evoenergy

Annual Planning Report 2018

Version: 1.0

Date: 21 December 2018

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REVIEW DATE

This document may not be reviewed once published, but will be replaced with the 2019 version by 31 December 2019.

Table of Contents

Version Control

Version No.	Date	Description of Version
1.0	21 December 2018	Initial issue

Document Authorisation

Name:	Dennis Stanley	Stephen Devlin
Position:	Branch Manager Asset Strategy	General Manager Energy Networks
Date:	21 December 2018	21 December 2018

Statement of Purpose

Evoenergy aims to provide efficient, cost-effective transmission and distribution services to our customers, whilst meeting their current and future reliability and power quality expectations, ensuring public safety and minimising environmental impact.

The purpose of the Annual Planning Report is to inform Customers, Generators, Investors, and Government about the Evoenergy electricity transmission and distribution network's current capability, anticipated investments to maintain that capability, drivers of future development needs and options to meet them.

In doing so we aim to provide information in a clear, concise and accurate way that:

- Enables us to have informed dialog with Generators and Customers to contribute to our understanding of their development plans;
- Clearly identifies and promotes opportunities for Generators and Customers to participate in the development of our plans for the network; and
- Informs investment and connection decisions.

It is our priority to have a transparent and accessible approach to the way we plan our network. This will encourage meaningful stakeholder participation in the planning process and improve the planning of the investments necessary to deliver transmission and distribution services to the people of the ACT.

Achieving the above will also meet the obligations in the National Electricity Rules (NER) and the ACT Technical Regulations law.

Evoenergy welcomes feedback on this Annual Planning Report, especially from external stakeholders considering investments that could either defer or accelerate network development. For all enquiries and for making written submissions please contact:

Evoenergy Distribution
Branch Manager – Asset Strategy
GPO Box 366
Canberra ACT 2601
Email: dennis.stanley@evoenergy.com.au

Executive Summary

Evoenergy is both a registered Distribution Network Service Provider and a Transmission Network Service Provider, and is required to produce a Distribution Annual Planning Report (DAPR) covering its distribution network and a Transmission Annual Planning Report (TAPR) for the transmission network. To align the publication of the DAPR and TAPR, the National Electricity Rules (NER) permits the publication of both documents in a combined Annual Planning Report.

Evoenergy publishes an Annual Planning Report to provide information about the electricity transmission and distribution networks in the ACT, to discuss current or emerging issues affecting the operation of these networks, proposed solutions to issues, and identify opportunities for external stakeholders to provide non-network solutions to these issues.

Energy is supplied to Evoenergy's network primarily from generation sources in neighbouring states. There is an increasing amount of embedded generation including the Royalla Solar Farm that generates up to 20 MW, the Mugga Lane Solar Park that generates up to 12.85 MW, the Williamsdale Solar Farm that generates up to 10 MW, and a large amount of small-scale rooftop solar photovoltaic (PV) generation amounting to approximately 84.2 MW of installed capacity. Maximum system demand in the 2018 calendar year was 623 MW.

This Annual Planning Report presents the results of Evoenergy's annual planning review, including joint planning with TransGrid Limited, the provider of bulk transmission network services to Evoenergy.

The objective of this Annual Planning Report (APR) is to provide customers and external stakeholders with an opportunity to:

- Assess the capability of Evoenergy's transmission and distribution system to transfer electrical energy to and from its present and future customers in the ACT.
- Understand how the transmission and distribution system may affect their operations.
- Identify locations that would benefit from embedded generation or demand-side management initiatives.

The APR also provides an outline of Evoenergy's reliability centred maintenance program and summarises the results of recent reliability improvement initiatives.

Key features of the planning outcomes are:

- Continued strategic focus on asset renewal, prioritised and optimised on the basis of asset condition and network risk, and integrated with growth-related investment needs.
- Overall minor growth in demand, though strong in some areas including Molonglo Valley, West Belconnen, Gungahlin and Canberra Central Business District.
- Joint planning with TransGrid for the completion of the Second Supply to the ACT project;
- Increasing investigations into non-network options and demand management strategies to defer planned network augmentations where it is economically viable and practicable to do so.
- Maintenance of current reliability performance levels into the future, with planned improvements driven by licence condition requirements and STPIS outcomes.
- A total of 8 network-need driven projects in the next 5 years that require the application of the Regulatory Investment Test for Distribution, including consideration of non-network solutions.
- Continued growth in the connection of small-scale rooftop solar photovoltaic energy generation and the integration of these and other emerging end-use technologies such as building energy management systems and battery storage systems.
- Introduction of innovative solutions such as OLTC distribution transformers in areas of high rooftop PV penetration, and the installation of intellirupters in high vegetation areas with the objective of reducing bushfire risk.

The Annual Planning Report outlines the details of the various investment programs and projects proposed by Evoenergy to meet its obligation as a licensed Transmission Network Service provider and distribution network Service Provider in the National Electricity Market. The APR presents the load forecast for the next ten-year period, and discusses solutions proposed to alleviate network constraints and meet load demand expected over the next five year period.

The APR identifies two zone substation issues and eleven distribution feeder issues, where energy at risk and/or asset condition constraints are subject to planning investigations during the next five year planning period. Proposals to eliminate or reduce risk during peak load periods are identified. Work to eliminate network constraints is planned when the economic value to customers of the unserved energy exceeds the capital cost of investment to eliminate the constraint. Where network constraints are identified, proponents of embedded generation and demand side management will be sought in accordance with Evoenergy's Demand Side Engagement Strategy.

The following issues are subject to planning investigations:

Issue	Estimated timing	Location of issue	Estimated Required reduction in load	Comments
East Lake Zone Substation Capacity	June 2019	East Lake, Kingston, Pialligo and Fyshwick suburbs	5.5 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Molonglo Valley	June 2021	Molonglo Valley – Denman Prospect, Whitlam, Coombs and Wright suburbs	4.5 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Canberra North, Lyneham & Dickson	Dec 2019	Donaldson St, Lyneham and Dooring St, Dickson	4.0 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Canberra CBD Central	Dec 2019	London Circuit, Canberra CBD	3.9 MW	Capacity required to supply new commercial developments
Supply capacity to Strathnairn	Dec 2019	Stockdill Drive, Strathnairn	0.8 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Gungahlin Town Centre	June 2020	Valley Ave, Gungahlin	3.6 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Kingston	Dec 2019	Eyre St, Kingston	2.0 MW	Capacity required to supply new residential and commercial developments
Supply to Tuggeranong Town Centre	Dec 2019	Anketell St, Tuggeranong	3.4 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Pialligo	Dec 2019	Brindabella Park, Pialligo	2.5 MW	Capacity required to supply new commercial developments
Supply capacity to Griffith	Dec 2019	Sturt St, Griffith	2.0 MW	Capacity required to supply new residential and commercial developments
Supply capacity to Mitchell	June 2022	Dacre St, Mitchell	1.3 MW	Capacity required to supply new commercial developments
Supply capacity to Belconnen Town Centre	June 2021	Cooinda St, Belconnen	5.2 MW	Capacity required to supply new residential and commercial developments

1. Introduction

1.1. About Evoenergy

ActewAGL was established in October 2000 when the Australian Gas Light Company (AGL) and Icon Distribution Investments Limited (formerly ACTEW Corporation), an ACT Government owned corporation, entered into Australia's first multi-utility joint venture. Today ActewAGL is made up of two partnerships:

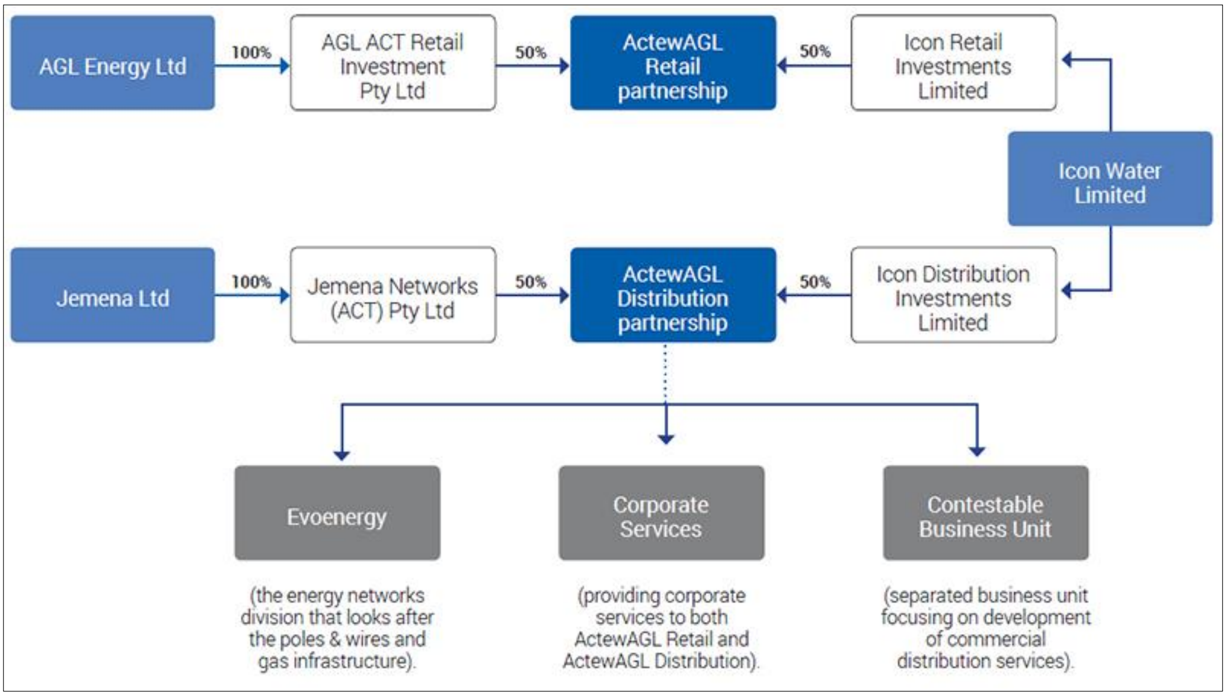
ActewAGL Retail is owned equally by Icon Retail Investments Limited and AGL ACT Retail Investments Pty Ltd.

ActewAGL Distribution, trading as Evoenergy, is owned equally by Icon Distribution Investments Limited and Jemena Networks (ACT) Pty Ltd.

Although ActewAGL (trading as Evoenergy from 1 January 2018) was established in October 2000, with our predecessors we've been supplying reliable essential services to the ACT since 1915.

ActewAGL Distribution (trading as Evoenergy) is licensed under the ACT Utilities Act 2000 (12 May 2016) to provide electricity transmission, distribution and connection services. Evoenergy is registered with the Australian Energy Market Operator (AEMO) as both a Transmission Network Service Provider (TNSP) and a Distribution Network Service Provider (DNSP), and operates in the National Electricity Market (NEM) as a Registered Participant. The NEM operates on an interconnected power system that includes the power systems of Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania.

The change of name to Evoenergy was required by the Australian Energy Regulator's (AER's) ring-fencing guidelines. Evoenergy is the name used by the electricity poles and wires, and gas pipe business and is part of the ActewAGL Distribution partnership, as shown in the following diagram.



The *National Electricity Law (NEL)* and *National Electricity Rules (NER)* are enacted in the ACT by the *Electricity (National Scheme) Act 1997*.

The National Electricity Objective as stated in the National Electricity Law 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."

Evoenergy's mission is:

Enable and empower the smart, vibrant, resilient, and sustainable city of Canberra – we 'Energise the Capital.'

Evoenergy's revenue for the provision of transmission and distribution network services is regulated. We prepare and submit on a five-yearly basis, a Regulatory Revenue Proposal to the Australian Energy Regulator

(AER). The AER reviews this proposal and sets the maximum allowable revenue that Evoenergy can collect from customers for each year of the five-year regulatory period. This determines the revenue that Evoenergy can recover from its customers and hence the funds that can be invested in the network in the form of Operational Expenditure (Opex) and Capital Expenditure (Capex).

Technical regulation is overseen by the ACT Technical Regulator of the Australian Capital Territory Government.

1.2. Evoenergy's operating conditions

Evoenergy is regulated by statutory and legislative requirements, including occupational, health and safety, environmental, competition, industrial, consumer protection and information laws, the National Electricity Rules, the ACT Utilities Act 2000, and the ACT Utilities (Technical Regulation) Act 2014. Evoenergy manages compliance with these laws and regulations through its internal policies and procedures. Management of the physical and financial assets as well as employees is through delegated authorities, from the Board, to executives and staff. Physical infrastructure assets are managed through an Asset Management System that has been certified as being compliant with ISO 55001.

Evoenergy's operating licence to provide Utility Services was granted on 29 June 2001 by the ACT Independent Competition and Regulatory Commission, a body corporate established under the Independent Competition and Regulatory Commission Act 1997 (ACT) ("ICRC") pursuant to the Utilities Act 2000 (ACT).

This licence confers on Evoenergy the right to provide Authorised Utility Services, including electricity transmission, distribution and connection services. Evoenergy may exercise the rights conferred on it in any part of the Territory.

Evoenergy's licence was varied on 1 July 2009 to provide gas distribution and connection services under the Utilities Act 2000 (ACT).

1.3. Evoenergy's function

Evoenergy provides electricity and gas services over an area of 2,358 square kilometres to 200,465 electricity and 146,951 gas customers, as at 30 June 2018, within the Australian Capital Territory. It also supplies 89 electricity and 3,841 gas customers in New South Wales.

Evoenergy is responsible for the operation, maintenance, planning and augmentation of the transmission and distribution system within the ACT. There are a small number of rural cross border high voltage lines feeding 89 rural customers within NSW. Because of the presence of the Brindabella Ranges the developed electricity network is mainly confined to the Canberra urban and surrounding rural areas on the north east side of the ACT.

We supply electricity and natural gas network services to customers in the ACT (and south-east NSW for natural gas). This includes:

- Conducting all maintenance, upgrade, and extension work on the distribution network.
- Performing connection, alterations, disconnection and reconnection.
- Providing emergency response.
- Maintaining quality and reliability of supply.

Evoenergy's company values form the basis for all works done by Evoenergy and are:

- Honesty
- Respect
- Health and Safety
- Teamwork
- Continuous Improvement
- Accountability

Evoenergy also owns and operates a telecommunications network that supports the operation of the electricity network.

1.4. Power of Choice

The Power of Choice (PoC) rule changes, driven by the Australian Energy Market Commission (AEMC), came into effect on 1 December 2017 and included a suite of reforms to the National Electricity Rules designed to encourage energy consumers to make more informed choices about how and when they use electricity.

These reforms also mean changes to roles and responsibilities. The metering services previously facilitated through non-contestable distribution services are now within the direct control of retailers. Retailers are responsible for coordinating meter installations, including new connections, additions and alterations (such as new solar PV installations), management of meter faults and end-of-life meter replacement programs. All of these have traditionally been the responsibility of DNSP's. Evoenergy engages with independent Metering Coordinator (MC) businesses as required.

Evoenergy has updated its Electricity Service and Installation (S&I) Rules which are available on our website.

1.5. Purpose of this document

This Annual Planning Report (APR) has been prepared to comply with the National Electricity Rules (NER) clause 5.12.2 Transmission Annual Planning Report (TAPR) and clause 5.13.2 and Schedule 5.8 Distribution Annual Planning Report (DAPR).
The purpose of this report is to inform market participants, stakeholders and interested parties, of the identified current and emerging constraints affecting Evoenergy's network, and the committed and proposed solutions to these issues. It identifies potential opportunities for non-network solutions such as embedded generation and demand-side management.

The APR provides information about Evoenergy's assessment and planning of its transmission and distribution capacity and Evoenergy's plans for development of the transmission network to meet demand over the next ten years, and development of the distribution network to meet demand over the next five years.

This report also details how Evoenergy plans to meet predicted demand for electricity supplied through its transmission lines, zone substations and high voltage feeders, and discusses the process to engage with non-network providers and customers to address network constraints and system limitations.

1.6. Audience

This APR provides information to existing customers, potential new load and generation customers, non-network solution providers, AEMO, the AER, and other interested parties. It also provides information to all readers on the operation, development and planning of Evoenergy's network, and the drivers for network investment.

1.7. Planning horizon of the APR

Evoenergy has used a ten-year planning horizon to prepare the demand and energy forecasts for its distribution network contained in this APR. The load forecasts show minimal change to demand over the planning period. The steady growth in demand from the residential and commercial sectors of the ACT is offset by the steady growth of embedded generation, in particular rooftop solar PV generation. Energy demand remains at a constant level and is forecast to decrease slightly over the planning period due to the increasing proliferation of rooftop solar PV throughout the region, coupled with the increasing efficiency of electrical appliances, and the advent of new battery storage systems.
Network development projects have been identified and are discussed in this APR for the next five-year planning period.

1.8. What has changed since 2017

The major changes for Evoenergy since the publication of the 2017 Annual Planning Report include:

- System maximum demand during the 2018 calendar year was 623 MW and occurred on 23 July 2018. This was less than the system maximum demand during the 2017 calendar year of 633 MW that occurred on 10 February 2017 when ambient temperature reached 41°C. The 2018 summer was considerably milder.
- The requirement for a second 132/11 kV 30/55 MVA transformer and 11 kV switchboard at East Lake Zone Substation to meet load growth in the East Lake / Kingston / Airport / Pialligo / Fyshwick area has been confirmed. This project is underway and is scheduled for completion by 30 June 2019.

- Stage 2 of the Second Point of Supply to the ACT project has commenced and will include a new TransGrid 330/132 kV bulk supply point substation at Stockdill Drive, West Belconnen, and a new 132 kV transmission line section to connect it to Evoenergy's Canberra–Woden 132 kV line. The project includes installation of a new OPGW conductor on the Canberra–Stockdill–Woden 132 kV transmission line.
- The requirement for the installation of additional reactive support in the northern part of the 11 kV network has been identified. This replaces the requirement for 132 kV reactive support.
- Generation capacity of the Mount Majura Solar Farm has increased from 2.3 MW to 3.6 MW. Generation capacity of the Mugga Lane Waste Transfer Station bio-gas generator has increased from 3.0 MW to 4.0 MW.
- A proposal has been developed to decommission the Fyshwick Zone Substation 66 kV assets and convert it to an 11 kV switching station supplied from East Lake Zone Substation.
- Stage 1 of supply to the Capital Metro Light Rail project has been completed and includes two 11 kV traction power stations and 11 kV supply to the Capital Metro depot / control centre.
- Installation of two new 11 kV feeders (Hamer and Flemington) from Gold Creek Zone Substation to Gungahlin Town Centre has been completed.
- Replacement of 132 kV line protection systems at City East Zone Substation, Gold Creek Zone Substation and Bruce Switching Station, has been completed.
- Evoenergy has adopted a more probabilistic approach to its planning methodology, eg the probability of an outage occurring at time of high load and resulting in unserved energy, forms a major component of planning decisions before Evoenergy commits to a network augmentation project.

Major customer-initiated developments currently underway or planned for construction over the next five-year period, include:

- Ginninderry Estate, West Belconnen – residential development.
- CSIRO Ginninderra Estate, Belconnen – residential development.
- The Republic, Belconnen Town Centre – multiple high-rise residential and commercial developments.
- Throsby Estate, Gungahlin – residential development.
- Taylor Estate, Gungahlin – residential development.
- Jacka Estate, Gungahlin – residential development.
- Gungahlin Town Centre East – residential and commercial development.
- Kingston Foreshore, Kingston – residential and commercial development.
- Denman Prospect Estate, Molonglo Valley – residential development.
- Whitlam Estate, Molonglo Valley – residential development.
- North Coombs, Molonglo Valley – residential development.
- North Wright, Molonglo Valley – residential development.
- South Quay, Tuggeranong Town Centre – multiple high-rise residential and commercial developments.
- Australian National University – construction of permanent replacement 11 kV bulk supply point switching station and construction of second 11 kV bulk supply point switching station.
- Canberra Data Centre Fyshwick No. 2 – commercial development.
- Canberra Data Centre Hume No. 4 – commercial development.
- Canberra central business district – several residential and commercial developments.
- Electric bus charging station, Woden.
- Proposed 20 MW solar farm to be constructed at Symonston. Connection options being evaluated.
- Proposed 55 MW solar farm to be constructed at Wallaroo. Connection options being evaluated.
- Proposed 10 MW solar farm to be constructed at Stromlo. Connection options being evaluated.
- 132 kV Transmission line relocations Molonglo Valley. Approximately 14.7 km of overhead 132 kV transmission lines that currently traverse the Molonglo Valley (sections of Canberra–Woden and Civic–Woden lines) are to be relocated and replaced with underground cables to provide space for a major residential development. Coupled with this proposed project, the site for the future Molonglo Zone Substation has been relocated.
- 132 kV Transmission line relocations East Lake Zone Substation to Causeway Switching Station. Approximately 5.5 km of overhead 132 kV transmission lines that currently traverse the Jerrabomberra Wetlands (sections of East Lake–Telopea Park and East Lake–Gilmore lines) are to be relocated and replaced with underground cables to provide space for a major residential development. Coupled with this proposed project, the Causeway 132 kV Switching Station will be decommissioned and removed.
- 132 kV Transmission line relocations Lawson. Approximately 1.6 km of overhead 132 kV transmission lines that currently run approximately 800 m northwest and southeast of Belconnen Zone Substation (sections of Latham–Belconnen and Belconnen–Bruce lines) are to be relocated and replaced with

underground cables to provide space for a major residential development. A section of these 132 kV cables will be directional drilled beneath Lake Ginninderra.

1.9. Overview of this document

Chapter 1:	Introduces Evoenergy and the purpose of the Annual Planning Report, and summarises the main changes since the 2017 Annual Planning Report.
Chapter 2:	Explains the framework under which Evoenergy operates; the key aspects of network development and asset management strategies; and how customers and generators can participate in the planning process.
Chapter 3:	Describes Evoenergy's electricity network as it exists today and our planning philosophy for its future development.
Chapter 4:	Describes the current performance of Evoenergy's network against reliability targets, and summarises information about anticipated reliability performance, anticipated network augmentations, and asset management programs that impact system performance.
Chapter 5:	Describes the forecast electricity demand and energy requirements over the next ten years; discusses past and future trends; the impact of emerging technologies on forecasts; and assesses whether the existing generation supply can meet the forecast demand.
Chapter 6:	Describes Evoenergy's asset renewals program.
Chapter 7:	Describes those parts of Evoenergy's network forecast to require enhancement or development to meet forecast load demands or relieve constraints, and describes the options considered to achieve this. It also highlights any proposed augmentations that may be subject to the Regulatory Investment Tests for Transmission or Distribution.
Chapter 8:	Discusses strategies regarding demand-side management and why these are important to Evoenergy from a planning and investment perspective.
Chapter 9:	Discusses emerging technologies and why these are important to Evoenergy from a planning and investment perspective.
Appendices:	Provide additional and supporting data.

1.10. Feedback and enquiries

Evoenergy welcomes feedback on this Annual Planning Report. We welcome enquiries from interested parties to participate in non-network opportunities, demand-side management, and embedded generation, to assist Evoenergy manage its existing and forecast network issues.

Please address enquiries to:

Evoenergy Branch Manager – Asset Strategy
GPO Box 366
Canberra ACT 2601
Email: dennis.stanley@evoenergy.com.au

2. Planning Considerations

This chapter discusses relevant aspects of the legal framework that regulates how Evoenergy carries out network planning and augmentation activities in the ACT, and discusses key aspects of network planning and asset management strategies. It also discusses our engagement of stakeholders and customers in the network planning process.

2.1 The regulatory framework & operating environment

Evoenergy operates under the National Electricity Rules (NER) which are managed and updated by the Australian Energy Market Commission (AEMC).

Evoenergy is a Registered Participant in the National Electricity Market (NEM). This is the Australian wholesale electricity market and the associated electricity transmission grid. The NEM is operated by the Australian Energy Market Operator (AEMO) which controls the wholesale generation, dispatch and transmission of electricity in Queensland, New South Wales, South Australia, Victoria, the ACT and Tasmania. The NEM is not a physical thing but a set of procedures that AEMO manages in line with the National Electricity Law (NEL) and the National Electricity Rules. The market uses sophisticated systems to send signals to generators instructing them how much energy to produce each five minutes so that production is matched to consumer requirements, spare capacity is kept ready for emergencies, and the current energy price can be calculated. NEM infrastructure comprises both state and private assets managed by many participants.

Evoenergy is subject to the NEL and NER which regulate the 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.

In addition, there are local territory requirements that Evoenergy must comply with under the terms of our license issued by the ACT Government. The ACT has a Technical Regulator whose role is to ensure safe and reliable energy services to the community. The Utilities Technical Regulation team (UTR) supports the Technical Regulator. The Director-General of the Environment and Planning Directorate is the ACT Technical Regulator. The ACT's economic regulator is the Independent Competition and Regulatory Commission (ICRC).

Technical regulation ensures the safe and reliable delivery of energy to the ACT community. The Utilities (Technical Regulation) Act 2014 sets out technical requirements for energy utilities. The specifics of many requirements are set out in technical codes made under the Act.

2.1.1 National Electricity Rules

The NER Chapter 5 describes the planning, design and operating criteria that must be applied by Network Service Providers to their networks. These criteria specify certain electrical performance standards that must be met such as voltage levels, voltage unbalance, voltage fluctuations, harmonics levels, protection operating times, power quality and power system stability.

2.1.2 Electricity Distribution Supply Standards Code

The Electricity Distribution Supply Standards Code 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 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.

2.1.3 Electricity Transmission Supply Code

The Electricity Transmission Supply Code sets out performance standards to be met by TransGrid's and Evoenergy's transmission networks in the ACT. Implications for meeting this code are described in Section 7.5.1 Second Point of Supply to the ACT project.

2.1.4 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.

2.1.5 Revenue Determination

The revenue Evoenergy earns from providing transmission and distribution services in the ACT is set by the AER. Evoenergy prepares and submits a revenue proposal to the AER on a five-yearly basis. The current Revenue Determination covers the period 1 July 2014 to 30 June 2019. This revenue amount determines how much Evoenergy is able to invest in capital projects and what it can spend on operational expenditure to maintain and operate the network in a secure and reliable state. Evoenergy has submitted its revenue proposal for the 2019-24 period to the AER.

2.1.6 Service Target Performance Incentive Scheme

For the regulatory period from 2014-19 and future regulatory periods Evoenergy is subject to the AER's Service Target Performance Incentive Scheme (STPIS).

For full details of the STPIS refer to the *AER Electricity Distribution Network Service Providers - Service Target Performance Incentive Scheme Guideline v2.0 - 14 November 2018 (STPIS Guidelines)*.

Reliability refers to the extent that customers have a continuous supply of electricity. The main objective of the STPIS is to provide TNSP's and DNSP's with an incentive to maintain or improve reliability levels and consumer response without increasing costs. STPIS achieves this by rewarding network businesses that outperform their targets or by penalising network businesses that do not.

The Evoenergy STPIS scheme has two components:

- Reliability of Supply (unplanned SAIDI and SAIFI).
- Customer Service (telephone response time).

Both SAIDI and SAIFI are subdivided into Urban and Rural components. The definitions for the reliability of supply components are:

Unplanned SAIDI (System Average Interruption Duration Index)
The sum of the duration of each unplanned sustained customer interruption (in customer minutes) divided by the total number of distribution customers (urban or rural). Unplanned SAIDI excludes momentary interruptions (one minute or less).

Unplanned SAIFI (System Average Interruption Frequency Index)
The total number of unplanned sustained customer interruptions divided by the total number of distribution customers (urban or rural). Unplanned SAIFI excludes momentary interruptions (one minute or less). Key points:

- The parameters are separately applied to the two feeder types that Evoenergy has – urban and short rural.
- The performance targets are set at the start of each regulatory period and will remain the same for the full 5 year regulatory period.

The targets are generally set based on the average level recorded over the previous five years. For further detailed discussion on performance metrics, refer to Section 4.2.

2.1.7 Capital Expenditure Sharing Scheme

For the regulatory period from 2014-19 and future regulatory periods Evoenergy is subject to the AER's Capital Expenditure Sharing Scheme (CESS).

The main objective of the CESS is to provide DNSPs with an incentive to undertake efficient capital expenditure (capex) during a regulatory control period. It achieves this by rewarding DNSPs that outperform their capex allowance by making efficiency gains and spending less than forecast or by penalising DNSPs that spend more than their capex allowance because of a lack of efficiency gains.
Evoenergy's strategies to manage the CESS include:

1. Ensuring that the annual capex budget matches or is lower than the AER Approved Allowance for each regulatory year. This includes the annual reforecast budgets.
2. Ensuring that final actual capex in any regulatory year does not exceed budget and/or the AER Approved Allowance.
3. The development of internal capex benchmarking targets based on optimal industry performance.
4. Close co-ordination of the Asset Management Maintenance and Capital Programs with the Program of Works delivery to achieve a timely capex program.

For full details of the CESS refer to the *AER Capital Expenditure Incentive Guideline for Electricity Network Service Providers, November 2013 (CESS Guidelines)*.

2.1.8 Distribution Loss Factors

As electricity flows through the transmission and distribution networks, energy is lost due to electrical resistance and the heating of conductors and devices such as transformers. The losses are can be up to approximately 10% of the total electricity transported between power stations and end users (including up to 5% via the distribution network).

Energy losses on the network must be factored in at all stages of electricity production and transport, to ensure the delivery of adequate supply to meet prevailing demand and maintain the power system in balance. In practical terms, this means more electricity must be generated than indicated in simple demand forecasts to allow for this loss during transportation.

The impact of network losses on spot prices is mathematically represented as transmission and distribution loss factors. Loss factors are calculated and fixed annually to facilitate efficient scheduling and settlement processes in the NEM.

Evoenergy calculates and prepares a report annually of its distribution loss factors (DLFs) to comply with the AER's regulatory requirement. The DLF methodology can be found on Evoenergy's website[1], and Evoenergy's DLF for each network level can be found publicly at AEMO's website[2].

[1] https://www.evoenergy.com.au/-/media/evoenergy/about-us/evoenergy-loss-factor-methodology.pdf

[2] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Loss-factor-and-regional-boundaries/Distribution-loss-factors-for-the-2018-19-financial-year

2.2 Evoenergy integrated planning

2.2.1 Integrated planning strategies – Asset Management, Network Development & Network Reliability

Significant organisational changes and investments have been made to date which will allow Evoenergy to respond to the regulatory and commercial challenges facing the business, and to optimise network performance through improved alignment of planning, asset management and regulatory compliance. Targeted activities to ensure alignment and improve network performance include:

- Achieve electricity Service Target Performance Incentive Scheme (STPIS) targets through proactive management of:
    - Timely response to network outages.
    - Delivering and implementing risk based condition based management of assets.
    - Incorporating reliability performance requirements into network investment business cases.
    - Effective call centre performance management.
    - Targeted reliability improvements upgrading the most unreliable feeders.
    - Root cause analysis of network faults.
    - Expanded use of Failure Mode and Effects Analysis (FMEA).
- Determine and deliver opportunities for asset utilisation improvement, through:
    - Reviewing network supply security standards.
    - Incorporating asset utilisation into network investment business cases.
    - Proactive monitoring of network design practices.
    - Improved alignment of data flow and connection between asset management applications.
- Review our bushfire mitigation program prior to the commencement of the bushfire season and conduct an internal exercise to test bushfire emergency preparedness.
- Deliver a Program of Work (PoW) with particular focus on:
    - Achieving budget targets and efficiency of PoW delivery.
    - Improved PoW reporting that includes earned value metrics.

