Appendix 5.23: Molonglo zone substation PJR

Regulatory proposal for the ACT electricity distribution network 2019-24
January 2018

Disclaimer: On 1 January 2018, the part of ActewAGL that looks after the electricity network changed its name to Evoenergy. This change has been brought about from a decision by the Australian Energy Regulator. Unless otherwise stated, ActewAGL Distribution branded documents provided with this regulatory proposal are Evoenergy documents.

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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
Project Number	17519206

Contents

Reference documents

Document	Version	Date
National Electricity Rules	102	
National Electricity Law		19.12.13
Utilities Act (ACT)		2000
Utilities (Management of Electricity Network Assets Code) Determination		2013
Evoenergy Maximum Demand Forecast		2017
Molonglo Zone Substation Regulatory Investment Test Consultation Report SM1117		26.5.14
ActewAGL Annual Planning Report		22.12.17
Distribution Network Augmentation Standard SM1197	1.1	12.5.15
Evoenergy Risk Assessment Tables PR4660.2	1.0	12.1.17
Evoenergy Quality of Supply Strategy SM11150	1.0	8.10.15
Evoenergy Asset Management Strategy SM1192	2.12	22.6.15
Evoenergy Mobile Substation Deployment PR1191	1.0	8.5.15
Evoenergy Peak Demand Reduction Strategy	2.0	22.8.17
Augmentation NPV Model Methodology	1.0	29.9.17

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 North Weston, Coombs, Wright, Denman Prospect and Whitlam. The development of this area will include 21,000 residential dwellings, plus commercial and community facilities. The new development is likely to incorporate high energy efficiency and solar PV, incorporated within the demand forecast.

Existing 11 kV feeders to the area have insufficient capacity to meet the forecast load beyond winter 2022.

The selected option is the construction of a new 132/11 kV zone substation in the Molonglo Valley with future 11 kV feeders from the zone substation to serve the residential areas as they develop.

It is proposed that the new zone substation will be equipped initially with Evoenergy's 132/11 kV 14 MVA mobile substation (MOSS) ex Angle Crossing by June 2022. 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 2026-27. 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 investigated included 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 feeders and permanent zone substation were excluded due to a high net present cost (compared to the preferred option). Demand management was not considered feasible due to the insufficient existing capacity such that there is a requirement for greater than 40% of new demand to be offset. The grid battery was excluded due to a higher 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, excluding contingency, and excluding 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 2021-22 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 2026-27 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.

The proposed expenditure for the 2019-24 Regulatory Control Period is $6,178,600 excluding corporate overheads, excluding contingency, and excluding 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 20 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. The SLA has published an indicative land release programme that indicates development will proceed at approximately 800 dwellings per annum. A population of approximately 55,000 people is expected to ultimately live in the Molonglo Valley. Maximum demand of the Molonglo Valley is forecast to grow steadily to approximately 50 MVA over the next 20 years.

The Molonglo Valley is being developed by the ACT Government's Suburban Land Agency (SLA):

