Appendix 5.22: Molonglo Valley 11kV feeders 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 Valley 11 kV Feeders**
Expenditure type	Capital Expenditure
Business Group	Asset Strategy
Regulatory Period	1 July 2019 to 30 June 2024
Total Project Cost Estimate	$4,694,000 excluding corporate overheads, excluding contingency, and excluding GST
Five year total spend 2019-24	$4,694,000 excluding corporate overheads, excluding contingency, and excluding GST
CAPEX category	ENAA Distribution
Primary driver	Load growth in Molonglo Valley
Project Number	20001374

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
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
Project Justification Report Molongo Zone Substation	0.5	9.1.18
Evoenergy Peak Demand Reduction Strategy	2.0	22.8.17
Augmentation NPV Model Methodology	1.0	29.9.17

1. Executive Summary

A new zone substation is to be constructed to supply the growing demand of the Molonglo Valley. The proposed Molonglo Zone Substation project is described in the Project Justification Report for project PN 17519206. It is proposed that the new zone substation will be equipped initially with Evoenergy's 132/11 kV 14 MVA mobile substation by June 2022. A permanent 132/11 kV 30/55 MVA transformer and 11 kV switchboard is scheduled to be installed by June 2027 and a second transformer and switchboard by June 2030.

This Project Justification Report describes the proposed 11 kV feeder network to be installed from the new Molonglo Zone Substation to supply the Molonglo Valley. 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. Existing 11 kV feeders to the area have insufficient capacity to meet the forecast load beyond winter 2021.

The proposed 11 kV feeders from Molonglo Zone Substation will inter-tie with Civic, Woden, Belconnen and Latham zone substations, with the opportunity to offload these zone substations onto Molonglo Zone Substation, and to provide backup security of supply in the event of an outage at Molonglo Zone Substation (whether it be planned or unplanned).

The proposed Molonglo Zone Substation site is on the northern side of William Hovell Drive approximately 500m to the east of Coulter Drive.

11 kV feeders from the new zone substation will be installed progressively to serve the residential areas as they develop. As part of the Molonglo Zone Substation project, spare 150mm diameter conduits will be installed to the switchyard fence boundary. Spare conduits will also be installed as part of the proposed 132 kV underground cable installation works, and as part of the ACT Government's developments in the area (eg across Coulter Drive and William Hovell Drive, and down John Gorton Drive).

A preliminary cost estimate for the selected option is **$4,494,000 excluding corporate overheads, excluding contingency, and excluding GST**. Feeder installations will be carried out in stages as development and load increases. These works will be carried out during the 2019-24 Regulatory Control Period.

Other options such as the installation of feeders from existing zone substations and non-network options have been considered and evaluated.

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.

2. Strategic Context and Expenditure Need

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 Suburban Land Agency (SLA) has published an indicative land release programme that indicates development will proceed at approximately 1,000 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.

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 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.

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. This is based on 100% rooftop PV on all detached or terraced dwellings, but minimal rooftop PV on apartment buildings. 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 2.0 kVA per dwelling).

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. Load forecasts indicate that these feeders will reach their firm capacity limits around mid-2022 as the load of new developments in the Molonglo Valley increases. The proposed Whitlam suburb is at planning stage with construction scheduled to commence around 2019-20.

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. This shows that following the proposed upgrade of the Black Mountain feeder, available capacity will be exceeded by mid-2022. Loss of a feeder 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**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Streeton Feeder load forecast	5.5	1.8	2.3	3.0	3.8	5.0	6.0	7.0	8.0	9.0	10.0
Streeton Feeder spare capacity		3.5	3.2	2.5	1.7	0.5	-0.5	-1.5	-2.5	-3.5	-4.5
Hilder Feeder load forecast	5.2	4.8	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Hilder Feeder spare capacity		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	1.7	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		3.3	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**
Cumulative Additional Forecast Load (MVA)		**1.7**	**3.3**	**11.6**	**13.6**	**15.6**	**17.6**	**19.6**	**21.6**	**23.6**	**25.6**
Total spare capacity available		**7.2**	**5.6**	**3.6**	**1.6**	**-0.4**	**-2.4**	**-4.4**	**-6.4**	**-8.4**	**-10.4**

The Molonglo Valley Forecast is based on the rate of dwellings construction as described in the ACT Government's Indicative Land Release Program 2017-21. Evoenergy will continue to connect new dwellings from the extended Streeton, Hilder and Black Mountain feeders until such time as all available spare capacity has been utilised. This is forecast to occur by winter 2022.

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 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."

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.'

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 (based on ADMD 2.0 kVA per dwelling). 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).

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.

