufficient network capacity in the area and thus would result in Evoenergy breaching its obligations to provide a reliable and secure power supply. This option is not a prudent or acceptable solution and would place considerable load at risk in the event of a feeder contingency.

4.1.3. Option 2: Install new 11 kV feeders from existing zone substations

Option 2 considers the installation of ten new underground 11 kV cable feeders in stages to Molonglo Valley from existing zone substations to meet the growing load demand. Due to the de-rating effect of installing multiple cable feeders in common trenches a thermal capacity of 5 MVA per feeder has been assumed.

Typically an urban zone substation supplies an area of radius approximately 5 km. There are four zone substations within 10 km of the Molonglo Valley load centre. These are Latham (8.5 km), Belconnen (7.2 km), Civic (5.3 km) and Woden (5 km).

Woden Zone Substation has firm ratings of 95 MVA summer and winter. It has a two-hour emergency rating of 95 MVA summer and 114 MVA winter. Forecast load growth at Woden Zone Substation without and with the proposed Molonglo Zone Substation is shown in Table 4. The two-hour emergency cyclic rating is the maximum short time load that a transformer can carry nominally once or twice in its operating life under fault conditions, while still maintaining an acceptable loss of life. Evoenergy uses the two-hour rating on the assumption that remote and manual switching can be done to either transfer or shed load within this duration.

Table 4: Woden Zone Substation Load Forecast

	Woden Zone Substation Load Forecast without Molonglo Zone Substation		Woden Zone Substation Load Forecast with Molonglo Zone Substation (June 2021 commissioning)	
Year	Summer POE 50	Winter POE 50	Summer POE 50	Winter POE 50
2019	75.4	85.7	75.4	85.7
2020	77.6	88.8	77.6	88.8
2021	79.5	91.1	79.5	83.3
2022	81.3	93.4	74.4	83.3
2023	83.0	95.6	74.4	83.3
2024	84.0	96.0	74.4	83.3
2025	84.3	96.4	74.4	83.3
2026	84.6	96.8	74.4	83.3
2027	84.9	97.2	74.4	83.3
2028	85.2	97.6	74.4	83.3

Load is growing steadily at Woden, Latham, Civic and Belconnen zone substations. The ability of these zone substations to supply up to 50 MVA additional load at Molonglo Valley, either individually or collectively without significant augmentation (eg additional transformer capacity) would be difficult to achieve.

Load transfer capability from Latham, Belconnen, Civic and Woden zone substations to neighbouring zone substations is shown in Table 5. Load transfer capacity is based on the spare capacity of zone substation transformers and the spare capacity of interconnecting 11 kV feeders between substations. This load transfer capacity will decrease as load increases on zone substations and interconnecting feeders. The 2026 figures are estimated based on expected load growth of interconnecting feeders.

Table 5: Load transfer capacity between zone substations (MVA)

		From							
		Latham		Belconnen		Civic		Woden	
	Year	2017	2026	2017	2026	2017	2026	2017	2026
To	Latham			9.97	3.00				
	Belconnen								
	Civic			5.93	2.00				
	Woden								
	City East			5.93	2.00	7.99	2.50		
	Telopea Park							5.88	2.00
	Wanniassa							18.97	11.00

There are no spare feeder circuit breakers at Woden Zone Substation. There are three spare feeder circuit breakers at Latham Zone Substation and six spare feeder circuit breakers at Civic Zone Substation (although five of these are proposed to be used for other projects – three new feeders to ANU plus two new feeders to Canberra CBD).

Under this option it is proposed to install 5 new 11 kV cable feeders from Latham Zone Substation and a further 5 new 11 kV cable feeders from Civic Zone Substation to Molonglo Valley. It is preferred not to install feeders from Belconnen due to the lack of spare transformer capacity, or from Woden due to the lack of spare feeder circuit

breakers and the difficulty of installing cables beneath the Molonglo River. Some doubling up of feeders (ie two per circuit breaker) would be required, although this is not preferred due to diminished security and reliability (ie a feeder fault would trip its twin healthy feeder).

Route length from Latham is assumed to be 9.0 km and from Civic to be 8.0 km. The project would be implemented in stages:

Stage 1 (2021) – all civil works (trenching and directional drilling and installation of conduits) for the Latham–Molonglo feeders and installation of two feeder cables Latham–Molonglo.
Stage 2 (2023) – installation of third feeder cable Latham–Molonglo.
Stage 3 (2025) – installation of fourth feeder cable Latham–Molonglo.
Stage 4 (2027) – installation of fifth feeder cable Latham–Molonglo.
Stage 5 (2029) – all civil works (trenching and directional drilling and installation of conduits) for the Civic–Molonglo feeders and installation of two feeder cables Civic–Molonglo.
Stage 6 (2031) – installation of third feeder cable Civic–Molonglo.
Stage 7 (2033) – installation of fourth feeder cable Civic–Molonglo.
Stage 8 (2035) – installation of fifth feeder cable Civic–Molonglo.

A preliminary cost estimate for Option 2 is $28,880,500 excluding corporate overheads, contingency and GST. Refer to cost estimates, cash flows and NPC comparison in Appendices A2 and B.

Installing new 11 kV feeders from Civic to Molonglo Valley would be problematic due to Black Mountain lying between the two sites. Cables would need to be installed around the northern perimeter of Black Mountain so feeder lengths to Molonglo Valley would be approximately 8.0 km.

In addition to de-rating, the long lengths of cable feeders from Latham and Civic would create issues with voltage drop and network losses, so voltage regulators or similar devices would be required at the Molonglo Valley end of feeders.

The quality, reliability and security of supply may be reduced under this option due to the length of underground feeders with multiple joints in close proximity to each other. A 9.0 km feeder would require 17 joints plus two terminations, ie a joint approximately every 500 m. Experience shows that the majority of cable faults occur at joints.

Option 2 is not selected due to its lower net present cost (NPC), constructability issues, the distance from Latham and Civic zone substations to Molonglo Valley, future reliability concerns, potential voltage drop and network loss issues. 11 kV voltage regulators would be required which would add to the estimated cost. Extending the 11 kV switchboards at Latham and Civic would also be difficult to achieve as there is limited space available in each switchroom.

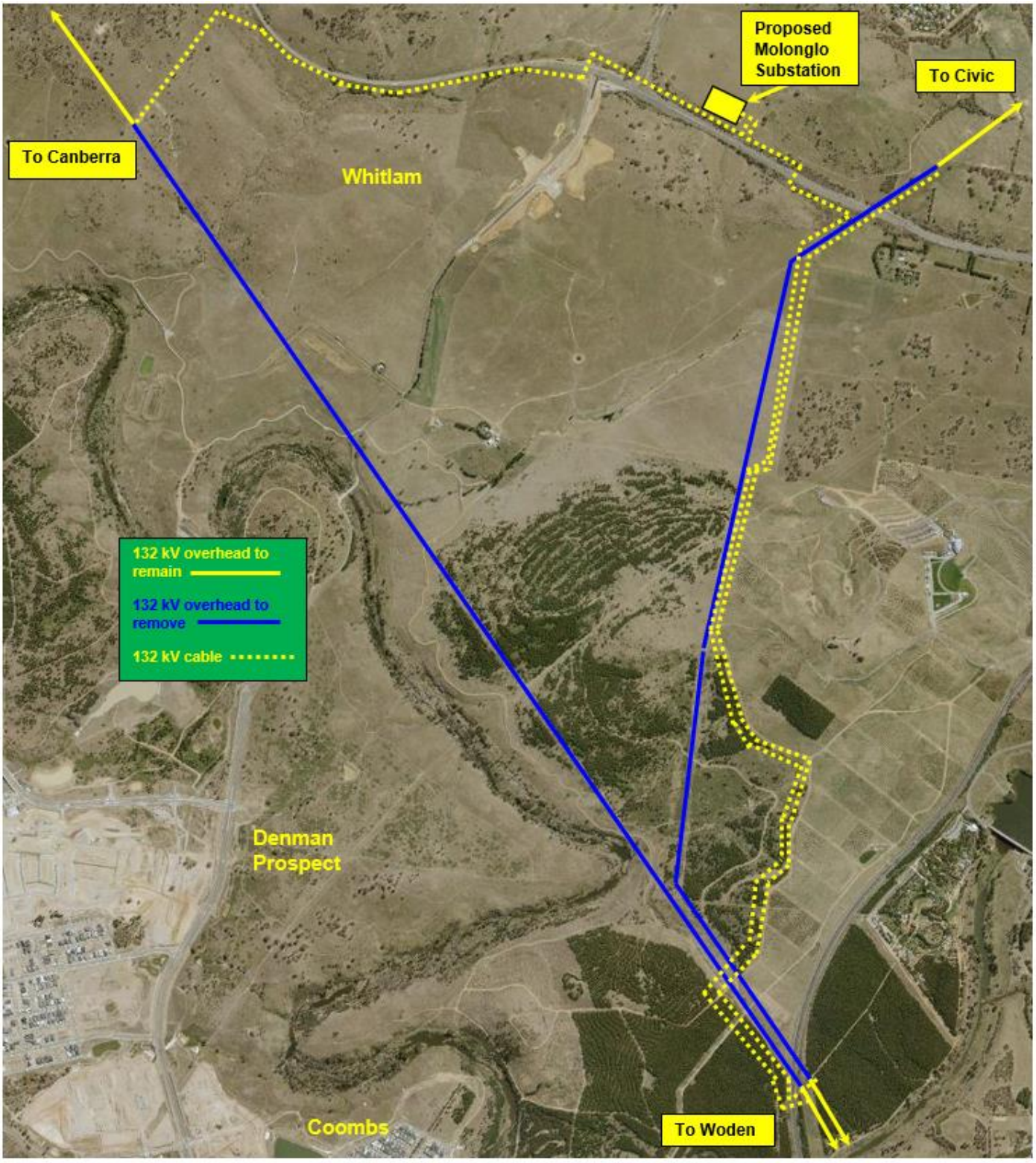
4.1.4. Option 3: Construct Molonglo Zone Substation in two stages

Option 3 proposes to establish a new 132/11 kV zone substation at Molonglo by June 2021.