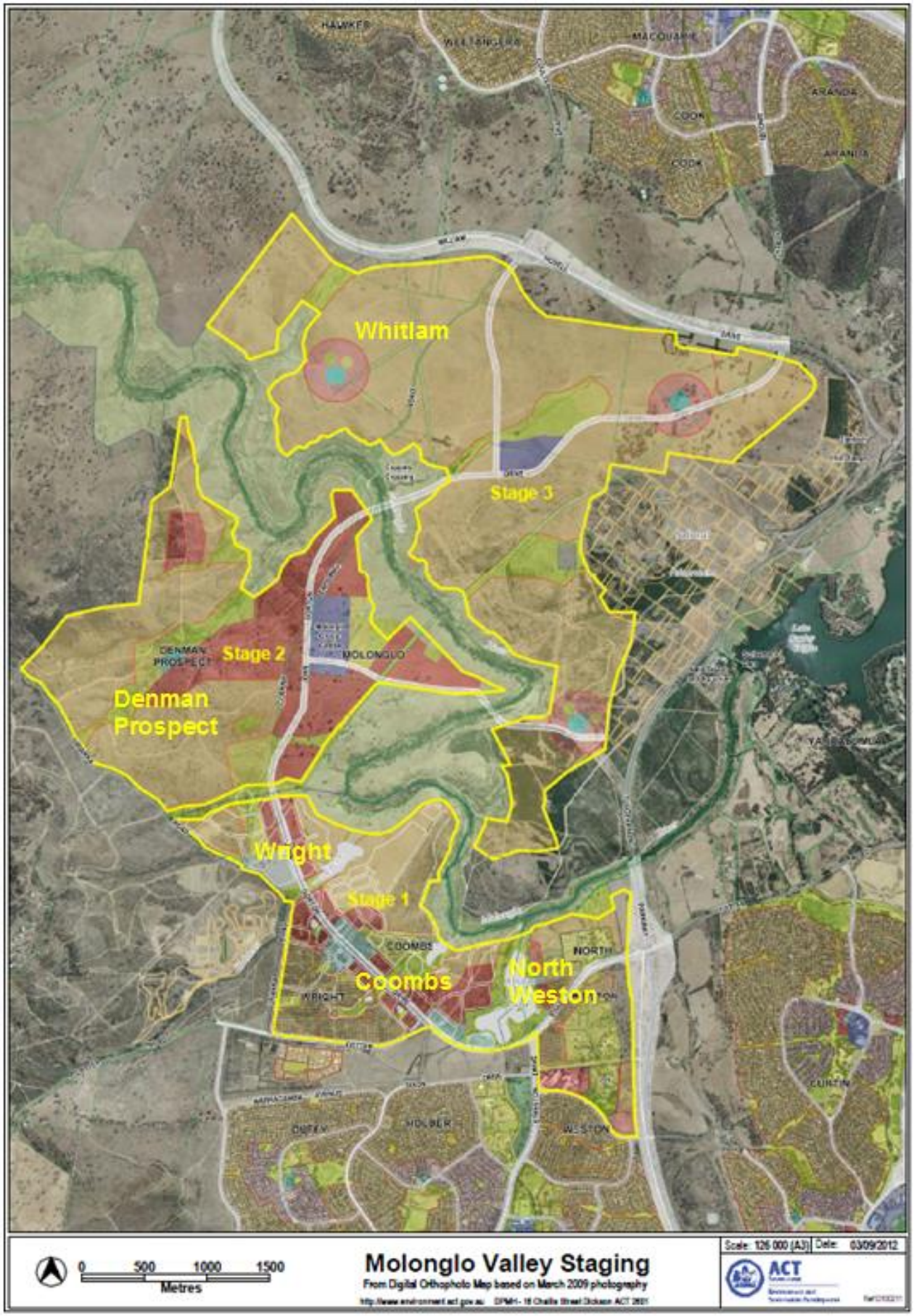
- Stage 1 comprises the suburbs of North Weston, Coombs and Wright, and is approximately 50% complete. It will include approximately 6,000 dwellings.
- Stage 2 comprises the suburb of Denman Prospect, and is currently under construction. It will include approximately 4,500 dwellings.
- Stage 3 comprises the suburb of Whitlam and is scheduled to commence construction in 2019-20. It will include approximately 10,500 dwellings.

Figure 1 shows the proposed stages of development of the Molonglo Valley (source SLA).

The proposed Whitlam suburb is at planning stage with construction scheduled to commence around 2020-21.

The developer of Denman Prospect has mandated the installation of 3 kW rooftop PV generation on all detached dwellings in Stage 1A (390 dwellings), but it has not been mandated for multi-unit developments or other suburbs. Battery storage systems are voluntary. It is unlikely that multi-unit dwellings (apartment buildings) will have rooftop PV installed. Detached dwellings comprise approximately 30% of all dwellings in Denman Prospect, so this is the maximum likely penetration rate.

Figure 1: Stages of development of Molonglo Valley



2.2. Existing infrastructure in Molongolo 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.

The first stage of development of the Molonglo Valley is well advanced and comprises North Weston, Coombs and Wright suburbs. Stage 2 is under construction, comprising the suburb of Denman Prospect. Supply is being provided to Denman Prospect through two extended 11 kV feeders from Woden Zone Substation (Hilder feeder and Streeton feeder), and it is proposed to upgrade the Black Mountain feeder from Civic Zone Substation to provide further capacity and supply security.

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 2.0 MVA pa on average. This is based on an ADMD of 2.0 kVA per dwelling which is lower than Evoenergy's standard 2.5 kVA due to the anticipated high penetration of rooftop PV and battery storage systems. 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).