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

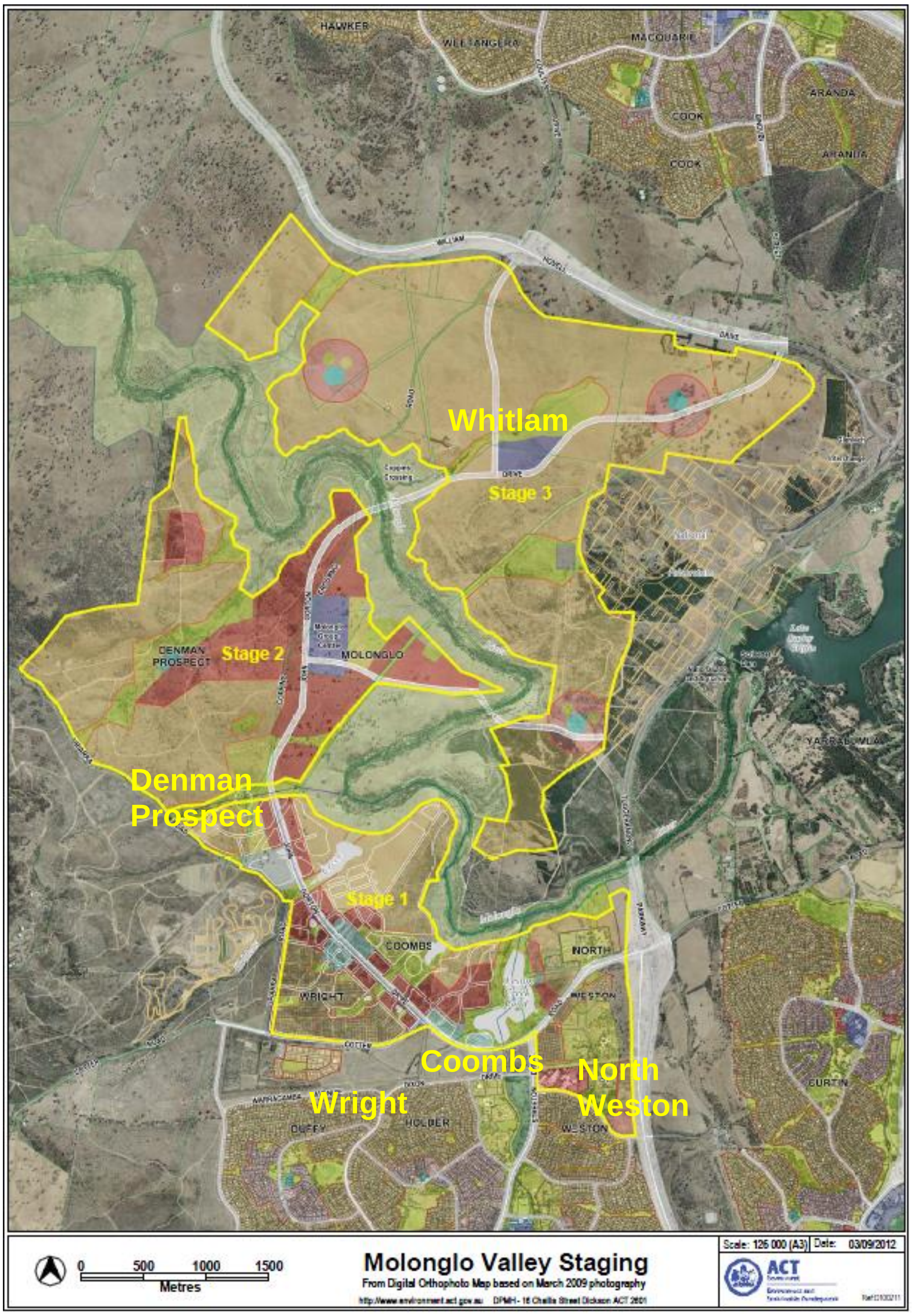
Stage 1 comprises the suburbs of North Weston, Coombs and Wright, and is approximately 50% complete. It will include approximately 6,000 dwellings.

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 around 2019-20. It will include approximately 10,500 dwellings.

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

Figure 1: Stages of development of Molonglo Valley



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 provide 11 kV supply to the Molonglo Valley District as listed in Table 2.

Table 2: Options considered for 11 kV 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 in stages: Five feeders from Latham Zone Substation and Five feeders from Civic Zone Substation.	Not selected due to lower NPC
2	**Network**	**Construct new 11 kV cable feeders from proposed Molonglo Zone Substation in stages**	**Selected as higher NPC**
3	Non-network	Demand side management and embedded generation	Not selected as does not meet minimum requirements and lower NPC
4	Mixed - Option 2 plus batteries	Delayed preferred network option using non-network options	Not selected as cost of delay exceeded benefits

4.1. Options analysis

4.1.1. Do Nothing Option

The 'Do Nothing' option will result in insufficient network capacity in the area and thus will result in Evoenergy breaching its obligations to provide a reliable and secure power supply. This option is not a prudent or acceptable solution.

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.

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).

Forecast load growth at Latham, Belconnen, Civic and Woden zone substations is shown in Table 3.

Table 3: Zone Substations Load Growth

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	100
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**
2017	51.19	72.71	58.80	58.41	57.95	56.29	78.89	77.74
2018	52.68	74.55	59.32	59.93	61.08	67.20	83.12	79.81
2019	52.15	75.40	60.50	61.26	73.62	77.38	84.68	83.34
2020	50.98	77.28	60.69	61.92	76.35	80.88	85.03	84.08
2021	49.60	78.76	62.36	62.93	75.99	82.73	86.71	89.75
2022	49.34	80.55	62.86	62.81	74.37	84.13	86.33	94.03
2023	48.94	82.21	63.33	62.14	73.26	85.67	86.74	96.59
2024	47.07	82.58	63.35	61.49	71.72	86.37	87.40	98.51
2025	46.87	82.87	62.66	61.20	70.43	87.29	87.42	101.46
2026	44.71	83.41	63.20	60.82	69.90	87.67	87.38	104.31

The figures in Table 3 indicate that load is growing steadily at all of these zone substations so their ability 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. As shown in Table 3, the load at Belconnen Zone Substation is forecast to exceed its 2-hour emergency rating by 2023. Load at Woden Zone Substation is also forecast to approach its 2-hour rating by 2030.

Load transfer capability from Latham, Belconnen, Civic and Woden zone substations to neighbouring zone substations is shown in Table 4. 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 4: 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

Under Option 1 it is proposed to install 5 new 11 kV cable feeders from Latham Zone Substation to Molonglo Valley and a further 5 new 11 kV cable feeders from Civic Zone Substation to Molonglo Valley. 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 500 m. Experience shows that the majority of cable faults occur at joints.

Option 1 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 operationally and there is limited space available in each switchroom.

4.1.3. Option 2: Construct new 11 kV Cable Feeders from proposed Molonglo Zone Substation in stages

Option 2 proposes to install new underground 11 kV cable feeders from the proposed Molonglo Zone Substation to supply existing and new loads in the Molonglo Valley.

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 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.

The proposed site for the Molonglo Zone Substation is on the northern side of William Hovell Drive approximately 500m east of Coulter Drive. Figure 2 shows the location of the proposed site and the proposed 132 kV transmission lines relocation works.