2.2.2. Asset Management Strategy

Evoenergy's Asset Management Strategy is intended to define the strategic objectives and approach to the management of its physical assets, in a manner that:

- Is optimised and sustainable in terms of whole-of-life, whole-system cost over the long-term.
- Assists in the delivery of Evoenergy's strategic plans and objectives.
- Appropriately considers how Evoenergy will supply current and future demand via the management of the condition and performance of the asset base, ensuring that asset management plans are coordinated with network development plans.
- Ensures that asset renewals are based on asset condition and risk of failure rather than purely on age.
- Meets the required level of service in the most cost-effective way through the efficient use and maintenance of existing assets and the prudent investment in new assets.
- Ensures safety of people and protection of property and the environment.
- Appropriately considers the necessary current and future Asset Management capabilities of the organisation, in terms of people, processes, systems, equipment and data to achieve the identified outputs and objectives.

Evoenergy prepares technical specifications for the procurement of major primary assets. These include requirements for an assessment of whole-of-life costs, including electrical losses. The method of assessing these costs is included in the specification and is taken into account when selecting the successful tenderer.

Evoenergy's Asset Management Strategy and Asset Management Objectives are directed at maintaining assets according to the principles of Risk Centred Maintenance (RCM). The governing factor in RCM analysis is the impact of a functional failure at the equipment level, and tasks are directed at a limited number of significant items - those whose failure might have safety, environmental or economic consequences. The continual assessment of assets follows the "Plan–Do–Check–Act" based approach.

Evoenergy's Asset Management Policy, Strategy and Objectives may be found published on Evoenergy's website.

The Asset Management Strategy has been updated since the previous publication with a reference to "Consideration of Risk for Evoenergy Regulatory Proposal 2019 -2024". Evoenergy's provision of distribution network services inherently involves risk.

These risks include:

- Risks to the community and workforce:
  - Electrical safety risks
  - Workplace safety risks
  - Bushfire and other environmental risks
- Risks to customers' quality of supply including:
  - Power quality
  - Reliability

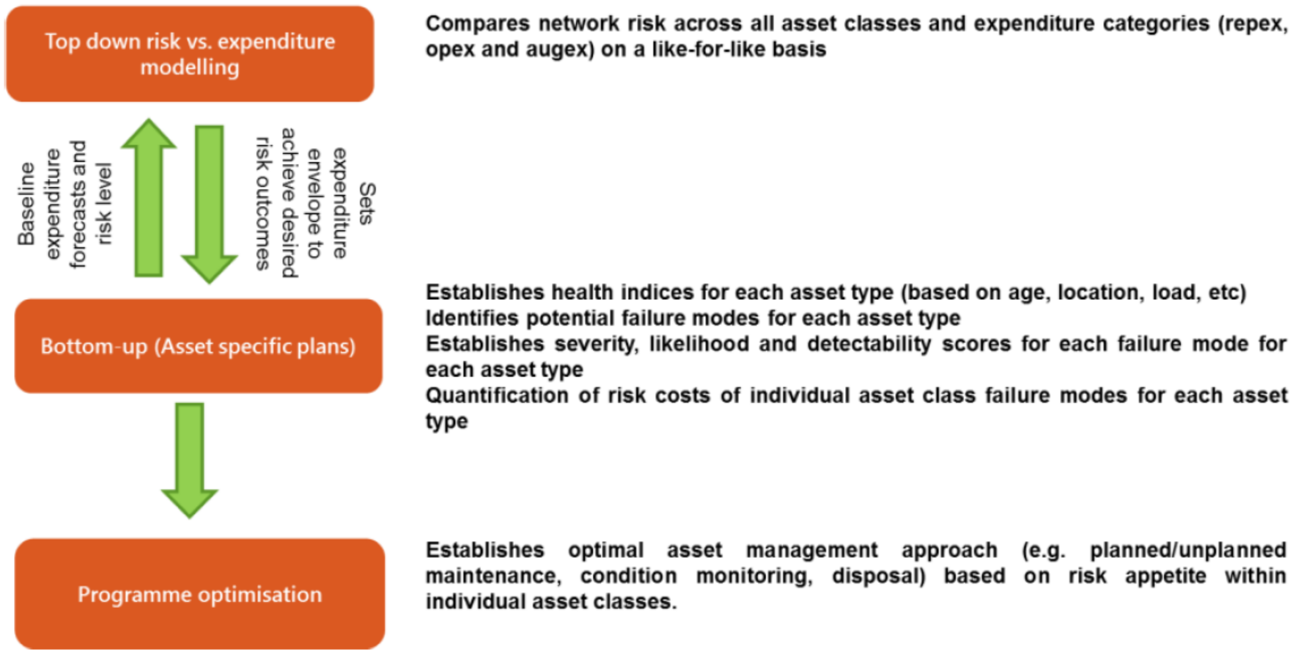
Evoenergy seeks to minimise risks via the following activities:

- Programmatic replacement of ageing, defective, failed and otherwise high risk assets.
- Monitoring of assets to detect and/or predict defects or failure.
- Inspection of assets to detect ageing, defective, failed and otherwise high risk assets.
- Routine and non-routine maintenance to rectify ageing, defective, failed and otherwise high risk assets.
- Provision of sufficient capacity (including redundancy) to meet demand and demand growth.
- Training and management systems underpinning the above.

Evoenergy sets expenditure across these activities to achieve a level of quantified residual risk that is acceptable to its customers and the community as well as to meet relevant regulatory and license based requirements. Quantifying risk in this way ensures that under-investment does not leave Evoenergy's community, its workforce or its customers exposed to unacceptable risk and conversely that over investment (whereby risk is reduced beyond acceptable levels) does not leave customers exposed to unnecessarily high prices.

Evoenergy achieves this via a top-down and bottom-up approach to risk assessment as shown in Figure 2.1.

Figure 2.1 – Top down and bottom up approaches to risk assessment



The bottom-up approach requires asset managers, via asset specific plans to identify the activities required to maintain acceptable levels of risk across individual asset groups and the associated level of expenditure. The bottom-up approach is sufficiently detailed to enable consideration of risk at the asset level but has the potential to result in over-expenditure at the aggregate level, whereby the same risk outcome is targeted by multiple activities.

To mitigate potential over-expenditure due to the bottom-up expenditure forecast, Evoenergy applies a top-down approach to risk management. The top-down approach considers how expenditure can be optimised across asset categories and expenditure categories to achieve the desired level of risk at least cost.

Evoenergy considers the results of both the top-down and bottom-up expenditure forecasts and determines a final expenditure envelope. The final expenditure envelope reflects the expenditure envelopes set via the top-down approach tempered by the technical and practical realities of individual asset needs as determined via the bottom-up approach.

Certification of Asset Management System to ISO 55001:

ISO 55001 was published in February 2014 (superseding the PAS 55 Standard) and states the specification for an integrated, effective management system for asset management, the intent being to maximize value for money from assets. Evoenergy has adopted ISO 55001 as the reference for measuring asset management continuous improvement and compliance.

In 2016 Evoenergy participated in an international benchmarking project, the Asset Management Customer Value Project. The results showed Evoenergy to be performing well against other international and national participants and provided a good base to commence the ISO 55001 compliance maturity assessment.

In July 2017 the JAS-ANZ accredited auditor Bureau Veritas assessed Evoenergy's Asset Management System in a Stage 1 audit and deemed it to meet the requirements the next stage (Stage 2) for ISO 55001 certification. Evoenergy successfully completed the Stage 2 audit by Bureau Veritas in November 2017 and attained certification with the International Standards Organisation standard for Asset Management ISO 55001 on 11 January 2018.


BUREAU VERITAS
Certification
BUREAU VERITAS 1828

Certification

Awarded to

ACTEWAGL

T/a EVO ENERGY

Cnr Oakden and Anketell Street, Greenway, ACT
AUSTRALIA

Bureau Veritas certify that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standards indicated below

STANDARD

ISO 55001:2014

SCOPE OF SUPPLY

Planning, Design, Development, Installation, Operation and Maintenance of Electricity Transmission and Distribution Assets

Original Approval Date: **11 January 2018**

Subject to the continued satisfactory operation of the organisation's Management System, this certificate is valid until: **10 January 2021**

To check the validity of this certificate please call tel. **1800 855 190**

Further clarification regarding the scope of this certificate and the applicability of the Management System requirements may be obtained by consulting the organisation.

Certificate Number: **AU002633-1**

Date: **11 January 2018**

Andrew Mortimore
General Manager - Bureau Veritas Certification

Managing office: Bureau Veritas Pty Ltd, 3/435 Williamstown Road, Port Melbourne, Victoria, 3207

Issuing office: Bureau Veritas Pty Ltd, 3/435 Williamstown Road, Port Melbourne, Victoria, 3207

JAS-ANZ

Annual audits are undertaken on our Asset Management System in order to retain our certification to ISO 55001. The most recent audit was undertaken during November 2018.

Certification to ISO 55001 ensures Evoenergy has the visibility, capability and control to satisfy increasing customer and Regulator expectations.

2.2.3. Network Development Strategy

Evoenergy's network development strategy incorporates providing adequate supply to existing and new customers with prudent investment decision making, whilst applying risk management principles to achieve an appropriate balance between supply adequacy, security, reliability and safety at the lowest cost to our customers.

Evoenergy incorporates long term strategic planning with short term planning to ensure appropriate network developments meet the long term needs of our customers.

The nature of the transmission and distribution industry is changing rapidly with the emergence of new technologies (refer to Chapter 9) and the development of the network must be done so as to cater for these 'non-traditional' factors.

As assets near the end of their economic lives and require replacement, we consider whether a straight like-for-like replacement is the best solution or whether the network can be reconfigured in a way to minimise the costs of asset renewals.

Evoenergy plans and develops its transmission and distribution networks in an integrated way, for example the best way to resolve a transmission constraint could be to implement a distribution solution.

For all major investment projects we investigate non-network options and seek alternative proposals from external third parties.

2.2.4. Network Reliability Strategy

Transmission network reliability is measured in terms of the number of loss of supply events that occur in a year and the amount of unserved energy that results from such outages. Evoenergy's 132 kV transmission network is very secure in that all zone substations have at least two sources of 132 kV connection (i.e. N-1 security). In addition most zone substations have at least two power transformers and the 11 kV network is interconnected between zone substations allowing load transfer in the event of a contingency.

Distribution network reliability is measured in terms of the frequency and duration of unplanned interruptions to customers. Measurement factors include SAIDI, SAIFI and CAIDI (refer Section 4.2).

Evoenergy's strategy is to maintain or improve existing levels of reliability throughout the network through the deployment of devices such as auto-reclosers and remote controlled switches, and the use of our Advanced Distribution Management System (ADMS).

2.3. Customer Connections

Customers can connect to Evoenergy's system at either high voltage (11 kV) or low voltage (400/230 V) level, depending on their requirements. Customer connections can be either load or generation or a combination of the two. Most load and embedded generation connections (for example, rooftop PV) are connected to the low voltage system. Larger customer loads or embedded generators (such as solar farms) are generally connected to the high voltage system. Metering is installed at the high or low voltage point of connection accordingly.

Larger load connections such as a greenfield residential estate may require Evoenergy to augment the up-stream portion of the network (e.g. provide a new 11 kV feeder). Such augmentations form part of the shared network that is not funded by a specific customer.

Larger load or generation connections require a detailed technical study to be undertaken to determine the impact on the network to ensure adequacy of the proposed connection point with regards to capacity, safety and power quality.

Proposed customer connections are included in load forecasts which provide a key input to network planning.

2.4. Stakeholder Engagement

Evoenergy firmly believes in the principle of follow through as it applies to stakeholder engagement. After consultations have taken place, stakeholders are advised of how their suggestions have been taken on board, what risk or impact mitigation measures will be put in place to address their concerns, and how project impacts are being monitored. Furthermore, aside from project-affected groups, other stakeholders are consulted on issues that address their particular concerns, such as the environmental, social, economic, and governance performance of the business. This process offers a platform to report back on the process of stakeholder engagement itself, such as

- who has been consulted;
- on what topics; and
- with what results.

Keeping track of the commitments made to various stakeholder groups at various times, and communicating progress made against these commitments on a regular basis, requires appropriate systems and organisation. The following factors have been taken into account in determining Evoenergy's stakeholder engagement strategy: Evoenergy actively

- determines what information needs to be reported to which stakeholders, by what method and how frequently;
- updates its commitments register and discloses progress to affected and interested parties. In particular, Evoenergy publicises any material changes to commitments or implementation actions that vary from publicly disclosed documents;
- makes appropriate monitored results publicly available;
- reports on the process of stakeholder engagement as a whole, both to those stakeholders who are directly engaged, and to other interested parties; and
- provides information reported to stakeholders in non-technical and easily understandable formats.

Further information on Evoenergy's engagement with stakeholders, including media and the public can be found on Evoenergy's Consumer Engagement website[3].

[3] http://www.Evoenergy.com.au/Networks/About-our-network/Initiatives/Consumer-engagement.aspx

3. The Evoenergy Electricity Network

3.1. Overview of the network

This chapter describes Evoenergy's transmission and distribution network in the ACT and how it fits in the supply chain between generating power stations and end use customers, and discusses issues affecting the National Transmission Flow Path (NTFP).

3.2. Characteristics of the Evoenergy network

The Evoenergy network consists of an interconnected 132 kV transmission network supplying twelve 132/11 kV zone substations and two 132 kV switching stations. There is also a single 66/11 kV zone substation. All 132 kV and 66 kV connections have N-1 transmission security with the exception of Tennent Zone Substation which is connected via a single circuit 132 kV tee-connection. There are three bulk supply points supplying the Evoenergy network, all owned and operated by TransGrid Limited as follows:

- Canberra 330/132 kV bulk supply substation.
- Williamsdale 330/132 kV bulk supply substation.
- Queanbeyan 132/66 kV bulk supply substation.

Evoenergy's assets include 132 kV transmission lines, 66 kV sub-transmission lines, 132/11 kV and 66/11 kV zone substations, 22 kV and 11 kV distribution feeders, 22/0.415 kV and 11/0.415 kV distribution substations, low voltage 400 V circuits, and equipment such as distribution pillars and pits to provide connection points to customers. Evoenergy also owns a 132/11 kV 14 MVA mobile substation that can be deployed as required at short notice.

East Lake and Tennent zone substations are the two substations that have one power transformer only, although a second transformer will be installed at East Lake by 30 June 2019. All other zone substations have two or three power transformers, providing N-1 transformer security.

There are currently 249 x 11 kV feeders. Most of these are interconnected with other feeders (i.e. a meshed 11 kV network) and provide links between zone substations. There are also two 22 kV distribution feeders, supplied via 11/22 kV step-up transformers at Woden Zone Substation.

Approximately 53% of Evoenergy's distribution network is underground, although less than 2% of the transmission network is underground.

There are 25 customers directly connected at 11 kV, two customers directly connected at 22 kV, and no customers directly connected at either 66 kV or 132 kV. The remaining customers are connected to the low voltage network (400 V three phase or 230 V single phase). 11 kV / 415 V distribution stations are ground-mounted, pole-mounted, or installed inside buildings such as chamber substations, and range in size from 25 kVA to 1500 kVA.

Customers are primarily commercial, light industrial or residential connections. There are no major industrial customers.

The majority of electricity consumed by customers in the ACT is generated outside the ACT. There are some small embedded generation facilities in the ACT, the largest being the Royalla Solar Farm at Royalla which has a peak output of 20 MW. Mugga Lane Solar Park at Mugga Lane, Hume has a maximum design output of 12.85 MW. Williamsdale Solar Farm at Williamsdale has a maximum design output of 10.6 MW. Mount Majura Solar Farm at Majura has a maximum design output of 3.6 MW. There is a bio-gas generator installed at Mugga Lane waste transfer station (4 MW) and another at Belconnen waste transfer station (3 MW), a co-gen plant (1.2 MW) at the Harman defence facility and a co-gen plant (1.4 MW) at the Canberra airport.

There is approximately 84.2 MW of installed domestic rooftop photo-voltaic (PV) generation capacity consisting of 21,695 installations as at 30 June 2018. This represents approximately 10.9% of Evoenergy's customers. These are distributed all over the ACT. Their impact on zone substation summer peak demand is a reduction that ranges from 0.2% - 3.0% depending on the level of penetration in the area. Their impact on zone substation winter peak demand is negligible.

Electrical energy consumed in the ACT is generated mainly outside the ACT and enters via TransGrid's transmission network. Electrical energy generated within the ACT accounts for approximately the following percentages of all electrical energy consumed by Evoenergy's customers:

- Bio-gas = 1% all year round.
- Large scale solar farms = 2% winter to 4% summer.
- Rooftop solar PV = 1% winter to 4% summer.

To date there are approximately 800 domestic battery systems connected beyond-the-meter and no battery storage systems connected directly to the Evoenergy distribution network. Evoenergy is trialling twelve publicly accessible electric vehicle charging stations across the ACT. There are three rapid-charge and nine fast-charge electric vehicle charging stations connected to the low voltage network (refer Section 9.5).

System peak demand usually occurs in winter. In 2018 the winter peak demand was 623 MW at 8:00 am on 23 July 2018 when output from solar PV was minimal. The summer peak demand was 567 MW at 4:00pm on 23 January 2018 when output from solar PV was high.

Evoenergy owns, operates and maintains a telecommunications network that supports the operation of the electricity network. It provides bearers for control, protection and data signalling, telephone handsets and mobile radios for operations and maintenance activities. Telecommunications assets include optical fibres on transmission and distribution lines, digital microwave radios and associated repeater stations.

3.3. Transmission/Distribution system

Figure 3.1: Evoenergy Transmission System

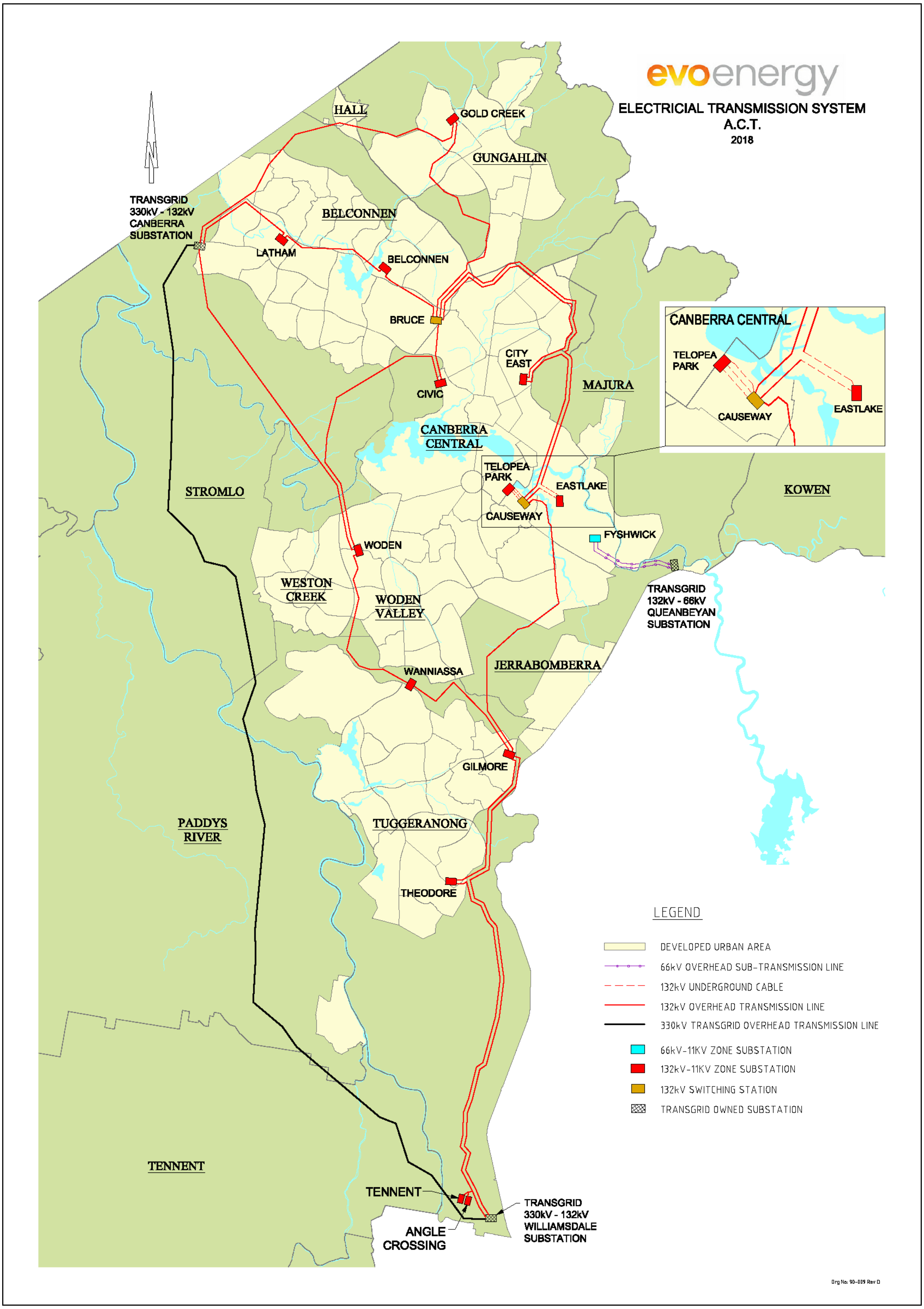


Figure 3.2 presents a schematic diagram of the ACT transmission network.

Figure 3.2: ACT Existing Transmission Network Schematic Diagram

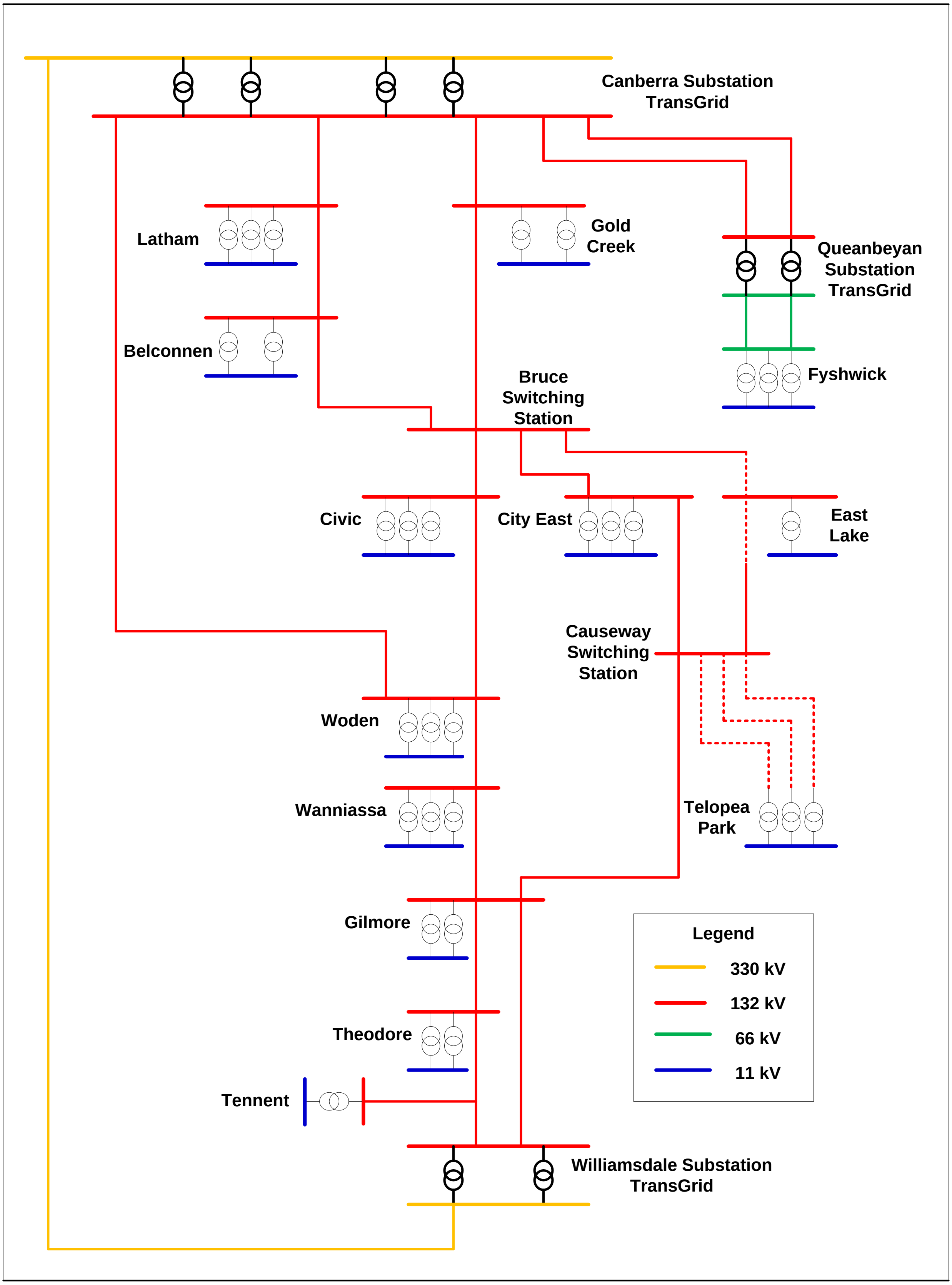
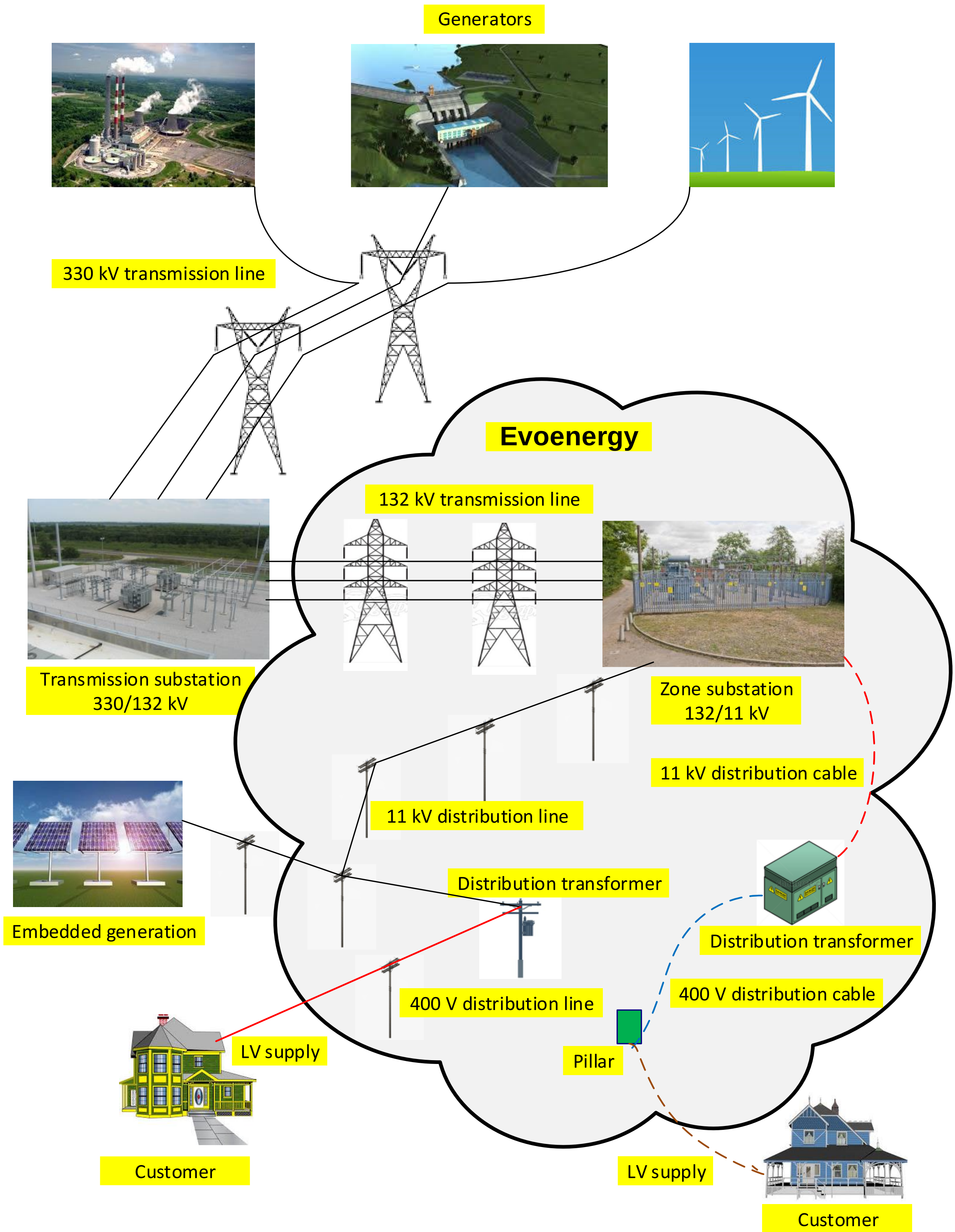


Figure 3.3 illustrates where Evoenergy fits in the electricity supply chain.

Figure 3.3: Electricity Supply Chain



A summary of Evoenergy's major network assets is shown Table 3.1.

Table 3.1: Evoenergy Network Assets

Asset Type	Nominal Voltage	Quantity
Bulk Supply Points	330/132 kV	2
	132/66 kV	1
Transmission Lines	132 kV	189 km Overhead
	132 kV	6 km Underground
Sub-transmission Lines	66 kV	7 km overhead
Switching Stations	132 kV	2
Zone Substations	132/11 kV	12 (+ 1 mobile substation)
	66/11kV	1
Power transformers	132/11 kV	28
	66/11 kV	3
Feeders	22 kV	2
	11 kV	249
22/0.415 kV Substations	22 kV & 400 V	10
11/0.415 kV Substations	11 kV & 400 V	5,079
Number of transmission towers and pole structures	132 kV	917
	66 kV	52
Number of poles	22 kV, 11 kV and 400 V	50,685
Circuit km of distribution overhead lines	22 kV, 11 kV and 400 V	2,365 km
Circuit km of distribution underground cables	11 kV and 400 V	3,007 km
Number of customer connections	22 kV	2
	11 kV	25
	400 V / 230 V	200,438
Coverage area		2,358 km^2
System maximum demand		623 MW
Telecommunications network		Fibre optic and radio

Table 3.2 lists Evoenergy's zone substations, their year of commissioning and their installed total capacity and firm capacity (N-1 rating).

Table 3.2: Evoenergy's Zone Substations

Zone Substation	Year commissioned	Voltage	Total capacity	Firm capacity	No of transformers
Angle Crossing (mobile substation)	2012	132/11 kV	15 MVA	0 MVA	1
Belconnen	1977	132/11 kV	110 MVA	55 MVA	2
City East	1979	132/11 kV	171 MVA	114 MVA	3
Civic	1967	132/11 kV	165 MVA	110 MVA	3
East Lake	2013	132/11 kV	55 MVA	0 MVA	1*
Fyshwick	1982	66/11 kV	75 MVA	50 MVA	3
Gilmore	1987	132/11 kV	90 MVA	45 MVA	2
Gold Creek	1994	132/11 kV	114 MVA	57 MVA	2
Latham	1971	132/11 kV	150 MVA	100 MVA	3
Telopea Park	1986	132/11 kV	150 MVA	100 MVA	3
Tennent	2017	132/11 kV	15 MVA	0 MVA	1
Theodore	1990	132/11 kV	90 MVA	45 MVA	2
Wanniassa	1975	132/11 kV	150 MVA	100 MVA	3
Woden	1967	132/11 kV	150 MVA	100 MVA	3

* A second 55 MVA 132/11 kV transformer has been ordered for East Lake Zone Substation and is scheduled to be installed and commissioned by 30 June 2019.

3.4. Planning Philosophy

The planning and development process for both transmission and distribution networks, is carried out in accordance with the National Electricity Rules (NER) Chapter 5 Part B Network Planning and Expansion. Planning for the transmission network is carried out in accordance with the NER Section 5.12 Transmission annual planning process and for the distribution network in accordance with the NER Section 5.13 Distribution annual planning process.