Evoenergy proposes to construct the new 132/11 kV Molonglo Zone Substation by June 2021 to meet the load forecast provided in Table 1. Until June 2021 the increasing load of new developments in the area will be met by connections to the Streeton feeder (supplied from Woden Zone Substation) and the Black Mountain feeder (supplied from Civic Zone Substation). The Streeton and Black Mountain feeders will be operated up to their thermal limits until the Molonglo Zone Substation and feeders are available.

The proposed site for the Molonglo Zone Substation is on the northern side of William Hovell Drive approximately 500m east of Coulter Drive. The 132 kV Canberra–Woden and Civic–Woden transmission lines that traverse the Molonglo Valley are proposed to be relocated (replaced with underground cables) as part of a separate project that will be fully funded by the Suburban Land Agency. Figure 2 shows the location of the proposed substation site and the proposed 132 kV transmission lines relocation works.

Figure 2: Proposed development of Molonglo Valley



The Molonglo Zone Substation would be equipped initially with one 132/11kV 30/55 MVA transformer and one 11 kV switchboard by June 2021, with provision made for an additional two transformers and additional two 11 kV switchboards to provide future capacity and security. It is proposed to install a second 132/11kV 30/55 MVA transformer and second 11 kV switchboard by 2030, although exact timing will depend on the rate of load growth and the value of energy at risk (due to a contingency of the single transformer). This would provide N-1 security at Molonglo Substation for the foreseeable future. 132/11 kV 30/55 MVA YNd1 transformers are standard at Evoenergy's zone substations.

132 kV connection would be via loop-in-loop-out connection to the Stockdill–Woden 132 kV transmission line. Note that Stockdill Substation will initially provide a tee-connection only to Evoenergy's Canberra–Woden line, but by 2023 TransGrid proposes to construct a 132 kV bus at Stockdill and install line protection circuit breakers for both the Stockdill–Canberra and Stockdill–Woden 132 kV circuits. This will provide Canberra–Stockdill and Stockdill–Woden circuits.

The substation layout and general arrangement would be similar to other Evoenergy zone substations featuring outdoor air-insulated 132 kV switchgear and SF6-insulated circuit breakers, and indoor 11 kV switchgear (air-insulated busbars and vacuum circuit breakers), eg Gold Creek Zone Substation. Refer to the preliminary single line diagram in Appendix D.

11 kV feeders will be reticulated through the suburbs of North Weston, North Wright, North Coombs, Denman Prospect and Whitlam under separate projects as demand grows and as these suburbs are developed.

Load would be transferred from Civic Zone Substation (approx 5.4 MVA) by reconnecting the Black Mountain feeder to Molonglo Zone Substation and from Woden Zone Substation (approx 3.2 MVA) by reconnecting the Streeton feeder to Molonglo Zone Substation. Future 11 kV feeders will inter-tie with Woden, Civic, Belconnen and Latham zone substations strengthening the security of the meshed network. Maximum demand of Molonglo Zone Substation is forecast to reach 50 MVA by 2036 based on the 20-year development plan for the Molonglo Valley.

The preliminary estimated cost of this option is $15,739,350 excluding corporate overheads, contingency and GST (refer cost estimate Appendix A.2), being $12,226,350 for Stage 1 (by June 2021) and $3,513,000 for Stage 2 (approx 2030). Timing of Stage 2 would depend on the rate of load growth in the Molonglo Valley, which will be monitored and forecast carefully.

The augmentation cost of this proposal exceeds $5 million so this project would be subject to the Regulatory Investment Test for Distribution (RIT-D). A RIT-D was commenced in May 2014 and the process needs to be completed.

11 kV feeders would be constructed to supply the Molonglo Valley as described in the Project Justification Report for PN 20001734 Molonglo Valley 11 kV Feeders.

Option 3 is not selected due to its lower NPC.

4.1.5. Option 4: Install mobile substation initially followed by permanent Molonglo Zone Substation in two stages

Option 4 proposes to relocate Evoenergy's 132/11 kV 15 MVA mobile substation (MOSS) from Angle Crossing to the Molonglo Zone Substation site as the first stage of development. The zone substation site would be developed including all earthworks, fencing, earthgrid, drainage and roading. The project would be carried out in three stages.

Stage 1 would comprise relocation and establishment of Evoenergy's mobile substation (MOSS) to the Molonglo Zone Substation site by June 2021. Stage 2 would comprise the installation of one 132/11 kV 30/55 MVA transformer, associated 132 kV switchgear, 11 kV switchroom and one 11 kV switchboard by 2026. Stage 3 would comprise installation of a second 132/11 kV 30/55 MVA transformer and second 11 kV switchboard by 2030, and removal of the MOSS.

132 kV connection would be via loop-in-loop-out connection to the proposed Stockdill–Woden 132 kV transmission line as described in Option 2 above. The 132 kV UGOH structures and bus would be established at Molonglo zone Substation at Stage 1 to enable connection of the MOSS and connection of a permanent transformer at Stage 2.

Stage 2 would comprise establishment of the permanent zone substation with one 132/11 kV 30/55 MVA transformer and one 11 kV switchboard. This transformer would operate in parallel with the MOSS providing 15 MVA firm capacity. Stage 3 would comprise the installation of a second 132/11 kV 30/55 MVA transformer and second 11 kV switchboard. The MOSS would then be removed. This would provide Molonglo Zone Substation with 55 MVA firm capacity.

The preliminary estimated cost of this option is **$16,652,600 excluding corporate overheads, contingency and GST** (refer cost estimate Appendix A.3), being **$6,178,600 for Stage 1 (by June 2021)**, $6,961,000 for Stage 2 (approx 2026), and $3,513,000 for Stage 3 (approx 2030). Timing of Stages 2 and 3 would depend on the rate of load growth in the Molonglo Valley area, which will be monitored and forecast carefully.

The augmentation cost of this option exceeds $5 million so this project would be subject to the Regulatory Investment Test for Distribution (RIT-D).

Option 4 is selected due to its higher (ie least negative) net present cost (NPC).

4.1.6. Option 5: Non-network solution

Option 5 considers non-network initiatives including:

- Incentives to realise the potential of latent demand management within the customer base.
- Incentives to encourage the uptake of additional demand management within the customer base.

These options are further discussed within the Demand Management Paper.

To defer all investment to the next regulatory control period (beyond 2024), it is estimated that non-network solutions would need to provide a maximum demand of approximately 13.7 MVA pa.

Latent demand management within the existing customer base was investigated, with a maximum estimated capacity of 0.48 MVA. This does not meet the minimum capacity required of 13.7 MVA to enable the new feeder to be deferred.

These non-network options are summarised in Table 6.

Table 6: Summary of latent demand management

Non-network Option		Streeton Feeder	Hilder Feeder	Black Mountain Feeder	Total
Controllable load	**Capacity**	0.03 MVA	0.03 MVA	0.03 MVA	**0.09 MVA**
Customer – owned embedded generation	**Capacity**	0.1 MVA	0.1 MVA	0.1 MVA	**0.3 MVA**
Customer – owned energy storage	**Capacity**	0.02 MVA	0.02 MVA	0.02 MVA	**0.06 MVA**
Load curtailment	**Capacity**	0.01 MVA	0.01 MVA	0.01 MVA	**0.03 MVA**
Totals	**Capacity**	**0.16 MVA**	**0.16 MVA**	**0.16 MVA**	**0.48 MVA**

In summary, a maximum demand reduction of 0.48 MVA could be achieved if all the above non-network options were implemented. This is not sufficient to defer investment.

Third party non-network proposals will be requested via the RIT-D process and via Evoenergy's website demand management portal and may identify additional opportunities.