Figure 2: Proposed site of Molonglo Zone Substation

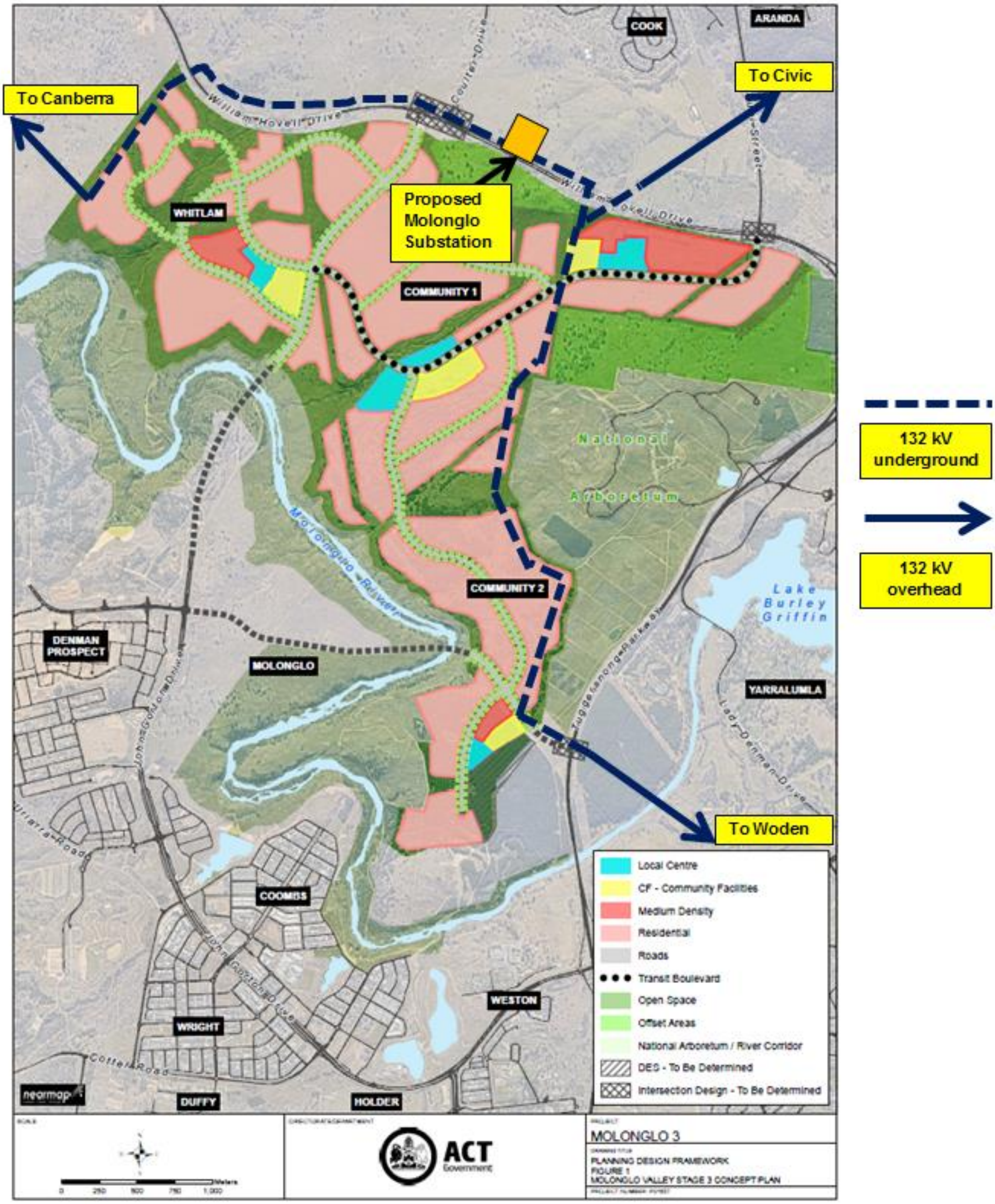
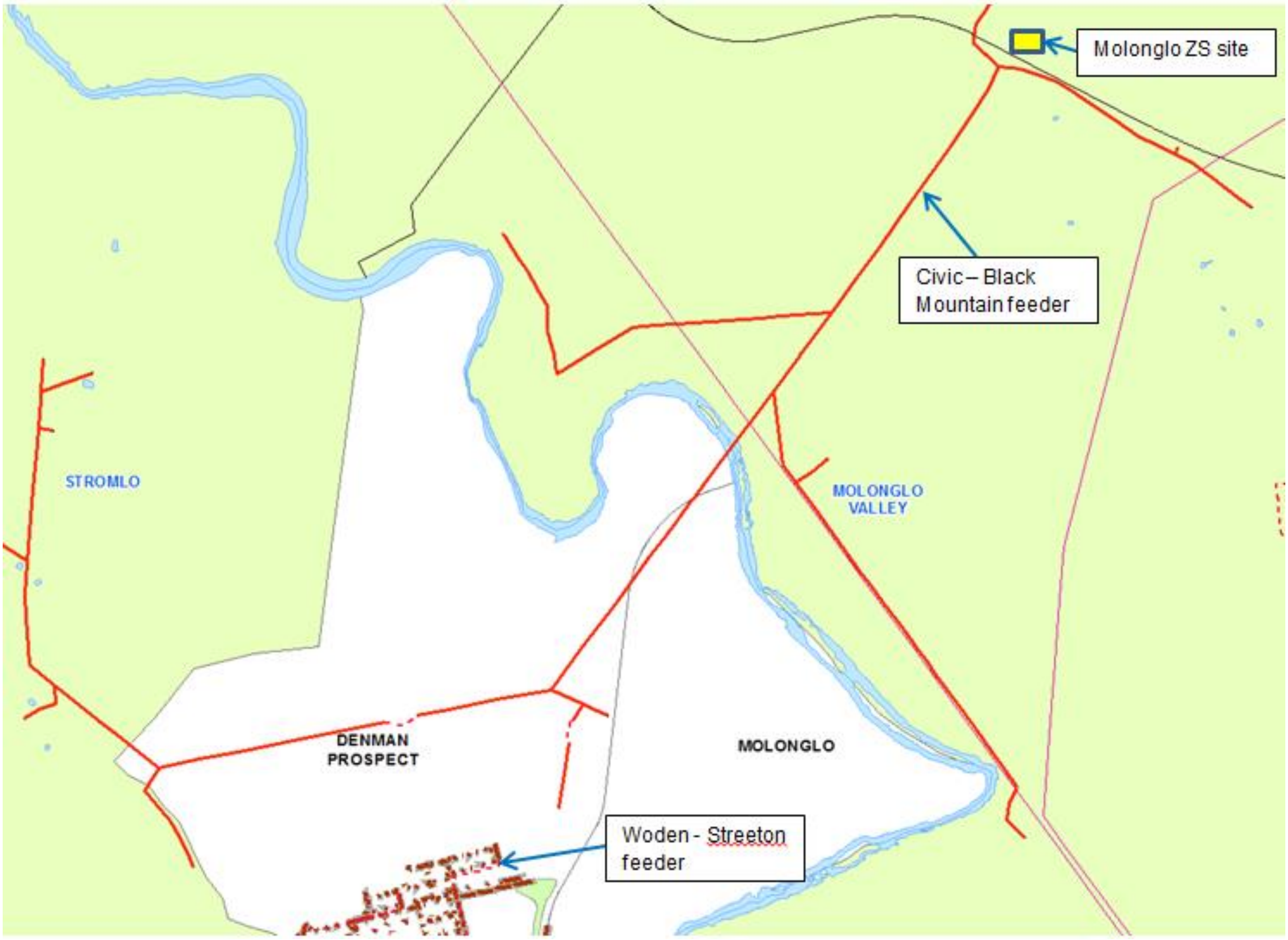