Table 1 shows a summary of the load forecast in the Molonglo Valley for the next 10 years on the existing 11 kV feeders to the area.

These forecast loads make allowance for predicted penetration of rooftop solar PV and battery storage systems. 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 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. Fewer 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 at lower levels than today (ie 2.5 kVA per dwelling).

Table 1 shows that following the proposed upgrade of the Black Mountain feeder, available firm capacity will be exceeded by mid-2022. Loss of one of these feeders will result in unserved energy until repairs are made.

Table 1 Load forecast of existing feeders supplying Molonglo Valley

Load Forecast for Molonglo Valley - Coombs, Wright, North Weston, Denman Prospect and Whitlam suburbs.												
Year	**Feeder firm rating MVA**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Streeton Feeder load forecast	5.5	0.8	1.5	2.3	3.0	3.8	5.0	6.0	7.0	8.0	9.0	10.0
Streeton Feeder spare capacity		4.7	4.0	3.2	2.5	1.7	0.5	-0.5	-1.5	-2.5	-3.5	-4.5
Hilder Feeder load forecast	5.2	4.1	4.8	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Hilder Feeder spare capacity		1.1	0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Black Mountain Feeder load forecast (post upgrade)	5.0	1.4	1.7	1.7	3.0	4.2	5.0	6.0	7.0	8.0	9.0	10.0
Black Mountain feeder (post upgrade) spare capacity		3.6	3.3	3.3	2.0	0.8	0.0	-1.0	-2.0	-3.0	-4.0	-5.0
Additional Load (MVA)			**1.7**	**1.6**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**
Total Molonglo Valley Forecast Load (MVA)		**6.3**	**8.0**	**9.6**	**11.6**	**13.6**	**15.6**	**17.6**	**19.6**	**21.6**	**23.6**	**25.6**
Total spare capacity available		**9.4**	**7.7**	**6.1**	**4.1**	**2.1**	**0.1**	**-1.9**	**-3.9**	**-5.9**	**-7.9**	**-9.9**

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 Regulations (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 commenced 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 2021-22.

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 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.

Evoenergy's planning standards are determined on an economic basis but expressed deterministically so that peak demand can be met with an appropriate level of backup should a credible contingency event occur. A credible contingency event is the loss of a single network element, which occurs sufficiently frequently, and has such consequences, as to justify Evoenergy to take prudent precautions to mitigate. This is commonly referred to as an N-1 event.

Zone substation capacity must be augmented if the forecast zone substation maximum demand based on 50% PoE under N-1 conditions exceeds the two-hour emergency rating.

Major zone substation augmentation such as the installation of an additional transformer will not be considered until all other options such as load transfer to adjacent zone substations and non-network options have been fully explored and implemented.

For high voltage (11kV) distribution feeders in urban areas Evoenergy specifies that there should be a minimum of two effective feeder ties to meet two-for-three arrangement where it is economically viable, i.e. two feeders able to supply the load normally supplied by three feeders. A firm rating is assigned to each feeder based on its thermal rating and the number of feeder ties available.

Distribution high voltage feeder capacity must be augmented or demand management solutions provided if the forecast 50% PoE feeder maximum demand exceeds the firm ratings as given in Table 3.

Table 3: Feeder Firm Rating standard

Feeder configuration	Firm rating as percentage of thermal capacity
Two or more feeder ties	75%
One feeder tie	50%
Feeders operating in parallel	{(N-1)/N}%[1]
Partial feeder tie	100% or less[2]
No feeder tie	100%

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 the 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).

[1] "N" represents the number of feeders operating in parallel.

[2] A partial feeder tie refers to a tie with limited back feeding capacity. The firm capacity of a feeder with a partial feeder tie may be set below 100% its thermal capacity.

4. Options Assessment

Evoenergy has considered four options to supply the Molonglo Valley District as listed in Table 4.