Where there is insufficient latent demand management within the customer base, there is further opportunity to incentivise customers to adopt additional technologies to reduce demand. This includes opportunities to permanently reduce demand (such as energy efficiency technology or power factor correction) as well as opportunities to adopt technology to enable participation in demand response markets (such as embedded generation, battery storage, building management systems). For the purposes of the evaluation, it is assumed that no more than 30% of demand growth can be offset using additional demand management.

For Molonglo Valley it was determined that more than 50% of demand growth would need to be offset by demand management to enable investment to be deferred, implying that new demand management is unlikely to defer investment.

4.1.7. Option 6: Grid battery to defer Option 4

Option involves the installation of a grid battery to defer Option 4 (or 3). This option has the advantage of deferring the investment until greater certainty in future demand is known. However, given the relatively high certainty of future demand for this project and the relatively high cost of the grid battery, this option was assessed as higher cost than the Network Options 3 or 4 with a preliminary cost estimate of $22,477,980 excluding corporate overheads, contingency and GST. This results in a deferral of one year only, with investment in the network option commencing in 2020. Any further deferral was assessed as less economic than the preferred network option.

Refer to cost estimates, cash flows and NPC comparison in Appendices A and B.

4.1.8. Option 7: Grid battery only

This option explored the use of a grid battery only. A grid battery, although more expensive than a traditional network solution on a per MVA basis, has advantages over a traditional network solution. A network battery is modular and also able to be redeployed, meaning it can represent a more economic option in an environment of demand uncertainty or where demand is expected to increase for a short period and then decline.

In the case of Molonglo however, the grid battery was not economic due to the relative certainty of demand with a preliminary cost estimate in excess of $100m to supply the entire load. Refer to cost estimates, cash flows and NPC comparison in Appendices A and B.

4.1.9. Options Analysis

Table 8 shows a summary of the forecast load growth in the Molonglo Valley for the next 10 years and the ability of the options considered to supply this load growth. These forecast loads make allowance for predicted penetration of rooftop solar PV and battery storage systems. This shows that available thermal capacity of existing feeders (including the extended Hilder feeder) would be exceeded by mid-2021.

The bottom two rows of the table show the impact of the two credible options being considered (ie Option 2: Construction of feeders from existing zone substations, and Option 4: Construction of Molonglo Zone Substation and associated feeders).

Table 7: Forecast Load Growth and Impact of Augmentation Options

Molonglo Valley Development - Load Forecast @ 29.8.18									
Year	2018	2019	2020	2021	2022	2023	2024	2025	2026
Residential Loads (MVA)									
Coombs	0.5	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Wright	0.4	0.7	0.5	0.5	0.2	0.1	0.1	0.1	0.1
Weston	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Denman Prospect	1.8	0.6	1.0	1.0	1.0	1.0	0.5	0.4	0.5
Whitlam		1.9	1.5	1.5	1.5	0.2	0.2	0.2	
Additional Residential Load (MVA) @ 2.5 kVA ADMD	2.9	3.7	3.3	3.3	3.0	1.5	1.0	0.9	0.8
Block Loads (MVA)									
Wright - hotel etc				0.5	0.7				
Denman Prospect Commercial centre						0.5	0.5	0.5	0.5
Stromlo Aquatic Park				0.5					
Stromlo Leisure Centre					1.0	1.0			
North Wright School				0.2					
Additional Non-residential Load (MVA) ADMD	0.0	0.0	0.0	1.2	1.7	1.5	0.5	0.5	0.5
Total Additional Load (MVA) ADMD	2.9	3.7	3.3	4.5	4.7	3.0	1.5	1.4	1.3
Cumulative Additional Load (MVA) ADMD	2.9	6.6	9.9	14.4	19.1	22.1	23.6	25.0	26.3
Spare thermal capacity Streeton and Black Mountain feeders (MVA) - **Do Nothing Option**	7.0	3.3	0.0	-4.5	-9.2	-12.2	-13.7	-15.1	-16.4
Spare thermal capacity Streeton, Black Mountain and extended Hilder feeders (MVA) - **Option 1**	8.4	4.7	1.4	-3.1	-7.8	-10.8	-12.3	-13.7	-15.0
Spare thermal capacity Streeton and Black Mountain feeders and new feeders from Latham and Civic (10 MVA in 2021, 5 MVA in 2023, 5 MVA in 2025) - **Option 2**	7.0	3.3	0.0	5.5	0.8	2.8	1.3	4.9	3.6
Spare thermal capacity Streeton and Black Mountain feeders and Molonglo Zone Substation and feeders (15 MVA in 2021, 15+55 MVA in 2025) - **Option 4**	7.0	3.3	0.0	10.5	5.8	2.8	1.3	54.9	53.6

The forecast load growth for the Molonglo Valley shown in Table 7 above indicates:

- All available thermal capacity of the existing Streeton and Black Mountain feeders would be exhausted by the end of 2020. This is the Do Nothing Option and does not meet the minimum requirements.
- All available thermal capacity of the Streeton, Black Mountain and extended Hilder feeders would be exhausted by winter 2021. This is Option 1 and does not meet the minimum requirements.
- Construction of the new feeders from Latham and Civic zone substations commencing 2021 could provide the additional capacity required. This is Option 2 and meets the project requirements.
- Construction of Molonglo Zone Substation and associated 11 kV feeders commencing 2021 could provide the additional capacity required. This is Option 4 and meets the project requirements.

The Molonglo Valley load forecast is based on the rate of construction as indicated by developers. Evoenergy will continue to connect new customers to the Streeton and Black Mountain feeders until such time as all available spare thermal capacity has been utilised. Under the Do Nothing Option or Option 1, all available spare thermal capacity would be utilised by the end of 2020. Beyond this time the Do Nothing Option or Option 1 would mean that new customers would not be able to be supplied. This would place Evoenergy in breach of its obligation to make supply available to new customers in the ACT.

In addition, Evoenergy's Distribution Network Augmentation Standards require 11 kV feeders to be operated to their maximum firm rating only, not their maximum thermal rating. Loading feeders to their thermal capacity with no backup capacity available from other feeders would be an extremely risky approach that would result in considerable unserved energy in the event of an unplanned outage. It should also be noted that the Black Mountain feeder is an overhead 11 kV line so any cable connections being made to it (to supply Whitlam suburb) would require an outage. This would result in considerable planned unserved energy.

Loss of a feeder will result in unserved energy until repairs are made. Although 8 hours outage duration has been used for "Value of Energy at Risk" calculations (refer Appendix B2), it should be noted that Evoenergy's maintenance staff do not normally repair cable faults after the hours of darkness. A feeder fault on the existing feeders supplying Molonglo Valley is most likely to occur in the early evening during winter months when the load is greatest. It would typically take 24 hours for such a fault to be located and repaired. Under normal firm-rating conditions, Evoenergy would be able to isolate the faulted section and back-feed from adjacent feeders to reduce customer outage time. This will not be the case when feeders are loaded to their maximum thermal rating.

Construction of new feeders (either from existing zone substations or new Molonglo Zone Substation) must commence by the end of 2020 to be available by winter 2021.

4.1.10. Summary of Options Analysis

Table 8: Summary of Options

Option	Description	Total Capital Cost 2019-2039	Capital Cost 2019-24	20 year Net Present Cost	Outcome
0	Do nothing. Connect all new loads to Streeton and Black Mountain feeders and operate to their thermal ratings.	$0	$0	$0	Not selected as does not meet need
1	Extend Hilder feeder. Operate Streeton, Black Mountain and Hilder feeders to their thermal ratings.	$4,055,000	$4,055,000	N/A	Not selected as does not meet need
2	Construct new 11 kV feeders from existing zone substations: Five feeders from Latham Zone Substation and Five feeders from Civic Zone Substation.	$28,880,500	$11,998,600	-$16,234,891	Not selected due to lower NPC
3	Construct new Molonglo Zone Substation in two stages	$15,739,350	$12,226,350	-$12,449,004	Not selected due to lower NPC
4	**Construct new Molonglo Zone Substation in three stages (Stage 1 = MOSS) (PN 17519206)**	**$16,652,600**	**$6,178,600**	**-$9,673,179**	**Selected due to higher NPC**
	Overall project: **Construct new 11 kV feeders from Molonglo Zone Substation (PN 20001374);** **Construct new Molonglo Zone Substation (PN 17519206)**	**$21,346,600**	**$10,872,600**	**-$10,336,712**	**Selected due to higher NPC**
5	Demand management	N/A	N/A	N/A	Not selected as does not meet need
6	Grid battery to defer Option 3	$22,477,980	$12,003,980	-$15,291,273	Not selected as deferral not economic
7	Grid battery only	N/A	$4,899,505	>-$100M	Not selected as deferral not economic

4.2. Recommendation

The selected option is Option 4, the construction of a new 132/11 kV zone substation in the Molonglo Valley in three stages, to be sited on the northern side of William Hovell Drive to the east of Coulter Drive. 132 kV connection will be via a loop-in-loop-out connection to the Stockdill–Woden 132 kV transmission line.