Figure 3 shows the existing 11 kV feeders in the Molonglo Valley area.

Figure 3: Existing 11 kV feeders Molonglo Valley



The overhead Civic – Black Mountain feeder traverses the Molonglo Valley from William Hovell Drive to Uriarra Road, and continues north-westwards to supply some small rural loads in the Stromlo area. It is proposed that a new cable feeder from Molonglo Zone Substation will connect to the Black Mountain feeder at Holborrow Ave (the new east-west arterial road that traverses Denman Prospect Estate). The overhead section of the Black Mountain feeder from Molonglo Zone Substation to Holborrow Ave will subsequently be decommissioned and removed. This will allow development of the Whitlam Estate to the east of John Gorton Drive to proceed unimpeded. There is one pole mounted distribution transformer S159 at “Glenloch farm” on the southern side of William Hovell Drive which is currently connected to the Black Mountain feeder via an overhead 11 kV spur line. Supply to this will need to be arranged either from a new radial underground 11 kV spur off a new feeder or by connecting S159 to S3313, a pole mounted distribution transformer located approximately 900m to the east. Ultimately supply to Glenloch should be provided from the new underground reticulation network in Whitlam.

Note the 132 kV Canberra–Woden and Civic–Woden transmission lines that traverse the Molonglo Valley will be relocated (most likely underground) as part of a separate project that will be fully funded by the SLA (refer Figure 2).

Another feeder from Molonglo Zone Substation will be installed to Coulter Drive and connect to the Civic Zone Substation end of the Black Mountain feeder (nominally at pole POL 30965). Recloser 6846 and its associated bypass links are to be removed from POL 25142, three spans north of POL 30965. This will provide a strong 11 kV tie between Civic and Molonglo zone substations.

Future feeders northwards up Coulter Drive will enable 11 kV inter-ties to Latham Zone Substation (eg via Bowley, Weir and Elkington feeders) and to Belconnen Zone Substation (eg via Benjamin and Cameron South feeders).

All feeder cables emanating from Molonglo Zone Substation will be 11 kV 3c/400mm^2 AL XLPE as far as the first connection point to an existing or new pole-mounted or ground-mounted structure such as an overhead gas switch or a ground-mounted distribution substation. Spare 150mm conduits will be installed with all new feeder cables, especially where installed in dedicated or shared trenches. These will be used for future new or replacement cables. Spare 63mm conduits will be installed with all feeders for future possible fibre optic cables for communications purposes.

11 kV feeders will 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. The proposed route for these cables will be across William Hovell Drive and southwards down either side of John Gorton Drive. A new William Hovell Drive / John Gorton Drive intersection is to be constructed by the Civil Infrastructure & Capital Works Branch of the ACT Government. This is currently at planning stage but is proposed to be implemented within the next two years. Evoenergy has specified its requirements for power cable conduits to be installed across William Hovell Drive and down John Gorton Drive as these works proceed. The following conduits have been specified:

- 2 banks of 6 x 200mm plus 2 x 80mm conduits across William Hovell Drive (west of intersection) for possible future 132 kV connection to Molonglo Zone Substation.
- 2 banks of 6 x 150mm conduits across William Hovell Drive (one bank west and one bank east of intersection) for future 11kV connections to Molonglo Zone Substation.
- 1 bank of 6 x 150mm conduits down both sides of John Gorton Drive (ie 2 banks in total) from William Hovell Drive crossing to southern limit of works.
- 1 bank of 3 x125mm conduits into each side road off John Gorton Drive.
- Distribution substation located at the north-west corner of the Road 1 / John Gorton Drive intersection (for supply to streetlights and traffic lights).

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.

11 kV feeders are proposed to be installed from Molonglo Zone Substation as follows:

2017-22: Prior to Molonglo Zone Substation and not part of this project:

Extend Streeton and Hilder feeders from Woden Zone Substation, and Black Mountain feeder from Civic Zone Substation into North Wright, North Coombs and Denman Prospect.

2022-24: Following commissioning of Molonglo Zone Substation – all cables to be 11 kV 3c/400mm^2 AL XLPE:

1. Install feeder to POL 30965 and connect to Black Mountain feeder via an 11 kV pole-mounted gas switch. Remove aerial recloser 6846 and associated bypass link. Cable length approximately 1.2 km.
2. Install feeder down John Gorton Drive, across proposed new Coppins Crossing bridge to Holborrow Ave and throughjoint to underground cable that runs westwards to Denman Prospect Stage 1B community centre distribution substation. This will provide a link to Streeton feeder. This will replace the existing overhead section of Black Mountain feeder. Cable length approximately 4.0 km.
3. Install feeder down John Gorton Drive, across proposed new Coppins Crossing bridge to North Coombs and connect to a suitable distribution substation to provide a link to Woden-Hilder feeder. Cable length approximately 5.0 km.