The primary objective of planning is to ensure that customers are able to receive a sufficient and reliable supply of electricity of high quality now and into the future. Evoenergy's planning standards are set to ensure 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 that occurs sufficiently frequently, and has such consequences, as to justify the NSP to take prudent precautions to mitigate. This is commonly referred to as an N-1 event. Typically there is a high level of redundancy applied to electricity networks. This reflects the implications of network service failures, noting that communities and businesses have a low tolerance to electricity supply interruptions.

Evoenergy applies probabilistic planning techniques to assess supply security constraints. Deterministic criteria are used only as a trigger for further investigation. The probabilistic planning approach includes:

- Assessment of likelihood of failure of network elements.
- Assessment of consequence in the event of failure. This includes assessing the probability and quantity of unserved energy resulting from an unplanned outage of a network element. The value of unserved energy is calculated using the Value of Customer Reliability figure (currently $26.93/kWh for residential customers).

- Consideration of back-up capacity via load transfers between inter-tied feeders or between adjacent zone substations.
- A sensitivity analysis for key parameters such as load growth, cost and non-network demand management.
- A determination of economic timing for network augmentation and the net present value of options based on demand forecasts.

For greenfield residential developments such as the Molonglo Valley, probabilistic planning tends to result in a staged approach to provision of supply capacity, eg use of mobile substation at Stage 1, construction of single transformer zone substation at Stage 2, and installation of second zone substation transformer at Stage 2. Installation of distribution feeders is similarly staged. Timing is determined by the load growth of the area being supplied.

The early identification, consultation and monitoring of emerging network limitations and prospective network developments is aimed at providing proponents of non-network solutions adequate time to prepare proposals.

Evoenergy's planning approach to addressing load growth or network constraint issues, is to use probabilistic analysis techniques coupled with fully exploring non-network solutions such as demand-side management, before investing in network augmentation. This approach takes into account the combination of demand forecasts, asset ratings and asset failure rates to identify the severity of constraints and the required timing of solutions.

Customers will offer demand response capabilities when the reward for demand response is greater than the value they place on that supply. This can include accepting some degree of direct load control or capacity limitation. Deterministic planning criteria, strictly applied, do not facilitate NSPs offering this type of optimisation decision to customers, as it focuses entirely on the level of reliability and security of supply, not the value of that supply to customers. A probabilistic planning framework therefore offers a different range of opportunities for demand management.

Evoenergy runs a load flow model of the network using a computer software program known as ADMS (Advanced Distribution Management System). This system is linked to our Supervisory Control and Data Acquisition (SCADA) system and obtains and analyses data such as the status of network assets (e.g. positions of circuit breakers), current flows and voltage levels throughout the network, in real time. This system is used to identify issues such as power flow constraints or voltage level issues on the network, and is used to model what-if scenarios such as the effect of a new load or generation connection. Using this tool, Evoenergy is able to identify existing and emerging constraints that form the basis of our asset management and network development plans.

Evoenergy's planning process is an annual process and covers a minimum forward planning period of ten years. The process commences with a comprehensive analysis of all indicators and trends to forecast the future load on the network. A detailed analysis of the network is then carried out to identify performance and capability shortcomings, i.e. constraints.

Evoenergy uses a two hour emergency cyclic rating for all its zone substation power transformers. Evoenergy has adopted the use of two hour emergency ratings and normal cyclic ratings, and uses the ADMS system to regularly record and reassess the cyclic loading capability of zone substation equipment, based on equipment manufacturer's recommendations and relevant Australian and international standards. Evoenergy maintains a high level of zone substation power transformer utilisation by using the two hour emergency cyclic rating, and effective load balancing between zone substations wherever possible. Load balancing is an integral initial solution to network augmentation planning.

Chapter 7 describes the outcomes of our annual planning process. If the augmentation or replacement cost of a proposal exceeds $5 million, we undertake a Regulatory Investment Test in line with the requirements of the NER (section 5.16 for transmission RIT-T and section 5.17 for distribution RIT-D). The purpose of the Regulatory Investment Test is to identify the credible option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the market. A preferred option may have a negative net economic benefit (that is, a net economic cost) where the identified need is for reliability corrective action.

Evoenergy ensures the following prior to committing to any large investment:

- Investments are cost effective and consider whole-of-life costs associated with a new asset.
- Timing of the new investment is defined to meet the requirement of the need when it reaches the point that the need cannot otherwise be met.
- Appropriate investment procedures are followed, including business case and Board approval, and execution of the RIT-T or RIT-D if required.
- Works are timed to ensure smooth capital and replacement cash flows, and availability of resources.
- Works are coordinated as required with other utilities and/or network service providers, and to meet customer needs.

Figure 3.4 illustrates Evoenergy's network planning process.

Figure 3.4: Evoenergy's network planning process

Planning Inputs and Drivers:

- Demand forecasts
- Security standards
- ACT technical regulations
- Demand side management criteria
- Embedded generation connections
- RIT-T and RIT-D processes
- Company policies & standards
- Financial objectives
- Equipment ratings
- Reliability standards
- Quality of supply
- System constraints
- Equipment condition reports
- Network augmentation criteria
- Stakeholder obligations
- Strategic benefits
- Load transfer capacity
- National Electricity Rules
- Network performance targets
- Customer load connections
- Capital approval process
- Design manual
- Health & Safety
- Legal & Statutory obligations

Planning Process:

- Load flow studies
- Identify emerging constraints
- Identify power quality improvements
- Joint planning with TransGrid
- Prepare Development Applications
- Economic analysis – NPV studies
- Load forecasting
- Strategic alignment
- Fault level studies
- Identify credible network options
- Identify security improvements
- Options analysis
- Select preferred options
- Risks analysis
- Capital approval governance
- Security of supply
- Network capacity analysis
- Identify credible non-network options
- Identify network reliability improvements
- Carry out RIT-T or RIT-D
- Prepare business case and project approval
- Model/simulate network
- Customer consultation
- Financial analysis (NPV)

Planning Outputs:

- Programme of Works
- Zone Substation development reports
- Uprate existing assets
- Asset renewals & replacements
- Meet security & reliability standards
- Regulatory Information Notice
- Development Application submissions
- RIT-T or RIT-D consultation reports
- Project technical specifications
- Land access & easement agreements
- Tender or contract for procurement
- Five-yearly regulatory proposal
- Network modelling
- Non-network solutions
- Annual Planning Report
- Capital investment approval
- Demand-side management contracts
- Tender of contract for design & construction
- Build new network infrastructure if required
- Network augmentation projects
- Customer connections

4. Network Performance

4.1. Introduction

This chapter discusses the performance of the Evoenergy electricity network. There are a number of factors that contribute to network performance and these include the following:

- Network reliability which is measured in terms of the number and duration of customer outages.
- Network security which measures the power system's capacity to continue operating within defined technical limits even if a major power system element such as a transmission line or zone substation transformer, fails. Such failures are known as 'credible contingency events'.
- Constraints that restrict access to the network for maintenance purposes without the need to disrupt supply to customers.
- Major system incidents that may have been as a result of structural or geographic weaknesses.
- The level of photovoltaic generation penetration and the ability of the network to cope.
- The condition of the assets making up the network.
- Vegetation encroachment on network assets.
- Network fault levels and the ability of the network to cope.
- The quality of the power supply in terms of voltage stability, harmonic content, freedom from flicker, and security from shocks and stray voltages.
- The level of network losses.
- The level of network information systems penetration.
- Any network innovations such as automatic fault isolation and restoration.

4.2. System reliability and performance metrics

Evoenergy's service standards obligations arise mainly from the application of the ACT Utilities (Technical Regulation) Act. That Act requires Evoenergy to comply with all relevant industry and technical codes, any directions by the Independent Competition and Regulatory Commission (ICRC) or the ACT Technical Regulator. Relevant codes include the Consumer Protection Code, the Electricity Distribution Supply Standards Code and the Electricity Transmission Supply Code.

The network reliability measures and standards are adopted from the Supply Standards Code and the referred Australian Standards therein which set out parameters for electricity supply through the Evoenergy network.

The minimum distribution supply reliability standards are detailed in the Supply Standards Code, Schedule 2. Section 6.1 of the Code also specifies that Evoenergy must publish supply reliability targets annually for the following year, which include:

- **SAIDI**: System Average Interruption Duration Index. The ratio of total customer minutes interrupted to total customers served. This is a performance measure of network reliability, indicating the total minutes, on average, that customers are without electricity during the relevant period.
- **SAIFI**: System Average Interruption Frequency Index. The ratio of total customer interruptions to total customers served. This is a performance measure of network reliability, indicating the average number of occasions each customer is interrupted during the relevant period.
- **CAIDI**: Customer Average Interruption Duration Index. The ratio of total customer time interrupted to total customer interruptions. Measured in minutes and indicates the average duration an affected customer is without power. CAIDI = SAIDI/SAIFI.

The reliability targets specified in the Electricity Distribution Supply Standards Code are shown in Table 4.1.

Table 4.1: Electricity Distribution Supply Standards Code Annual Reliability Targets

Parameter	Target	Units
Average outage duration pa (SAIDI)	91.0	Minutes
Average outage frequency pa (SAIFI)	1.2	Number
Average outage time pa (CAIDI)	74.6	Minutes

Evoenergy has set internal business targets of 32.1 minutes for unplanned SAIDI and 0.62 for unplanned SAIFI within the overall externally set SAIDI target of 91 minutes and SAIFI target of 1.2 in the Electricity Distribution Supply Standards Code.

As previously discussed in Section 2.1.6, the AER introduced on 1 July 2015 a Service Target Performance Incentive Scheme (STPIS) as part of the 2014-19 Regulatory Determination period. The STPIS reliability targets set by the AER for the 2015-19 period for unplanned outages are shown in Table 4.2. The targets for 2015-16 and 2016-17 were retrospectively changed by the AER in 2018.

Table 4.2: AER STPIS Reliability Performance Targets for Unplanned Outages:

Year	2015-16	2016-17	2017-18	2018-19
Unplanned SAIDI				
Urban feeder	31.91	31.91	30.32	30.32
Short rural feeder	49.32	49.32	46.86	46.86
Unplanned SAIFI				
Urban feeder	0.616	0.616	0.585	0.585
Short rural feeder	0.942	0.942	0.895	0.895

Table 4.3 shows Evoenergy's actual performance indicator figures for the 2017-18 financial year, for both planned and unplanned outages. Figures for the previous 5 years are included for comparison purposes. Approximately 62% of Evoenergy's 11 kV feeders are classified as *urban* with the remaining 38% classified as *short rural*.

Table 4.3: Evoenergy Reliability Performance

Key Performance Indicators Distribution Network		Feeder category			Supply Code Overall target
		Urban	Rural Short	Overall network	
SAIDI					
2011-15 average	Overall actual	78.88	87.71	80.03	91.0
	Planned actual	47.44	43.53	47.33	
	Unplanned actual	31.44	44.18	32.70	
2015-16	Overall actual	76.22	56.61	74.01	91.0
	Planned actual	40.49	26.36	38.89	
	Unplanned actual	35.73	30.25	35.12	
2016-17	Overall actual	83.91	82.44	83.74	91.0
	Planned actual	44.80	39.70	44.21	
	Unplanned actual	39.11	42.74	39.53	
2017-18	Overall actual	94.57	78.56	88.49	91.0
	Planned actual	64.76	44.45	57.05	
	Unplanned actual	29.81	34.11	31.44	
	STPIS Unplanned Target for 2015-19	30.32	46.86		
SAIFI					
2011-15 average	Overall actual	0.811	1.016	0.829	1.2
	Planned actual	0.213	0.196	0.212	
	Unplanned actual	0.598	0.818	0.618	
2015-16	Overall actual	0.876	0.725	0.860	1.2
	Planned actual	0.104	0.109	0.185	
	Unplanned actual	0.682	0.616	0.675	
2016-17	Overall actual	0.883	1.042	0.902	1.2
	Planned actual	0.215	0.190	0.212	
	Unplanned actual	0.669	0.852	0.690	
2017-18	Overall actual	0.65	0.77	0.70	1.2
	Planned actual	0.20	0.21	0.20	
	Unplanned actual	0.45	0.56	0.49	
	STPIS Unplanned Target for 2015-19	0.585	0.895		
CAIDI					
2011-16 average	Overall actual	97.29	87.91	96.52	74.6
	Planned actual	223.31	220.48	223.72	
	Unplanned actual	52.53	54.31	52.94	
2015-16	Overall actual	86.97	78.12	86.10	74.6
	Planned actual	208.44	242.43	210.76	
	Unplanned actual	52.38	49.11	52.03	
2016-17	Overall actual	267.12	259.28	265.99	74.6
	Planned actual	208.63	209.10	208.68	
	Unplanned actual	58.49	50.18	57.31	
2017-18	Overall actual	145.49	102.03	126.41	74.6
	Planned actual	323.80	211.67	285.25	
	Unplanned actual	66.24	60.91	64.16	
	No STPIS CAIDI target				

The number of unplanned loss of supply events (multi-premise) for the 2017-18 financial year was 614.

The reliability of supply component of the STPIS scheme will apply financial rewards for each year within the regulatory control period to Evoenergy on the basis of performance relative to targets. The maximum annual revenue at risk for the reliability of supply component is between +2.5% (upper limit) and –2.5% (lower limit).

Both SAIDI and SAIFI components exclude major event days such as extreme weather or bushfire conditions.

Evoenergy has various programs underway aimed at improving system reliability and reducing overall SAIDI, SAIFI and CAIDI indices. These include:

- Trialling Distribution Fault Analysers (DFAs) on underground networks to prevent outages.
- Installation of auto reclosers and intellirupters to minimise the number of customers affected when outages occur.
- Installation of feeder ties in high outage risk areas.
- Trailing a Virtual Power Plant (VPP) as a "virtual" load shedding scheme to reduce outages during network constraints.
- Risk Centred Maintenance (RCM), targeted maintenance and replacement to minimise failures and thus reduce unplanned outages.
- Decommission legacy assets, to prevent outages.
- Installation of fault location and remote control devices to reduce restoration time.
- Improving vegetation management on ACT unleased territory land (previously managed by ACT Government Transport Canberra and City Services Directorate).

4.3. System constraints and security

A system constraint is a situation where the power flow through a part of the transmission or distribution network must be restricted in order to avoid exceeding a known technical limit. Examples of technical limits include the thermal rating of conductors or other equipment such as transformers, operating voltage levels, and equipment protection settings. Some constraints can exist under normal operating conditions; however they are most likely to occur when an element (such as a transmission line or distribution feeder) is out of service.

Evoenergy has a meshed 132 kV network in that all 132/11 kV zone substations are connected to two or more 132 kV lines, ie they have N-1 transmission security (refer Figure 3.2). The exception is Tennent Zone Substation which is connected radially via a 132 kV tee-off. However the load at Tennent is small and a backup 11 kV feeder supply is provided to it from Wanniassa Zone Substation. Evoenergy's sole 66/11 kV zone substation, Fyshwick, is supplied via two single circuit 66 kV lines from TransGrid's Queanbeyan Substation so also has N-1 transmission security.

All 132 kV lines have sufficient capacity to supply full capacity to each zone substation without constraint in the event of an outage of a 132 kV transmission line (refer Appendix D).

The 132 kV network is supplied from two TransGrid 330/132 kV bulk supply substations (Canberra and Williamsdale). As Williamsdale Substation is supplied radially from Canberra Substation at 330 kV, a constraint has been identified jointly by TransGrid and Evoenergy whereby in the event of a total outage of Canberra Substation, supply to Evoenergy's 132 kV network would be interrupted. This issue is to be addressed in the current planning period (refer section 7.5.1).

All zone substations with the exception of East Lake and Tennent zone substations have two or more power transformers (i.e. N-1 transformer security). East Lake Zone Substation has one only 132/11 kV transformer but a second is proposed to be installed in 2019 (refer section 7.5.2). In the interim, in the event of a transformer contingency, supply can be restored to all customers via 11 kV feeder ties to Telopea Park and Fyshwick zone substations.

The majority of the 11 kV distribution network is meshed with links between feeders and between zone substations. Evoenergy constantly monitors loads on all feeders and analyses the impact of proposed new connections. Such analysis is done using the Advanced Distribution Management System (ADMS). Transfer capability between zone substations via the 11 kV network is carefully monitored and managed, with open points between feeders changed to cater for load growth whilst avoiding constraints such as thermal loading of conductors.

As the majority of generation and bulk transmission is located externally to the ACT, system frequency is not able to be controlled by Evoenergy. However in the event of a major system event such as a large generator or 330 kV transmission line contingency, frequency could drop below the normal operating frequency excursion band. Under clause 4.2.6 (c) of the NER, in such an event all affected TNSPs and DNSPs must be able to shed load quickly until frequency is restored to avoid the problem escalating. NER clause 4.3.1 (k) specifies that a DNSP must be able to shed up to 60% of its total load during an under-frequency event to allow for prompt restoration or recovery of the power system. Evoenergy is in the process of installing under frequency load shedding (UFLS) relays at all of its zone substations, to trip feeders according to a set hierarchy (i.e. feeders supplying critical loads such as hospitals would be the last to be tripped).

Evoenergy's network operations control centre is located at Fyshwick. Evoenergy has a disaster recovery facility (DRF) at Civic Zone Substation. The DRF is basically a backup control centre with full SCADA and remote control facilities. Should a failure of the main control centre occur, the system could continue to be operated fully and securely from the DRF.

4.4. Significant system events

A significant event on Evoenergy's network is classified as an unplanned outage that results in more than two SAIDI minutes (equivalent to all of our customers, on average, having their power supply interrupted for two minutes or longer). Such events are usually the result of major equipment failure, major weather events, or major bushfire events. Two significant systems events occurred during the 2017-18 financial year as follows:

- 12 January 2018 – 3.99 SAIDI minutes
- 18 March 2018 – 2.54 SAIDI minutes

4.5. Photovoltaic penetration

Domestic rooftop photovoltaic (PV) generation systems are currently installed on approximately 9.4% of homes in the ACT. These vary in size from 1 kW – 10 kW capacity. The level of penetration is increasing steadily due to a number of reasons that include:

- Cost of PV systems is decreasing as more units are produced (i.e. reduced manufacturing costs) and more suppliers are competing for this market.
- Some developments (notably Denman Prospect Estate and Ginninderry Estate) have incentivised the installation of rooftop PV systems all new detached dwellings to be constructed.
- Modern homes are being built with a PV system incorporated into the original design which avoids the costs associated with retrofitting later.
- The climate in the ACT is conducive to PV with long sunshine hours annually.
- The ACT Government is promoting its 100% renewable energy target and encouraging the installation of PV systems.
- Increased awareness of the public to climate change issues and the benefits of renewable energy.

There has also been an increase in small scale rooftop PV systems being installed on commercial and community buildings over the last year. These systems range in size from 30 kW – 200 kW.

At times of low load and high PV generation (typically middle of the day during summer months), power flows in the reverse direction, i.e. from customers to network. Reverse power flows tend to raise voltage levels on the low voltage network. High levels of generation export can exceed the ratings of Evoenergy's equipment (especially power cables and distribution transformers). Evoenergy must control reverse power flows to avoid these issues.

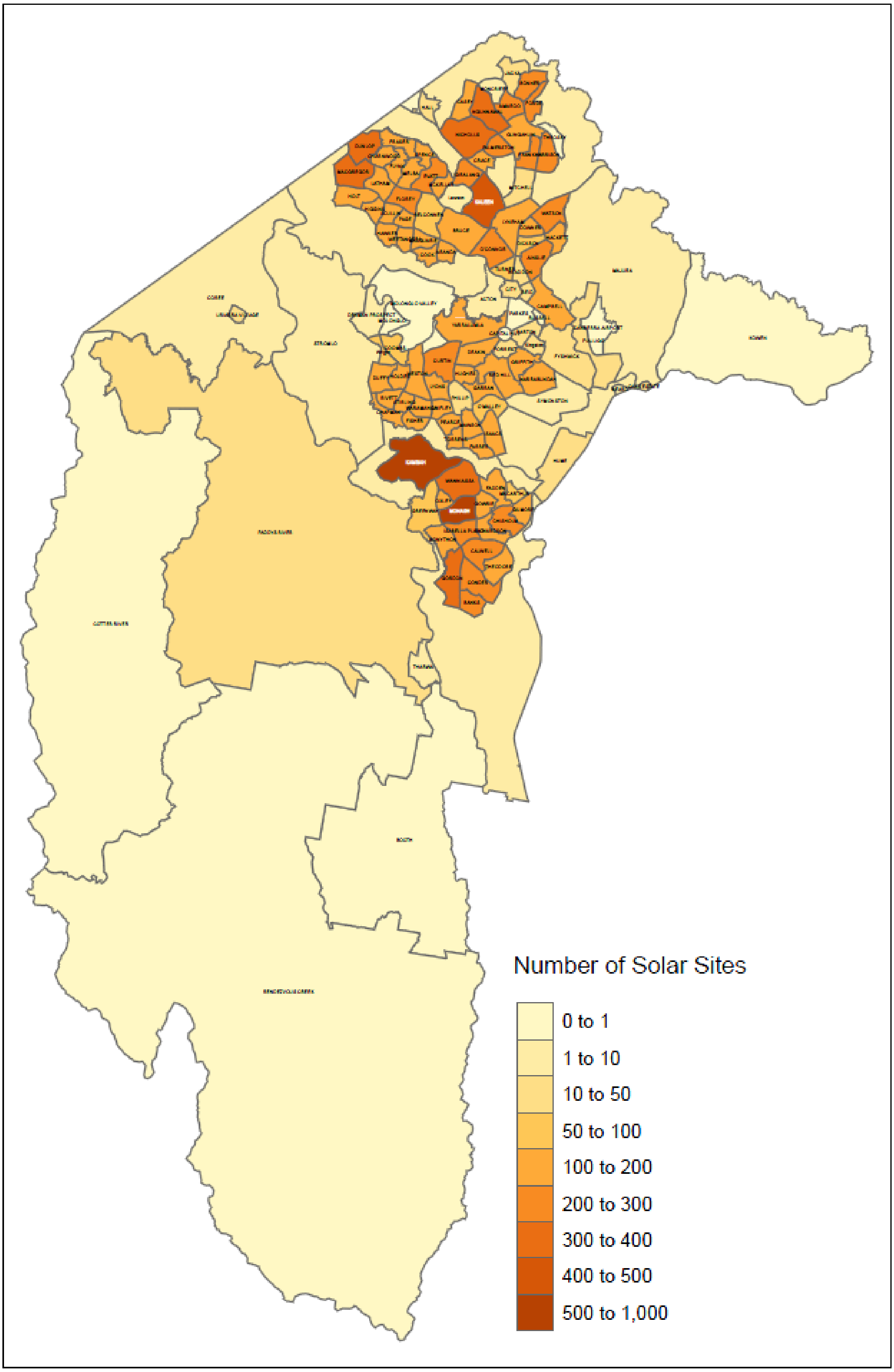
Photovoltaic penetration in the ACT is widespread as shown in Table 4.4 and Appendix E.

Table 4.4: Photovoltaic penetration by zone substation (excluding network level PV) as at 31 October 2018

Zone Substation	Number of PV installations	Total capacity installed (W)
Belconnen	1,844	6,794,295
City East	1,386	5,433,320
Civic	979	4,117,894
East Lake	38	518,467
Fyshwick	60	644,109
Gilmore	1,122	4,453,250
Gold Creek	3,423	13,692,962
Latham	3,519	12,830,385
Telopea Park	859	4,080,376
Theodore	1,816	6,595,408
Wanniassa	3,546	12,531,153
Woden	3,103	12,509,983
TOTAL	**21,695**	**84,202,602**

Figure 4.1 shows the distribution of domestic rooftop solar PV installations throughout the ACT.

Figure 4.1: Number of Rooftop Solar PV Installations per Suburb



4.6. Ageing assets

Electricity transmission and distribution networks are constructed of a range of asset types that have specific maintenance, refurbishment and replacement life cycles.

Primary assets, those with the purpose of transmitting and distributing energy, such as poles, conductors, switchgear and transformers, generally have an asset standard design life of around 45 – 60 years before requiring replacement.

Secondary assets, those with the purpose of measuring, monitoring, controlling, communicating and providing protection for primary assets, generally have an asset standard design life of around 15 – 20 years.

Evoenergy has prepared Asset Specific Plans (ASPs) for each class of asset, and from these plans has developed maintenance programs for each asset for its whole life cycle, including condition monitoring, periodic maintenance, renewal and leading to its ultimate replacement (refer Chapter 6).

Before replacing an asset such as a distribution substation, Evoenergy reviews its network plan for that location. In some cases, load growth (or reduction) may deem it more appropriate to replace with a larger or smaller distribution substation or decommission the asset rather than simply a like-for-like replacement. In this way Evoenergy integrates its planning to coordinate asset management spending with network development spending to provide the most appropriate and cost effective solutions.

Assets are replaced as the result of a condition and risk assessment, i.e. an asset is not just replaced because it has reached its 'retirement age'. It is replaced because its forecast risk exceeds its replacement plus net present value costs.

Evoenergy's network comprises long-life assets. It is essential that we invest in growth, replacement and maintenance works to ensure we continue to deliver a highly reliable and safe network for our customers and the community.

Evoenergy has made prudent investments to maintain supply quality and reliability, reduce safety and environmental risk, ensuring the most cost-effective asset management strategy is adopted.

The Evoenergy network includes approximately 52,000 poles, the majority of which are timber and subject to gradual rotting and subsequent loss of strength. Poles are inspected and assessed against reliability maintenance criteria (RCM) on a rotating annual program. Should maintenance methods such as installation of pole nails be deemed to no longer be effective, a pole will be listed for replacement as part of the annual replacement program. Low voltage poles are replaced with two-part fibreglass poles in locations that are difficult to access (typically urban residential property back yards), while high voltage and transmission poles are generally replaced with pre-stressed spun concrete poles.

The 66 kV switchgear at Fyshwick Zone Substation has been assessed as being at end of life and cannot continue to operate reliably. This switchgear has exceeded its design life, is experiencing increasing operational defects and declining performance. It is recommended this switchgear is de-commissioned, and this is the preferred option for network augmentation project "Decommission Fyshwick Zone Substation" in the 2019-24 period (refer section 7.5.4).

The following diagrams show the age distribution of Evoenergy's assets as follows:

Figure 4.2 Poles
Figure 4.3 Switchgear
Figure 4.4 Underground Cables
Figure 4.5 Transformers
Figure 4.6 Overhead conductors
Figure 4.7 SCADA, control and protection equipment