Financial analysis (refer Appendix B) shows Option 4 to be the preferred option as it has the highest net present cost (ie least negative) of all credible options. It also has the lowest capital cost. The overall project, ie construction of new Molonglo Zone Substation and associated 11 kV feeders has the highest NPC of all credible options.

Stage 1 will comprise relocation and establishment of Evoenergy's mobile substation (MOSS) at the Molonglo Zone Substation site by June 2021. Stage 2 will comprise the installation of one 132/11 kV 30/55 MVA transformer, associated 132 kV switchgear, 11 kV switchroom and one 11 kV switchboard by 2026. Stage 3 will comprise installation of a second 132/11 kV 30/55 MVA transformer and second 11 kV switchboard by 2030, and removal of the MOSS.

The new substation will provide capacity and security of supply to the new suburbs being developed in the Molonglo Valley. It will also take over some load that is currently supplied by Civic and Woden zone substations, thereby releasing some capacity for these substations to supply developments in their surrounding suburbs.

The completed substation will have provision for a future third 132/11 kV transformer and third 11 kV switchboard to meet future load growth if required.

The preliminary estimated cost of the selected option of new Molonglo Zone Substation to be constructed in three stages is **$16,652,600 excluding corporate overheads, contingency and GST** (refer cost estimate Appendix A3), being **$6,178,600 for Stage 1 (by June 2021)**, $6,961,000 for Stage 2 (approx 2026), and $3,513,000 for Stage 3 (approx 2030). Timing of Stages 2 and 3 would depend on the rate of load growth in the Molonglo Valley area, which will be monitored and forecast carefully.

The major assets will add to Evoenergy's regulated asset base and will have an economic life of 50 years.

Proposed 11 kV feeders (to be installed under PN 20001374) will provide ties to existing feeders from Latham, Belconnen, Civic and Woden zone substations, and thus provide some backup supply capability and load transfer capability in the future.

The new substation will provide capacity and security of supply to the new suburbs being developed in the Molonglo Valley and will provide a secure and adequate power supply to the forecast population of 55,000 residents.

The Regulatory Investment Test for Distribution (RIT-D) will be completed in accordance with the National Electricity Rules.

Appendix A: Preliminary Cost Estimates

A.1 Cost Estimate – Option 1: Extend Hilder Feeder

Molonglo Valley : Extend Hilder Feeder to Denman Prospect and Whitlam (requires directional drilling beneath Molonglo River to Whitlam); Overhead to Underground conversion of Black Mountain feeder to provide for Whitlam Estate development.					
Preliminary Estimate ± 30% Accuracy					
Description	**Notes**	**Unit**	**$/Unit**	**Quantity**	**Cost**
Trenching and drilling					$3,297,500
Clearing of route where required	Allowance	m2	$10	3000	$30,000
Directional drilling for Hilder feeder including beneath Molonglo River	Assume drilling with no rock. Assume three conduits per drill.	m	$600	4000	$2,400,000
Open trenching and backfilling for Black Mountain feeder conversion	Assume excavation with no rock.	m	$300	2500	$750,000
Cable jointing and haulage pits	Assume every 500m	ea	$3,000	15	$45,000
Traffic management		m	$5	6500	$32,500
Reinstatement incl revegetation as required	Excavation, no rock (minor boulders only). Site is mostly flat.	m3	$40	1000	$40,000
Cabling works					$624,500
11 kV 3c/400mm2 XLPE cable		m	$56	6500	$364,000
Throughjoints	Assume every 500m	ea	$1,000	15	$15,000
Terminations en route to existing distribiutin substations		ea	$1,500	12	$18,000
Conduit, cable cover and marker tape		m	$15	6500	$97,500
Cable installation labour and plant		m	$20	6500	$130,000
11 kV Switchgear					$8,000
11 kV feeder CBs		ea	$75,000		$0
11 kV Test & Commissioning		lot	$2,000	4	$8,000
Electrical (Secondary System)					$0
Protection & Control					$0
P&C Secondary Cabling	per feeder panel	ea	$2,250		$0
P&C Test & Commission	Allowance	ea	$2,500		$0
DC Supply System					$0
DC Cabling	per switchgear panel/bay	ea	$5,000		$0
DC Test & Commission	Allowance	ea	$2,000		$0
SCADA					$0
SCADA connections for new feeder panels		ea	$2,000		$0
Test & Commissioning	Allowance	ea	$2,000		$0
Indirect Costs					$125,000
Development Application	Allowance	ea	$10,000	1	$10,000
Contractor's Preliminaries, site establishment and disestablishment	Allowance	ea	$15,000	1	$15,000
Project management and administration	Allowance	ea	$100,000	1	$100,000
Project Sub Total without overheads					**$4,055,000**
Overheads					
Overall average overhead rate	Allowance	27%	$1,094,850	1	$1,094,850
Project Sub Total with overheads					**$5,149,850**
Contingency					
All project works	Preliminary allowance	15%	$772,478	1	$772,478
Project budget total					**$5,922,328**

A.2 Cost Estimate – Option 2: 11 kV Feeders to Molonglo Valley from existing zone substations

Molonglo Valley supply from existing substations via new 11 kV feeders. Assume five feeders from Latham @ 9km each and five from Civic @ 8km each. Assume two trenches from each substation. Total trenching/boring route length approx 2 x 9 km + 2 x 8 km = 34 km					
Preliminary Estimate ± 30% Accuracy					
Description	**Notes**	**Unit**	**$/Unit**	**Quantity**	**Cost**
Trenching and drilling					$19,612,000
Clearing of route where required	Allowance	m2	$10	100000	$1,000,000
Directional drilling	Assume drilling with no rock. Assume two or three cables per trench. Assume 75% of 34 km total route	m	$600	25500	$15,300,000
Open trenching and backfilling	Assume excavation with no rock. Backfill with bedding sand and native soil. Assume two or three cables per trench. Assume 25% of 24 km total route length can be	m	$300	8500	$2,550,000
Cable jointing and haulage pits	Assume every 500m	ea	$3,000	64	$192,000
Traffic management		m	$5	34000	$170,000
Reinstatement incl revegetation as required	Excavation, no rock (minor boulders only). Site is mostly flat . Extracted volume stockpile for use within Molonglo Development.	m3	$40	10000	$400,000
Cabling works					$7,660,000
11 kV 3c/400mm2 XLPE cable		m	$56	85000	$4,760,000
Throughjoints	Assume every 500m	ea	$1,000	320	$320,000
Terminations	Assume distribution substations at Molonglo established under estate reticulation works.	ea	$1,500	20	$30,000
Conduit and marker tape	Assume all cables installed in conduit	m	$10	85000	$850,000
Cable installation labour and plant		m	$20	85000	$1,700,000
11 kV Switchgear					$750,000
11 kV feeder CB panels	Assume able to extend switchboards at existing zone substations	ea	$75,000	10	$750,000
11kV Test & Commissioning	per CB	lot	$2,000	10	$20,000
HV Connections					$40,000
11kV Cable Termination		ea	$1,000	20	$20,000
HV Cables and connections Test &	Allowance	ea	$2,000	10	$20,000
Electrical (Secondary System)					$90,500
Protection & Control					$32,500
P&C Secondary Cabling	per feeder panel	ea	$2,250	10	$22,500
P&C Test & Commission	Allowance	ea	$2,500	4	$10,000
DC Supply System					$58,000
DC Cabling	per switchgear panel/bay	ea	$5,000	10	$50,000
DC Test & Commission	Allowance	ea	$2,000	4	$8,000
SCADA					$28,000
SCADA connections for new feeder panels		ea	$2,000	10	$20,000
Test & Commissioning	Allowance	ea	$2,000	4	$8,000
Indirect Costs					$700,000
Development Application	Allowance	ea	$100,000	1	$100,000
Contractor's Preliminaries, site establishment and disestablishment	Allowance	ea	$100,000	1	$100,000
Project management and administration	Allowance	ea	$500,000	1	$500,000
Project Sub Total without overheads					**$28,880,500**
Overheads					
Overall average overhead rate	Allowance	27%	$7,797,735	1	$7,797,735
Project Sub Total with overheads					**$36,678,235**
Contingency					
All project works	Preliminary allowance	15%	$5,501,735	1	$5,501,735
Project budget total					**$42,179,970**