Table 4: Options considered for supply to Molonglo Valley District

Option	Option type	Description	Evaluation
0	Network	Do nothing	Not selected as does not meet minimum requirements
1	Network	Construct new 11 kV cable feeders from existing zone substations: Five feeders from Latham Zone Substation and Five feeders from Civic Zone Substation.	Not selected due to lower NPC
2	Network	Construct new Molonglo Zone Substation in two stages	Not selected due to lower NPC
3	**Network**	**Install mobile substation initially followed by permanent Molonglo Zone Substation**	**Selected as higher NPC**
4	Non-network	Demand side management	Not selected as does not meet minimum requirements and lower NPC
5	Mixed	Delayed preferred network option using grid battery	Not selected as cost of delay exceeds benefits
6	Non-network	Grid battery	Not selected due to lower NPC

4.1. Options analysis

4.1.1. Do Nothing Option

The 'Do Nothing' option would result in insufficient network capacity in the area to meet demand during a contingency event.

The value of energy at risk is estimated to be approximately $2,375 over a five year period based on the probability of a contingency event at the same time as demand exceeding firm capacity.

Despite, the relatively low value of energy at risk, the Do Nothing option would result in Evoenergy breaching its Distribution Network Augmentation Standards and thus its obligation to provide a reliable and secure power supply.

4.1.2. Option 1: 11 kV feeders from existing zone substations

Option 1 considers the installation of ten new underground 11 kV cable feeders to Molonglo Valley from existing zone substations to meet the growing load demand.

There are four zone substations that could supply the Molonglo Valley load. These are Latham, Belconnen, Civic and Woden.

Forecast load growth at these zone substations is shown in Table 5.

Table 5: Zone Substations Load Growth (50% POE forecasts)

Zone Substation	Latham		Belconnen		Civic		Woden	
Rating	**Summer MVA**	**Winter MVA**	**Summer MVA**	**Winter MVA**	**Summer MVA**	**Winter MVA**	**Summer MVA**	**Winter MVA**
Continuous firm rating	95	100	55	55	110	110	95	95
2-hour emergency rating (max 10 times per year)	95	114	63	76	114	143	95	114
Load forecast per year (without Molonglo Valley load)	**Summer MVA**	**Winter MVA**	**Summer MVA**	**Winter MVA**	**Summer MVA**	**Winter MVA**	**Summer MVA**	**Winter MVA**
2018	52	68	58	60	57	49	76	78
2019	51	68	62	62	56	48	78	78
2020	52	69	62	63	56	49	80	81
2021	52	70	65	65	59	56	82	83
2022	53	69	65	65	63	57	82	84
2023	54	70	65	66	64	57	80	83
2024	54	71	66	66	63	56	78	82
2025	54	72	66	67	63	56	75	79
2026	56	73	68	68	63	56	74	78
2027	56	74	69	69	63	56	72	77

As shown in Table 5, the load at Belconnen Zone Substation is forecast to exceed its 2-hour emergency rating by 2021, so a third transformer would be required to enable supply to Molonglo Valley.

Load transfer capability from Latham, Belconnen, Civic and Woden zone substations to neighbouring zone substations is shown in Table 6. 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 6: Load transfer capacity between zone substations (MVA)

To	From							
	Latham		Belconnen		Civic		Woden	
Year	2017	2026	2017	2026	2017	2026	2017	2026
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.

Under Option 1 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 across the Molonglo River.

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 1 is $28,880,500 excluding corporate overheads, contingency and GST. Refer to cost estimates, cash flows and NPC comparison in Appendices A 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.

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 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 will require 17 joints plus two terminations, ie a joint approximately every 500m. Experience shows that the majority of cable faults occur at joints.

Option 1 is not selected due to its lower 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 operationally and there is limited space available in each switchroom.

4.1.3. Option 2: Construct Molonglo Zone Substation in two stages

Option 2 proposes to establish a new 132/11 kV zone substation at Molonglo by June 2022. Until June 2022 the increasing load of new developments in the area will be met by extensions of the Hilder and Streeton feeders (supplied from Woden Zone Substation) and upgrade of the Black Mountain feeder (supplied from Civic Zone Substation). Upgrade of the Black Mountain feeder, scheduled to be carried out by December 2017, will enable the Molonglo Zone Substation to be deferred until June 2022 (it was originally scheduled for construction by 2017-18). Beyond June 2022 the existing 11 kV feeders supplying the Molonglo Valley will be unable to meet the demand and provide a secure and reliable supply.

As part of the Molonglo Valley development, the SLA has requested the relocation of sections of two Evoenergy 132 kV transmission lines; approx 4.7 km of the Canberra–Woden line and 3.4 km of the Civic–Woden line. It is proposed that development of the Molonglo Zone Substation will be done in conjunction with these relocations.