Figure 4.2: Poles – Quantity currently in service by age and material

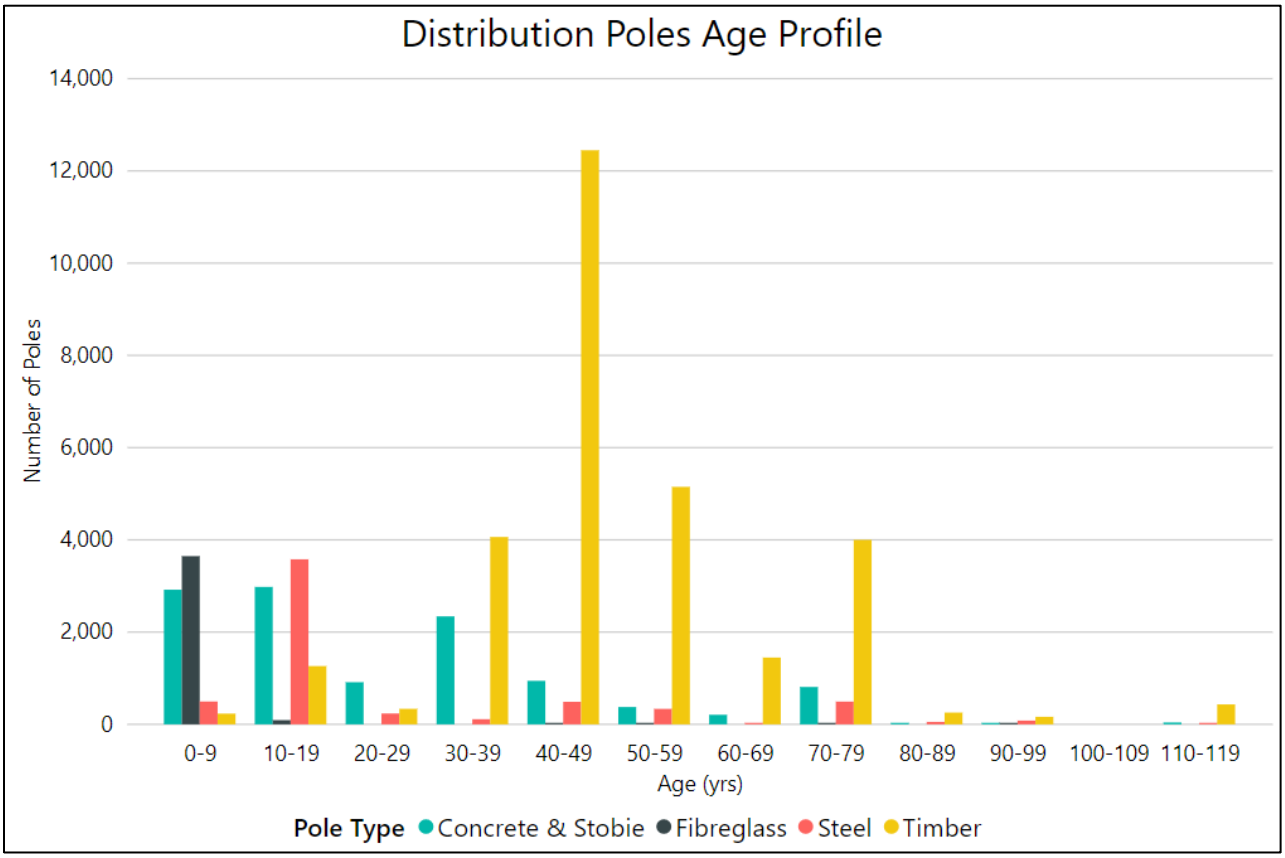


Figure 4.3: Switchgear – Quantity currently in service by age and type

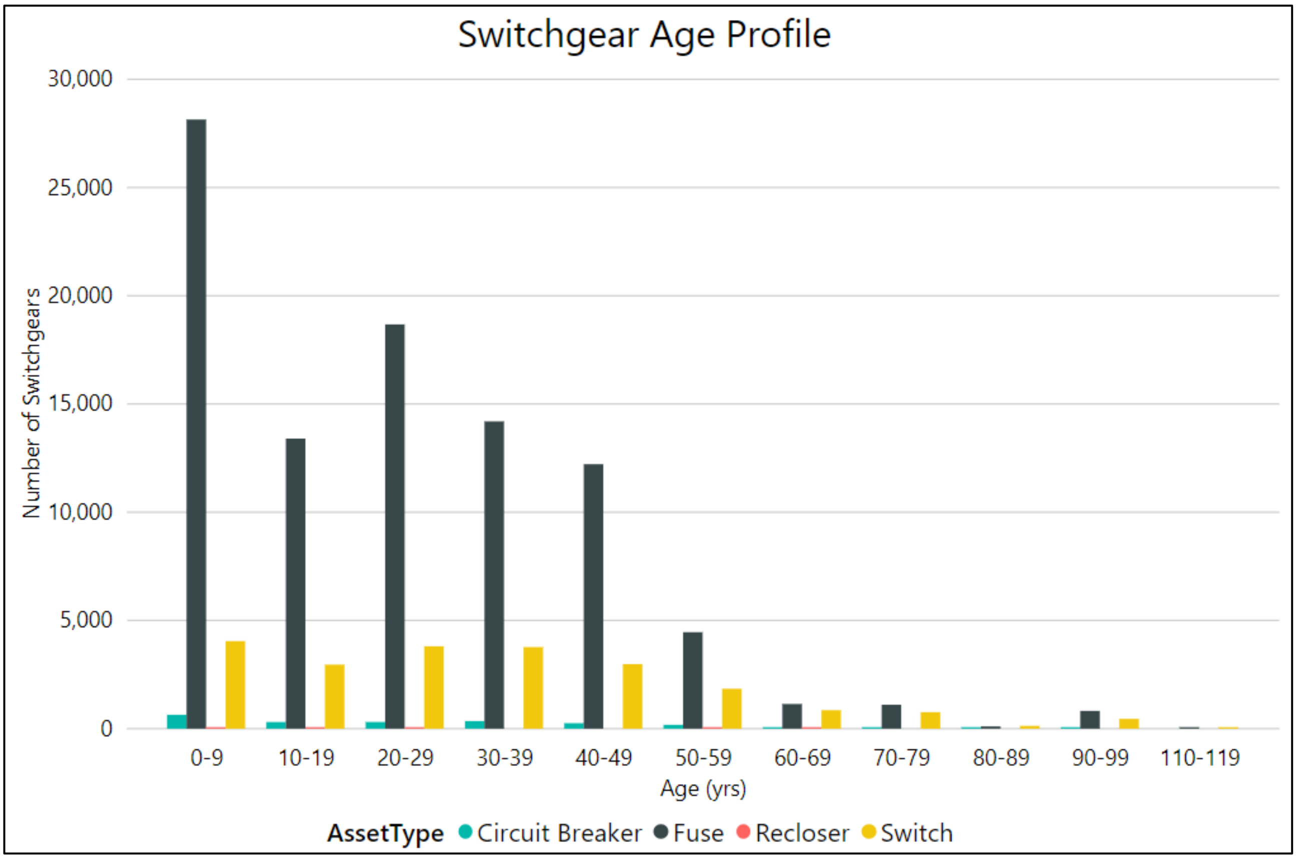


Figure 4.4: 11 kV Cables – Quantity currently in service by age and type

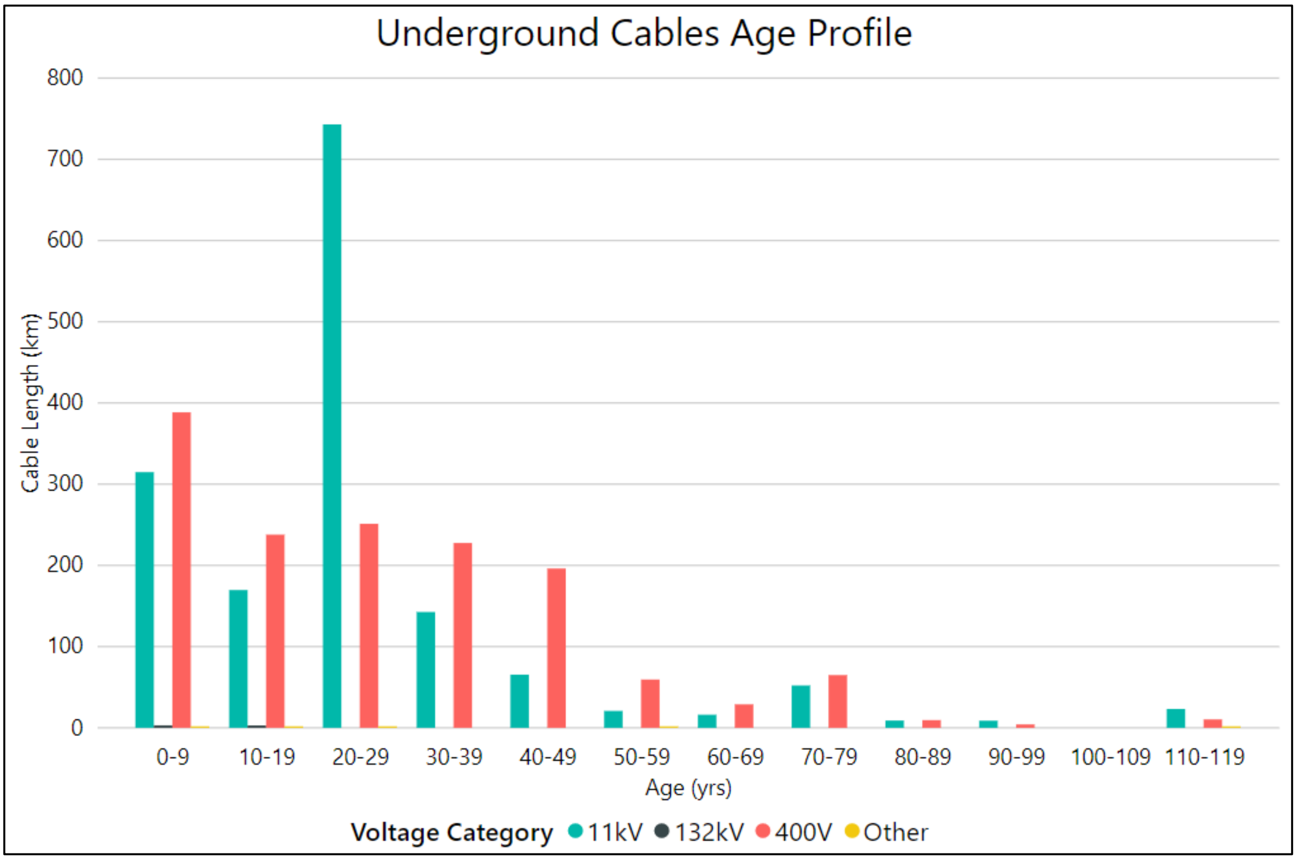


Figure 4.5: Transformers – Quantity currently in service by age and type

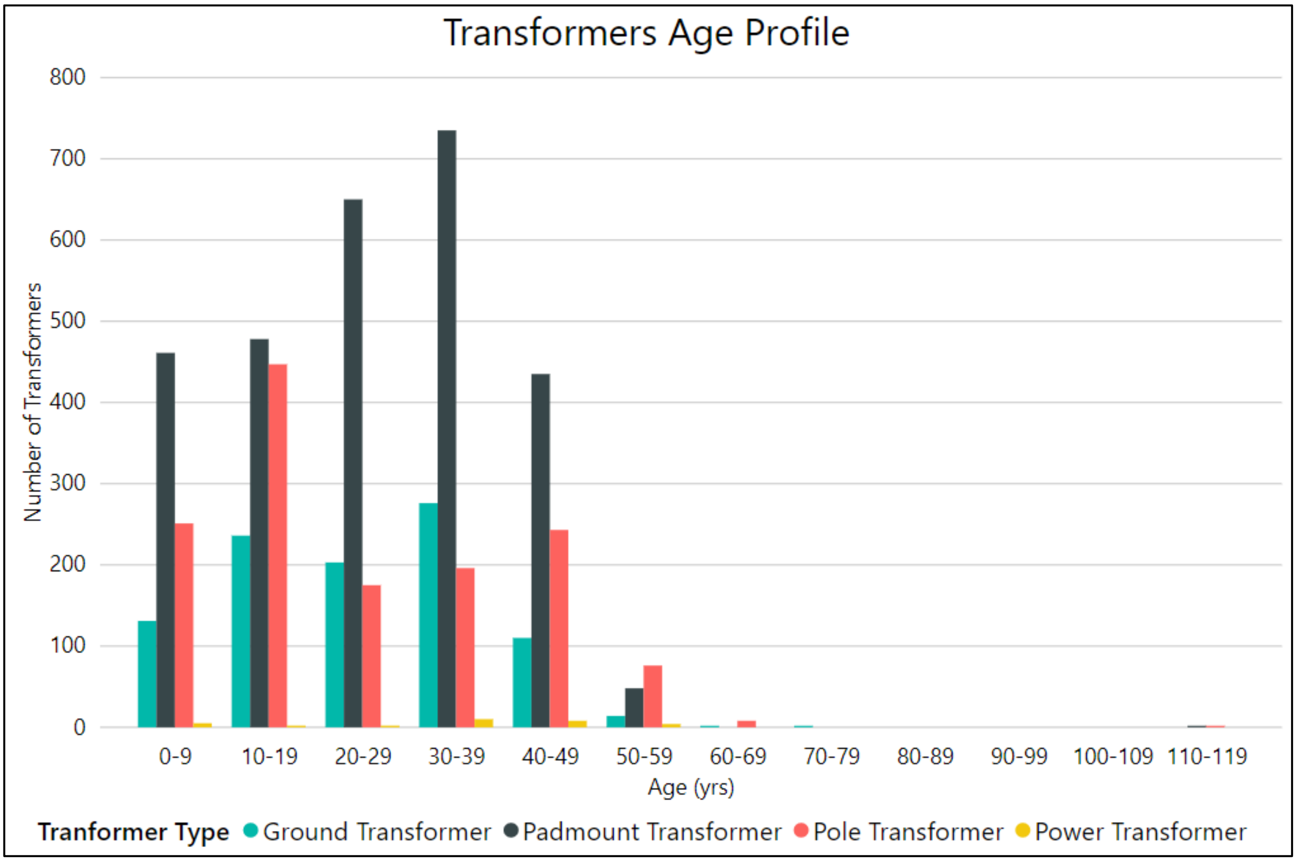


Figure 4.6: Overhead Conductors – Quantity currently in service by age and type

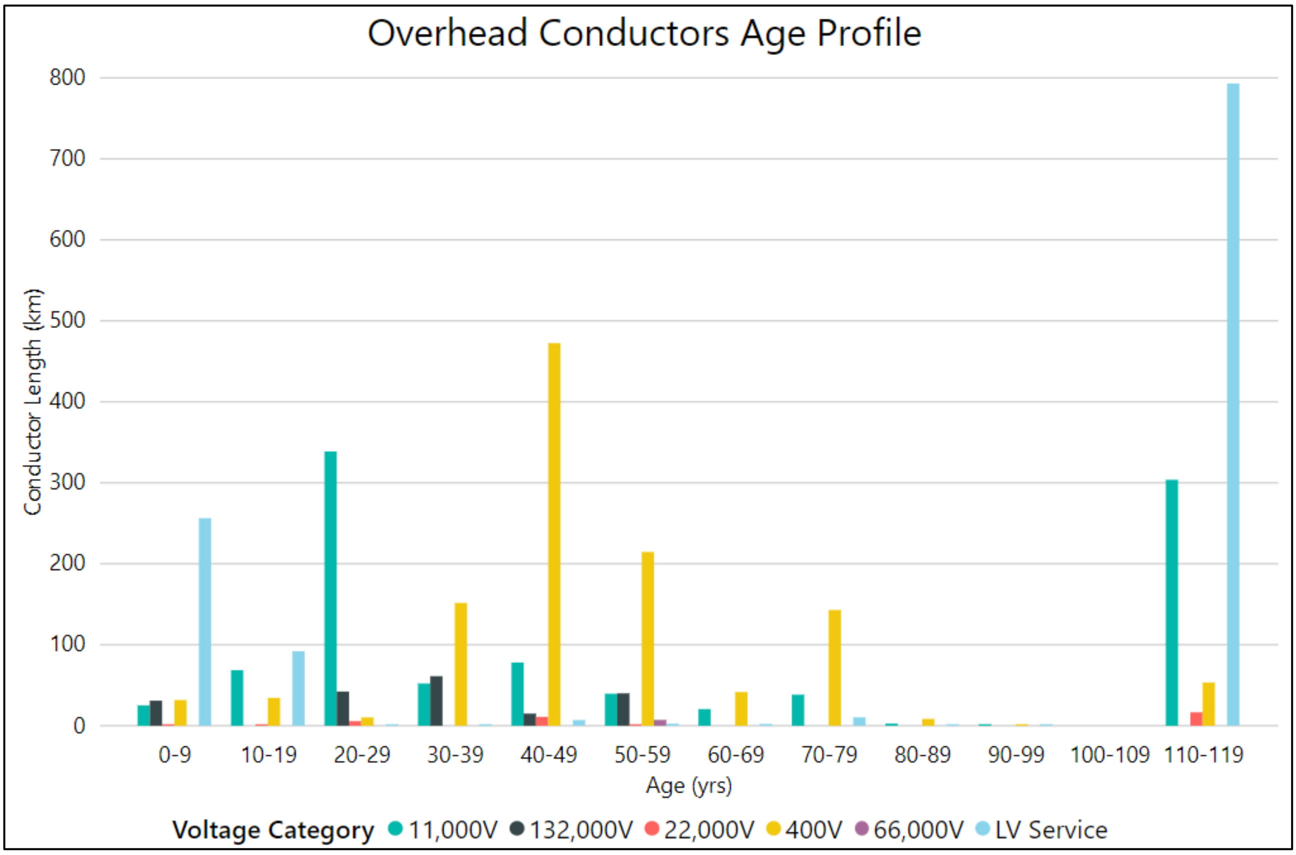
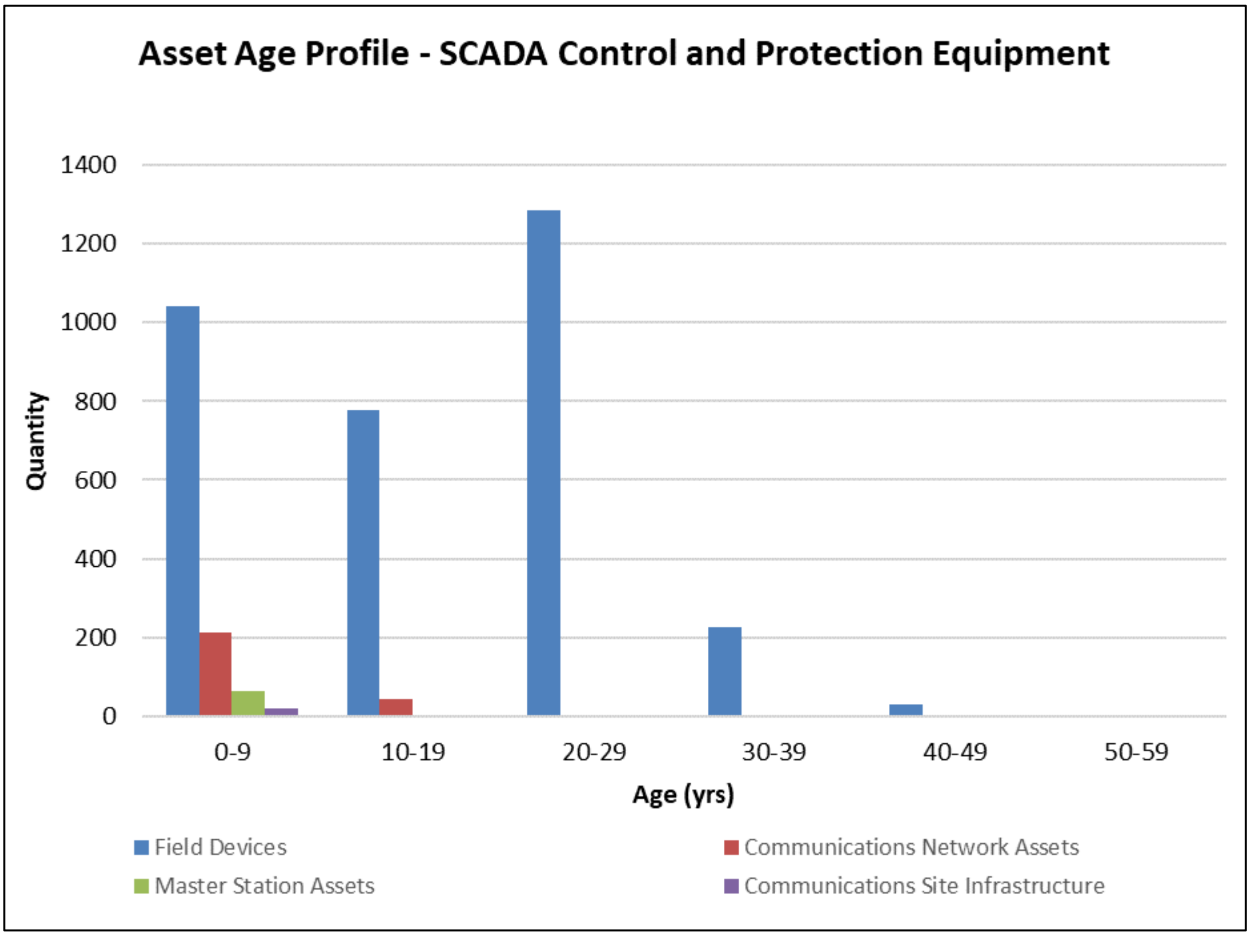


Figure 4.7: SCADA, Control and Protection Equipment – Quantity currently in service by age and type



The majority of secondary protection and SCADA equipment has an effective life of approximately 15–20 years.

4.7. Fault level

Fault level is defined in terms of current (kA). The fault current is the maximum current that would flow at that point in the network should a short circuit fault occur. Major equipment elements such as circuit breakers, switchgear, cables and busbars are specified to withstand the maximum possible fault level. This equipment is designed to withstand the thermal and mechanical stresses experienced due to the high currents in short circuit conditions.

Fault level is also an indication of a power system’s strength. Higher fault current levels are typically found in a strong power system, while lower fault current levels indicate a weaker power system. A strong power system exhibits better voltage control in response to a system disturbance, whereas a weak power system is more susceptible to voltage instability or collapse. For example connection points with higher fault levels experience less voltage flicker during load switching compared with those that have lower fault levels. System strength is a measure of the ability of a power system to remain stable under normal conditions and to return to a steady state condition following a system disturbance.

High voltage overhead lines that are insufficiently fault rated may cause the conductors to clash, sag below minimum ground clearance, or even break when subjected to a fault current. Such situations can occur when network augmentations such as the construction of a new zone substation increase the fault levels in the distribution network.

Conversely increasing amounts of power electronic converter generation (e.g. PV generation) connected to the network, replacing synchronous generation, serves to reduce fault levels and consequently reduce system strength.

Evoenergy specifies new 11 kV equipment to be capable of withstanding 25 kA three-phase short circuit fault current. Maximum 11 kV fault level on the network has been calculated at approximately 12.2 kA. Evoenergy’s 11 kV network is non-effectively earthed via the neutral earthing transformers at zone substations. This keeps the fault level generally less than 3 kA and increases the longevity of 11 kV equipment.

Evoenergy specifies new 132 kV equipment to be capable of withstanding 31.5 kA three-phase short circuit fault current. Maximum 132 kV fault level on the network has been calculated at approximately 24.0 kA.

The high voltage system supplied by the 132 kV transmission network is not effectively earthed employing a neutral earthing transformer to limit 11 kV earth fault current to 3 kA. The wide use of earthing transformers to limit feeder earth (zero sequence) fault levels at zone substations is a unique characteristic of Evoenergy’s network. Note that 3 kA is not used for earthing design as there is always some circuit impedance and/or fault impedance.

Electricity network earthing and protection systems are designed, installed, operated and maintained with care to avoid injury to persons or damage to property or the environment.

4.8 Power quality

Power quality refers to the network’s ability to provide customers with a stable sinusoidal waveform free of distortion, within voltage and frequency tolerances.

Power quality issues manifest themselves in voltage, current or frequency deviation, which result in premature failure, reduced service life or incorrect operation of customer equipment.

The NER Schedules 5.1a, 5.1 and 5.3 detail the applicable power quality design and operating criteria that must be met by Evoenergy. The ACT Electricity Distribution Supply Standards Code provides details of power quality standards to be met by Evoenergy (refer to Appendix F). Evoenergy’s Service and Installation Rules describe the applicable power quality design and operating criteria that must be met by our customers.

Electricity customers have ever-increasing expectations and are becoming less tolerant of power quality and reliability issues. Some modern appliances are not suited to events that occur on distribution networks due to their sensitivity and design.

At all voltages in Evoenergy's network, the quality of supply is maintained to provide a safe and secure source of electricity to our customers.

Power quality is measured by the installation of mobile power quality analysers in various locations on the distribution network. Measurements are taken on both a proactive and reactive basis.

Optimisation of network power quality enhances asset lifetimes due to reductions in operating stresses (e.g. lower transformer iron losses and resultant heating from harmonic voltage distortion).

Evoenergy has a proactive program to survey power quality across the distribution network. This program features the following:

- 70 randomly selected survey sites per year.
- For each site, measurements are taken at the customer's point of supply.
- This provides Evoenergy with a network-wide picture of power quality through a structured randomised program.

This program is compliant with AS.61000.4.30 - Testing and measurement techniques - Power quality measurement methods.

During the 2017-18 financial year, in addition to routine pro-active power quality monitoring, Evoenergy investigated and resolved 1355 power quality enquiries from customers including:

- 238 high voltage levels (all associated with solar PV installations).
- 4 low voltage level complaint.
- 2 advice regarding EMF levels.
- 859 low voltage distribution network supply faults.
- 252 fluctuating voltage complaints (all associated with flickering lights).

Works are undertaken as required to address power quality issues, including:

- Alteration of distribution transformer tap positions.
- Replacement of distribution transformers – typically upgrades or replacement of fixed-tap transformers with transformers equipped with multi-tap selectors.
- Load shifting – either between low voltage circuits or between distribution transformers.
- Balancing of loads between phases.
- Conductor upgrades – either overhead lines or underground cables.

Evoenergy forecasts that supply voltage and power quality issues will increase with the forecast increase in rooftop solar PV and installation of other distributed energy resources (DER). All customers including those without embedded generation will be affected and experience increasing flicker, sags, swells and voltage issues. This will result in a negative experience for Evoenergy customers as they cannot utilise equipment to its full potential or maximise return on their investment in distributed generation.

To address these issues, Evoenergy proposes to install real-time low voltage distribution substation monitoring to permit proactive energy and voltage management as an alternative to network reinforcement and additional asset replacement expenditure. The proposed network monitoring solution will offer customers an overall lower cost compared with other options such as additional network asset investment. Evoenergy's project justification report for Distribution Substation Monitoring is available on the on the AER website[4]. This project is proposed for the 2019-24 regulatory period and is subject to the final determination by the AER.

4.8.1 Steady State Voltage

Voltage levels at customers' premises must be supplied and maintained within regulation limits to ensure correct operation of appliances and safety to equipment and personnel. Exceeding the upper voltage limit may result in insulation breakdown and subsequent equipment damage, whilst operating below the lower limit impacts on power quality and could cause fuses to blow due to higher current.

Voltage levels on the 132 kV bus at Canberra and Williamsdale bulk supply substations, is controlled by TransGrid via its 330/132 kV interconnecting transformers' on-load tap changers (OLTCs) and 132 kV capacitor banks. Similarly the 66 kV bus voltage at Queanbeyan bulk supply substation is controlled by TransGrid.

[4] https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/evoenergy-actewagl-determination-2019-24/revised-proposal.

The 11 kV bus voltage at each zone substation is maintained by the voltage-regulating relay which controls the tap position of the 132/11 kV transformers. In order to maintain the voltage within limits along the 11 kV feeders, the bus voltage is varied according to network conditions (loading, incoming voltage, feeder voltage drops, embedded generation etc). Line drop compensation is varied to manage high voltage caused by embedded generation connections along the feeder.

Evoenergy has installed TNSP metering on the 11 kV group circuit breakers at all 132/11 kV zone substations. In addition to providing metering functions, these meters provide accurate voltage measurements and other power quality information to the ADMS in real time.

Evoenergy monitors steady state voltage levels and responds to customer complaints where required. Evoenergy shall use the implementation of the ADMS and the application of smart metering technology to further ensure compliance of steady state voltage levels.

Steady state phase-neutral low voltage at the customer's point of supply is maintained at 230 V +10% / -6% in accordance with Australian Standards AS/NZS 60038 and AS 61000.3.100.

Distribution system voltage levels have been observed to fluctuate in areas of the network where there is a high penetration of rooftop PV generation. Evoenergy is currently trialling a distribution transformer fitted with an OLTC at Denman Prospect, a new residential suburb with 100% rooftop PV penetration.

4.8.2 Rapid Fluctuations in Voltage (Flicker)

Voltage fluctuations are defined as repetitive or random variations in the magnitude of the supply voltage. The magnitudes of these variations do not usually exceed 10 per cent of the nominal supply voltage, however small magnitude changes occurring at certain frequencies can give rise to an effect known as flicker. Voltage fluctuations may cause spurious tripping of relays, interference with communications equipment, and may trip electronic equipment.

Flicker is usually customer-generated due to the following:

- Frequent starting of induction motors – mainly the direct on line starting of induction motors.
- Electric welders.
- Arc furnaces.

Evoenergy responds to a customer report of flicker by installing a mobile power quality analyser. Evoenergy advises the customer if the flicker is due to its operations, or rectifies if caused by Evoenergy's equipment.

Maximum permissible voltage flicker levels are specified in TR IEC 61000.3.7:2012.

4.8.3 Voltage Dips

Voltage dips are typically caused by events such as lightning or faults on adjacent feeders, or are generated by equipment located within customers' premises (e.g. induction motor starting).

Dips caused by faults on adjacent feeders can propagate throughout the network, affecting customers' supply voltage on all feeders at the zone substation. Although only customers on the faulted feeder experience an interruption, many experience the reflected voltage sags generated by the fault.

Evoenergy monitors voltage dips as part of its proactive power quality monitoring program. Evoenergy uses its SCADA system and protection records to analyse events and uses its mobile power quality analysers to assist in the analysis and rectification of voltage dips. Evoenergy shall use the implementation of numerical protection devices and the ADMS to further reduce the overall number of voltage dips on the network. Evoenergy proposes to review fault switching and investigate the use of auto-reclosers, sectionalisers and fault passage indication devices to reduce fault switching.

4.8.4 Switching Voltage Transients

Switching transients are primarily associated with the operation of circuit breakers and are typically the consequence of the switched current being extinguished prior to the natural current zero value of the sinusoidal current waveform. This characteristic is termed as current chopping.

The chopping of the current results in transient voltages being generated which enter and travel through the interconnected network. Switching transients can also be generated by the switching of lumped capacitances (e.g. capacitor banks).

Switching transients are typically high frequency, short duration voltage conditions (mainly overvoltage conditions) which can result in damage to sensitive equipment.

Evoenergy shall manage switching transient voltages through switchgear procurement standards (i.e. utilising switching equipment that has small chopping current characteristics) and asset specific maintenance regimes, and routine maintenance programs designed to avoid excessive switch contact arcing.

4.8.5 Voltage Difference Neutral to Earth

Voltage differences between neutral and earth can present the risk of damage to electrical equipment at customers' premises as well as a risk of electric shock and fire. Typically voltage differences can be caused by such things as:

- Inadequate earthing (high earth resistance or open circuit earth) at substations.
- Inadequate bonding of earth and neutral in Multiple Earth Neutral (MEN) systems.

Evoenergy adheres to the relevant distribution substation earthing requirements and advises customers of correct earthing practices. Evoenergy includes neutral to earth monitoring as part of its power quality monitoring program to assist with classifying neutral to earth voltage non-compliance.

Target voltage difference between neutral and earth is < 10 V steady state (5 minute average) at the point of supply.

4.8.6 Earth Potential Rise

Earth potential rise refers to the localised increase in the voltage of an object that should remain at earth potential, and is typically caused by a fault current passing through an earth connection that is inadequate for the magnitude of the fault current. This can be due to:

- Inadequate sizing of the earth conductor relative to the maximum fault current.
- High impedance between the earth conductor and the mass of earth (true earth).

Under such conditions the passage of the fault current through the inadequate earth connection will result in a voltage increase on the earth connection for the duration of the fault. This condition can present risk of electric shock to a person who may be standing on "true earth" but is in contact with the inadequately earthed device. It can also result in damage to sensitive equipment.

Evoenergy complies with earth potential rise requirements by basing its network designs on reference publications[5]. Evoenergy's system is designed to ensure that step and touch voltages arising from earth potential rise are within the allowable limits of Australian Standard AS/NZS 7000. Evoenergy inspects the earth connections on its system on a five-yearly program.

4.8.7 Voltage Unbalance

Voltage unbalance typically results from:

- Unbalanced phase impedances.
- Unbalanced phase loadings.
- Interaction between phases (induced voltages) on overhead lines.

Unbalanced voltages can result in high neutral currents which introduce the potential for high neutral to earth voltage difference, and the generation of negative sequence voltages that can damage three-phase induction motors.

Evoenergy manages voltage unbalance within the required limits through appropriate design practices and transformer procurement specifications. Evoenergy uses its mobile power quality analysers and quality of

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[5]ENA EG-O Power System Earthing Guide
ENA EG-1 Substation Earthing Guide
AS 3835 – EPR – Protection of Telecommunication Network
AS/NZS 4853 – Electrical Hazards on Metallic Pipelines

supply survey procedures to identify and rectify voltage unbalance. This is supported through the use of ADMS calculations to ensure compliance.

4.8.8 Direct Current (DC) Component

A high DC component of the neutral voltage can cause damage to electronic devices and impact on the correct operation of protective devices. It can also lead to an increase in losses and result in heating within electrical and electronic equipment.

Evoenergy ensures that customer's inverters connected to the network adhere to the relevant standards and regulatory requirements.

Evoenergy publishes on its website the "Requirements for Connection of Embedded Generators up to 5 MW to the Evoenergy Distribution Network "document. This includes the requirement that inverters must comply with the requirements of the Clean Energy Council (CEC) and Australian Standard AS/NZS 4777 (Grid connection of energy systems via inverters).

4.8.9 Harmonics

Harmonics are usually customer-generated. Non-linear loads such as industrial equipment (e.g. arc welders), variable speed drives, uninterruptible power supplies, and office equipment, are all sources of harmonic currents. Harmonic currents flowing in transformers cause an increase in the copper (resistive) losses and iron (magnetising) losses. Harmonic distortion can cause the supply voltage waveform to depart from sinusoidal in a repetitive manner. This can affect the operation of computer equipment, create noise on radio and television receivers, and cause vibration in induction motors.

Evoenergy responds to customer requests to measure and analyse harmonic levels. Evoenergy uses its mobile power quality analysers and undertakes harmonic monitoring as part of its power quality surveys. Evoenergy is currently investigating the use of the ADMS to identify areas of the network where harmonic levels are outside regulation limits and explore the potential of real-time harmonic monitoring at zone substations.

Customers must ensure that harmonic distortion caused by their equipment does not exceed the limits prescribed in Australian Standard AS/NZS 61000 parts 3.2, 3.4, 3.12 and TR IEC 61000.3.6.2012.

4.8.10 Electromagnetic Fields (EMF)

Electromagnetic fields are a key design consideration for bare electrical conductors such as overhead lines and bus-work, particularly those which operate at high voltage. For conductors with an earth shield, such as underground cables, the fields are encapsulated within the cable and do not present external hazards.

Electromagnetic fields incorporate both electric fields resulting from the voltage on conductors and also the magnetic fields generated by the current flowing in the conductors. Both phenomena result in a "grading" of the respective fields from the conductor to the nearest earth location. In terms of voltage there will be a voltage "gradient" between the conductor and earth. In terms of current there will be a grading of the magnetic field (flux density) from the conductor to the earth.

Depending on the strength of these fields minute currents can be induced in the bodies of animals and humans. Research is inconclusive at present but there are concerns as to the health implications of exposure to electromagnetic fields. As such there are strict guidelines for the management of electromagnetic fields incorporated into the design of overhead lines and high current equipment.

The Energy Networks Australia (ENA) Association has published an EMF Management Handbook (January 2016)[6] which describes EMF's in detail and methods to mitigate magnetic fields. Evoenergy follows these guidelines where practicable and complies with the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Guidelines in the design of its network with respect to electromagnetic fields.

4.8.11 Inductive Interference

Inductive interference refers to the ability of the magnetic fields generated by current flowing in typically overhead line conductors, to cause interference with other electromagnetic radiation such as radio, television and communication signals.