A.2 Cost Estimate – Option 3: New Molonglo Zone Substation in two stages

Molonglo Zone Substation - site northern side of Wiiliam Hovell Drive. 132 kV cable in cable out. 132 kV AIS. Indoor 11 kV. Stage 1 One transformer and switchboard (2021). Stage Two second transformer and switchboard (2030).							
Preliminary Estimate ± 30% Accuracy							
Description	**Notes**	**Unit**	**$/Unit**	**Stage 1 Quantity**	**Stage 1 Cost**	**Stage 2 Quantity**	**Stage 2 Cost**
Civil & Structural					$5,647,300		$277,500
Earthworks					$624,000		$0
Clearing of site 180m x 180m		m2	$10	32400	$324,000		$0
Landscaping /screening / plantings outside switchyard	Allowance	lot	$100,000	1	$100,000		$0
Cut & Fill - benching of site	Excavation, no rock (minor boulders only). Site is mostly flat. Extracted volume stockpile for use within Molonglo Development.	m3	$40	5000	$200,000		$0
Site Works					$1,052,000		$0
Substation earthgrid		m2	$50	6400	$320,000		$0
Supply, place, compact crushed gravel (blue metal)		m2	$30	6000	$180,000		$0
Switchyard climbproof fence		m	$1,500	320	$480,000		$0
Site Perimeter farm fence and gate		m	$100	720	$72,000		$0
Concrete Works					$1,055,000		$180,000
Outdoor switchgear pier foundation (light)	Incl excavation, formwork, concrete, rebar & anchor bolts per 'footing'	ea	$4,000	15	$60,000	15	$60,000
Outdoor switchgear pier foundation (medium)	Incl excavation, formwork, concrete , rebar & anchor bolts per 'footing'	ea	$8,000	15	$120,000	15	$120,000
11kV Switchgear / control / secondary systems building basement	Excavation, no rock (minor boulders only).	m3	$100	800	$80,000		$0
132/11kV transformer pad incl bund	Wall to 0.3m (higher walls are brick)	ea	$225,000	3	$675,000		$0
11/0.4kV transformer pad incl bund		ea	$12,000	2	$24,000		$0
Neutral earthing transformer pad incl bund		ea	$12,000	2	$24,000		$0
Diesel Genset Pad incl Bund		ea	$12,000	1	$12,000		$0
Transformer Runway	5m wide, heavy load reinforced concrete pad	m	$1,000	60	$60,000		$0
Roads & Walkways					$408,400		$0
Site Access Road - from Coulter Drive	Bitumen, 4m wide	m	$660	500	$330,000		$0
Parking & Loading areas	Bitumen	m2	$130	280	$36,400		$0
Light Vehicle / Walkway	Bitumen, 2.5m wide	m	$210	200	$42,000		$0
Ducts and Culverts					$195,200		$0
HV Ducting HD PVC Conduit		m	$200	200	$40,000		$0
HV Cable Duct	Transformers to 11 kV switchboards, under transformer runway	m	$400	60	$24,000		$0
Secondary Cabling Culvert	Precast box culvert	m	$600	160	$96,000		$0
Cable ladders & trays		m	$220	160	$35,200		$0
Buildings & Structures					$1,677,500		$97,500
132/11 kV Transformer Blast Wall 15m each	4.5m high	m	$6,500	15	$97,500	15	$97,500
11 kV Switchgear / control / secondary systems building	In-situ construction, over basement. Loading and access 'platform'. Incl VESDA, Central A/C, Small Power & Light, Operator facilities and amenities.	m2	$3,000	400	$1,200,000		$0
132 kV Gantry	Portal gantry, incl foundation	ea	$90,000	2	$180,000		$0
132 kV Cable termination structures	Galvanised steel. Incl foundation	ea	$100,000	2	$200,000		$0
Oil Containment System					$184,000		$0
Oil-water separation tank	Type Puraceptor Class 1, incl excavation/fill	ea	$150,000	1	$150,000		$0
Ducting for oil-water		m	$200	120	$24,000		$0
Secondary dam (sedimentation dam)	Earthworks + lining	lot	$10,000	1	$10,000		$0

Drainage, Water & Sewage					$451,200		$0
Drainage Ducts/culverts	Footprint related	m2	$33	6400	$211,200		$0
Fresh water tank, and piping	Allowance	lot	$140,000	1	$140,000		$0
Sewage tank, and piping	Allowance	lot	$100,000	1	$100,000		$0
Electrical (Primary System)					$3,533,800		$2,626,000
132 kV Switchgear					$1,085,800		$238,000
145 kV Dead Tank CB, 3150 A, incl bushing CT & structure. SF6 excl.	Transformer CBs	ea	$100,000	1	$100,000	1	$100,000
145 kV Live Tank CB, 3150 A, incl structure. SF6 excl.	Line CBs	ea	$75,000	2	$150,000		$0
145 kV Horizontal Double Break Disconnector (Motorised) 2000 A & Earth switch (Manual), incl structure.	With Earth Switch	ea	$21,000	2	$42,000		$0
145 kV Horizontal Double Break Disconnector (Motorised) 2000 A incl structure.	Without Earth Switch	ea	$17,000	7	$119,000	1	$17,000
145 kV VT (post type). Incl structure. (1x3-ph)	Line VTs	ea	$30,000	2	$60,000		$0
145 kV CT (post type). Incl structure. (1x3-ph)	Line CTs	ea	$54,000	2	$108,000		$0
145 kV Surge Arrester, incl surge counter. Excl structure. (1x3-ph)	Cable Terminations. (Transformers to be c/w tank-mounted surge arrestors)	ea	$6,900	2	$13,800		$0
132 kV Busbar, 2000 A	Rigid bus, tubular Al on post supports. 15m bay 3 phase	ea	$65,000	2	$130,000		$0
132 kV jumpers/busbars	Twin Uranus per phase, incl post insulators and fittings	bay	$150,000	1.5	$225,000	0.5	$75,000
SF6 Gas - estimate 10kg per single pole (LTCB) and 30kg per DTCB	Allowance for first fill and levy	kg	$1,200	90	$108,000	30	$36,000
132 kV switchgear Test & Commissioning	Allowance	bay	$20,000	1.5	$30,000	0.5	$10,000
132/11 kV Transformer					$1,400,000		$1,400,000
132/11 kV 30/55MVA ONAN/ODAF, OLTC, YNd1	With 11 kV Bushing CT & 132 kV Neutral CT. 132 kV and 11 kV air bushings but consider 11 kV cable boxes. Including delivery and installation	ea	$1,280,000	1	$1,280,000	1	$1,280,000
Transfomer insulating oil		litre	$1	20000	$20,000	20000	$20,000
Transformer Test & Commissioning	Allowance	ea	$100,000	1	$100,000	1.0	$100,000
11 kV Switchgear					$790,000		$790,000
12 kV Switchboard air-insulated double bus, vacuum CBs (2 x Incomer 2500A, 10 x Feeders 12500 AR, 1 x Bus-coupler 2500A)	Incl Duplicate Protection & SCADA Interface and installation (swbd only $680k)	ea	$750,000	1	$750,000	1	$750,000
11 kV Switchboard Metering/Earthing Panel	Incl SCADA Interface	ea	$20,000	1	$20,000	1	$20,000
11 kV Test & Commissioning	per switchboard - allowance	lot	$20,000	1	$20,000	1	$20,000
HV Connections					$174,000		$114,000
132 kV Cable	Cables installed as part of 132 kV relocation project. Cable termination structures and 132 kV bus to be installed beforehand - 6 cables per circuit	m	$500	0	$0		$0
132 kV Cable Termination - jointing per 3-phase circuit	Two x single core 1600mm2 Cu XLPE cables per phase	ea	$30,000	2	$60,000		$0
11 kV Aerial Bus	At transformer 11 kV terminal (delete if cable boxes on transformers)	ea	$20,000	1	$20,000	1	$20,000
11 kV Cable 1c/800mm2 Cu XLPE two per phase	For connection between transformers and 11kV switchboards - assume 60m	m	$100	480	$48,000	480	$48,000
11 kV Cable 3c/35mm2 AL XLPE	For connections to 11/0.4 kV station services transformers and neutral earthing transformers - assume 50m each	m	$100	100	$10,000	100	$10,000
11 kV Cable Termination 1c/800mm2 Cu XLPE		ea	$750	16	$12,000	16	$12,000
11 kV Cable Termination 3c/35mm2 Al XLPE		ea	$1,000	4	$4,000	4	$4,000
HV Cables and connections Test & Commissioning	Allowance	lot	$20,000	1	$20,000	1	$20,000
Primary (ancillary equipment)					$84,000		$84,000
11/0.4 kV Auxiliary supply transformer 200 kVA	Cable-in cable-out	ea	$40,000	1	$40,000	1	$40,000
11kV Earthing transformer 3000 Amps	Civil/Structure/Electric S&I	ea	$40,000	1	$40,000	1	$40,000
Primary (ancillary) Test & Commissioning	Allowance	lot	$2,000	2	$4,000	2	$4,000