The Molonglo Zone Substation would be equipped initially with one 132/11kV 30/55 MVA transformer and one 11 kV switchboard by June 2022, 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.

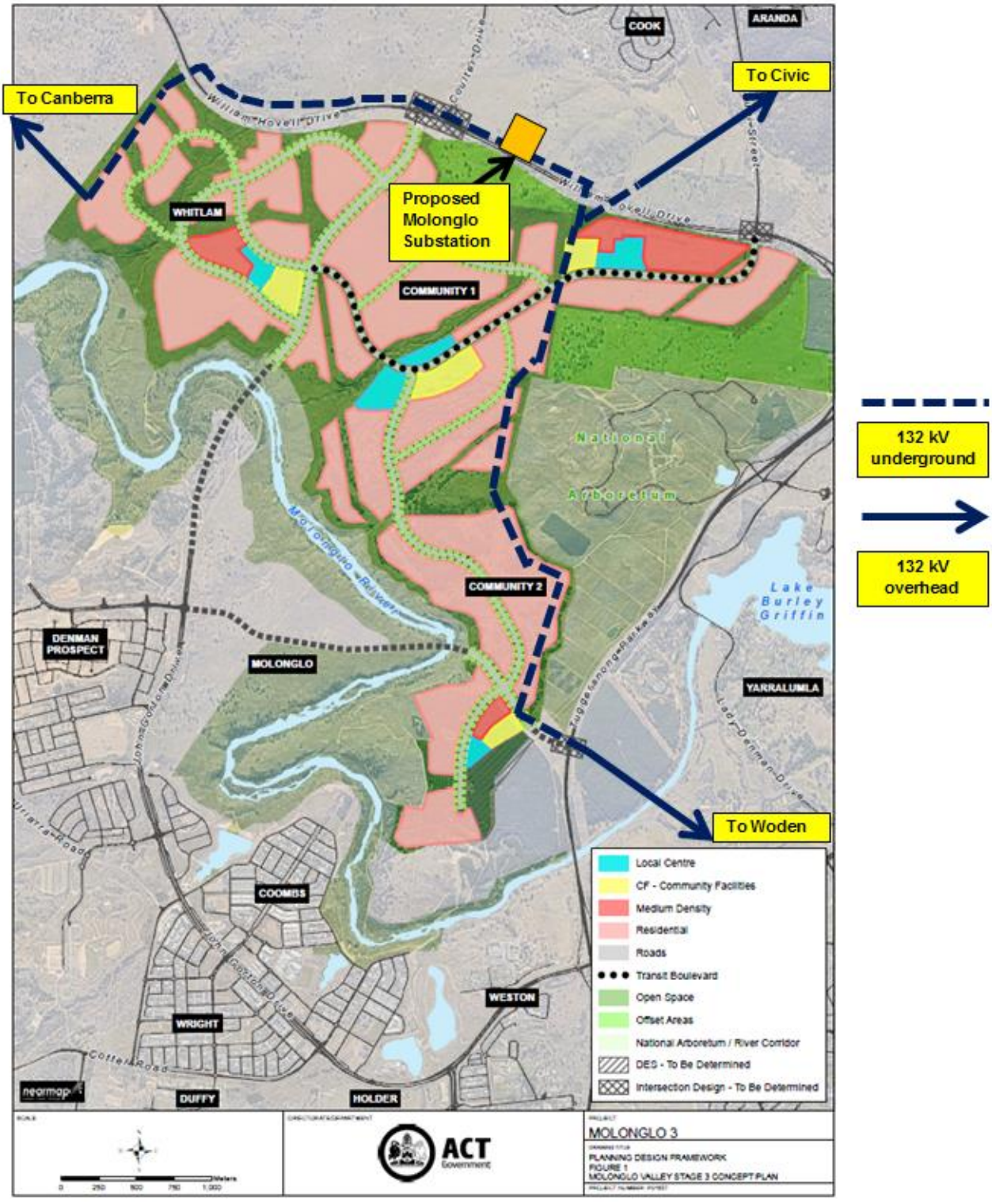
132 kV connection would be via loop-in-loop-out connection to the Stockdill–Woden 132 kV transmission line. Note that Stockdill Substation will initially provide a tee-connection only to Evoenergy's Canberra–Woden line, but by 2023 TransGrid proposes to construct a 132 kV bus at Stockdill and install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