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[6] http://www.ena.asn.au/sites/default/files/emf_handbook_2016

Evoenergy shall continue to undertake routine maintenance programs to ensure all equipment is in good working condition, in particular all HV and LV overhead lines, to ensure that inductive interference is within the limits specified in Australian Standard AS 2344:2016 Tables 1 and 2 (limits of radiated radio disturbance from overhead AC power lines and high voltage equipment).

4.8.12 Power Factor

Power factor relates to the relationship between real and reactive power. In an alternating current (AC) system the in-phase portions of voltage and current waveforms produce “active” or real power which is the capacity of the electricity system to perform work. The out of phase portions of voltage and current waveforms produce “reactive” power. The combination of active and reactive power is termed apparent power. A low or poor power factor will result in inefficiency due to high apparent power loading with a low real power delivery.

Evoenergy monitors power factor as part of its programmed proactive and reactive monitoring of the network. Evoenergy uses the ADMS to identify areas of the network that may be experiencing power factor issues. Metering data is also used to identify installations with power factor outside acceptable limits.

Customers can gain significant benefits by improving the power factor at their premises. These benefits include reduced electricity costs, increased plant load capacity and utilisation, and better voltage regulation. Improvement of power factor is usually achieved by the installation of capacitors.

Evoenergy requires that the power factor at the point of common coupling between Evoenergy’s network and the customer’s installation shall be between 0.9 lagging and unity. Leading power factor is unacceptable. Details can be found in Evoenergy’s Service & Installation Rules for Connection to the Electricity Distribution Network which can be found on our external website.

4.8.13 Automatic under Frequency Load Shedding

Power system frequency control is achieved by the instantaneous balancing of electricity supply and demand. If electricity supply exceeds demand at an instant in time, power system frequency will increase. Conversely, if electricity demand exceeds supply at an instant in time, power system frequency will decrease. The amount and rate of change of frequency compared with the mismatch in supply-demand depends on the physical characteristics of electrical equipment and control systems.

To operate a power system, the system frequency must be maintained within a close margin around the nominal level of 50 Hz, and additionally, the Rate of Change of Frequency (RoCoF) must remain within specified limits. Failure to do so risks disconnection of customers or even potential equipment damage.

The National Electricity Rules S5.1.10 requires network operators to have a proportion of their load available for shedding by under-frequency relays. This is required to arrest the collapse of the national grid in the event of a major contingency that results in a sudden large deficiency of generation, such as could occur due to tripping of several generating units or tripping of transmission interconnectors. NSPs in consultation with AEMO must ensure that a sufficient amount of load (minimum 60% of expected demand) is under the control of automatic under-frequency load shedding (UFLS) relays that operate in the event of a major contingency to ensure the network system frequency remains within the prescribed limits. NSPs must therefore provide, install, operate and maintain facilities for automatic load shedding and conduct periodic testing of the facilities without requiring load to be disconnected.

Evoenergy applies under-frequency protection at the 11 kV level within its zone substations.

Currently there are five zone substations (Theodore, Gilmore, Gold Creek, Latham, and Wanniassa) with under frequency systems installed. Five further under frequency systems are planned to be installed in 2019 (at Woden, Belconnen, City East, East Lake and Civic zone substations).

4.8.14 Summary of Power Quality Standards, Codes and Guidelines

A summary of the power quality standards, codes and guidelines applicable to the ACT is as follows:

- NER Schedule 5.1a – System Standards.
- NER Schedule 5.1 – Network Performance Requirements to be provided or co-ordinated by Network Service Providers.

- NER Schedule 5.3 – Conditions for Connection of Customers.
- AS 2344:2016 – Limits of electromagnetic interference from overhead a.c. power lines and high voltage equipment installations in the frequency range 0.15 MHz to 3000 MHz.
- AS/NZS 3000:2007 – Australian/New Zealand Wiring Rules.
- AS/NZS 7000:2016 – Overhead Line Design.
- TR IEC 61000.3.6:2012 – Electromagnetic compatibility (EMC) Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems.
- AS/NZS 61000 – Electromagnetic Compatibility (various sub-standards).
- AS/NZS 60038:2012 – Standard Voltages.
- HB 264:2003 – Power quality handbook.
- AS/NZS 4777 Grid connection of energy systems via inverters.
- Evoenergy Service & Installation Rules for Connection to the Electricity Distribution Network.
- Evoenergy Requirements for Connection of Embedded Generators up to 5 MW to the Evoenergy Distribution Network.

4.9 System Losses

As power flows through the transmission and distribution networks, a portion is lost due to the electrical resistance and heating of the conductors and transformers. Across the network these losses may be up to 3%–5% of the total energy transported. These losses are allowed for throughout the transmission and distribution networks to ensure that supply meets demand and the power system remains secure, ie more electricity is generated than is consumed by customers.

Distribution Loss Factors (DLFs) represent the average energy loss between the distribution network connection point and the transmission network connection point to which it is assigned.

Evoenergy periodically reviews open points on the network, to enable the network to be reconfigured to reduce losses. This includes load balancing between zone substation transformers.

The cost of electrical losses is factored into the assessment of tenders for new distribution and zone substation power transformers. The life cycle cost assessment ensures that the capital cost is not the dominant factor in the assessment of transformer tenders. The methodology takes into account the estimated losses over the life of the transformer ensuring better energy efficiency and environmental outcomes.

Electrical losses in the network are proportional to the square of the current. Having a higher power factor results in a lower current, for the same amount of useful energy, and therefore reduces network losses. Maximum demand and capacity charges, if they are effective in reducing peak load on the network, will also result in reduced currents and therefore reduced network losses.

Under the NER section 3.6.3, Evoenergy is required to calculate and publish the distribution loss factors on its network. Publishing of the loss factors improves transparency of the network loss performance to retailers and customers. Evoenergy has engaged GHD Hill Michael Consultants to calculate distribution loss factors for both site specific customers (embedded generators with output greater than 10 MW and load customers with maximum demand greater than 10 MW) and average DLFs for non-site specific customers. The entire population of high voltage distribution feeders was analysed for these calculations. Evoenergy's Advanced Distribution Management System (ADMS) was used to calculate the DLFs. This system allows for the entire distribution network from zone substation transformers to distribution transformers to be modelled. All network elements have known loss characteristics including copper and iron losses for both zone and distribution transformers and impedance and length of all conductors. Losses on the 132 kV transmission network are calculated using a PSS Sincal transmission network model.

The effects and costs of distribution losses are included in the system planning analysis and investment strategy as inputs to determining any augmentation required to the system capacity to maintain the supply-demand balance.

4.10 Information Technology

Evoenergy utilises a set of core Information Technology (IT) applications that forms our asset information systems to manage the Electricity Network. Our focus has been on consolidating and leveraging these asset information systems to support the business in continuous innovation and realisation of benefits. To this end, a number of key projects have been undertaken, including:

Automating Data Flow between Systems

- The integration our Meter Data and Billing system, Velocity with ArcFM and ADMS
  - This enables the automatic syncing of meter installations, increasing the speed by which our network information is updated while decreasing manual effort.
  - With customers mapped to customers to up-to-date network supply points, the accuracy of customer notifications of planned outages is improved.

Field Mobility

- This enables work crews to execute key works management activities in the field including the closure of work orders, leading to improved timeliness, availability and accuracy of data as well as minimising paper printing.

Development of a Customer Portal.

- The customer portal enables end users to register and log in to a portal to view consumption data and provide feedback.

The future state asset information systems operational environment is one that embodies a single, integrated, geospatial solution, built upon enterprise integration that improves data visibility and have a clear customer focus. The functionality of the asset information systems will continue be developed to meet the three key business capabilities: enabling and coping with disruption, operational effectiveness, and operational efficiency. This will be achieved through continuous functionality releases, upgrades or system replacements and the implementation of enterprise integration and data architecture.

The following are areas of IT focus for Evoenergy:

4.10.1 Customer Engagement

A continued focus for Evoenergy is our customer centricity. Providing our customers with more information about their energy consumption and network outages are key aspects of improving data visibility and strengthening the relationship with our customers. In addition, we are digitizing customer interactions, making it easier for our customers to work with us and obtain the information they require, and receive an overall improved experience. The expected benefits include:

- More information, enabling customers to better manage their energy usage.
- Ensuring that our industry customers see interactions with us as adding value to their business.

4.10.2 Data Visibility & Availability

The value in our data is not in the collection or analysis, but using the data to change processes and improve outcomes. Evoenergy proposes to implement a data architecture that enables data to be more easily viewed, analysed, reported and displayed across the business and to our customers. The expected benefits are:

- Reduction in the effort involved in creating new reports.
- More in-depth trend analysis that can be leveraged to improve end to end business processes.
- Ability to make more meaningful information available to customers to improve interactions and enable our customers to have greater management of their energy usage.

4.10.3 Field Digitization

With the implementation of works management mobility, there is an opportunity to continue to build on the mobility platform and devices to further digitize the workforce activities. This includes the provision of offline, regularly updated, network maps and safety work method statements. These additional digitization initiatives will follow the creation of an approved Mobility Roadmap, which will identify the overall strategy for field digitization as well as the various applications and platforms, ensuring the continued roll out is implemented effectively, and only delivering activities that have clear benefits to the customer. The benefits anticipated from further building on field mobility include:

- Faster data capture and higher degree of accuracy, enabling richer data analysis, and further improving the end to end process for planned outage notifications to customers.

- Continuing to improve the safety of our workforce and the public through increased availability of accurate up-to-date information.

4.10.4 Enterprise Integration

The asset information systems are closely integrated, are point to point and are highly complex. The integration between our works management and meter data and billing system for example, consists of a total of nine point to point integrations. Evoenergy will implement a service bus to simplify the environment, and ensure the applications can be managed in a more efficient and prudent manner. The following benefits are expected:

- The service bus will enable the removal of point to point integrations, enabling applications to be built, maintained, and released independently. This reduces the implementation risk of large scale projects by reducing overall scope, as well as reducing project costs.
- Greater monitoring and more effective integrations will ensure that information is not lost between applications. This is key to cross system processes such as re-energisations.

4.10.5 Management of Distributed Energy Resources (DERs)

Our asset information systems will evolve, as Evoenergy evolves into a DSO/DSM. Our systems must cope with the changes distributed energy resources (DERs) will bring to the management of the electricity grid. Our real time control system – ADMS will need to have a more granular view of DERs, ensuring actions can be undertaken to manage two-way power flows, as well as the variability associated with increased renewable energy connected to the network. The key benefit is that we can encourage and enable the proliferation of DERs, embedded networks and micro-grids in the ACT. This ensures that our customers can have greater control over how they receive energy, manage consumption and reduce costs.

4.11 Metering

Evoenergy has a population of approximately 209,000 domestic and commercial meters in operation. Following the commencement of the Power of Choice (PoC) changes that took effect on 1 December 2017, new meter installation became the responsibility of retailers. Final requests to Evoenergy Distribution to install meters (including alterations and replacements) were submitted by 30 November 2017. All requested works were completed by 30 March 2018.

As Evoenergy does not install meters anymore, we expect a reduction in meter assets under management over time. Evoenergy will have ongoing responsibility for the maintenance and testing of all existing Evoenergy metering installations.

Customers should contact their retailer for metering installations and alterations.

4.11.1 Smart Meters

The Power of Choice rules require all new and replacement meters to be Type 1-4 meters (smart meters). Evoenergy is exploring opportunities to work with retailers and metering providers to utilise smart meters to provide the following functionality:

4.11.1.1 Outage management

An enhanced smart meter could communicate with the control centre when supply is lost thus quickly indicating that a fault has occurred and its location. The network operator would also be able to ascertain if the fault is on the network side or the customer's side of the meter.

4.11.1.2 Network planning

Smart meters can provide accurate information of energy use and load data that can be used for network energy and demand forecasts. This would assist the future planning of low voltage networks in particular where standard values of load for customers are currently used, known as After Diversity Maximum Demand (ADMD) values. The impact of embedded generation such as rooftop PV and battery energy storage systems would be able to be analysed accurately so that future networks are designed appropriately. This would enable future network augmentations to be optimised and existing assets to be utilised fully.

4.11.1.3 Demand management

Enhanced smart meters can be used to support demand side management by providing customers with details of their energy consumption and costs via web-portals, and providing customers with a range of energy plans to meet their individual needs.

4.11.1.4 Power quality monitoring

Enhanced smart meters can be used to record condition monitoring parameters that can be used for analysing network power quality to ensure compliance with standards. For example, Evoenergy currently investigates voltage complaints by installing temporary logging equipment at the customer's premises. Such information would potentially be accessible remotely in future from a smart meter.

4.11.1.5 Remote disconnection and reconnection of supply

Smart meters have an integrated mains supply contactor that provides the capability to remotely disconnect or reconnect customer supplies from the network.

4.11.2 Transmission Network Service Provider (TNSP) Metering

Evoenergy has installed TNSP metering at all of its zone substations. TNSP metering is a necessary part of the electricity market settlement process as defined in the National Electricity Rules (NER) chapter 7 and administered by the Australian Energy Market Operator (AEMO).

The TNSP metering interfaces with secondary systems equipment at Evoenergy's zone substations. These interfaces are at defined connection points between the 132 kV transmission network and the 11 kV distribution network. The TNSP metering has been installed in new dedicated metering panels and complies with AEMO requirements and Australian Standard AS/NZS 1284.13:2002 (Electricity metering in-service compliance testing).

5. System load and energy demand, and the supply-demand balance

5.1. Introduction

This chapter describes the methodology and assumptions made for calculating a ten-year forecast of maximum summer and winter load demands for each zone substation, bulk supply point and whole of system. These forecasts are used to identify potential future constraints in the network.

Load demand forecasting is one of the main inputs to network planning. Load forecasts are used to identify parts of the network that may become overloaded due to load growth and require augmentation, and to identify other parts of the network where spare capacity may be available. Load demand forecasting is complex because of its dependence on a number of factors such as climatic conditions, population growth, uptake of embedded generation and emerging technologies, and economic factors such as electricity tariffs. Evoenergy prepares and updates a rolling 10-year load forecast, identifying expected summer and winter maximum demands for the whole network, each zone substation and each 11 kV feeder.

Load growth varies from year to year and is not uniform across the whole network. It is not unusual to find parts of the network that grow at three or four times the average network growth rate, while other parts of the network experience no growth at all.

Evoenergy has prepared forecasts of maximum demand for each zone substation and the transmission system as follows:

- Whole of system and bulk supply points: refer Appendix B; and
- Zone substations: refer Appendix C.

5.2. Forecasting methodology

5.2.1. Key definitions

5.2.1.1 Maximum Demand

Maximum demand is the highest level of instantaneous demand for electricity averaged over a 30-minute period, and is estimated for summer and winter seasons. Maximum demand projections include load supplied by the network, network losses, and auxiliary loads.

5.2.1.2 Probability of Exceedance (POE)

Probability of Exceedance (POE) is a generalised approach to electricity demand forecasting. Probability of Exceedance is the probability, as a percentage, that the maximum demand level will be met or exceeded (eg due to ambient temperature) in a particular period of time. Due to the high proportion of residential load in the ACT, maximum demand is highly dependent on weather conditions. Thus, there is substantial uncertainty inherent in maximum demand forecasts. Evoenergy prepares maximum demand forecasts with 10%, 50% and 90% POE's:

- A 10% POE maximum demand projection is expected to be exceeded, on average, one year in 10.
- A 50% POE maximum demand projection is expected to be exceeded, on average, five years in 10 (or one year in two).
- A 90% POE maximum demand projection is expected to be exceeded, on average, nine years in 10.

The 50% POE maximum demand forecast is used for planning purposes.

5.2.1.3 Diversity Factor

Diversity factor is the ratio of the sum of the individual non-coincident maximum demands of the parts of a system to the maximum demand of the whole system under consideration. Diversity factor is generally ≥ 1.

$$\textit{Diversity Factor} = \frac{\textit{Sum of non} - \textit{coincident maximum demands of parts of system}}{\textit{Maximum demand of whole system}}$$

5.2.1.4 Load Factor

Load factor is defined as the average load divided by the peak load in a specified time period such as annually, quarterly or monthly. Load factor is generally ≤ 1. Evoenergy encourages its customers to improve their load factor, ie spread their load more evenly over the time period required.

$$Load\ Factor = \frac{Average\ demand\ in\ a\ given\ time\ period}{Maximum\ demand\ in\ the\ same\ given\ time\ period}$$

5.2.1.5 Power Factor

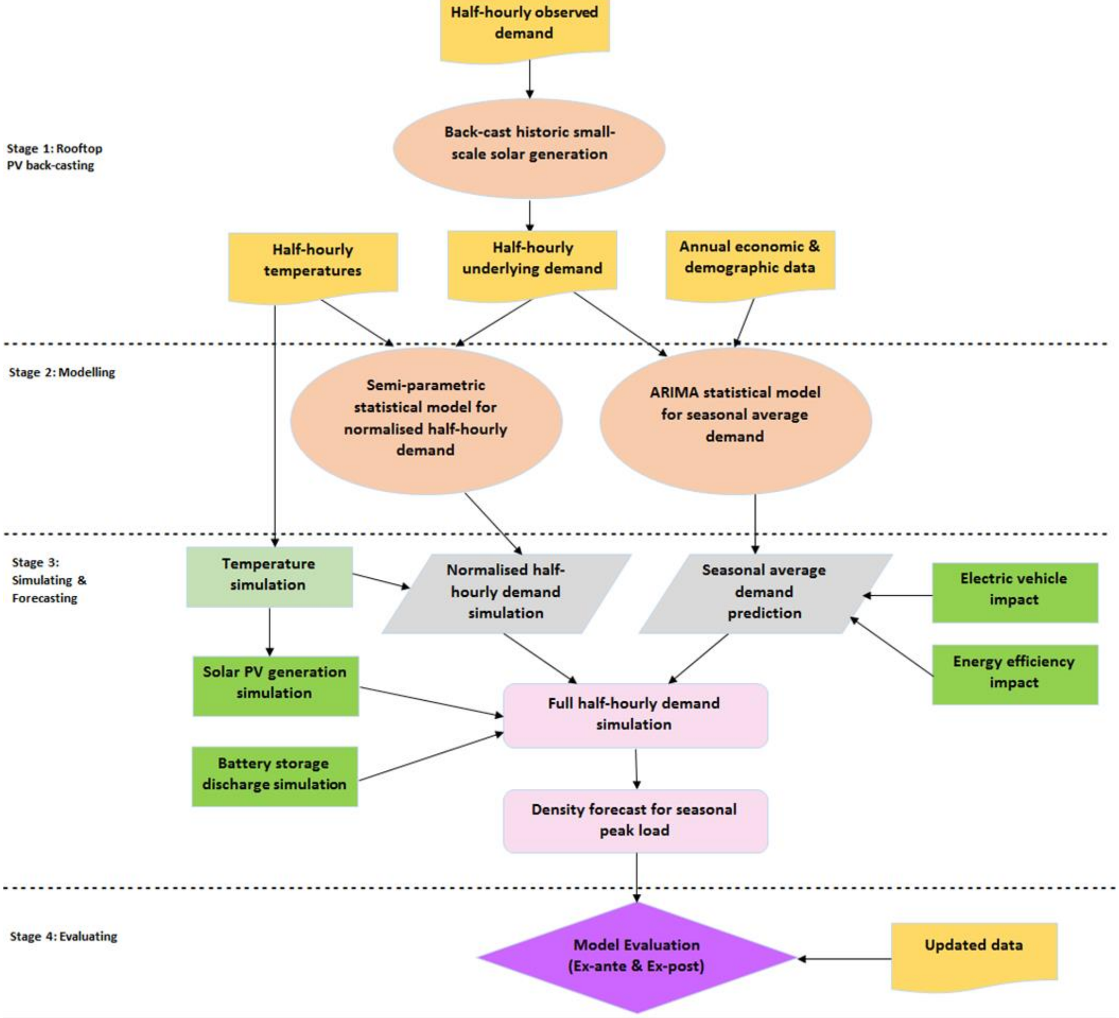
The power factor of an AC electrical power system is defined as the ratio of the real power (MW) used to do work to the apparent power (MVA) supplied to the circuit. Power factor is generally > 0 and ≤ 1. Evoenergy sets minimum target levels for power factor throughout the network and at customer connection points. Higher power factor allows the existing network to deliver more useful energy, ie real power.

$$Power\ Factor = \frac{MW}{MVA}$$

5.2.2 Forecasting methodology for distribution

Evoenergy has adopted and implemented AEMO's maximum demand forecast methodology which uses the Monash Electricity Forecasting Model (MEFM) which is based on the paper by Hyndman and Fan (2010)[7]. For more technical details about this methodology, the Monash Electricity Forecasting Model Technical Report is available at AEMO's website. Figure 5.1 illustrates the Integrated MEFM load forecasting process.

Figure 5.1: Block diagram of the Integrated Monash Electricity Forecasting Model.



[7] R. J. Hyndman and S. Fan (2010) "Density Forecasting for Long-term Peak Electricity Demand", IEEE Trans. Power Systems, 25(2), 1142–1153. http://robjhyndman.com/papers/peak-electricity-demand/

Key features of the integrated MEFM load forecasting methodology are:

- Integrated MEFM has four sub-models:
    1. Half-hourly model (HH model);
    2. Seasonal average demand model (annual model);
    3. Solar PV model (PV model); and
    4. Battery storage discharge model.
- Adjusted half-hourly demand where each year of demand is normalised by seasonal average demand is an input to the HH model.
- Annual model considers seasonal average demand against all possible economic and demographic drivers including energy efficiency variables.
- Forecasts calculated from the annual model are adjusted based on electric vehicle uptake impact on average energy consumption.
- Forecasts calculated from half-hourly and PV generation models are based on ambient temperature simulations.
- For the HH model, temperature and calendar variables are selected through a cross-validation procedure based on mean squared error (MSE).
- The coincident maximum demand contribution of block loads to the total maximum demand of bulk supply points and zone substations are calculated using diversity factors.
- The final demand forecast simulation = (HH model forecast × Annual model forecast) - Solar PV simulation forecast –Battery storage discharge simulation forecast.

5.2.2.1 Rooftop Solar PV Generation

The uptake of rooftop solar PV generation in the ACT has been increasing steadily over the past five years. There is currently approximately 84.2 MW of small scale (primarily residential) rooftop PV installed capacity.

Summer peak demand on Evoenergy's network occurred at 4:00 pm on 23 January 2018. Rooftop PV generation at the time had a small impact on this. Winter peak demand occurred at 8:00am on 23 July 2018. Rooftop PV generation at the time was negligible so had no impact on this. Future installation of battery energy storage systems may have greater impact on these peak demands.

Rooftop PV generation does impact on energy consumption however, throughout the year.

5.2.2.2 Forecasting model accuracy

The accuracy of the forecasting model has been verified by comparing the actual maximum demand with the 10%, 50% and 90% POE forecasts. Tables 5.1 and 5.2 show the 2018 zone substation and system summer and winter maximum demand forecasts compared with actual measured values.

Table 5.1: 2018 Summer forecast maximum demand (MW)

Zone Substation	10% POE	50% POE	90% POE	Actual
Belconnen	65	58	51	54
City East	86	75	67	66
Civic	65	57	51	55
East Lake	24	20	16	19
Fyshwick	33	29	24	28
Gilmore	42	34	26	26
Gold Creek	73	60	48	62
Latham	59	52	44	52
Telopea Park	94	86	77	83
Theodore	30	24	19	24
Wanniassa	72	63	55	59
Woden	86	76	67	79
System	649	587	526	567

Table 5.2: 2018 Winter forecast maximum demand (MW)

Zone Substation	10% POE	50% POE	90% POE	Actual
Belconnen	64	60	56	57
City East	74	68	63	67
Civic	54	49	45	51
East Lake	24	20	14	18
Fyshwick	27	23	19	24
Gilmore	41	35	30	30
Gold Creek	76	68	60	71
Latham	73	68	63	67
Telopea Park	89	84	80	85
Theodore	33	29	26	28
Wanniassa	83	77	72	73
Woden	84	78	72	83
System	665	627	596	623

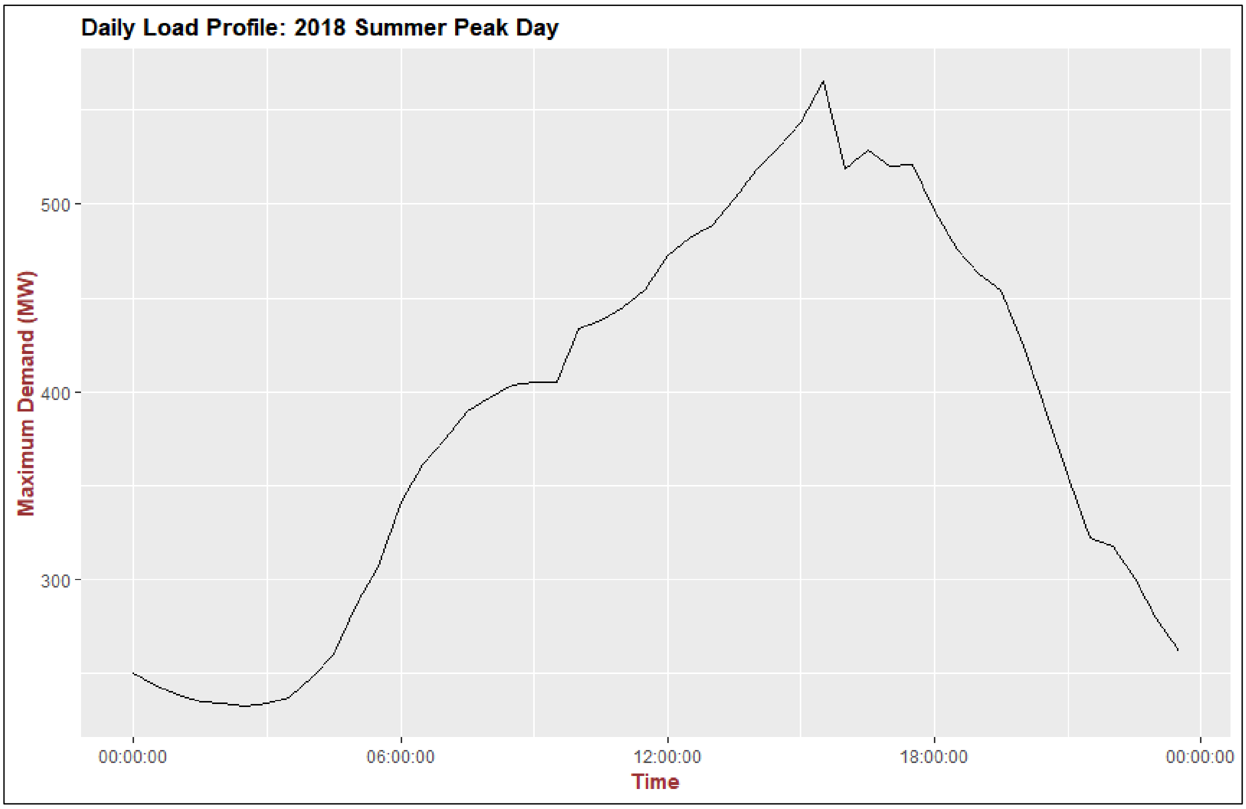
5.3. Historical demand

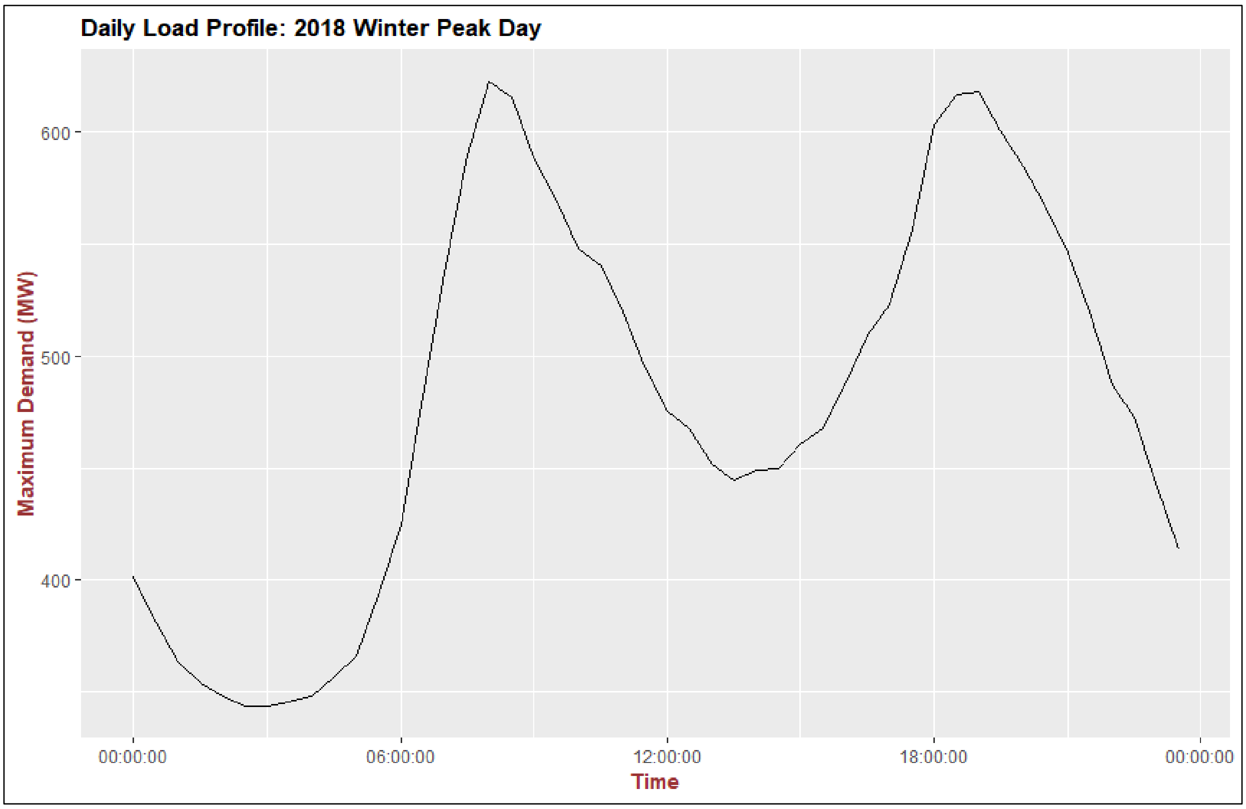
Key features of the historical demand over the past 10 years are as follows:

- Summer maximum demand is very weather dependent. For example summer 2012 and 2015 maximum demands fell below 500 MW due to mild weather conditions.
- Summer maximum demand increased steadily until 2011 and has experienced a decline from 2012 onwards. This is due to the introduction of the Government's solar generation incentive scheme and subsequent increase in rooftop solar PV installations.
- Winter maximum demand has been more consistent than summer. Improvements in the energy efficiency of new buildings, space heating and household appliances have resulted in small growth only of winter maximum demand despite an increasing customer base.
- In the 2017-18 summer period, the hottest day was 7 January 2018 whereas the peak summer demand occurred at 4:00pm on 23 January 2018 and was 567 MW.
- In the 2018 winter period, the coldest day was 23 July 2018, when the peak winter demand occurred at 8:00am and was 623 MW. This is the first year that winter peak demand has occurred in the morning.

2018 summer and winter maximum demand day load profiles are shown in Figure 5.2.

Figure 5.2: Daily load profile for 2018 summer and winter maximum demand days





5.4. Forecast Demand

5.4.1 ACT System Demand Forecast

Factors that influence load forecasts include climatic conditions, economic and demographic conditions, and emerging technologies such as solar PV generation, battery storage systems, electric vehicle charging, instantaneous hot water heating systems, energy efficiency schemes, and the trend away from gas to all-electric dwellings (particularly apartment buildings).