4. Install feeder down John Gorton Drive, across proposed new Coppins Crossing bridge to North Wright and connect to a suitable distribution substation to provide a link to Streeton feeder. Cable length approximately 5.0 km.
5. Install feeder down John Gorton Drive, across proposed new Coppins Crossing bridge to North Coombs and connect to North Weston and connect to a suitable distribution substation. Cable length approximately 5.0 km.
6. Install feeder down western side of John Gorton Drive to proposed distribution substation located at the north-west corner of the Road 1 / John Gorton Drive intersection (for supply to streetlights and traffic lights). This feeder will continue westwards as Road 1 develops. Cable length approximately 1.4 km.

7. Install feeder down eastern side of John Gorton Drive to Road 1 / John Gorton Drive intersection. This feeder will continue westwards as Road 1 develops. Cable length approximately 1.4 km.

Note the replacement Coppins Crossing bridge over the Molonglo River has yet to be designed. At design stage Evoenergy will specify its requirements for power cable conduits on either side.

2025-30: All cables to be 11 kV 3c/400mm^2 AL XLPE:

Install additional feeders to Denman Prospect Stages 2 and 3, and to Whitlam suburb as these areas are developed. Electrical Master Plans will be prepared as part of the Estate Development Plan (EDP) process. Cables throughout these estates will be installed in common services trenches.

All new feeders installed during this period whilst Molonglo Zone Substation has just one transformer will need to be tied to existing feeders from other zone substations, to provide back-up security in the event of an outage of the Molonglo Zone Substation transformer.

The Molonglo Zone Substation transformer No 1 in association with feeder ties will provide approximately 20 MVA firm capacity to the Molonglo Valley until the second transformer is installed around 2030.

2030 onwards: All cables to be 11 kV 3c/400mm^2 AL XLPE:

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 will operate in parallel with transformer No 1 providing 55 MVA firm capacity.

The preliminary estimated cost of this option is $4,694,000 excluding corporate overheads, contingency and GST (refer cost estimate Appendix A). Timing of additional feeder cables will depend on the rate of load growth in the Molonglo Valley, which will be monitored and forecast carefully.

Option 2 is selected due to its higher (ie least negative) NPC.

4.1.4. Option 3: Non-network solution

Option 3 considers non-network initiatives including demand side management and alternative supply measures such as embedded generation. The developer of Denman Prospect proposes to make this suburb energy efficient by requiring the mandatory installation of 3 kW rooftop solar PV generation on every detached dwelling. This will reduce energy demand but will require significant uptake of energy storage, e.g. battery storage installations, to have a major impact on the overall maximum demand of the network. In particular winter maximum demand usually occurs around 6:00pm throughout the month of July when there is no PV generation, so peak shaving would require the use of battery storage devices. To date just one residential battery has been installed in Coombs, Wright and Denman Prospect suburbs. System maximum demand over the last twelve months occurred at 5:00pm on 10 February 2017. At that time output from solar farms in the ACT was less than half their rated capacity so the same could be assumed for rooftop PV.

As prices of battery storage systems are anticipated to fall over coming years, it is expected that the rate of uptake will increase and ultimately all 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. It is not expected that customers will install a battery system on its own to

take advantage of energy arbitrage (ie purchasing energy at low demand, low tariff times to charge their battery, then discharge the battery at high demand, high tariff times).

Stage 1B of Denman Prospect Estate includes 34 apartment buildings comprising 1,547 units. North Wright and North Coombs developments include 7 proposed apartment buildings. Installation of solar PV or battery energy storage is not mandatory for apartment buildings so standard demand levels and load profiles are expected for these buildings. Based on the expected penetration levels of rooftop PV and battery storage systems, coupled with smaller dwelling sizes and energy efficient appliances, Evoenergy has calculated for the Molonglo Valley After Diversity Maximum Demand (ADMD) at 2.0 kVA per dwelling. There is a recent trend towards the installation of instantaneous electric hot water systems in apartment buildings and it is anticipated that new apartment buildings will include electric vehicle

(EV) charging facilities. Most new apartment buildings are also all-electric. These factors will potentially increase the ADMD per apartment unit.

Evoenergy is undertaking a Smart Network trial in Stage 1A of Denman Prospect Estate (comprising 390 dwellings) to assess the viability and effectiveness of network-controlled load demand of customer devices beyond the meter (eg solar PV generation systems, battery storage systems, hot water heating systems, heat pumps / air conditioners, swimming pool pumps and EV charging stations). Uptake and usage by customers of gas to meet their energy needs will also be monitored in real time. The outcome of this project will enable load forecast calculations to be refined with a higher degree of accuracy and thus help confirm the timing requirement for capacity augmentation to the Molonglo Valley. At this stage timing is based on current dwellings construction rate, estimated uptake rate of rooftop PV, estimated uptake rate of battery storage, estimated uptake rate of EVs, and estimated uptake rate of instantaneous hot water heating systems. The trial will also help determine what additional facilities may be required to maintain power quality. This could include distribution transformers with on-load-tap-changers (OLTC), voltage regulators or dynamic VAR compensators (DVARs) to manage voltage regulation.

Modern light-emitting diode (LED) streetlight luminaires (typically 22 W each) have replaced compact fluorescent (CFL) streetlight luminaires (typically 42 W) in all new residential streets and alongside open space footpaths. High pressure sodium (HPS) streetlight luminaires (typically 150 W or 250 W) continue to be installed along main arterial roads and to illuminate pedestrian crossings, to meet the requirements of AS/NZS 1158: Lighting for Roads and Public Spaces. The overall reduced power consumption of streetlights has been accounted for in load forecasts.