Evoenergy proposes to construct the new 132/11 kV Molonglo Zone Substation by June 2022 to meet the load forecast provided in Table 1. Until June 2022 the increasing load of new developments in the area will be met by extensions of the Hilder and Streeton feeders (supplied from Woden Zone Substation) and upgrade of the Black Mountain feeder (supplied from Civic Zone Substation). Upgrade of the Black Mountain feeder, scheduled to be carried out by June 2017, will enable the Molonglo Zone Substation to be deferred until June 2022 (it was originally scheduled for construction by 2017-18). Beyond June 2022 the existing 11 kV feeders supplying the Molonglo Valley will be unable to meet the demand and provide a secure and reliable supply.

Figure 2 shows proposed location of Molonglo Zone Substation and associated undergrounding of 132 kV transmission lines (blue dashed lines denote proposed underground cable sections).

Figure 2: Proposed development of Molonglo Valley



11 kV feeders would be installed from Molonglo Zone Substation to 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 and Hilder feeders to Molonglo Zone Substation. Future 11 kV feeders will inter-tie with 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 2022) 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 developed throughout Molonglo Valley as follows (under separate projects):

- 2017-2022 Extend Streeton and Hilder feeders from Woden Zone Substation, and Black Mountain feeder from Civic Zone Substation.
- 2022-2030 Install feeders from Molonglo Zone Substation switchboard No 1 with inter-ties to feeders from Latham, Belconnen, Civic and Woden zone substations. Transformer No 1 in association with new feeder ties would provide approximately 20 MVA firm capacity to the Molonglo Valley until the second transformer was installed.
- 2030-2036 Install feeders from Molonglo Zone Substation switchboard No 2 with inter-ties to switchboard No 1 feeders and feeders from Latham, Belconnen, Civic and Woden zone substations. Transformer No 2 would operate in parallel with transformer No 1 providing 55 MVA firm capacity.

Option 2 is not selected due to its lower NPC.

4.1.4. Option 3: Install mobile substation initially followed by permanent Molonglo Zone Substation in two stages

Option 3 proposes to relocate Evoenergy's 132/11 kV 14 MVA mobile substation (MOSS) from Angle Crossing to the Molonglo Zone Substation site as a first stage of development. The zone substation site would be developed including all earthworks, fencing, earthgrid, drainage and roading. The project would then 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 2022. 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 2027. 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 at Stage 1 to enable connection of the MOSS and connection of a permanent transformer at Stage 2.

This would provide capacity of 132/11 kV 14 MVA and would be able to supply two 11 kV feeders; the MOSS has two feeder circuit breakers only. These feeders would be inter-tied to existing feeders from Woden and Civic zone substations to provide backup security should the MOSS trip due to a fault. 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 14 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 2022)**, $6,961,000 for Stage 2 (approx 2027), 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 3 is selected due to its higher (ie least negative) net present cost (NPC).

4.1.5. Option 4: Non-network solution

Option 4 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 8.4 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 8.4 MVA to enable the new feeder to be deferred.

These non-network options are summarised in Table 7.

Table 7: 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 it was determined that more than 40% 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.

4.1.6. Option 5: Grid battery to defer Option 3

A further option to adopt a grid battery to defer Option 3 (or 2) was also explored. This option has the advantage of deferring the investment until greater certainty is 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 Option 2 or 3 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 asssed as less economic than the preferred network option.

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

4.1.7. Option 6: 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 of in excess of $100m to supply the entire load. Refer to cost estimates, cash flows and NPC comparison in Appendices A and B.

4.1.8. 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	$0	$0	$0	Not selected as does not meet need
1	Construct new 11 kV cable 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
2	Construct new Molonglo Zone Substation in two stages	$15,739,350	$12,226,350	-$12,449,004	Not selected due to lower NPC
3	**Install mobile substation initially followed by permanent Molonglo Zone Substation**	**$16,652,600**	**$6,178,600**	**-$9,673,179**	**Selected due to higher NPC**
4	Demand management	N/A	N/A	N/A	Not selected as does not meet need
5	Grid battery to defer Option 3	$22,477,980	$10,830,480	-$15,291,273	Not selected as deferral not economic
6	Grid battery only	N/A	$7,040,829	>$100M	Not selected as deferral not economic

4.2. Recommendation

The selected option is Option 3, the construction of a new 132/11 kV zone substation in the Molonglo Valley, 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.