Evoenergy calculates load forecasts based on 10%, 50% and 90% POE. Network planning is based on the medium 50% POE forecast. Evoenergy's maximum demand forecasts for the ten year period 2019–28 have been calculated and are presented in Figures 5.3 and 5.4, and Table 5.3.

Figure 5.3: Summer 10-year system maximum demand forecast (2019–28)

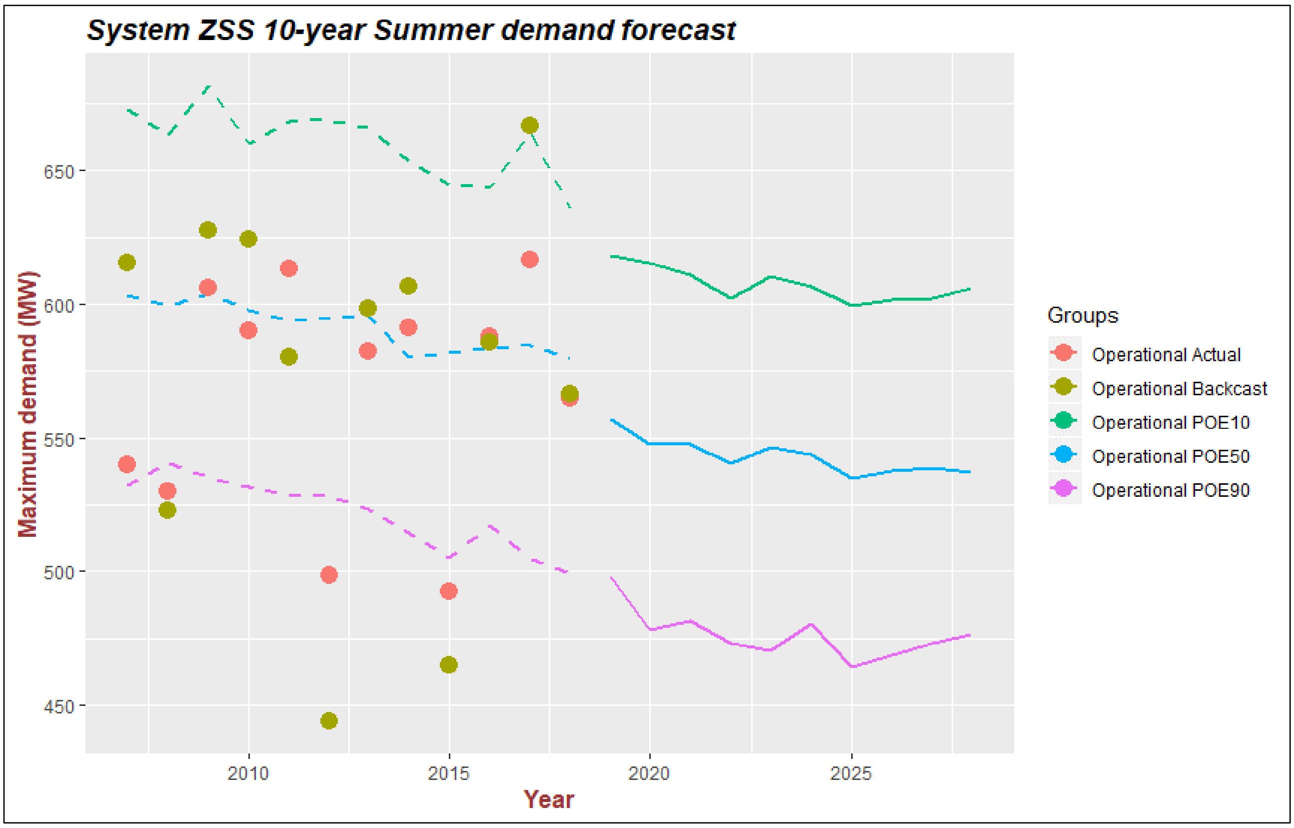


Figure 5.4: Winter 10-year system maximum demand forecast (2019–28)

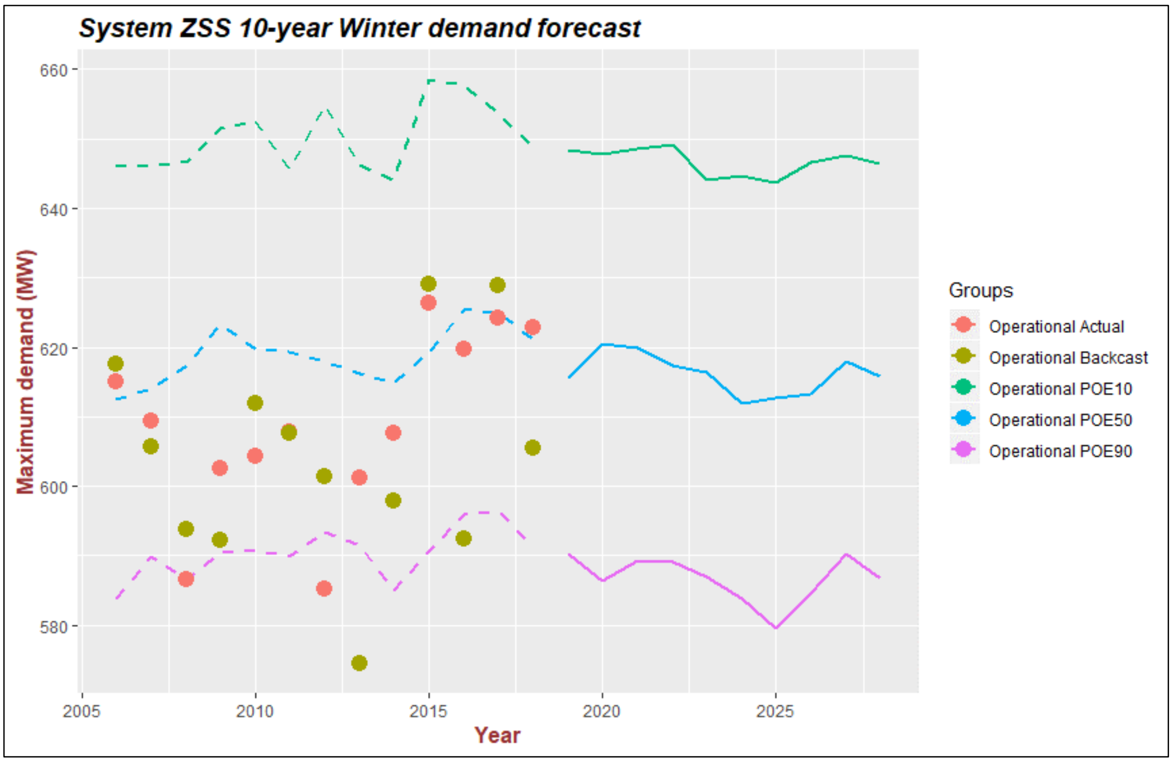


Table 5.3: System Summer and Winter Maximum Demand Forecast (MW)

Year	Summer			Winter		
	10%	50%	90%	10%	50%	90%
2018	618	557	498	648	616	590
2019	615	547	478	648	620	586
2020	611	548	482	649	620	589
2021	602	540	473	649	617	589
2022	610	546	470	644	616	587
2023	607	544	480	645	612	584
2024	600	535	464	644	613	580
2025	602	537	468	647	613	585
2026	602	539	473	648	618	590
2027	606	537	477	646	616	587

5.4.2 Zone Substation Load Forecasts

Table 5.4: Zone Substations Summer Maximum Demand Forecasts (MVA)

Zone Substation	Continuous Rating	Emergency two-hour Rating	PoE Forecast	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Belconnen	55	63	50%	56	62	66	68	69	69	68	68	68	68
			10%	63	68	73	75	76	76	75	75	75	75
City East	95	95	50%	73	81	88	93	100	98	98	99	99	101
			10%	85	92	99	104	111	110	111	112	114	114
Civic	110	114	50%	59	63	66	67	69	69	69	69	69	69
			10%	65	69	74	75	76	75	77	76	77	76
East Lake	43	54	50%	21	20	21	21	22	22	23	24	25	26
			10%	26	26	26	27	29	30	30	30	33	33
Fyshwick	28	28	50%	29	30	30	30	31	31	31	31	32	32
			10%	30	31	32	32	32	32	32	33	33	34
Gilmore	45	62	50%	31	32	34	35	36	38	39	41	42	44
			10%	39	40	42	43	44	47	48	49	51	53
Gold Creek	57	76	50%	67	69	74	73	78	79	82	84	86	89
			10%	79	83	88	88	93	97	98	102	104	108
Latham	95	95	50%	52	53	54	55	57	57	58	59	60	62
			10%	60	60	62	63	64	65	66	67	68	70
Telopea Park	100	114	50%	87	93	97	101	103	103	102	104	103	103
			10%	100	106	109	111	115	115	114	116	116	116
Tennent	15	15	50%	3	3	3	3	3	3	3	3	3	3
			10%	3	3	3	3	3	3	3	3	3	3
Theodore	45	62	50%	24	25	25	25	25	25	25	25	25	25
			10%	29	30	30	29	30	30	30	30	30	30
Wanniassa	95	95	50%	62	64	65	65	65	64	63	62	61	61
			10%	71	74	73	74	74	73	71	70	70	69
Woden	95	95	50%	77	80	84	86	88	88	88	88	88	88
			10%	87	91	95	96	98	99	98	99	99	98

Table 5.5: Zone Substations Winter Maximum Demand Forecasts (MVA)

Zone Substation	Continuous Rating	Emergency two-hour Rating	PoE Forecast	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Belconnen	**55**	**76**	***50%***	59	65	69	70	71	71	71	71	71	71
			10%	62	68	72	74	74	74	74	74	75	75
City East	**95**	**112**	***50%***	68	77	85	90	93	92	93	95	94	95
			10%	76	85	93	98	100	100	102	103	103	103
Civic	**110**	**143**	***50%***	53	57	59	61	62	62	62	63	63	63
			10%	56	59	62	63	65	65	65	66	66	66
East Lake	**43**	**54**	***50%***	18	18	19	19	20	20	21	22	22	23
			10%	20	20	20	21	22	22	23	24	24	25
Fyshwick	**28**	**28**	***50%***	24	25	25	26	27	28	29	30	31	31
			10%	24	25	26	27	28	28	29	30	31	32
Gilmore	**45**	**69**	***50%***	32	33	34	35	36	37	38	39	40	42
			10%	35	36	37	38	39	40	42	43	44	46
Gold Creek	**57**	**76**	***50%***	71	75	78	81	83	85	87	90	92	94
			10%	76	82	85	88	91	93	95	99	101	102
Latham	**95**	**114**	***50%***	67	69	70	72	73	74	74	76	77	78
			10%	71	73	75	76	77	78	78	80	81	83
Telopea Park	**100**	**114**	***50%***	85	91	96	99	99	99	99	100	100	100
			10%	90	97	101	104	106	106	105	106	107	107
Tennent	**15**	**1**[3]	***50%***	3	3	3	3	3	3	3	3	3	3
			10%	3	3	3	3	3	3	3	3	3	3
Theodore	**45**	**69**	***50%***	28	28	29	29	29	29	28	29	29	29
			10%	30	31	31	31	31	31	31	31	31	31
Wanniassa	**95**	**114**	***50%***	73	76	77	76	75	74	73	72	72	70
			10%	79	82	82	81	81	80	79	78	78	76
Woden	***95***	***114***	***50%***	82	87	89	90	92	92	92	93	93	93
			10%	88	94	97	98	99	99	98	100	100	99

5.4.2.1 Key features of the maximum demand forecasts

Table 5.6 summarises summer and winter 10% POE and 50% POE maximum demand annual average growth rates. Key features are as follows:

- Summer maximum demand has fluctuated over the last seven years due to increasing installation of rooftop PV systems and milder summer weather conditions (with the exception of summer 2017).
- The long term (10 years) 10% POE and 50% POE growth rates are very similar.
- A small rate of decline is expected in summer and a small rate of growth is expected in winter, primarily due to the increasing prevalence of rooftop solar PV generation.

Table 5.6: Summer and winter 10% POE and 50% POE maximum demand annual average growth rates (medium growth rate scenario)

Forecast maximum demand annual average growth rate		Summer			Winter		
		Actual	10% POE	50% POE	Actual	10% POE	50% POE
2011 - 2018	Historical	-1.2%	-0.7%	-0.4%	0.3%	0.1%	0.0%
2018 - 2019	0 -1 year growth		-2.8%	3.9%		0.0%	-0.9%
2019 - 2023	2 - 5 years growth		-0.3%	-0.5%		-0.2%	0.0%
2024 - 2028	6 -10 years growth		0.0%	-0.3%		0.1%	0.2%
2018 - 2028	1 - 10 years growth		-0.5%	-0.8%		0.0%	-0.1%

5.4.3 Bulk Supply Point (BSP) forecasts

Appendix B details the summer and winter maximum demand forecasts for the three TransGrid owned bulk supply substations Canberra, Williamsdale and Queanbeyan.

Canberra and Williamsdale are both 330/132 kV substations and supply Evoenergy's meshed 132 kV network. Queanbeyan 132/66 kV Substation supplies Evoenergy's Fyshwick Zone Substation only at 66 kV as well as some Essential Energy substations.

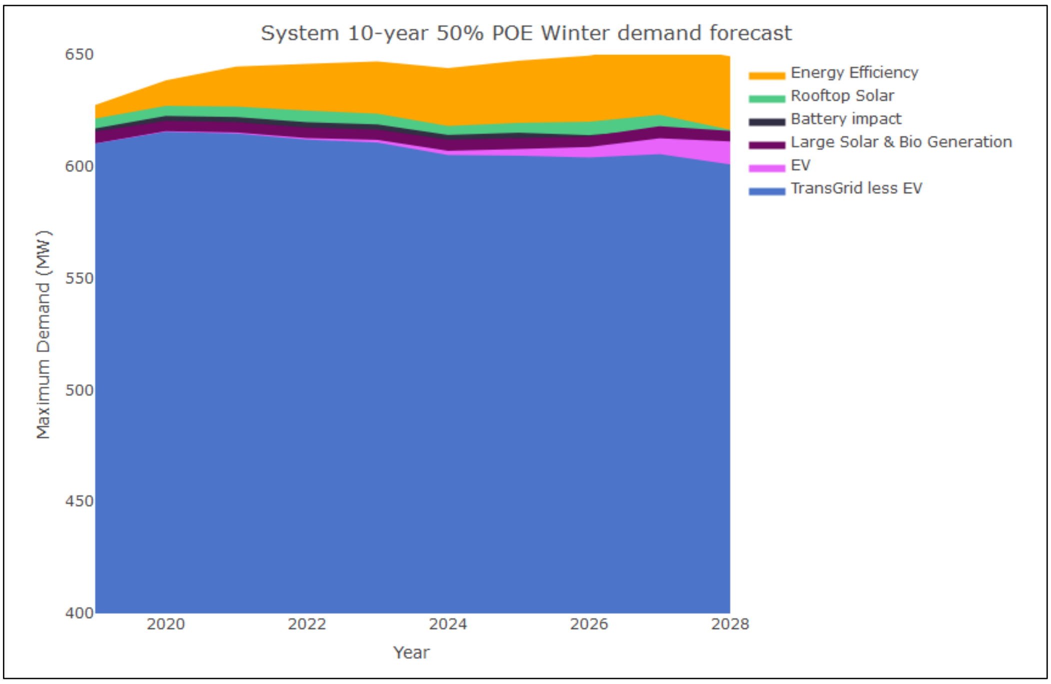
5.4.4 Zone Substation forecasts

Appendix C details the summer and winter maximum demand forecasts for Evoenergy's zone substations.

5.5 Impact of emerging technologies on load forecasts

Figure 5.5 illustrates the impact of emerging technologies on Evoenergy's forecast system summer maximum demand.

Figure 5.5: Emerging technologies impact on 50% POE system summer maximum demand forecast



5.6. Load Transfer Capability

Table 5.7 shows the load transfer capability (in MW) between Evoenergy's zone substations. Transfer capability is calculated based on spare capacity of zone substation transformers and spare capacity of interconnecting 11 kV feeders between substations.

Table 5.7: Load Transfer Capability (in MW) between Evoenergy's Zone Substations

Zone Substation		From												
		Latham	Belconnen	Gold Creek	Civic	City East	Telopea Park	East Lake	Fyshwick	Woden	Wanniassa	Gilmore	Theodore	Tennent
To	Latham		7.13	2.47										
	Belconnen													
	Gold Creek													
	Civic		3.06			7.88								
	City East		5.69		7.29		2.9							
	Telopea Park					2.75		14.76	3.64	5.06				
	East Lake													
	Fyshwick						0.63	6.27			0.48	0.48		
	Woden						11.47				8.87			
	Wanniassa						2.8		2.8	18.39		10.57	1.44	
	Gilmore								1.5		15.13		6.66	
	Theodore										6.31	3.36		
	Tennent													

6. Asset Renewals

6.1. Introduction

Asset renewal is simply defined as works that return an asset to its “as-new” condition. Depending on the type of asset, the renewal process may involve the replacement of components, such as overhead line insulators. Major assets such as zone substation power transformers may undergo a “mid-life” refurbishment which would include de-tanking of the core and windings. In order to realise the full potential of any asset, routine maintenance is required. This maintenance does not return the asset to its “as-new” condition, but controls premature deterioration and potential failure.

The cost of asset renewal is included in the “whole-of-life” cost of the asset.

All assets are assigned a “health profile” which is determined by combining the asset’s condition rating with its criticality rating. Condition is determined by the asset’s capacity to meet its service requirements, level of reliability and its level of obsolescence. Obsolescence is determined by maintenance requirements and availability of spares and support from suppliers. Criticality is determined from operational, safety and environmental consequences due to asset failure.

6.2 Compliance with National Electricity Rules re Asset Replacement

In compliance with the NER Schedule 5.8 (b1) and (b2) requirement to report plans to retire or de-rate network assets, Table 6.1 lists our current plans for asset retirement and de-rating.

Table 6.1: Asset Retirements and De-Rating (2018-2022)

Network Asset	Reason for Retirement / De-Rating	Effective Date	Proposed Replacement / Augmentation Work
Nona 11 kV feeder (supplying primarily residential customers in the Gungahlin area)	Nona feeder is historically unreliable. The past 4 years has seen 4 feeder faults, all of them during the winter peak period. Review of the loading trend on the feeder found that each cable fault occurred when the load on the feeder exceeded 300 Amps. Based on cable type and installation configuration, this feeder was rated at 325 Amps (winter continuous).	31 May 2019	A minor augmentation project has been proposed to install 165m of cable to connect Gribble feeder to Nona feeder. This will allow the transfer of 5 distribution substations from Nona to Gribble feeder and reduce the winter peak load to below 300 Amps. The Nona feeder will then be de-rated to 290 Amps (winter continuous).
Decommissioning of Fyshwick Zone Substation	Refer to Section 7.5.4		
Decommissioning of Causeway 132 kV Switching Station	Refer to Section 7.5.5		

Distribution assets that are approaching the end of their economic life are assessed for removal from the network, network augmentation or replacement in order to maintain the required network capacity and reliability. Occasionally at customer request and funding an asset may be relocated to allow for a proposed development. This could typically require the retirement of a section of overhead distribution line and its replacement with an underground cable.

Table 6.2 lists proposed network asset replacement expenditure where the total replacement cost of each asset type over the 5-year planning period is greater than $200,000.

Table 6.2: Asset Replacements (2019-2023)

Asset type to be replaced	Estimated Quantity and Cost in 2017-18 dollars											
	2019		2020		2021		2022		2023		Total	
	Qty	$ Cost	Qty	$ Cost	Qty	$ Cost	Qty	$ Cost	Qty	$ Cost	Qty	$ Cost
Battery (Distribution)	12	43,924	14	43,944	12	43,784	19	44,624	10	43,694	67	219,970
Distribution HV Switchboard Assembly	2	402,500	2	402,500	2	402,500	2	402,500	2	402,500	10	2,012,500
Distribution LV Switchboard Assembly	5	676,555	5	676,555	5	676,555	5	676,555	1	135,311	21	2,841,531
Distribution Substation or Switching Station Site	5	467,575	5	467,575	5	467,575	5	467,575	5	467,575	25	2,337,875
Ground mounted Transformer	2	134,486	2	134,486	2	134,486	2	134,486	2	134,486	10	672,430
LV Pillar	40	228,920	40	228,920	40	228,920	40	228,920	40	228,920	200	1,144,600
OH Line and Pole Hardware	570	1,502,700	570	1,502,700	570	1,502,700	570	1,502,700	570	1,502,700	2,850	7,513,500
OH Service	140	232,120	141	233,426	140	232,120	140	232,120	140	232,120	701	1,161,906
OH Switchgear or Recloser	51	541,356	51	541,356	51	541,356	51	541,356	51	541,356	255	2,706,780
Pole mounted Transformer	9	523,134	8	465,008	8	465,008	8	465,008	9	523,134	42	2,441,292
Pole	462	4,782,760	442	4,578,380	452	4,680,570	462	4,782,760	482	4,987,140	2,300	23,811,610
Ring Main Unit	6	168,276	6	168,276	6	168,276	6	168,276	6	168,276	30	841,380
UG HV Cable	32	2,878,633	33	3,245,463	32	1,889,317	32	2,448,062	30	5,724,597	159	16,186,071
UG LV Cable	186	899,814	186	899,814	186	899,814	186	899,814	186	899,814	930	4,499,070
Transmission Structure	5	104,620	5	104,620	6	104,620	6	104,620	6	104,620	28	523,100
Air Insulated Switchgear	4	136,000	4	136,000	4	136,000	4	136,000	1	34,000	17	578,000
Power Transformer Assembly	2	93,322	10	466,610	2	93,322	7	326,627	5	233,305	26	1,213,186
Zone Substation 11 kV Switchboard Assembly									1	3,071,400	1	3,071,400

6.3 Transmission Asset Renewal Programs

6.3.1 Transmission Line Protection

In order that 132 kV network protection meets the NER requirements for fault clearance times, Evoenergy is carrying out an upgrade program of its 132 kV transmission line protection schemes as follows:

- Upgrade protection and install unit line differential protection as OPGW becomes available.
- Upgrade sole protection schemes to duplicate protection.
- Install duplicate 132 kV circuit breaker failure protection.
- New protection relays are modern numerical type.

6.4 Distribution Asset Renewal Programs

All distribution assets are replaced via a rolling program based on an assessment of their condition and remaining economic life. All classes of distribution assets are renewed in this way (refer Table 6.2), including:

- Distribution transformers.
- 11 kV switchgear (switchboards, ring main units and air-break switches).
- 11 kV and 400 V underground cables and overhead conductors.
- Low voltage distribution pillars.
- Protection relays, communications and SCADA equipment.
- Batteries and battery chargers.
- Earthing equipment and systems.
- Poles.

The major distribution asset renewal programs involve distribution poles with poor structural condition as identified by the condition monitoring program, and underground cables. These assets are typically more than 60 years of age and have reached the end of their economic life. Evoenergy is trialling Non-Destructive Testing (NDT) in parallel with traditional testing methods for timber poles. NDT includes the use of acoustic, ultrasonic and gamma ray testing to measure its density and calculate its remaining service life until replacement is required. Replacement poles are typically concrete or fibreglass.

During 2018, the King Edward 11 kV feeder from Telopea Park Zone Substation failed several times and was deemed to be at the end of its economic life. This cable was over 60 years old and had numerous joints as the result of faults over its lifetime. As a result, approximately 2.3 km of PILC insulated copper cable was replaced with XLPE insulated aluminium cable. The replacement cable was commissioned in September 2018 at a cost of $2.5m.

Evoenergy has been undertaking a program to upgrade the earthing at its zone substations and 132 kV switching stations. Some of the earth grids at these sites are approaching 55 years of age. Testing has been undertaken at the following 12 oldest stations to assess the condition of the earth grids and measure soil resistivity and Earth Potential Rise:

1. 66/11 kV Fyshwick Zone Substation
2. 132/11 kV Wanniassa Zone Substation
3. 132/11 kV Latham Zone Substation
4. 132/11 kV Gold Creek Zone Substation
5. 132 kV Bruce Switching Substation
6. 132/11 kV Civic Zone Substation
7. 132/11 kV City East Zone Substation
8. 132/11 kV Woden Zone Substation
9. 132/11 kV Telopea Park Zone Substation
10. 132 kV Causeway Switching Substation
11. 132/11 kV Gilmore Zone Substation
12. 132/11 kV Theodore Zone Substation

While no major non-compliance or safety issue was identified, there are minor maintenance and remedial actions required at most of these stations to ensure safe operation of the earthing system. The overall testing and upgrade program is estimated to cost $1.1m and will be completed by June 2019.

6.5 Distribution Asset Maintenance

Evoenergy maintains its assets according to the principles of Risk Centred Maintenance (RCM). The governing factor in RCM analysis is the impact of a functional failure at the equipment level.

The process of developing an RCM program depends on selecting scheduled tasks that are both applicable and effective for a given asset. The fact that failure consequences govern the entire decision process makes it possible to use a structured decision approach, both to establish maintenance requirements and to evaluate proposed tasks.

Maintenance tasks are directed at assets where failure might have safety, environmental, reliability or economic consequences. Assets are classified as:

- Significant item - where failure may have serious safety, environmental, financial or operational consequence.
- Non-significant item - where failure has no impact on operating capability.
- Item with hidden function - where failure will not be evident and might therefore go undetected.

The net result of the decision process is a scheduled maintenance program that is based at every stage on the known reliability characteristics of the equipment in the operating context in which it is used.

6.6 SCADA Systems

Supervisory Control and Data Acquisition (SCADA) systems collect system status and analogue information from field devices. This data is used by Evoenergy's Advanced Distribution Management System (ADMS) and other operational systems to monitor and control the network. This data is also used for power systems analysis purposes to aid network planning and augmentation decision making. SCADA also provides asset condition monitoring information used for asset maintenance and informing replacement decisions.

Zone substation power transformers, switchgear and controllable distribution assets are critical elements of the electricity network and SCADA is important for safe and reliable operation.

Evoenergy's has deployed integrated SCADA and protection systems in recent years that use multifunction numerical devices in an interconnected communications network. Implementation costs have been reduced due to the development of reusable device templates and a reduction in the number of devices required as the result of installing multifunction protection relays and other devices. These systems are able to provide automated condition monitoring which is used to optimise asset maintenance.

New and replacement SCADA systems are implemented as follows:

- Remote Terminal Units (RTUs) use DNP3 protocol over IP for communications to the ADMS SCADA master station.
- Zone substation communications to the ADMS use the Evoenergy IP-MPLS optical fibre network. Critical distribution substation sites also use optical fibre communications where available.
- Communications for distribution substations, reclosers, switches and other field devices use the Evoenergy UHF Digital Radio Network, 3G/4G communications or mesh radio; depending on availability and best cost option for individual sites.
- The RTU operates as a data concentrator with monitoring and control performed in bay protection relays.

6.7 Protection Systems

Evoenergy uses protection systems at zone substations, switching stations and distribution substations. Protection relays are devices that monitor system conditions and detect abnormal conditions (such as those resulting from a fault on the system). The relays then quickly activate devices such as circuit breakers to isolate faulty electrical equipment and ensure the safety of our staff, the general public and property.
Evoenergy has identified the need to replace a number of defective and poor performing protection relays that have reached the end of their economic life. Evoenergy has a continuing program for planned relay

replacements at Gilmore and Gold Creek zone substations, and at Bruce Switching Station. Old electro-mechanical and static/electronic protection devices are being replaced with modern numerical relays.

As part of the secondary systems strategy, protection and SCADA replacements are proposed at Woden, City East and Wanniassa zone substations commencing in 2019.

All new or replacement protection systems will include the following:

- All protection devices will be multifunctional numerical control devices (IEDs) compliant with IEC 61850 and DNP3 standards.
- IEDs shall use DNP3 or IEC 61850 protocol for SCADA communications to RTUs.
- Protection and automation functions will be implemented in IEDs.
- Duplicate protection devices shall be installed in 132 kV zone substation applications as required by the NER.
- Main and backup protection devices shall be installed in 11 kV zone substation applications.

6.8 Telecommunication Systems

Evoenergy's telecommunications system are required to service a wide range of business requirements including network protection, SCADA, metering, security, telephony, video and corporate data services. The telecommunications strategy is developed around delivering a unified communications network to provide multiple services while maintaining cyber security and meeting individual service performance requirements.

The primary purpose of the telecommunications network is the support of ADMS/SCADA and protection of network assets. The telecommunications network also supports corporate WAN, VoIP (Voice over Internet Protocol) telephony, engineering LAN, CCTV monitoring and access control to sites.

Planned telecommunications projects – fibre optic network:

Evoenergy has a program to install Optical Ground Wire (OPGW) within our network to replace aged communications bearers such as radio. This involves replacing the existing overhead earth wire on 132 kV transmission lines with hybrid OPGW cables to provide an optical fibre communications capability to meet the following regulatory and business requirements:

- Upgrading our 132 kV transmission line protection systems to meet current NER network performance standards, ensuring regulatory compliance and safety for the community. Currently some 132 kV transmission line protection systems within the Evoenergy transmission network are non-compliant with the required fault clearance times under the NER and need to be upgraded.
- Providing a secure SCADA communication network enabling the Control Centre to monitor and operate zone substations in the Evoenergy network.
- Providing inter control centre SCADA communications and communications to the TransGrid and AEMO control centres, required by our role as a Transmission Network Service Provider (TNSP) in the national grid.
- Providing communications for security monitoring of substations and other operational communication services.

Communications Wide Area Network Deployment:

Evoenergy has a program to roll out a Multiprotocol Label Switching (MPLS) based Wide Area Network (WAN) to corporate office and zone substation locations. The WAN utilises the fibre optic and microwave links. This will deliver the business requirement for a secure SCADA communication network for the effective operation of the electrical network. In addition the network provides network protection, substation VoIP telephones, security systems and corporate data access.

The MPLS telecommunications upgrade program provides communications to all zone substations in the Evoenergy transmission network, and as of the end of 2018 is largely complete. This provides a communications system that is owned and operated by Evoenergy and is independent of 3rd party networks. It provides reliable communications even when other networks are affected by outages or during emergency events such as bushfires.

Other telecommunications upgrade programs include:

- Replacement of aging copper pilot cables with Optical Fibre cables. Pilot cables are used for 11 kV feeder protection and SCADA communications. This is necessary for providing safety and reliability in the 11 kV network.
- Progressive replacement of radio equipment in the SCADA Digital Data Radio Network (DDRN). This program will replace SCADA data radios as they reach the end of their serviceable life.

Figures 6.1 and 6.2 depict the proposed communications network program.