Electrical (Secondary System)					$1,226,250		$309,500
Protection & Control					$556,250		$309,500
132 kV Line Protection Panel	1 panel incl X and Y protection & SCADA Interface	ea	$80,000	2	$160,000		$0
132 kV Busbar Protection Panel	1 panel incl X and Y protection & SCADA Interface	ea	$80,000	1	$80,000		$0
132/11 kV Transformer Protection Panel	1 panel incl X and Y protection & SCADA Interface	ea	$80,000	1	$80,000	1	$80,000
132 kV Transformer AVR Panel		ea	$25,000	1	$25,000	1	$25,000
P&C Secondary Cabling	per P&C panel	ea	$2,250	5	$11,250	2	$4,500
P&C Test & Commission	Allowance	lot	$200,000	1	$200,000	1	$200,000
LV AC Supply					$280,000		$0
Diesel Genset - 200 kVA	Skid/kiosk mounted with integrated tank, noise reduction	ea	$125,000	1	$125,000		$0
LV AC Main Distribution Board	Incl protection and SCADA interface, automatic changeover of incoming supply	ea	$50,000	1	$50,000		$0
LV AC Cabling	Allowance	lot	$100,000	1	$100,000		$0
LV AC Test & Commission	Allowance	lot	$5,000	1	$5,000		$0
DC Supply System					$390,000		$0
125 V DC Battery bank	Duplicate DC systems	ea	$85,000	2	$170,000		$0
AC/DC Converter - Charger	Duplicate DC systems	ea	$40,000	2	$80,000		$0
DC Distribution Board	Duplicate DC systems	ea	$30,000	2	$60,000		$0
DC Cabling	Allowance	lot	$75,000	1	$75,000		$0
DC Test & Commission	Allowance	lot	$5,000	1	$5,000		$0
SCADA, Communication, Substation misc (lightning protection, lighting, security)					$1,019,000		$0
SCADA RTU and HMI (incl commissioning)	Duplicate RTU, single HMI	lot	$500,000	1	$500,000		$0
Communication End-Equipment Panel (incl commissioning)	Duplicate	lot	$250,000	1	$250,000		$0
Fibre Optic Breakout Panel (FOBOT)	Duplicate	ea	$20,000	2	$40,000		$0
Security - Intrusion Detection	Allowance	lot	$10,000	1	$10,000		$0
Security - CCTV	Allowance	lot	$50,000	1	$50,000		$0
Lightning Protection	15m pole with lightning arrester	ea	$7,000	14	$98,000		$0
External Lighting	10m pole with floodlights	ea	$1,500	14	$21,000		$0
SCADA, Comms, misc, Test & Commissioning	Allowance	lot	$50,000	1	$50,000		$0
Indirect Costs					$800,000		$300,000
Construction Environmental Management Plan CEMP	Allowance	ea	$100,000	1	$100,000		$0
Contractor's Preliminaries, site establishment and disestablishment	Allowance	ea	$100,000	1	$100,000	0.5	$50,000
Misc building approvals	Allowance	ea	$100,000	1	$100,000		$0
Project management and administration	Allowance	ea	$500,000	1	$500,000	0.5	$250,000
Stage Sub Total without overheads					**$12,226,350**		**$3,513,000**
Project Sub Total without overheads							**$15,739,350**
Overheads							
Overheads at average rate 43%	Allowance	27%			$3,301,115		$948,510
Stage Sub Total with overheads					**$15,527,465**		**$4,461,510**
Project Sub Total with overheads							**$19,988,975**
Contingency							
Contingency at 15%	Allowance	15%			$2,329,120		$669,227
Stage total wth all overheads and contingency					**$17,856,584**		**$5,130,737**
Project total with all overheads and contingency							**$22,987,321**

A.3 Cost Estimate – Option 4: MOSS followed by new Molonglo Zone Substation

Molonglo Zone Substation - site northern side of William Hovell Drive. 132 kV cable in cable out. 132 kV AIS. Indoor 11 kV. Stage 1 relocate MOSS (2021), Stage 2 one transformer and switchboard (2026), Stage 3 second transformer and switchboard (2030).									
Preliminary Estimate ± 30% Accuracy									
Description	**Notes**	**Unit**	**$/Unit**	**Stage 1 Quantity**	**Stage 1 Cost**	**Stage 2 Quantity**	**Stage 2 Cost**	**Stage 3 Quantity**	**Stage 3 Cost**
Civil & Structural					$3,199,600		$2,547,700		$277,500
Earthworks					$624,000		$0		$0
Clearing of site 180m x 180m		m2	$10	32400	$324,000		$0		$0
Landscaping /screening / plantings outside	Allowance	lot	$100,000	1	$100,000		$0		$0
Cut & Fill - benching of site	Excavation, no rock (minor boulders only). Site is mostly flat. Extracted volume stockpile for use within Molongo Development.	m3	$40	5000	$200,000		$0		$0
Site Works					$1,052,000		$0		$0
Substation earthgrid		m2	$50	6400	$320,000		$0		$0
Supply, place, compact crushed gravel (blue metal)		m2	$30	6000	$180,000		$0		$0
Switchyard climbproof fence		m	$1,500	320	$480,000		$0		$0
Site Perimeter farm fence and gate		m	$100	720	$72,000		$0		$0
Concrete Works					$0		$1,055,000		$180,000
Outdoor switchgear pier foundation (light)	Incl excavation, formwork, concrete, rebar & anchor bolts per 'footing'	ea	$4,000		$0	15	$60,000	15	$60,000
Outdoor switchgear pier foundation (medium)	Incl excavation, formwork, concrete, rebar & anchor bolts per 'footing'	ea	$8,000		$0	15	$120,000	15	$120,000
11kV Switchgear / control / secondary systems building basement	Excavation, no rock (minor boulders only).	m3	$100		$0	800	$80,000		$0
132/11kV transformer pad incl bund	Wall to be 0.3m (higher walls are brick)	ea	$225,000		$0	3	$675,000		$0
11/0.4kV transformer pad incl bund		ea	$12,000		$0	2	$24,000		$0
Neutral earthing transformer pad incl bund		ea	$12,000		$0	2	$24,000		$0
Diesel Genset Pad incl Bund		ea	$12,000		$0	1	$12,000		$0
Transformer Runway	5m wide, heavy load reinforced concrete pad	m	$1,000		$0	60	$60,000		$0
Roads & Walkways					$408,400		$0		$0
Site Access Road - from Coulter Drive	Bitumen, 4m wide	m	$660	500	$330,000		$0		$0
Parking & Loading areas	Bitumen	m2	$130	280	$36,400		$0		$0
Light Vehicle / Walkway	Bitumen, 2.5m wide	m	$210	200	$42,000		$0		$0
Ducts and Culverts					$0		$195,200		$0
HV Ducting HD PVC Conduit		m	$200		$0	200	$40,000		$0
HV Cable Duct	Transformers to 11 kV switchboards, under transformer runway	m	$400		$0	60	$24,000		$0
Secondary Cabling Culvert	Precast box culvert	m	$600		$0	160	$96,000		$0
Cable ladders & trays		m	$220		$0	160	$35,200		$0
Buildings & Structures					$480,000		$1,297,500		$97,500
132/11 kV Transformer Blast Wall 15m each	4.5m high	m	$6,500		$0	15	$97,500	15	$97,500
11 kV Switchgear / control / secondary systems building	In-situ construction, over basement. Loading and access 'platform'. Incl VESDA, Central A/C, Small Power & Light, Operator facilities and amenities.	m2	$3,000		$0	400	$1,200,000		$0
132 kV Gantry	Portal gantry, incl foundation	ea	$90,000	2	$180,000		$0		$0
132 kV Cable termination structures Strathnairn ZS and Canberra Substation	Galvanised steel. Incl foundation	ea	$100,000	3	$300,000		$0		$0
132 kV Cable Termination UGOH structure adjacent to tower STP95800	Two x single core 1600mm2 Cu XLPE cables per phase. Concrete poles - drg 12045-4-003	ea	$500,000	1	$500,000		$0		$0
Oil Containment System					$184,000		$0		$0
Oil-water separation tank	Type Puraceptor Class 1, incl excavation/fill	ea	$150,000	1	$150,000		$0		$0
Ducting for oil-water		m	$200	120	$24,000		$0		$0
Secondary dam (sedimentation dam)	Earthworks + lining	lot	$10,000	1	$10,000		$0		$0