Viable proposals from third parties that can significantly reduce maximum demand of the Molonglo Valley developments and enable Evoenergy to defer capacity augmentation have to date not been forthcoming. No third party non-network proposals have been received in response to the initial RIT-D public consultation report or the Annual Planning Report or to Evoenergy's website demand management portal. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 2.0 MVA pa to enable the deferral of any network augmentation. This would be in addition to currently proposed rooftop PV installations on all detached dwellings in Denman Prospect.

Any embedded generation must be fuelled by a renewable energy source to comply with the ACT Government's mandate that all electricity supplied to ACT consumers by 2020 must be generated from renewable sources. The ACT Government also has a target of achieving zero net carbon emissions by 2050. There is no viable hydro, wind or geothermal resource in the Molonglo Valley or surrounding vicinity, which leaves large scale solar generation with associated large scale battery storage as the main possible alternative to network augmentation. Therefore, other demand reduction measures such as on-site generation, co-generation and tri-generation[3] which are associated with commercial and industrial businesses are unlikely to be applicable in the immediate future and are therefore not considered further.

Establishment of a micro-grid in the Molonglo Valley is not considered viable due to the absence of a reliable and sustainable generation resource. During winter months it is common to have several consecutive days of cloud cover which significantly reduces the output and effectiveness of solar generation.

Evoenergy's Customer Engagement Strategy is published on our external website and a Demand Management Engagement Strategy is being prepared that will meet the requirements of the NER Section 5.13.1.

All known possible customer and network initiated demand reduction, embedded generation and energy storage solutions have been investigated, with maximum theoretical contribution each could provide (in MVA) and estimated cost to implement. The maximum estimated capacity achievable using non-network and demand management options is 1.06 MVA. This does not meet the minimum capacity required of 1.92 MVA by 2022 to enable the new zone substation and associated 11 kV feeders to be deferred.

These are summarised in Table 5.

[3] Tri-generation is the production of electricity, heat and cooling in the one process. Typically this means a gas fired generator producing electricity and heat with the exhaust heat going to an absorption chiller which produces chilled water and hot water for air conditioning or alternatively the heat is used to heat a swimming pool.

Table 5: Summary of non-network options

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**
	Cost	$45,000	$45,000	$45,000	**$135,000**
Energy efficiency	Capacity	0.03 MVA	0.03 MVA	0.03 MVA	**0.09 MVA**
	Cost	$15,000	$15,000	$15,000	**$45,000**
Customer – owned embedded generation	Capacity	0.1 MVA	0.1 MVA	0.1 MVA	**0.3 MVA**
	Cost	$210,000	$210,000	$210,000	**$630,000**
Customer – owned energy storage	Capacity	0.02 MVA	0.02 MVA	0.02 MVA	**0.06 MVA**
	Cost	$84,000	$84,000	$84,000	**$252,000**
Network – owned embedded generation	Capacity				
	Cost				
Power Factor Improvement	Capacity				
	Cost				
Load curtailment	Capacity	0.01 MVA	0.01 MVA	0.01 MVA	**0.03 MVA**
	Cost	$400,000	$400,000	$400,000	**$1,200,000**
Fuel switching	Capacity	0.1 MVA	0.1 MVA	0.1 MVA	**0.3 MVA**
	Cost	$5,000	$5,000	$5,000	**$15,000**
Demand aggregators	Capacity	0.1 MVA	0.1 MVA	0.1 MVA	**0.3 MVA**
	Cost	$100,000	$100,000	$100,000	**$300,000**
Automated feeder load sharing	Capacity				
	Cost				
Totals	Capacity	**0.36 MVA**	**0.36 MVA**	**0.36 MVA**	**1.06 MVA**
	Cost	**$859,000**	**$859,000**	**$859,000**	**$2,577,000**
Network – owned energy storage	Capacity	0.25 MWh	0.25 MWh	0.25 MWh	0.75 MWh
	Cost	$910,000	$910,000	$910,000	$2,730,000

In summary, a maximum demand reduction of 1.06 MVA could be achieved if all the above non-network options were implemented simultaneously, at an estimated cost of $2,577,000.

Notes:

The rates ($/MVA) used to calculate the costs in Table 5 are taken from the "Australian Generation Technology Report" produced by the CO2CRC reference group of the Electric Power Research Institute (EPRI)[4].

Appendix E provides the worksheet for non-network option evaluation. A brief description of each of the above non-network options is as follows:

Controllable Load:

Demand reduction achieved by controlling non-essential customer loads such as electric resistance water heaters.

Energy Efficiency:

Demand reduction achieved by replacing inefficient appliances with efficient appliances, eg replacing fluorescent lighting with LED luminaires.

Customer-owned Embedded Generation:

Embedded supply achieved by an increased uptake by customers of solar photovoltaic (PV) generation systems. The existing PV penetration in Molonglo Valley including the mandatory PV requirements in Denman Prospect is accounted for in the load forecast figures in Table 1.

[4] http://www.co2crc.com.au/wp-content/uploads/2016/04/LCOE_Report_final_web.pdf

Network-owned Embedded Generation:

Embedded supply achieved by network-owned medium or large-scale generation. There is limited potential for network-owned embedded generation in this area.

Customer-owned Energy Storage:

Demand reduction achieved by discharging customer-owned battery storage systems at times of peak demand. Estimate is based on a 1% battery uptake by June 2018.

Power Factor Improvement:

Demand reduction achieved by improving power factor. An average power factor of 0.95 has been observed in the Molonglo Valley so there is little scope for improvement.

Load Curtailment:

Demand reduction achieved by voluntary curtailment of load by customers at times of peak demand. Evoenergy is currently undertaking an SMS trial for residents connected to Weir feeder in Belconnen. This trial will indicate the potential effectiveness of this option.

Fuel Switching:

Demand reduction achieved by customers replacing electric appliances such as ovens and stove cooking tops with natural gas fuelled equivalents.

Demand Aggregators:

Demand reduction achieved by a third party Aggregator controlling customers' generation, storage and power usage.

Automated Feeder Load Sharing:

Demand reduction achieved by monitoring feeder loads in real time and automatically switching loads from heavily loaded to lightly loaded feeders.