Stage 1 would comprise relocation and establishment of Evoenergy's mobile substation (MOSS) at the Molonglo Zone Substation site by June 2022. 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 2027. 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.

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 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 2022)**, $6,961,000 for Stage 2

(approx 2027), 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.

This option has the highest (ie least negative) net present cost (NPC). It can be implemented in time to meet the project needs as identified, will provide a permanent solution, and will add to Evoenergy's regulated asset base. The major assets will have an economic life of 50 years.

Proposed 11 kV feeders (to be installed under separate projects) 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: 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 2: 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 (2022). 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 3: 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 (2022), Stage 2 one transformer and switchboard (2027), 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 1	Option 2	Option 3	Option 4*	Option 5	Option 6**
2019-20						
2020-21						
2021-22	$10,777,910	$12,226,350	$6,178,600		$1,131,380	$862,229
2022-23					$8,525,600	$807,455
2023-24	$1,220,780				$1,173,500	$1,345,759
2024-25					$1,173,500	$1,884,062
2025-26	$1,220,780					$3,229,821
2026-27			$6,961,000		$6,961,000	$4,575,580
2027-28	$1,220,780					$5,921,339
2028-29						$7,267,098
2029-30	$10,777,910	$3,513,000	$3,513,000		$3,513,000	$8,882,008
2030-31						N/A
2031-32	$1,220,780					N/A
2032-33						N/A
2033-34	$1,220,780					N/A
2034-35						N/A
2035-36	$1,220,780					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**	**N/A**	**$17,514,829**	**N/A**
2019-24 Regulatory Control Period Cost	**$11,998,600**	**$12,226,350**	**$6,178,600**	**N/A**	**$7,040,829**	**$3,015,443**

* Option 4 (demand management only) is not able to meet forecast demand.

** Option 5 (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.

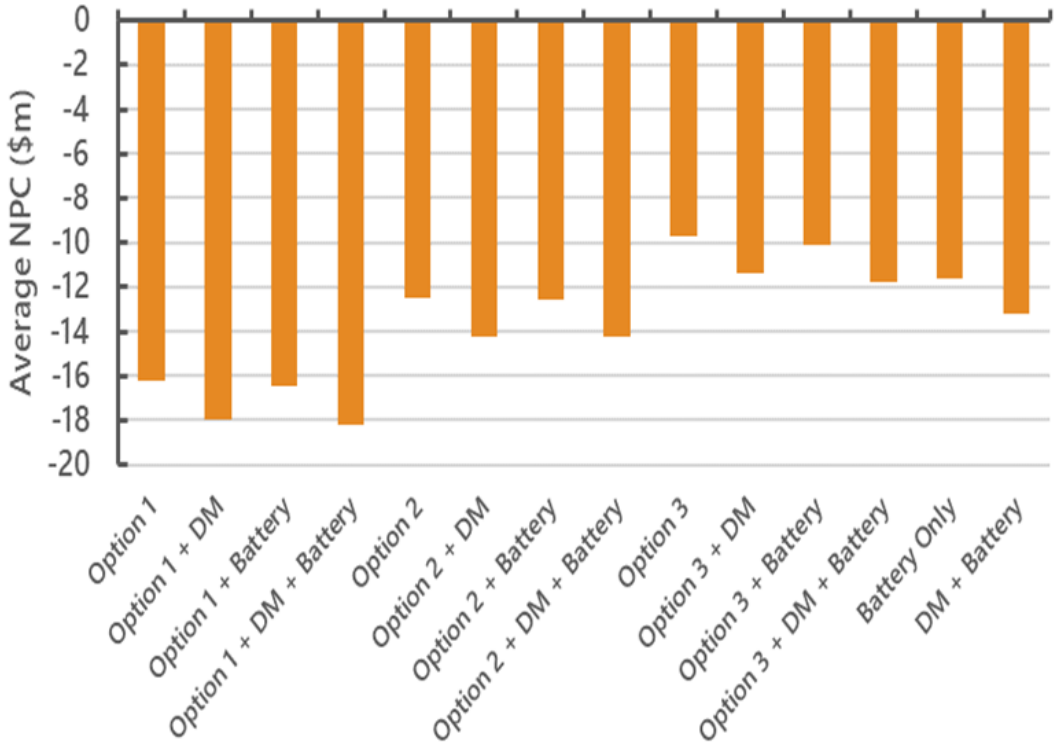
Options:

One – new 11 kV feeders from Latham and Civic zone substations
Two – construct new Molongo Zone Substation in two stages
Three – construct new Molongo Zone Substation in two stages
Four – non-network option (demand management)
Five – best mixed network and non-network combination (option three plus network battery)
Six –non-network option (network battery)

RESULTS (Average over 50 simulations):

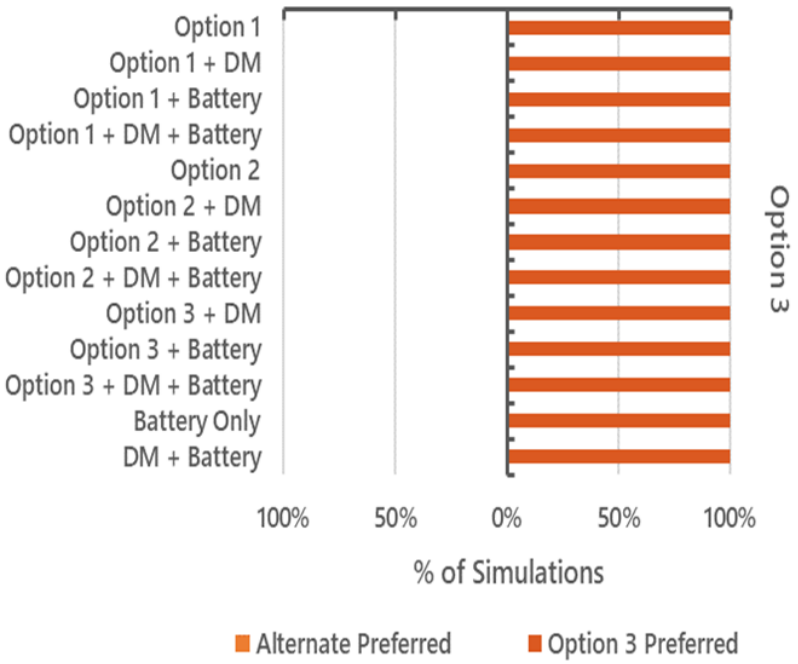
Option:	One	Two	Three	Four	Five	Six
NPC (2019-24)	-$8,911,396	-$10,108,996	-$5,108,593	N/A	-$8,458,241	-$2,483,441
NPC (2019-39)	-$16,234,891	-$12,449,004	-$9,673,179	N/A	-$15,291,273	-$21,623,284
Network Option total Capital Cost	$28,880,500	$15,739,350	$16,652,600	N/A	$22,477,980	N/A
Option Capital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

Average Net Present Cost for Each Network / Non-Network Combination:



Multiple combinations of network options, demand management and network batteries were tested using the Monte-Carlo model. The preferred option was selected on the basis of minimising the Net Present Cost.

Percentage of Simulations where the Selected Option had a Lower Cost than Other Options:



The random variation in peak demand growth in the Monte-Carlo model means that different options may be preferred in some simulations. The above chart shows that Option 3 was the preferred option in 100% of simulations.

Value of Risk:

Year	Volume of Energy at Risk (kWh)	Value of Energy at Risk ($)
2020	-	-
2021	438	2
2022	45,166	124
2023	303,080	622
2024	861,758	1,580

Notes:

Energy at risk is the volume of energy served above the firm rating each year. An indicative load duration curve has been used to determine the relationship between peak demand, firm rating and volume of energy in kWh.

Value at risk assumes:
Value of Customer Reliability = $26.93/kWh
Probability of Failure = 6% (3% annual probability of transformer failure + 3% probability of feeder failure)
Outage duration = 8 hours
Probability of failure in any given hour: 6% * 8 / 24 / 365
Value above firm rating = VCR * probability * volume of energy
All energy above the emergency rating is not served. This is equivalent to assuming a 100% outage probability for energy above this level.

In addition to the VCR cost, there are litigation, reputational and other financial risks that are included in the total:

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
= VCR / kWh + $120,000 / event.

Appendix C: Molonglo Zone Substation Conceptual Single Line Diagram