Drainage, Water & Sewage					$451,200		$0		$0
Drainage Ducts/culverts	Footprint related	m2	$33	6400	$211,200		$0		$0
Fresh water tank, and piping	Allowance	lot	$140,000	1	$140,000		$0		$0
Sewage tank, and piping	Allowance	lot	$100,000	1	$100,000		$0		$0
Electrical (Primary System)					$580,000		$3,473,800		$2,626,000
132 kV Switchgear					$0		$1,085,800		$238,000
145 kV Dead Tank CB, 3150 A, incl bushing CT & structure. SF6 excl.	Transformer CBs	ea	$100,000		$0	1	$100,000	1	$100,000
145 kV Live Tank CB, 3150 A, incl structure.	Line CBs	ea	$75,000		$0	2	$150,000		$0
145 kV Horizontal Double Break Disconnector (Motorised) 2000 A & Earth switch (Manual),	With Earth Switch	ea	$21,000		$0	2	$42,000		$0
145 kV Horizontal Double Break Disconnector (Motorised) 2000 A incl structure.	Without Earth Switch	ea	$17,000		$0	7	$119,000	1	$17,000
145 kV VT (post type). Incl structure. (1x3-ph)	Line VTs	ea	$30,000		$0	2	$60,000		$0
145 kV CT (post type). Incl structure. (1x3-ph)	Line CTs	ea	$54,000		$0	2	$108,000		$0
145 kV Surge Arrester, incl surge counter. Excl structure. (1x3-ph)	Cable Terminations. (Transformers to be c/w tank-mounted surge arrestors)	ea	$6,900		$0	2	$13,800		$0
132 kV Busbar, 2000 A	Rigid bus, tubular Al on post supports. 15m bay 3 phase	ea	$65,000		$0	2	$130,000		$0
132 kV jumpers/busbars	Twin Uranus per phase, incl post insulators and fittings	bay	$150,000		$0	1.5	$225,000	0.5	$75,000
SF6 Gas - estimate 10kg per single pole (LTCB) and 30kg per DTCB	Allowance for first fill and levy	kg	$1,200		$0	90	$108,000	30	$36,000
132 kV switchgear Test & Commissioning	Allowance	bay	$20,000		$0	1.5	$30,000	0.5	$10,000
132/11 kV Transformer					$0		$1,400,000		$1,400,000
132/11 kV 30/55MVA ONAN/ODAF, OLTC, YNd1	With 11 kV Bushing CT & 132 kV Neutral CT. 132 kV and 11 kV air bushings but consider 11 kV cable boxes. Including delivery and installation	ea	$1,280,000		$0	1	$1,280,000	1	$1,280,000
Transfomer insulating oil		litre	$1		$0	20000	$20,000	20000	$20,000
Transformer Test & Commissioning	Allowance	ea	$100,000		$0	1.0	$100,000	1.0	$100,000
11 kV Switchgear					$0		$790,000		$790,000
12 kV Switchboard air-insulated double bus, vacuum CBs (2 x Incomer 2500A, 10 x Feeders 12500 AR, 1 x Bus-coupler 2500A)	Incl Duplicate Protection & SCADA Interface and installation (swbd only $680k)	ea	$750,000		$0	1	$750,000	1	$750,000
11 kV Switchboard Metering/Earthing Panel	Incl SCADA Interface	ea	$20,000		$0	1	$20,000	1	$20,000
11 kV Test & Commissioning	per switchboard - allowance	lot	$20,000		$0	1	$20,000	1	$20,000
HV Connections					$80,000		$114,000		$114,000
132 kV Cable	Cables installed as part of 132 kV relocation project. Cable termination structures and 132 kV bus to be installed beforehand - 6 cables per circuit	m	$500	0	$0		$0		$0
132 kV Cable Termination - jointing per 3-phase circuit	Two x single core 1600mm2 Cu XLPE cables per phase	ea	$30,000	2	$60,000		$0		$0
11 kV Aerial Bus	At Transformer 11 kV terminal (delete if cable boxes on transformers)	ea	$20,000		$0	1	$20,000	1	$20,000
11 kV Cable 1c/800mm2 Cu XLPE two per phase	For connection between transformers and 11kV switchboards - assume 60m	m	$100		$0	480	$48,000	480	$48,000
11 kV Cable 3c/35mm2 AL XLPE	For connections to 11/0.4 kV station services transformers and neutral earthing transformers - assume 50m each	m	$100		$0	100	$10,000	100	$10,000
11 kV Cable Termination 1c/800mm2 Cu XLPE		ea	$750		$0	16	$12,000	16	$12,000
11 kV Cable Termination 3c/35mm2 Al XLPE		ea	$1,000		$0	4	$4,000	4	$4,000
HV Cables and connections Test &	Allowance	lot	$20,000	1	$20,000	1	$20,000	1	$20,000
Primary (ancillary equipment)					$0		$84,000		$84,000
11/0.4 kV Auxiliary supply transformer 200 kVA	Cable-in cable-out	ea	$40,000		$0	1	$40,000	1	$40,000
11kV Earthing transformer 3000 Amps	Civil/Structure/Electric S&I	ea	$40,000		$0	1	$40,000	1	$40,000
Primary (ancillary) Test & Commissioning	Allowance	lot	$2,000		$0	2	$4,000	2	$4,000
Install MOSS					$500,000		$0		$0
Relocate MOSS from Angle Crossing to		ea	$500,000	1	$500,000		$0		$0

Electrical (Secondary System)					$630,000		$589,500		$309,500
Protection & Control					$240,000		$309,500		$309,500
132 kV Line Protection Panel	1 panel incl X and Y protection & SCADA Interface	ea	$80,000	2	$160,000		$0		$0
132 kV Busbar Protection Panel	1 panel incl X and Y protection & SCADA Interface	ea	$80,000	1	$80,000		$0		$0
132/11 kV Transformer Protection Panel	1 panel incl X and Y protection & SCADA Interface	ea	$80,000		$0	1	$80,000	1	$80,000
132 kV Transformer AVR Panel		ea	$25,000		$0	1	$25,000	1	$25,000
P&C Secondary Cabling	per P&C panel	ea	$2,250		$0	2	$4,500	2	$4,500
P&C Test & Commission	Allowance	lot	$200,000		$0	1	$200,000	1	$200,000
LV AC Supply					$0		$280,000		$0
Diesel Genset - 200 kVA	Skid/kiosk mounted with integrated tank, noise reduction	ea	$125,000		$0	1	$125,000		$0
LV AC Main Distribution Board	Incl protection and SCADA interface, automatic changeover of incoming supply	ea	$50,000		$0	1	$50,000		$0
LV AC Cabling	Allowance	lot	$100,000		$0	1	$100,000		$0
LV AC Test & Commission	Allowance	lot	$5,000		$0	1	$5,000		$0
DC Supply System					$390,000		$0		$0
125 V DC Battery bank	Duplicate DC systems	ea	$85,000	2	$170,000		$0		$0
AC/DC Converter - Charger	Duplicate DC systems	ea	$40,000	2	$80,000		$0		$0
DC Distribution Board	Duplicate DC systems	ea	$30,000	2	$60,000		$0		$0
DC Cabling	Allowance	lot	$75,000	1	$75,000		$0		$0
DC Test & Commission	Allowance	lot	$5,000	1	$5,000		$0		$0
SCADA, Communication, Substation misc (lightning protection, lighting, security)					$1,019,000		$0		$0
SCADA RTU and HMI (incl commissioning)	Duplicate RTU, single HMI	lot	$500,000	1	$500,000		$0		$0
Communication End-Equipment Panel (incl commissioning)	Duplicate	lot	$250,000	1	$250,000		$0		$0
Fibre Optic Breakout Panel (FOBOT)	Duplicate	ea	$20,000	2	$40,000		$0		$0
Security - Intrusion Detection	Allowance	lot	$10,000	1	$10,000		$0		$0
Security - CCTV	Allowance	lot	$50,000	1	$50,000		$0		$0
Lightning Protection	15m pole with lightning arrester	ea	$7,000	14	$98,000		$0		$0
External Lighting	10m pole with floodlights	ea	$1,500	14	$21,000		$0		$0
SCADA, Comms, misc, Test & Commissioning	Allowance	lot	$50,000	1	$50,000		$0		$0
Indirect Costs					$750,000		$350,000		$300,000
Construction Environmental Management Plan CEMP	Allowance	ea	$100,000	1	$100,000		$0		$0
Contractor's Preliminaries, site establishment and disestablishment	Allowance	ea	$100,000	1	$100,000	0.5	$50,000	0.5	$50,000
Misc building approvals	Allowance	ea	$100,000	0.5	$50,000	0.5	$50,000		$0
Project management and administration	Allowance	ea	$500,000	1	$500,000	0.5	$250,000	0.5	$250,000
Stage Sub Total without overheads					**$6,178,600**		**$6,961,000**		**$3,513,000**
Project Sub Total without overheads									**$16,652,600**
Overheads									
Overheads at average rate 43%	Allowance	27%			$1,668,222		$1,879,470		$948,510
Stage Sub Total with overheads					**$7,846,822**		**$8,840,470**		**$4,461,510**
Project Sub Total with overheads									**$21,148,802**
Contingency									
Contingency at 15%	Allowance	15%			$1,177,023		$1,326,071		$669,227
Stage total wth all overheads and contingency					**$9,023,845**		**$10,166,541**		**$5,130,737**
Project total with all overheads and contingency									**$24,321,122**

Appendix B: Financial Analysis

B.1 Capital Expenditure Cash Flow for Each Option

Financial Year	Option 2	Option 3	Option 4	Option 6	Option 7*
2019-20					
2020-21	$10,777,910	$12,226,350	$6,178,600	$1,131,380	$862,229
2021-22				$8,525,600	$807,455
2022-23	$1,220,780			$1,173,500	$1,345,759
2023-24				$1,173,500	$1,884,062
2024-25	$1,220,780				$3,229,821
2025-26			$6,961,000	$6,961,000	$4,575,580
2026-27	$1,220,780				$5,921,339
2027-28					$7,267,098
2028-29	$10,777,910				$8,882,008
2029-30		$3,513,000	$3,513,000	$3,513,000	N/A
2030-31	$1,220,780				N/A
2031-32					N/A
2032-33	$1,220,780				N/A
2033-34					N/A
2034-35	$1,220,780				N/A
2035-36					N/A
2036-37					N/A
2037-38					N/A
2038-39					N/A
Total Cost (20 years)	**$28,880,500**	**$15,739,350**	**$16,652,600**	**$22,477,980**	**N/A**
2019-24 Regulatory Control Period Cost	**$11,998,600**	**$12,226,350**	**$6,178,600**	**$12,003,980**	**$4,899,505**

Option 1 and Option 5 are not able to meet the forecast demand.