Network-leased Energy Storage:

Demand reduction achieved by one or more mobile, container sized, network-owned battery energy storage systems at times of peak demand. Due to the size of these batteries site acquisition costs and development approval may be necessary. Batteries are redeployable when no longer needed due to either peak demand reduction or implementation of a network option.

4.1.5. Summary of Options Analysis

Table 6: 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	-$9,317,050	Not selected due to lower NPC
2	**Construct new 11 kV cable feeders from Molonglo Zone Substation**	**$4,694,000**	**$4,694,000**	**-$3,346,982**	**Selected due to higher NPC**
3	Demand side management and embedded generation	$26,317,128	$6,130,746	-$13,570,947	Not selected as does not meet need
4	Delayed preferred network option using non-network options	$5,556,229	$5,556,229	-$3,552,502	Not selected as deferral not economic

4.2. Recommendation

The selected option is Option 2, the construction of new 11 kV underground feeders from the proposed 132/11 kV Molonglo Zone Substation. Cables are to be installed in stages from 2022-24.

Financial analysis (refer Appendix B1) shows Option 2 to be the best option due to higher NPV and IRR. It also has the lower capital cost.

The new feeders 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.

Timing is scheduled for completion by June 2024. Future additional feeder cables will be installed as the load growth and demand increases with further development of the Molonglo Valley. A second transformer and second 11 kV switchboard are to be installed at Molonglo Zone Substation around 2030.

The preliminary cost estimate for the selected option is **$4,694,000 excluding overheads, contingency and GST**.

This option has the highest (ie least negative) Net Present Cost (NPC). Refer to cost estimates, cash flows and NPC comparison in Appendices A and B. It can be implemented in time to meet the project needs as identified and will add to Evoenergy's regulated asset base. The major assets will have an economic life of 50 years.

Proposed 11 kV feeders will provide ties to existing feeders from Latham, Civic and Woden zone substations, and thus provide some backup supply capability and load transfer capability in the future.

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 @ 9 km each and five from Civic @ 8 km 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 34 km total route.	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.	m3	$40	10000	$400,000
Cabling works					$7,680,000
11 kV 3c/400mm2 XLPE cable		m	$56	85000	$4,760,000
Throughjoints	Assume every 500m	ea	$1,000	340	$340,000
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					$770,000
11 kV feeder CBs	Assume able to extend switchboards at Latham & Civic	ea	$75,000	10	$750,000
11kV Test & Commissioning	per CB	lot	$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: 11 kV Feeders to Molonglo Valley from Molonglo Zone Substation

Molonglo Valley supply from Molonglo Zone Substation via new 11 kV feeders. Assume seven feeders 2022-24. Others will follow as demand and development requires.					
Preliminary Estimate ± 30% Accuracy					
Description	**Notes**	**Unit**	**$/Unit**	**Quantity**	**Cost**
Trenching and drilling					$2,075,000
Clearing of route where required	Allowance	m2	$10	6000	$60,000
Directional drilling	Assume drilling with no rock. Assume three conduits per drill. Assume drilling across Coulter Drive only (70m). Conduits across William Hovell Drive will be installed by others.	m	$600	1400	$840,000
Open trenching and backfilling	Assume excavation with no rock. Backfill with bedding sand and native soil. Assume three cables per trench. Assume shared trench down John Gorton Drive.	m	$300	2000	$600,000
Cable jointing and haulage pits	Assume every 500m	ea	$3,000	20	$60,000
Traffic management		m	$5	23000	$115,000
Reinstatement incl revegetation as required	Excavation, no rock (minor boulders only). Site is mostly flat.	m3	$40	10000	$400,000
Cabling works					$2,255,000
11 kV 3c/400mm2 XLPE cable		m	$56	23000	$1,288,000
Throughjoints	Assume every 500m	ea	$1,000	26	$26,000
Terminations	Assume distribution substations at Molonglo established under estate reticulation works.	ea	$1,500	14	$21,000
Conduit and marker tape	Assume all cables installed in conduit	m	$10	46000	$460,000
Cable installation labour and plant		m	$20	23000	$460,000
11 kV Switchgear					$14,000
11 kV feeder CBs	Assume all supplied and equipped at Molonglo ZS	ea	$75,000		$0
11kV Test & Commissioning	per CB	lot	$2,000	7	$14,000
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					$350,000
Development Application	Allowance	ea	$50,000	1	$50,000
Contractor's Preliminaries, site establishment and disestablishment	Allowance	ea	$50,000	1	$50,000
Project management and administration	Allowance	ea	$250,000	1	$250,000
Project Sub Total without overheads					**$4,694,000**
Overheads					
Overall average overhead rate	Allowance	27%	$1,267,380	1	$1,267,380
Project Sub Total with overheads					**$5,961,380**
Contingency					
All project works	Preliminary allowance	15%	$894,207	1	$894,207
Project budget total					**$6,855,587**

Appendix B: Financial Analysis

B.1 Capital Expenditure Cash Flow for Each Option

Financial Year	Option 1	Option 2	Option 3*	Option 4**
2019-20				
2020-21				
2021-22	$10,777,910	$1,341,143	$3,170,077	$862,229
2022-23		$1,341,143	$538,304	$1,341,143
2023-24	$1,220,780	$2,011,714	$1,076,607	$1,341,143
2024-25			$1,345,759	$2,011,714
2025-26	$1,220,780		$1,345,759	
2026-27			$1,345,759	
2027-28	$1,220,780		$1,345,759	
2028-29			$1,345,759	
2029-30	$10,777,910		$1,345,759	
2030-31			$1,345,759	
2031-32	$1,220,780		$1,345,759	
2032-33			$1,345,759	
2033-34	$1,220,780		$1,345,759	
2034-35			$1,345,759	
2035-36	$1,220,780		$1,345,759	
2036-37			$1,345,759	
2037-38			$1,345,759	
2038-39			$1,345,759	
Total Cost (20 years)	**$28,880,500**	**$4,694,000**	**$26,317,128**	**$5,556,229**
2019-24 Regulatory Control Period Cost	**$11,998,600**	**$4,694,000**	**$6,130,746**	**$5,556,229**

Option 3 utilises a network owned battery which is modular and redeployable and has a 10 year lifetime. The battery is costed on a lease-like basis.
** Deferral in Option 4 is not exercised as it is not economic.