Figure 6.1 Fibre Optic Network – Northern ACT

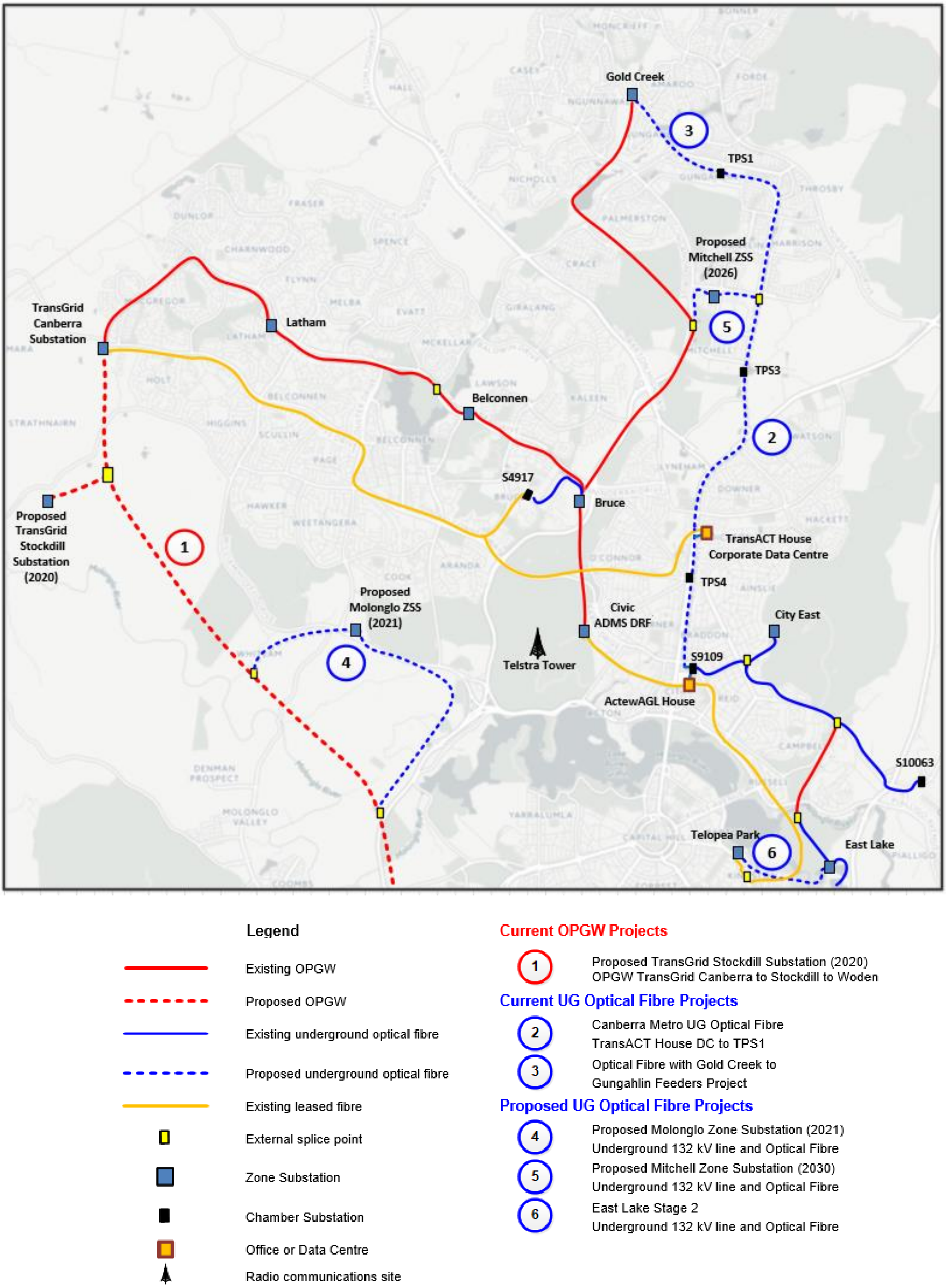
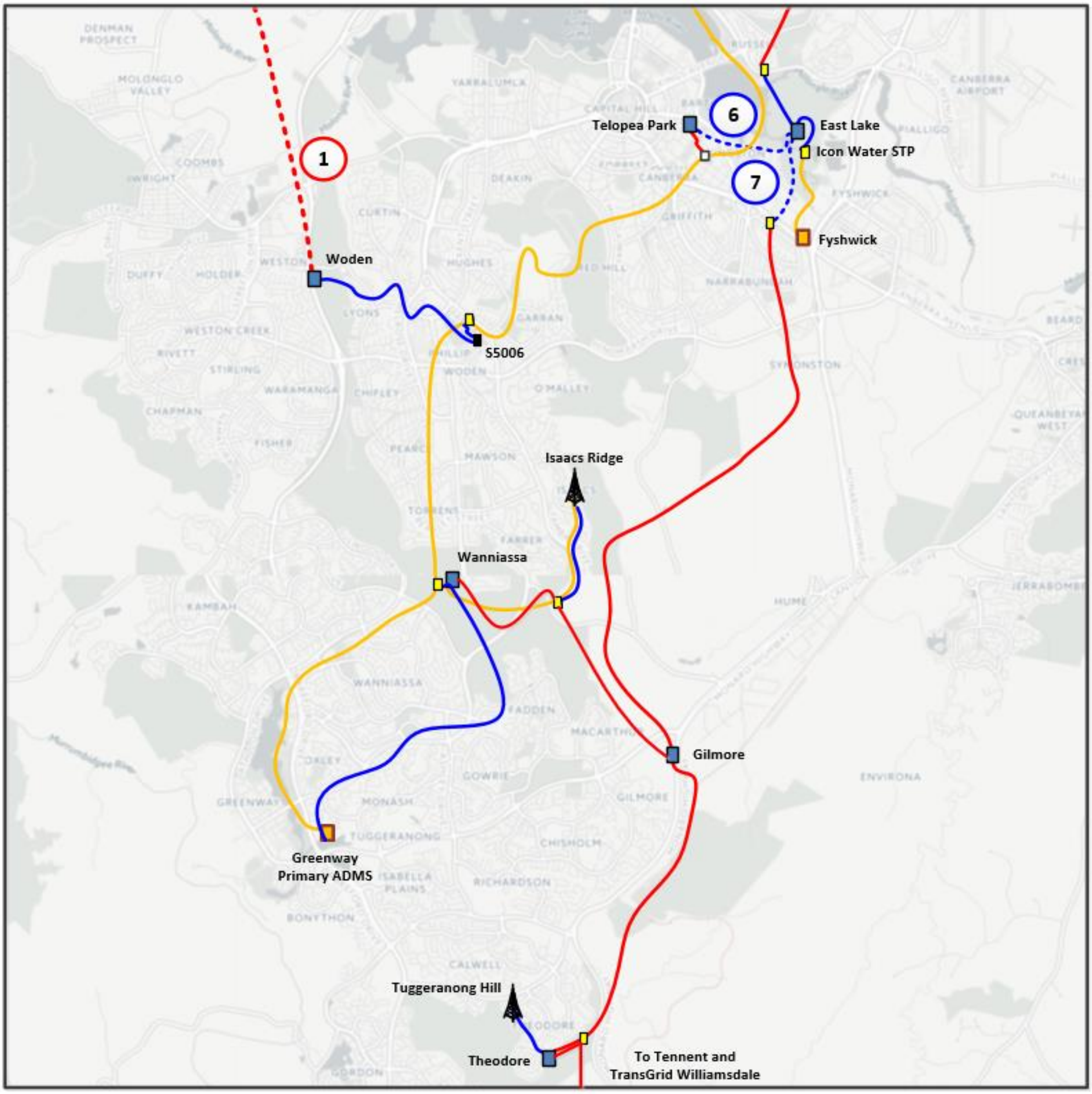


Figure 6.2 Fibre Optic Network – Southern ACT



Legend

- Existing OPGW
- Proposed OPGW
- Existing underground optical fibre
- Proposed underground optical fibre
- Existing leased fibre
- External splice point
- Zone Substation
- Chamber Substation
- Office or Data Centre
- Radio communications site

Current OPGW Projects

1 Proposed TransGrid Stockdill Substation (2020) OPGW TransGrid Canberra to Stockdill to Woden

Current UG / ADSS Optical Fibre Projects

7 UG / ADSS Dairy South Feeder to East Lake

Proposed UG Optical Fibre Projects

6 East Lake Stage 2 Underground 132 kV line and Optic Fibre

6.9 Vegetation Management

An amendment was made to the Utilities (Technical Regulation) Act 2014 via the Utilities (Technical Regulation) Amendment Bill 2017, which became effective on 1 July 2018. This amendment transferred the responsibility for vegetation management from Transport Canberra and City Services (TCCS) to Evoenergy, and the responsibility for inspections of privately owned electrical infrastructure outside the network boundary to Evoenergy.

Vegetation coming into contact with overhead power lines can cause transient or permanent disruption to supply. Transient faults are usually caused by short-term contact of vegetation with conductors and are normally cleared by the actions of automatic reclosers.

Evoenergy is also trialling the deployment of Intellirupters as an alternative to traditional reclosers to reduce the potential for bushfires resulting from recloser action. Refer to Section 9.13 for a description of Intellirupters.

To gain an accurate assessment of vegetation encroaching the transmission and distribution networks, Evoenergy has undertaken a Lidar survey of its entire network. Refer to Section 9.12 for a description of Lidar.

7. System Planning

7.1. Introduction

System planning studies are undertaken to assess the adequacy of the transmission and distribution network to meet current and forecast demands whilst meeting the quality of supply criteria stipulated in the NER. The key performance criteria that are addressed are: thermal overloading, power quality, supply security, and supply reliability. The studies have been conducted using Evoenergy's 2018 medium growth, 50 per cent POE demand forecast.

System planning is the process of investigating present and future system capability, optimising and fully utilising the existing system, and identifying, evaluating and initiating system upgrade requirements where required and where economically justified to do so. Long term system planning is necessary to ensure that security of the power system is maintained and that capacity is available to meet the future needs of our customers.

Maintaining the security of the power system requires the safe scheduling, operation and control of the power system on a continuous basis within system standard and technical limitations. A disturbance occurs when the power system unexpectedly incurs a change in supply, demand, connectivity, frequency or voltage level. Such disturbances can be the result of external incidents such as a line tripping due to a storm, or internal influences such as equipment failure. A disturbance that is considered to be reasonably possible under normal operating conditions is classified as a credible contingency, while low probability events are classified as non-credible.

System upgrades are driven by the need to maintain system reliability, to provide capacity for demand growth, and to relieve current or future system constraints.

The planning process is set out in the NER, and involves consultation with the public on any proposed upgrade requirements and the proposed options to address those requirements. The NER specifies the method for selecting the preferred option to addressing an issue from the feasible alternatives, which must include non-network options.

This chapter describes existing and emerging constraints on the Evoenergy network that have been identified to occur over the next ten years. It describes those issues that are proposed to be addressed over the next five-year planning period, and discusses options identified and proposed solutions. Opportunities for non-network solutions such as demand side management or embedded generation support required to defer the emerging issues are identified.

Details of system performance are included in Chapter 4. Details of demand forecasts are included in Chapter 5 and Appendices B and C.

Evoenergy's network is a meshed 132 kV transmission and meshed 11 kV distribution system, with the exception of Fyshwick Zone Substation which is supplied radially at 66 kV from TransGrid's Queanbeyan Substation. There are also two radial 22 kV feeders emanating from Woden Zone Substation, feeding Cotter and Tidbinbilla.

Figure 3.1 shows the transmission network and location of zone substations and switching stations geographically, and Figure 3.2 shows this information schematically.

7.2 Strategic Planning

Evoenergy's strategic planning focus is to develop and operate the transmission and distribution networks to effectively and efficiently cater for emerging technologies such as micro grids, embedded generation, smart networks, smart metering, electric vehicles, battery storage, hydrogen electrolysis, hydronic and vacuum waste services, dynamic ratings for transmission lines and power transformers; and identify any opportunities for stakeholder input. Our customers are embracing new technologies and increasingly taking control of their own energy generation, storage and usage. Power flows are becoming two-way based on generation and demand patterns, and Evoenergy is evolving from a traditional Distribution Network System Provider (DNSP) to a Distribution Services Operator (DSO).

The impact of our changing operating environment, influenced by factors such as the ACT Government's target that all energy consumed in the ACT by 2020 is generated from renewable sources, and the ACT Government's target to achieve net zero carbon emissions in the Territory by 2050, are key drivers in determining future investment in the generation, transmission, distribution and demand-side management sectors.

Rooftop solar PV are being incentivised by developers of large residential estates, and it is likely that battery energy storage and home energy management systems will be incentivised in the near future. Production of bio-gas from waste vegetation material is forecast to increase over the next few years. The extent that customers generate and store energy both for their own use and export, will have a major impact on the topology and dynamic control of the distribution network. These factors will influence future transmission and distribution infrastructure development and operation.

The ACT's climate provides for future extensive solar power generation, though is not conducive to generation from other sources such as hydro and wind. The effectiveness of future battery energy storage systems coupled with solar PV generation and the use of natural gas as an energy source, will have a major impact on Evoenergy's future network operations.

Many of Evoenergy's distribution assets are approaching the end of their economic life and strategies will be developed regarding their replacement. Such assets include urban backyard overhead low voltage lines. With increasing in-fill housing developments, these backyard lines are becoming increasingly difficult to access and maintain. The long-term strategy plan will provide strategic direction for the efficient utilisation of existing assets and future development of Evoenergy's transmission and distribution networks, to ensure a long-term sustainable and reliable electricity supply to the ACT.

7.3. Joint Planning with TransGrid

Evoenergy and TransGrid hold joint planning meetings bi-annually. The joint planning process ensures that the most economic solutions to issues are implemented, whether they are a network or non-network option, transmission or distribution option. The joint planning process covers:

- Evaluation of relevant limitations of both networks and progression of joint planning activities to address these limitations.
- Demand and energy forecasts.
- Non-network development proposals.
- Long term transmission and distribution developments.
- Annual planning reports.
- Public consultation and presentations to community groups.

Major projects are discussed such as TransGrid's proposed Stockdill Drive 330/132 kV bulk supply point substation as required for the second point of bulk supply to the ACT (refer sections 7.5.1 and 7.7). Regular project development meetings and exchanges of information (e.g. design drawings) are exchanged as such projects progress, and construction works are carried out in a coordinated manner.

Evoenergy and TransGrid also have regular discussions in addition to the formal joint planning meetings, to discuss and resolve technical issues. In October a joint training exercise was held between Evoenergy and TransGrid system controllers to simulate the actions required to be taken by both parties in the event of a major system contingency, such as a total outage of Canberra Substation.

TransGrid proposes to carry out replacement of some of its aging major assets at Canberra Substation, including the retirement of two 330/132 kV single phase transformer banks. Evoenergy will liaise closely with TransGrid throughout the implementation of this project to ensure continuity and security of supply to the ACT is maintained. Refer to TransGrid's Transmission Annual Planning Report 2018[8].

7.4 Inter-Regional Impact of Projects & Relevant National Transmission Flow Path developments

National Transmission Flow Paths (NTFPs) are those portions of transmission networks used to transport large amounts of electricity between generation and load centres. These are generally transmission lines of nominal voltage 220 kV and above. The Australian Energy Market Operator (AEMO) published an Integrated System Plan[9] (ISP) in July 2018. The ISP is a cost-based engineering optimisation plan that forecasts the overall transmission system requirements for the National Electricity Market (NEM) over the next 20 years.

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[8] https://www.transgrid.com.au/news-views/publications/Documents/Transmission%20Annual%20Planning%20Report%202018%20TransGrid.pdf

[9] http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2018/Integrated-System-Plan-2018_final.pdf

Evoenergy has no network infrastructure above 132 kV operating voltage.

The ISP discusses the integration of renewable generation and emerging technologies to the transmission grid, and the trend of expenditure to replacing ageing infrastructure outweighing investment in new network capacity. Ancillary services such as Network Support and Control Ancillary Services (NSCAS) and Frequency Control Ancillary Services (FCAS) are not regarded as an issue for Evoenergy due to the relatively small size of our network compared with other networks in the NEM, and the relatively small percentage of embedded generation connected to our network.

The ISP forecasts significant growth of renewable energy generation throughout the NEM, in particular solar and wind powered generation. Residential rooftop PV generation growth is projected to continue and be complemented by growth in residential battery storage systems, home energy management systems, and smart appliances.

The ACT lacks consistent wind resource but has long hours of sunshine throughout the year, so growth in solar farms and rooftop solar PV generation is predicted to continue. New rooftop solar PV systems are being subsidised by the ACT Government to encourage their uptake. It is also predicted that there will be significant increase in residential battery storage systems as prices continue to fall and battery technology improves.

None of the proposed projects described in this chapter will have a material inter-regional impact, ie they will not impose power transfer constraints or adversely influence the quality of supply to adjoining transmission or distribution networks.

7.5 Embedded generation

Generators connected directly to Evoenergy's distribution network rather than through the transmission network are called Embedded Generators (EGs).

There are a number of different types of embedded generator connected to our network as follows:

- Solar Photovoltaic
- Bio-gas (from land fill sites)
- Micro Hydro
- Cogeneration

Capacities of these EGs vary from domestic solar PV systems of typically 1-3 kW to a 20 MW solar PV farm. The total installed capacity of embedded generation is approximately 139 MW. Of this 84.2 MW is small-scale rooftop solar PV (refer Appendix E) and the remainder is a mixture of solar, hydro, gas and co-generation.

The process for connecting an Embedded Generator to Evoenergy's network depends mainly on its capacity. Capacity is divided into three categories: micro, medium and large. Table 7.1 lists the categories, capacities and network connection points that apply to each.

Table 7.1: Embedded Generator Network Connection Points

<table>
<tr><th>Category</th><th>Capacity</th><th>Network Connection Point</th><th>Type of Generator</th></tr>
<tr><td>Micro</td><td>Less than 30 kW</td><td>230 V ~ 400 V – Low Voltage Network</td><td>Solar PV
Micro Wind (Future)
Micro Gas (Future)</td></tr>
<tr><td>Medium</td><td>30 kW – 200 kW</td><td rowspan="2">400 V – Low Voltage Network</td><td rowspan="4">Any</td></tr>
<tr><td rowspan="3">Large</td><td>200 kW – 1500 kW</td></tr>
<tr><td>1500 kW – 5000 kW</td><td rowspan="2">11 kV to 132 kV High Voltage Network</td></tr>
<tr><td>> 5000 kW</td></tr>
</table>

Large scale embedded generators connected to Evoenergy's network are required to be scheduled in accordance with AEMO's operating rules as intermittent generators whereas smaller PV units are not required to be registered as they have either automatic or small generation exemption.

Evoenergy has developed technical guidelines and business processes to facilitate the connection of embedded generators. The published charges improve the clarity and transparency of requirements for embedded generators. Details are available on Evoenergy's external website[10].

The ACT Government has mandated that the ACT will be supplied by 100% renewable energy by 2020. This rules out any standby, back-up or peak shaving generation fuelled by non-renewable sources such as natural gas, diesel, compressed natural gas, liquefied petroleum gas, oil or coal. The ACT Government has also set a target for the ACT to be carbon-neutral by 2050. Other than solar PV generation there is little potential for other renewable energy generation within the ACT such as wind power, hydro power or bio-gas fuelled generation.

7.5.1 Solar Photovoltaic Generation

There are three large scale and one medium scale solar embedded generation installations connected to the Evoenergy network:

- PRV Solar Farm, Royalla, has a peak output capacity of 20 MW and is connected to Theodore Zone Substation via two dedicated 11 kV feeders.
- Mugga Lane Solar Park, Hume, has a peak output capacity of 12.85 MW and is connected to Gilmore Zone Substation via a dedicated 11 kV feeder.
- Williamsdale Solar Farm, Williamsdale, has a peak output capacity of 10.6 MW and is connected to Tennent Zone Substation via a dedicated 11 kV feeder.
- Mount Majura Solar farm, Mount Majura, has a peak output capacity of 3.6 MW and is connected to City East and East Lake zone substations via two shared 11 kV feeders.

Potential solar generation projects include:

- Solar Farm at Environa with a design output of 7 MW.
- Solar Farm at Symonston with a design output of 20 MW.
- Solar Farm at Wallaroo with a design output of 55 MW.
- Solar Farm at Stromlo with a design output of 10 MW.
- 2 MW solar generation installation proposed to be constructed at the Belconnen Waste Transfer Station.
- 2 MW solar generation installation proposed to be constructed at the Lower Molonglo Water Quality Control Centre.

There are 21,695 small-scale rooftop PV generation installations (as at 31 October 2018) of average size 3.9 kW connected to the low voltage 400 V system. Several rooftop solar PV installations are in the range 20-200 kW, typically on the roofs of commercial or industrial buildings. These installations are spread all over the ACT (for distribution by zone substation and feeder, refer to Appendix E). Total installed capacity of rooftop PV generation is 84.2 MW

Most of the generation produced by rooftop PV installations is used by the customers at their premises, although some is exported into Evoenergy's low voltage distribution network. As these installations are widely distributed on the network, Evoenergy has thus far experienced limited technical issues only such as excessive voltage rise, thermal overload of low voltage feeders, harmonic saturation, or load balancing issues on 11 kV distribution feeders.

The developers of several new residential developments in the ACT are mandating that rooftop solar PV generation be installed on all detached dwellings. This low voltage inverter based generation can contribute to higher voltages being seen on some parts of the low voltage network. Evoenergy has reviewed its connection standards regarding the maximum export voltages allowable from such inverters (refer Section 4.8.8).

Reliability of solar PV generation is inherently high as the equipment is primarily electronics based with no moving parts, compared with other forms of generation such as hydro or thermal. PV generation is unpredictable due to intermittent cloud cover. It is difficult to forecast availability and output accurately although research is being undertaken to correlate weather forecast information more closely with solar generation to provide a degree of forecasting capability in real time.

[10] https://www.evoenergy.com.au/emerging-technology/embedded-generation

7.5.2 Power Quality Issues Associated with Embedded Generation

Maintaining the supply-demand balance of the network will become more challenging as synchronous generation is replaced with asynchronous wind, large-scale PV and rooftop PV generation (possibly combined with battery storage) which are subject to intermittency as wind strength fluctuates and passing clouds affect solar generation. It will be particularly difficult at times when demand is low and renewable generation is high and it is conceivable that the network could become a net importer of energy in certain areas in the future, such as residential areas will 100% penetration of rooftop PV and battery storage. The challenges relate to how the system behaves during disturbances, and how much generation can be dispatched in order to match supply and demand.

Large-scale solar PV generation has a lower capacity factor (average power generated divided by rated peak power) than other forms of generation, and can be intermittent and difficult to forecast. The same applies to small-scale rooftop PV. Consecutive days of rain or cloud cover will significantly reduce PV output, so the network cannot rely on such generation and must be capable of operating without it.

Power quality issues that could result from an increase in asynchronous generation include voltage stability, frequency stability due to a lack of system inertia, and low fault levels which would impact on protection schemes and system strength.

Synchronous generators such as the Snowy Hydro scheme generators, produce power through directly connected alternating current machines, rotating at a speed synchronised to power system frequency. These generators produce inertia, which lessens the impact of changes in power system frequency following a disturbance such as loss of a generator or transmission line, resulting in a more stable system. Power systems with low inertia experience faster changes in system frequency following a disturbance, which could lead to system instability and under frequency load shedding. Asynchronous generators such as wind turbines and solar PV generators are connected to the power system via power electronic inverters. These generators contribute little inertia to the system unless coupled with a fly-wheel or similar.

Synchronous generators provide dynamic voltage support to the power system, particularly during and immediately following system faults. Synchronous generators provide considerably more fault current to the power system than asynchronous generators. Fault current helps maintain voltage stability during network faults. The replacement of synchronous generation with asynchronous generation reduces the fault current and can lead to a “weak” system. This can cause the following issues:

- DC/AC inverters not remaining operational through network faults, tripping off and requiring resetting to reconnect their generation. This is commonly known as ‘fault ride-through’ capability.
- Inability to achieve steady-state stability during system normal.
- Protection schemes unable to distinguish between system normal load current and fault current leading to an inability to detect and clear faults on the system.
- Slow rate of recovery following network faults.

Access to real time information of equipment connected beyond-the-meter such as rooftop PV generation, battery storage, and EV charging, will also become increasingly important in order to maintain power system stability and security

7.5.2.1 Voltage Stability

Synchronous generators provide considerable fault current to the network which helps maintain voltage stability during and immediately following network faults. Asynchronous generators provide much less fault current. This could lead to voltage instability during network faults. Most wind and large-scale PV generators in areas with poor voltage stability will struggle to remain connected to the network during network faults, and their power output may need to be restricted to manage this risk. Increasing rooftop PV could eventually cause high voltage issues on the distribution network so output from DC/AC inverters will need to be strictly adhered to.

Evoenergy's distribution network has been designed and constructed to allow for voltage drop from power flow through the high voltage network to the end of the low voltage network. With increasing connections of rooftop solar PV to the low voltage network, at times of low load and high generation, power flows in the reverse direction from the low voltage network to the high voltage network. This reverse power flow can cause voltage rise on the distribution network which has to be managed to keep voltage within regulatory limits, ie 230 V +10% / -6% at customer points of connection. High voltage may affect or damage connected appliances or electronic equipment.

High concentration of rooftop solar PV generation systems in one locality causes voltage variability at the local level, potentially degrading power supply and impacting the operation and lifespan of electrical appliances. The developer of the new Denman Prospect suburb in the Molonglo Valley has incentivised the installation of rooftop PV systems on all new detached dwellings. To maintain low voltage levels within regulatory limits, Evoenergy is planning to trial the installation of distribution transformers equipped with on-line tap changers (OLTC). Such OLTC transformers are used widely in Europe in areas of concentrated rooftop PV.

Ginninderry Estate is another large residential development where the developer has incentivised rooftop PV systems (ranging in size from 2 – 5 kW). Installation of OLTC distribution transformers has been proposed to mitigate this.

7.5.2.2 Frequency Stability

Traditional synchronous generators (rotating plant) have inertia which can support system frequency following a system disturbance such as loss of a transmission line or large generator. Asynchronous generators such as wind turbines and solar PV have little or no inertia, so a fast change to system frequency could result from a fault (sudden loss of generator or transmission line) which could lead to under-frequency load shedding on the distribution network. As the amount of non-scheduled embedded generation in the ACT increases, Evoenergy's network could become reliant on frequency controlled ancillary services (FCAS) provided by other regions to maintain frequency stability and the supply-demand balance.

Frequency control services in future will need to be sourced increasingly from non-traditional sources such as battery storage systems, demand-based resources, and renewable generation.

7.5.3 Hydro-electric

There is an existing micro-hydro generator connected to the Evoenergy network, the Stromlo micro-hydro which has a peak output capacity of 700 kW. This is connected to Woden Zone Substation via a shared 22 kV feeder.

7.5.4 Gas

There are two existing bio-gas fuelled generators connected to the Evoenergy network:

Mugga Lane Waste Transfer Station 4 MW. This is connected to Gilmore Zone Substation via a shared 11 kV feeder.

Belconnen Waste Transfer Station 3 MW. This is connected to Latham Zone Substation via a shared 11 kV feeder.

7.5.5 Co-generation

There are two existing gas fuelled so-generators connected to the Evoenergy network:

There is one gas fuelled co-generation plant at Harman rated at 1.2 MW. This is connected to Gilmore Zone Substation via a dedicated 11 kV feeder.

There is one gas fuelled co-generation plant at Canberra Airport rated at 1.4 MW. This is connected to Fyshwick Zone Substation via a shared 11 kV feeder.

7.6 Emerging Needs

Customer-initiated load growth is steady in the ACT, with approximately 7,000 new customer connections during the past twelve months. New developments are primarily residential greenfield estates, urban renewal housing (replacement of old single storey dwellings with multi-storey apartment buildings), community developments such as schools, commercial developments such as shopping centres and data centres, and infrastructure developments such as the Canberra light rail project. System maximum demand is expected to remain at its current level over the planning period due to the increasing effects of embedded generation, energy storage, and energy efficient appliances. This will result in decreasing investment in network augmentations and increasing investment in asset replacements.

Accurate demand forecasting is essential to the planning and development of Evoenergy's distribution network. Evoenergy uses the same demand forecasting model as AEMO. Demand forecasts are calculated at the whole of system level, at each zone substation, and at each distribution feeder for the forward planning period. These forecasts are used to identify emerging network limitations and identify network risks that need to be addressed by either network or non-network solutions. The forecasts are then used as an input to the timing and scope of capital expenditure, or the timing required for demand reduction strategies to be established, or risk management plans to be put in place.

Evoenergy has analysed existing and emerging needs on its network using the Advanced Distribution Management System (ADMS). Such needs are met firstly by utilising available spare capacity within the network, e.g. by transferring load between feeders or between zone substations whilst ensuring all security and reliability criteria are maintained. Analysis is conducted on feeder tie points to determine the feeder capacity available to support loads of adjacent feeders during contingency events.

Section 7.7 describes network developments with a capital cost in excess of $2 million proposed to be carried out over the five-year planning period to meet emerging needs.

7.7 Proposed Network Developments

Proposed developments have been identified through the planning process for the forward ten-year planning period. Load forecasts and new major customer connection requests have been the inputs for the maximum demand forecasting. Because of the relatively small geographic area of the electricity network within the ACT, it is not broken down into separate regions for planning purposes. The full geographic extent of the network is shown in Fig. 3.1. Figure 7.1 shows a schematic diagram of the existing ACT transmission network.