* Option 7 (network battery only) requires an unreasonably large number of batteries beyond 2030 due to continued forecast demand growth in the Molonglo Valley.

B.2 NPC Analysis

The Net Present Cost (NPC) was calculated using a Monte-Carlo simulation model. The simulation randomly selects a peak demand growth rate for each year that is within ± 10% of the forecasted loads expected in the Molonglo Valley. The use of a Monte-Carlo simulation results in selection of the best option that is robust to uncertain peak demand growth forecasts.

Investment within the simulation is dynamic – investment decisions change based on the randomly selected growth rates from previous years. Investment occurs automatically when the firm rating is breached so the value of energy at risk is always zero. In options where multiple investments are available the cheapest is selected.

Summary Financial Analysis Results for Supply to Molonglo Valley

The summary below shows the average values for the selected characteristics after 50 simulations.

Options:

Two – new 11 kV feeders from Latham and Civic zone substations – credible option.
Three – construct new Molonglo Zone Substation in two stages – credible part option.
Four – construct new Molonglo Zone Substation in three stages – credible part option.
Six – best mixed network and non-network combination (option three plus network battery) – non-credible option.
Seven – non-network option (network battery) – non-credible option.
Overall project – new Molonglo Zone Substation and 11 kV feeders from Molonglo Zone Substation – credible selected option.

RESULTS (Average over 50 simulations):

Option:	Two	Three	Four	Six	Seven	Overall
NPC (2019-24)	-$8,911,396	-$10,108,996	-$5,108,593	-$8,458,241	-$2,483,441	-$8,151,917
NPC (2019-39)	-$16,234,891	-$12,449,004	-$9,673,179	-$15,291,273	-$21,623,284	-$10,336,712
Network Option total Capital Cost	$28,880,500	$15,739,350	$16,652,600	$22,477,980	N/A	$21,346,600
Option Capital Cost (2019-24)	$11,998,600	$12,226,350	$6,178,600	$10,830,480	$3,015,443	$10,872,600
Option Capital Cost (2019-39)	$28,880,500	$15,739,350	$16,652,600	$22,477,980	N/A	$21,346,600

The overall project (Molonglo Zone Substation plus feeders) is the preferred option as it has a higher (ie less negative) net present cost than Option 2, the only other credible option. The overall project also has a lower total capital cost than Option 2.

Unserved Energy:

The volume of unserved energy in kWh under the Do Nothing option is shown in the following table:

Year	Volume of Unserved Energy (kWh)	Value of Unserved Energy
2019	270,151	$7,275,166
2020	4,609,263	$124,127,453
2021	14,033,828	$377,930,988
2022	26,082,962	$702,414,167
2023	33,927,252	$913,660,896
2024	37,205,482	$1,001,943,630

Notes:

The amount of load and duration above the firm rating of each existing feeder has been calculated using the actual historical load profile curve for each feeder plus the expected load profile curves of forecast new loads.

Unserved energy = (load above feeder firm rating x probability of an outage occurring at the time of such exceedance x outage duration) + all load above feeder thermal rating (ie when the load exceeds the thermal rating of the feeder, all such energy is assumed to be unserved).

Value of Unserved Energy assumes:

- Value of Customer Reliability = $26.93/kWh. This is the figure published by AEMO in 2014 for Residential Customers.
- CPI = 2% pa.
- Probability of failure of supply to a customer = 6% (= 3% probability of zone transformer failure + 3% probability of feeder failure).
- Probability of failure in any given hour = 6% / (24 x 365).
- Outage duration = 8 hours. This is a conservative figure as cable faults can often take longer than 8 hours to locate and repair.
- Value of unserved energy = Volume of unserved energy x VCR.
- All energy above the thermal rating is not served. This is equivalent to assuming a 100% outage probability for energy above this level.

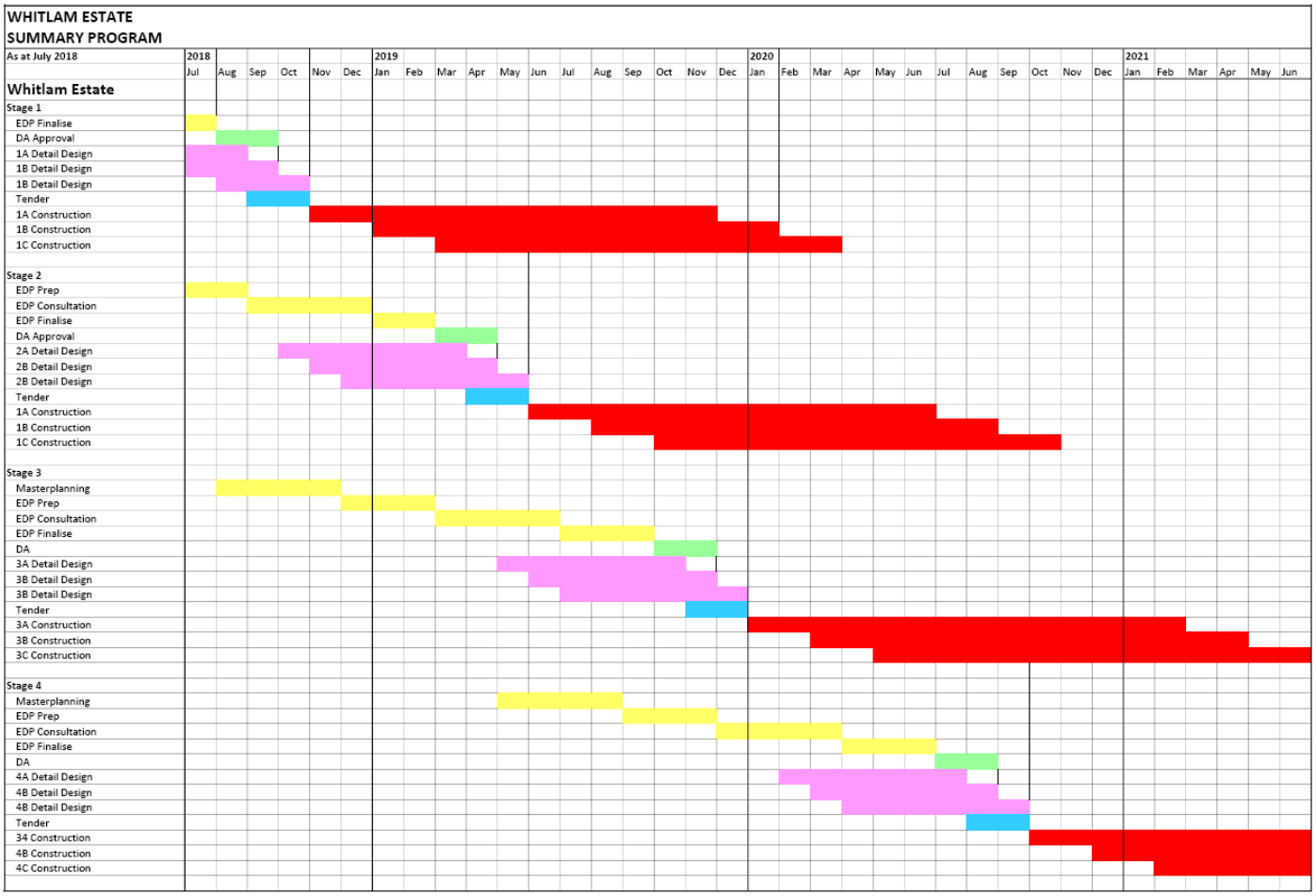
At the time of investment the value of unserved energy exceeds the annualised cost of this proposed augmentation, so the proposed new Molonglo Zone Substation is considered to be economically justified.

In addition to the value of unserved energy, there are litigation, reputational and other financial risks to be added to the overall risk cost as follows:

Litigation costs = $100,000 / event
Reputational risk cost = external consultations and communications costs = $10,000 / event.
Financial risk cost = internal investigation costs = $10,000 / event.

Total risk cost = Reliability risk cost + Litigation + Reputational risk cost + Financial risk cost
= Value of unserved energy + $120,000 / event.

Appendix C: Whitlam Estate Development Program



Appendix D: Molonglo Zone Substation Conceptual Single Line Diagram