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.

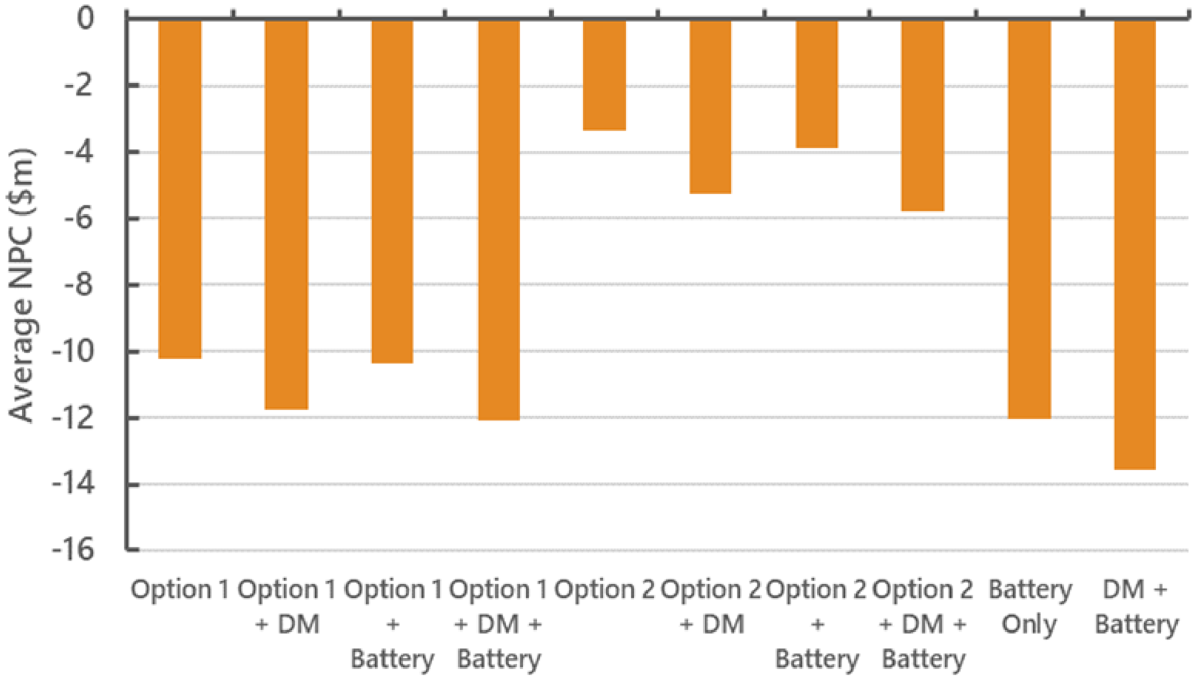
Options:

One – new 11 kV feeders from Latham and Civic zone substations
Two – new 11 kV feeders from Molonglo Zone Substation
Three – best non-network option (network battery)
Four – best mixed network and non-network combination (option two plus network battery)

RESULTS (Average over 50 simulations):

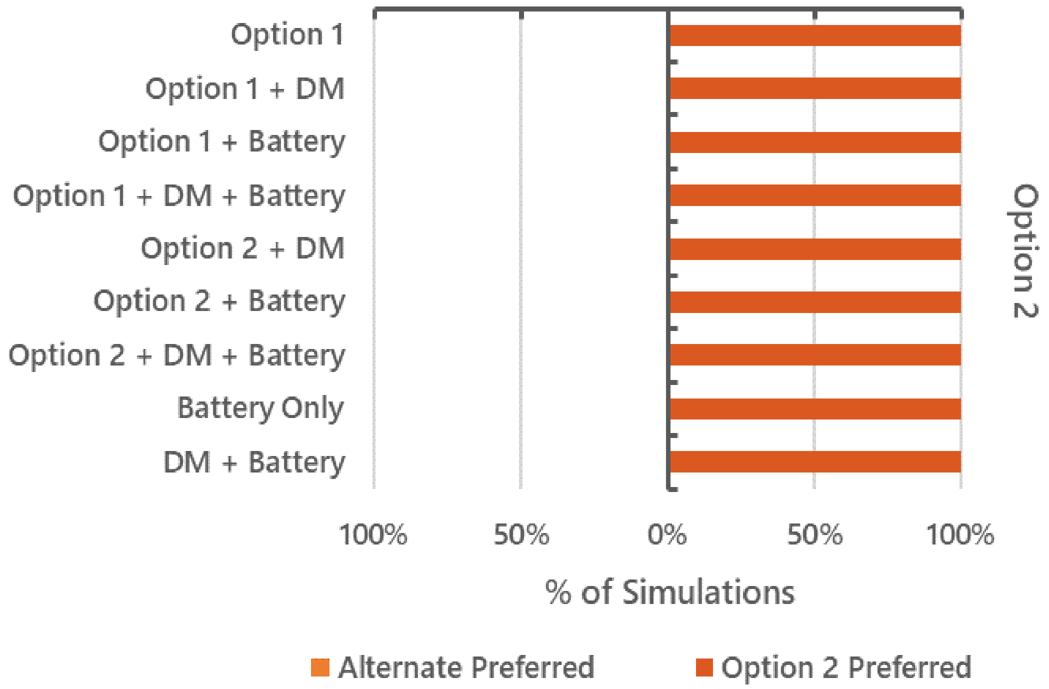
Option:	One	Two	Three	Four
NPC (2019-2024)	-$9,317,050	-$3,043,324	-$4,772,354	-$3,552,502
NPC (2019-2039)	-$14,433,553	-$3,346,982	-$13,570,947	-$3,856,159
Network Option total Capital Cost	$28,880,500	$4,694,000	-	$4,694,000
Option Capital Cost (2019-2024)	$11,998,600	$4,694,000	$6,130,746	$5,556,229
Option Capital Cost (2019-2039)	$28,880,500	$4,694,000	$26,317,128	$5,556,229

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 2 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.