Figure 7.1 Existing Transmission Network

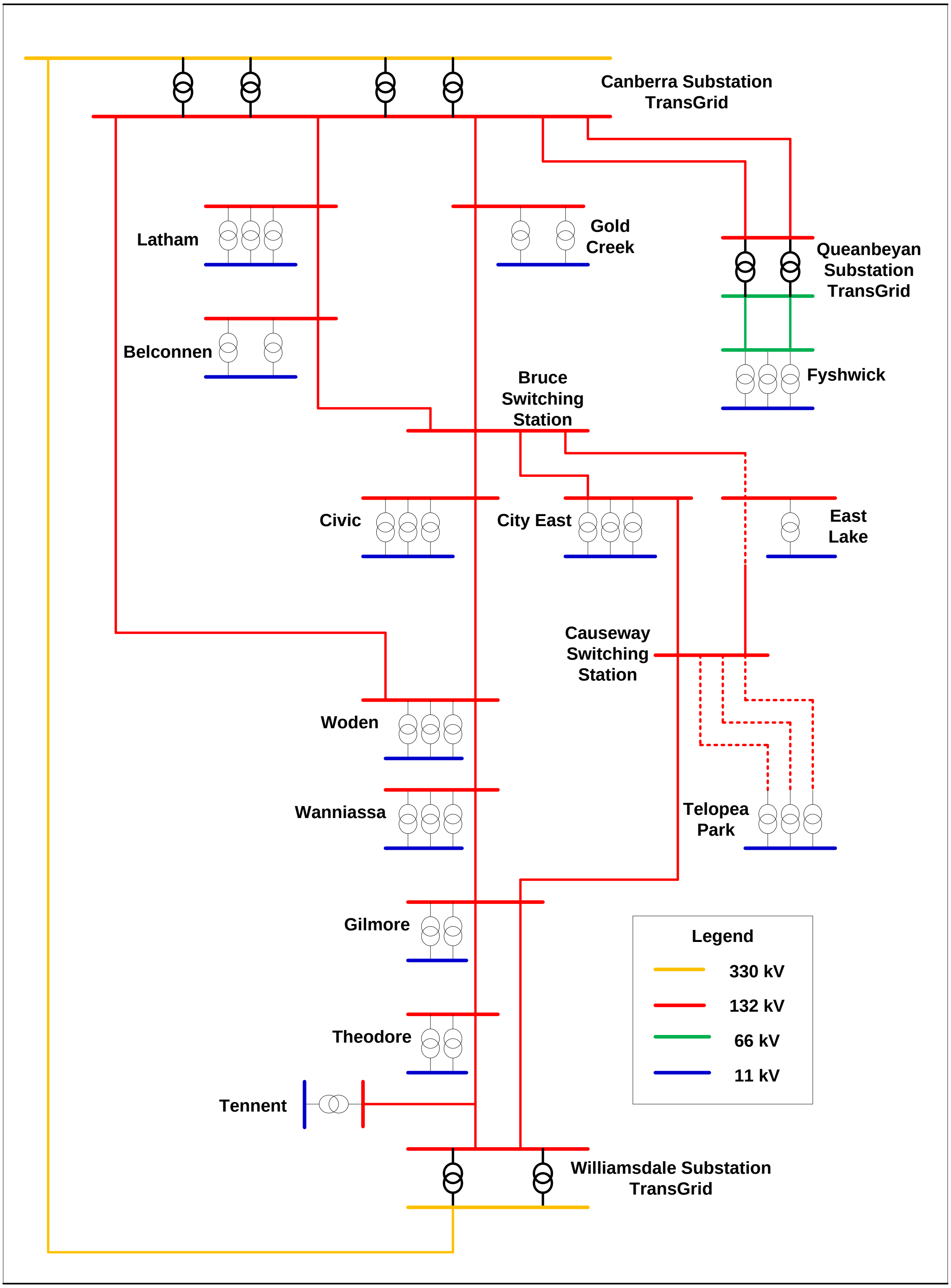


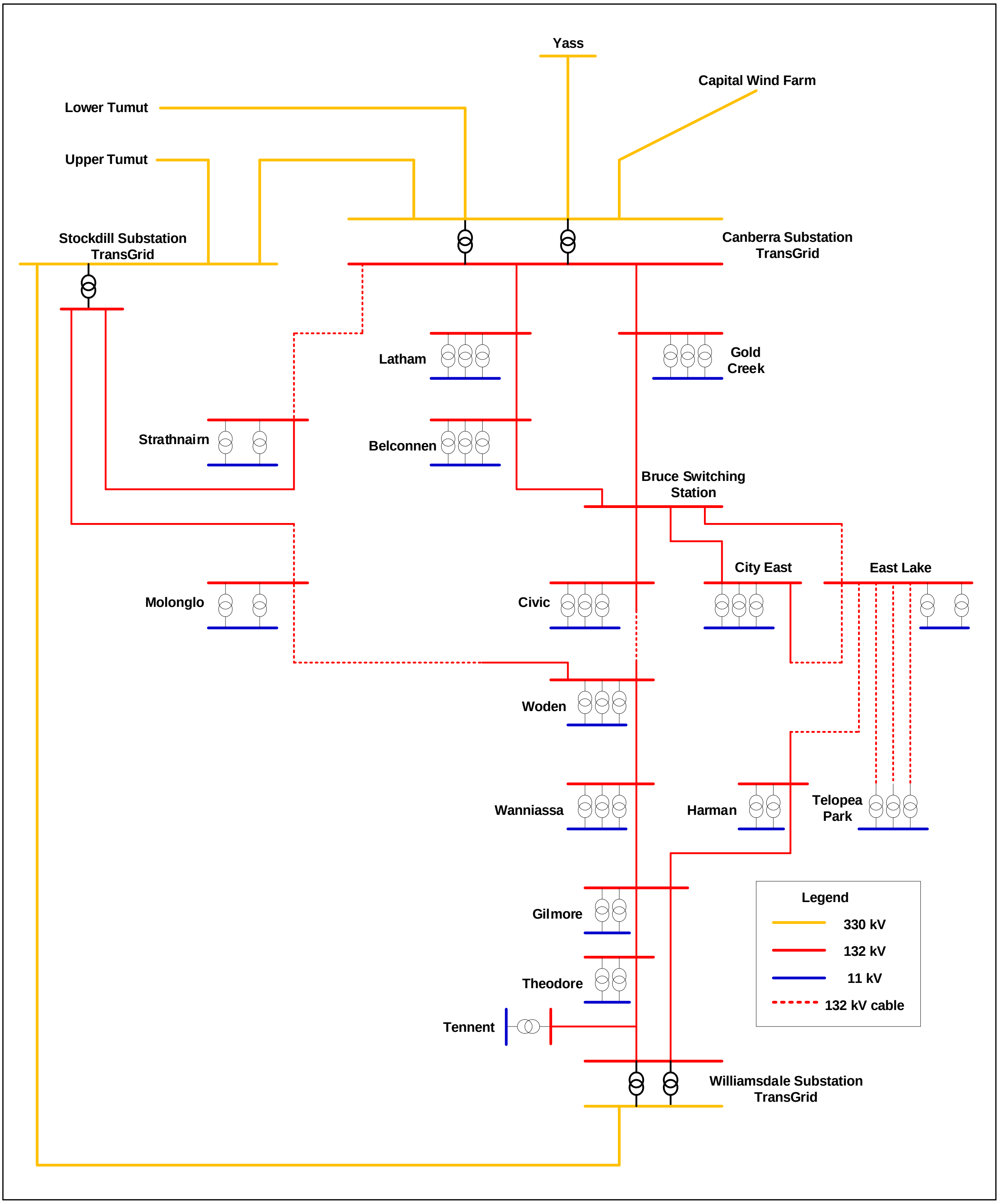
Table 7.2 presents future proposed major developments that are programmed to commence during the five-year planning period, and the timing of their completion. These projects are described in the following sections.

Table 7.2: Proposed Major Network Developments

Asset Type	Proposed Development	Estimated Start	Estimated Completion	Estimated Cost
TransGrid – Evoenergy Bulk Supply Point	Stockdill Substation 330/132 kV	2019	2020	NA
Transmission System	Construct 132 kV transmission line from Stockdill Substation to Canberra–Woden line.	2019	2020	$7.15 m
Zone Substation	East Lake Zone Substation second transformer and 11 kV switchboard	2018	2019	$4.16 m
	Molonglo Zone Substation Stage 1	2019	2021	$8.34 m
	11 kV 10 MVAR capacitor banks at Latham, Gold Creek, Belconnen and Molonglo zone substations	2020	2022	$2.21 m
	Decommission Fyshwick Zone Substation 66 kV assets	2022	2024	$5.46 m
Switching Station	Decommission Causeway 132 kV Switching Station	2019	2020	NA
Distribution System	Supply to Canberra CBD West	2018	2019	$2.77 m
	Supply to Canberra CBD Central	2019	2020	$1.28 m
	Supply to Strathnairn	2019	2019	$2.17 m
	Supply to Gungahlin Town Centre	2019	2020	$3.46 m
	Supply to Kingston	2019	2020	$0.46 m
	Supply to Tuggeranong Town Centre	2019	2020	$2.48 m
	Supply to Pialligo	2019	2020	$4.28 m
	Supply to Canberra North, Lyneham and Dickson	2020	2021	$7.90 m
	Supply to Griffith, Red Hill, Forrest and Narrabundah	2020	2021	$2.56 m
	Supply to Mitchell	2021	2022	$5.71 m
	Supply to Belconnen Town Centre	2022	2023	$3.27 m
	Molonglo Valley Feeders	2022	2025	$6.71 m
Secondary System	Installation of Optical Ground Wire (OPGW) on 132 kV transmission lines	2015	2019	$5.25 m
	SCADA communications upgrade, optic fibre to distribution substations	2015	2024	$4.28 m

Figure 7.2 shows future development of the transmission network over the next ten years.

Figure 7.2 Future (10 years) Transmission Network



7.7.1 Security of Bulk Supply to the ACT

The commissioning of TransGrid's Williamsdale 330/132 kV Substation in February 2013 introduced a second 132 kV bulk supply point into the ACT to address power system security requirements by providing two geographically independent 330 kV points of connection to the ACT network. Williamsdale Substation is linked to Evoenergy's network at Theodore and Gilmore 132 kV Zone Substations (refer Figure 7.1).

The latest version of the ACT Electricity Transmission Supply Code states:

TransGrid must plan, design, construct, test, commission, maintain, operate and manage its electricity transmission networks and geographically separate connection points that supply customers in the ACT and that will operate at 66 kV and above, whether or not those networks and connection points are in the ACT, to achieve the following:

(a) the provision of two or more geographically separate connection points operated at 132 kV and above to supply electricity to the ACT 132 kV network;

(b) at all times provide continuous electricity supply at maximum demand to the ACT 132 kV and 66 kV network throughout and following a single credible contingency event;

(c) until 31 December 2020, provide electricity supply at 30 MVA to the ACT 132 kV or 66 kV network within one hour following a single special contingency event and 375 MVA within 48 hours of this event; and

(d) from 31 December 2020, provide continuous electricity supply at 375 MVA to the ACT 132 kV network immediately following a single special contingency event and agreed maximum demand within 48 hours of this event.

To meet the above criteria TransGrid proposes:

Item (a) is met already by Canberra and Williamsdale 330/132 kV bulk supply point substations.

Item (b) is met already by Canberra and Williamsdale 330/132 kV, and Queanbeyan 132/66 kV bulk supply point substations, all of which have N-1 security.

Item (c) can be met by supplying 30 MVA via Queanbeyan 132/66 kV (to Fyshwick 66/11 kV Zone Substation) in the event of a special contingency event affecting Canberra Substation (and consequently affecting Williamsdale Substation also as Williamsdale is connected radially at 330 kV from Canberra). Queanbeyan Substation is normally supplied at 132 kV via Canberra Substation, but this supply can be switched to Yass Substation by TransGrid via remotely operated switches at Spring Flat Switching Station. The 375 MVA criteria within 48 hours requirement would be met by constructing a temporary 330 kV connection between the Upper Tumut–Canberra line and the Canberra–Williamsdale line, thus bypassing Canberra Substation.

To comply with Item (d) TransGrid proposes to construct a new 330/132 kV Substation at Stockdill Drive, West Belconnen. This will have one 375 MVA transformer. The Upper Tumut–Canberra 330 k line will be diverted to Stockdill (bypassing Canberra Substation). The Canberra–Williamsdale 330 kV line will be reconnected to Stockdill Substation to become the Stockdill-Williamsdale line. A new 330 kV line will be constructed from Stockdill to Canberra. Evoenergy will construct a new double circuit 132 kV line section from Stockdill to connect to the Canberra–Woden 132 kV line to form a Stockdill–Canberra circuit and a Stockdill–Woden circuit. This arrangement will provide the immediate 375 MVA back-up capability to the ACT in the event of a total loss of Canberra Substation.

Within one hour of a special contingency event affecting Canberra Substation, TransGrid proposes to reconnect Queanbeyan 132 kV from Yass Substation (via Spring Flat Switching Station) and within 48 hours to construct a temporary connection from the Yass 330 kV line to the Canberra–Latham 132 kV line and reconnect to Yass 132 kV bus. This would provide full load capacity to the ACT.

TransGrid proposes to retire two aged single-phase transformer banks at Canberra Substation.

Power systems analysis shows that under this development the originally proposed Theodore–Gilmore 132 kV line upgrade will not be required. However analysis shows that in the event of a total Canberra Substation outage, voltage levels in the northern part of Evoenergy's network would fall below regulation levels. In order for voltage levels to be maintained, Evoenergy has investigated the installation of reactive support equipment, with the most cost effective solution being the installation of an 11 kV 10 MVAr capacitor bank at each of

Evoenergy's northern zone substations as follows: Latham, Gold Creek, and Belconnen (by December 2020), Molonglo (by June 2022), and Strathnairn (by June 2040).

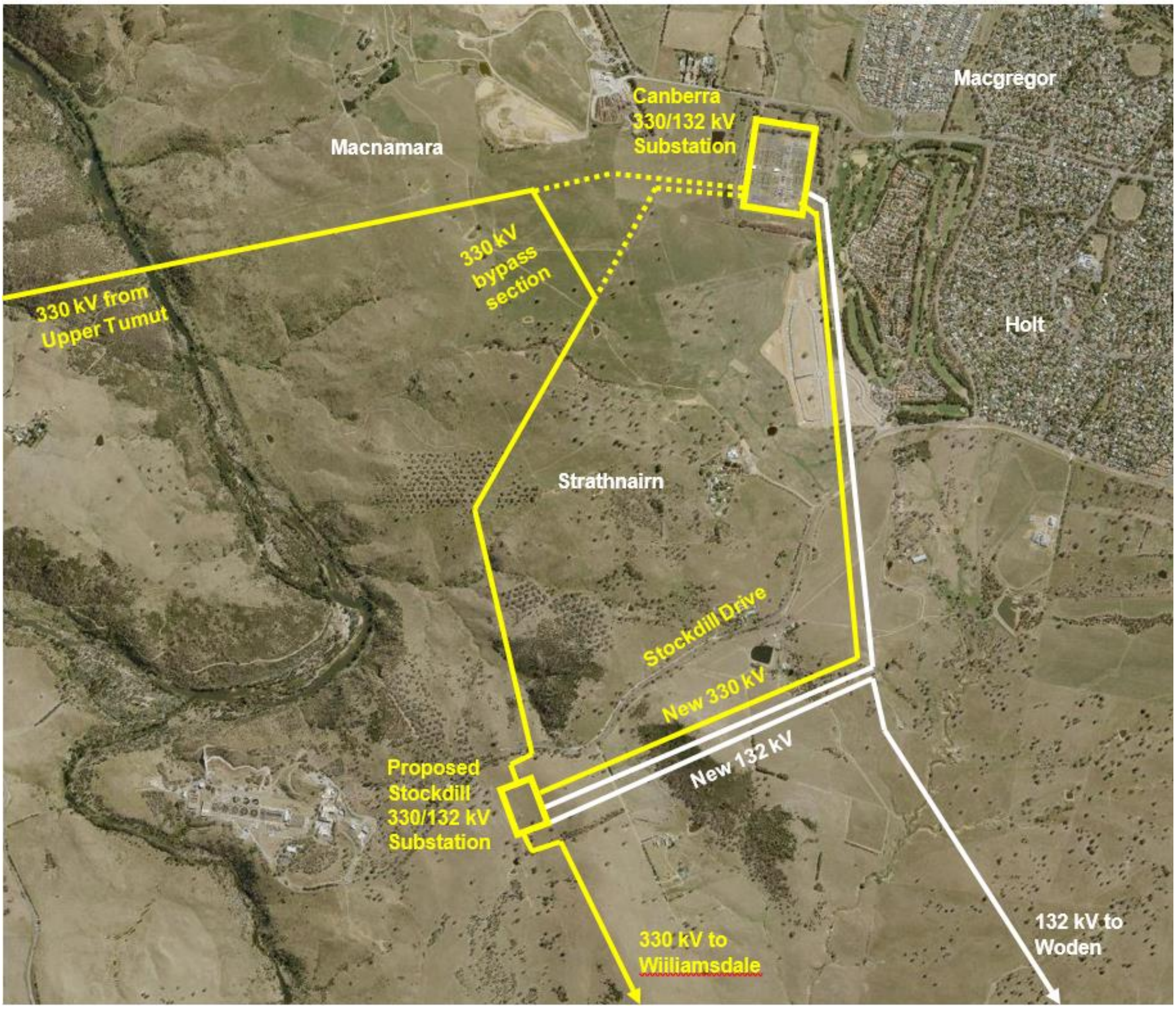
Other options investigated regarding reactive power support devices included a 132 kV 50 MVAr capacitor bank and a 132 kV 50 MVAr statcom. These options are both more expensive than 11 kV capacitor banks and would be used only in the event of a special contingency event affecting the whole of Canberra Substation. The 11 kV capacitors can be installed in stages and can be used continuously to improve 11 kV bus voltages and reduce MVA loads on zone substation transformers.

No non-network alternative to this project has been identified. Estimated cost of the Stockdill Substation to Canberra–Woden132 kV transmission line plus installation of OPGW on the Canberra–Stockdill–Woden line is $7.15 m and proposed project completion is by December 2020.

A joint Regulatory Investment Test for the Security of Supply project was completed by Evoenergy and TransGrid in 2009.

Figure 7.3 illustrates the scope of this project

Figure 7.3: Proposed Stockdill Substation and 132 kV line connection



In the interim period until completion of this project, in the event of a loss of Canberra Bulk Supply Substation, a contingency plan has been made by TransGrid which has constructed assets at its Yass and Canberra substations to deal with this eventuality.

Estimated cost of the 11 kV 10 MVAr capacitor banks is as follows:
Stage 1 – Latham, Gold Creek and Belconnen $1.64 m with proposed completion by December 2020.
Stage 2 – Molonglo $0.57 m with proposed completion by June 2022.
Stage 3 – Strathnairn $0.57 m with proposed completion by June 2040.

7.7.2 East Lake Zone Substation second transformer

East Lake Zone Substation was commissioned in 2013 with one 132/11 kV 30/55 MVA transformer and one 11 kV switchboard. Space and foundation pads have been provided in the switchyard for a further two transformers. Space and cable trenches have been provided in the control building for a further two 11 kV switchboards. The 132 kV switchgear at East Lake is indoor gas-insulated switchgear (GIS) and has an existing spare circuit breaker complete with secondary systems, designated for a second transformer.

The maximum demand at East Lake Zone Substation is currently approximately 18 MVA (winter) and 19 MVA (summer) and is forecast to increase steadily to 30 MVA over the next ten years as load grows in the Kingston, Pialligo, Majura and Fyshwick areas. This growth rate will be exceeded should some customer-initiated projects currently at enquiry/design stage, continue to be fully implemented. More 11 kV feeders will need to be installed and supplied from East Lake. Growth is being driven primarily by the commercial and industrial sectors in the Fyshwick area (eg data centres) and in the Kingston area (eg multi-storey residential apartment buildings).

The maximum demand at Telopea Park Zone Substation is increasing steadily towards its continuous rating of 100 MVA. It is desired to transfer some load from Telopea Park to East Lake.

The maximum demand at Fyshwick Zone Substation is currently approximately 23.5 MVA (winter) and 25.2 MVA (summer) and is forecast to exceed its continuous rating of 28 MVA by winter 2019. It is proposed to decommission the 66 kV assets at Fyshwick Zone Substation and convert it to an 11 kV switching station only, to be supplied by three high capacity express 11 kV feeders from East Lake (refer Section 7.5.4).

Should the sole transformer at East Lake fail, the contingency plan is to transfer its load to Telopea Park and Fyshwick via inter-connecting feeders. Beyond June 2019 it is forecast that there will be insufficient capacity in these inter-connecting feeders to enable full load transfer and this would result in unserved energy.

A second 132/11 kV 30/55 MVA transformer has been ordered and will be installed at East Lake Zone Substation by June 2019, where it will provide additional capacity and N-1 security. A neutral earthing transformer and a second 13-panel 11 kV switchboard have also been ordered and will be installed at East Lake Zone Substation, to provide connection points for proposed and future 11 kV feeders to supply the East Lake, Kingston, Pialligo, Majura and Fyshwick areas.

Estimated cost is $4.16 million and proposed project completion is by June 2019.

No non-network alternative to this project was identified.

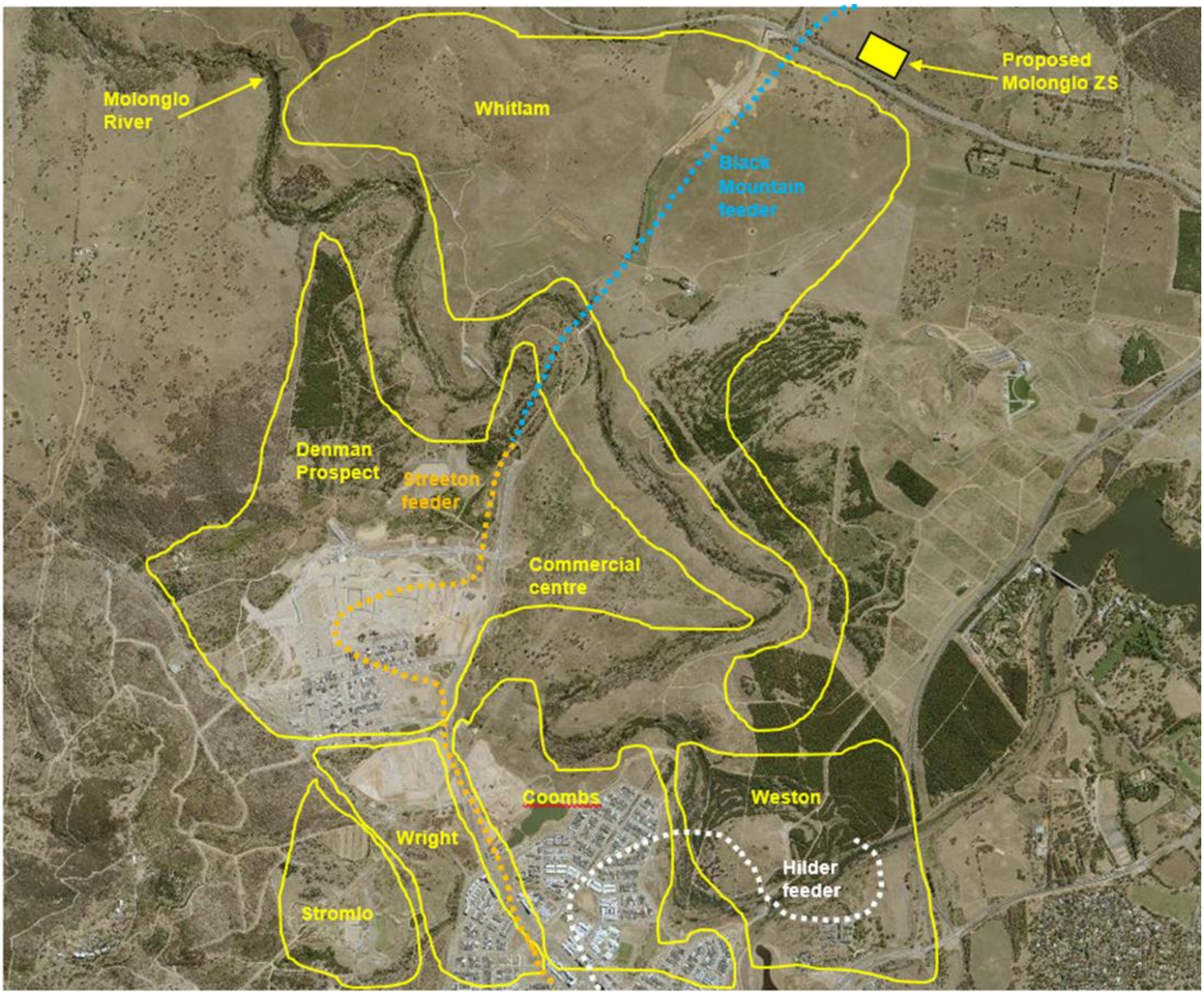
7.7.3 Molonglo Zone Substation

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 areas of Weston Creek and south of Belconnen. The area is being developed by the Suburban Land Agency as a residential district. Land servicing has commenced for the initial developments and when fully developed over the next 30 years, the Molonglo Valley District including the new suburbs of North Weston, Coombs, Wright, Denman Prospect and Whitlam will support an estimated 21,000 dwellings plus shopping centres, schools and community facilities, plus the proposed Stromlo Forest Park Aquatic Centre and Leisure Centre.

The first phase of development of the Molonglo Valley is underway, comprising Denman Prospect, Wright and Coombs suburbs. Supply is being provided to these developments through two extended 11 kV feeders from Woden Zone Substation and one extended 11 kV feeder from Civic Zone Substation. The first stage of the new Whitlam suburb is due to commence construction in 2019. Initial supply to Whitlam will be provided by the Black Mountain feeder from Civic Zone Substation.

Figure 7.4 shows the proposed areas of development of the Molonglo Valley and the routes of existing 11 kV feeders. It also shows the site of the proposed Molonglo Zone Substation.

Figure 7.4: Development of Molonglo Valley



Load forecasts indicate that these feeders will reach their capacity limits by mid-2021 as the load of new developments in the Molonglo Valley increases. The maximum demand in the Molonglo Valley is forecast to increase steadily to 50 MVA over the next 30 years. Evoenergy proposes to provide long-term capacity and security to the Molonglo Valley District by constructing a new 132/11 kV Molonglo Zone Substation at a site on the northern side of William Hovell Drive, east of Coulter Drive.

The *Electricity Distribution (Supply Standards) Code* 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.

The proposed Molonglo Zone Substation is required to meet the Electricity Distribution (Supply Standards) Code.

Evoenergy has considered four options to supply the Molonglo Valley District as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Do nothing – connect all loads to existing feeders and operate to their thermal ratings	N/A	Not preferred as does not meet need
2	Network	Construct new 11 kV cable feeders to Molonglo Valley from Latham and Civic zone substations	$36.68m	Not preferred
3	Non-network	Demand side management	N/A	Not preferred as does not meet need
4	Network	Construct new Molonglo Zone Substation	$22.51m	Preferred

Options 1 is discounted as the existing feeders do not have sufficient spare capacity to meet the forecast demand.

Option 2 is discounted due to its high capital cost and the limited availability of spare feeder circuit breakers at Latham and Civic zone substations.

Option 3 considers demand side management initiatives including demand reduction and alternative supply measures such as embedded generation. The majority of demand of these developments is residential dwellings. The developer of Denman Prospect has incentivised the installation of rooftop solar PV generation systems on all detached dwellings. This will reduce energy demand but would 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 demand usually occurs around 6:00pm throughout the months of July and August when there is no PV generation, so peak shaving would require the use of battery storage devices.

Stage 1B of Denman Prospect Estate includes 34 apartment buildings comprising 1888 units. North Wright and North Coombs developments also include 7 proposed apartment buildings. Installation of solar PV or battery energy storage is not common for apartment buildings so standard demand levels are expected for these units. Evoenergy has calculated After Diversity Maximum Demand (ADMD) of 2.5 kVA per unit for apartment buildings. There is also a recent trend towards the installation of instantaneous electric hot water systems in apartment buildings, which will potentially increase the ADMD per unit.

Other demand reduction measures such as on-site generation, co-generation and tri-generation[11] which are associated with commercial and industrial businesses will not be applicable in the immediate future and are therefore not considered further.

Option 4 proposes to establish a new 132/11 kV zone substation at Molonglo by winter 2021. The new Molonglo Zone Substation will be equipped initially with Evoenergy's 132/11kV 14 MVA mobile substation (previously installed at Angle Crossing). Stage 2 comprising installation of one 132/11 kV 30/55 MVA transformer and one 11 kV switchboard is proposed to be completed by the end of the 2025-26 financial year though this will depend on the actual rate of load growth. Stage 3 comprising installation of a second 132/11 kV 30/55 MVA transformer and second 11 kV switchboard is proposed to be completed by the end of the 2029-30 financial year though this will depend on the actual rate of load growth.

Ultimate maximum demand of Molonglo Zone Substation is forecast to reach 53 MW by 2046 based on a 30-year development plan for the Molonglo Valley. 132 kV connection will be via loop-in-loop-out to the Canberra–Woden 132 kV circuit.

This is the preferred option. Estimated cost is $22.51 million, comprising $8.34 m for Stage 1 (establishment of the substation site and installation of the mobile substation; $9.43 million for Stage 2 (installation of one transformer and switchboard) and $4.74 million for Stage 3 (installation of second transformer and switchboard). Proposed project completion is by June 2021 for Stage 1, June 2026 for Stage 2 and June 2030 for Stage 3.

The augmentation cost of this proposal exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in January 2019.

[11] 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.

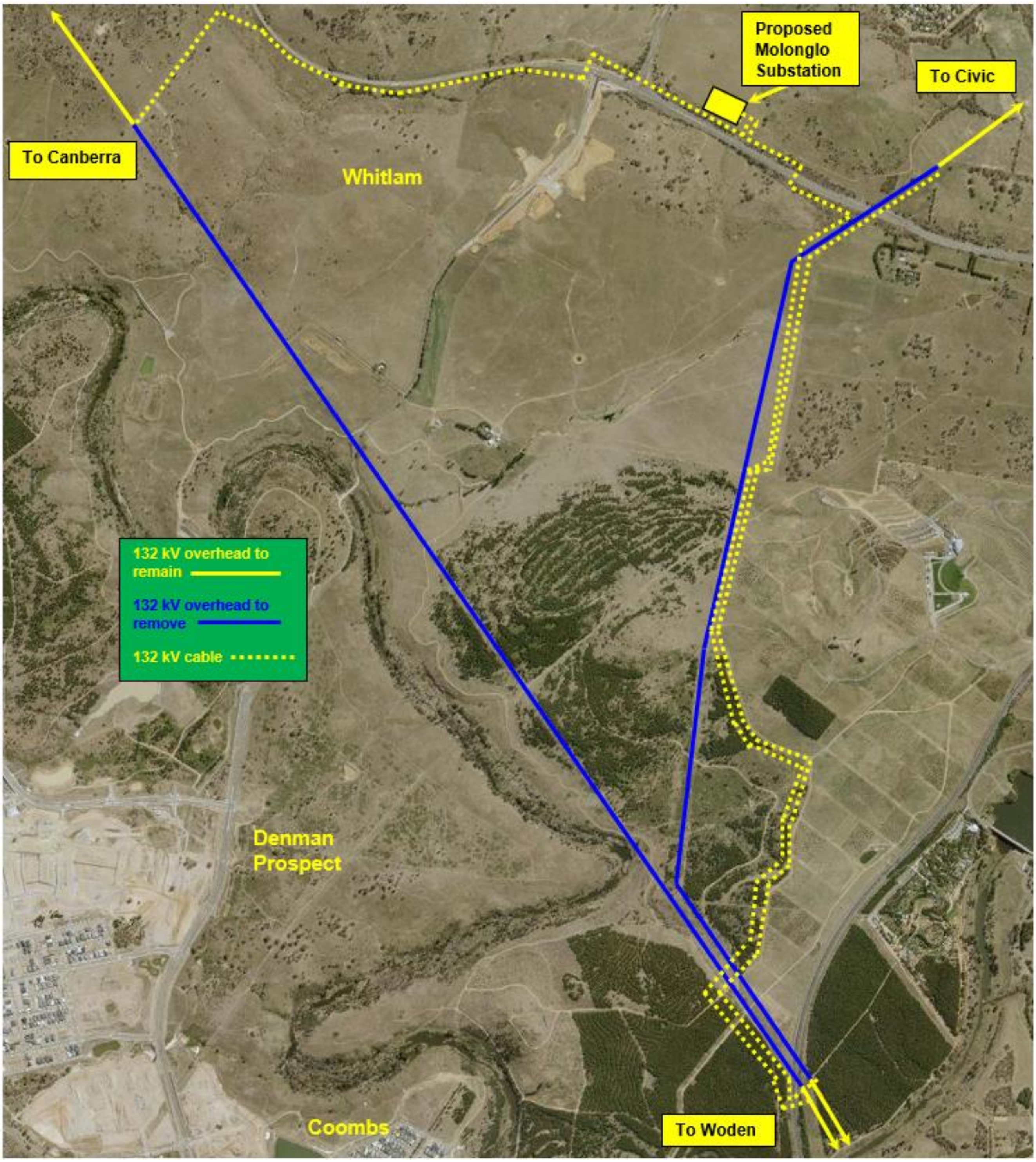
Viable proposals from third parties that can significantly reduce maximum demand of the Molonglo Valley developments and enable Evoenergy to defer construction of the Molonglo Zone Substation are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 4.5 MW in 2021, 9.2 MW in 2022, and 12.2 MW in 2023 and so on, to enable the Molonglo Zone Substation project to be deferred. This would be in addition to currently proposed rooftop PV installations on all detached dwellings.

As part of the proposed residential developments, the Suburban Land Agency has requested the replacement of sections of two Evoenergy 132 kV transmission lines that traverse the Molonglo Valley with underground cables. The underground cable sections will be approximately 9.1 km long on the Canberra–Woden line and 5.6 km long on of the Civic–Woden line. The undergrounding project will be carried out in two stages as follows:

- Stage 1: Canberra–Woden line section by mid-2020.
- Stage 2: Civic–Woden line section approximately 2030.

Figure 7.5 shows the site of the proposed Molonglo Zone Substation and associated undergrounding of 132 kV transmission lines (yellow dashed lines denote proposed underground cable sections).

Figure 7.5 Proposed development of Molonglo Valley



7.7.4 Decommissioning of Fyshwick Zone Substation 66 kV Assets

Fyshwick Zone Substation was constructed and commissioned in 1982. It was originally deemed to be a "temporary substation". It is supplied radially from TransGrid's Queanbeyan 132/66 kV Substation via two single circuit wooden pole 66 kV transmission lines. Fyshwick Zone Substation is the only zone substation on Evoenergy's network that comprises 66 kV assets with Evoenergy's other 12 zone substations all connected to Evoenergy's 132 kV meshed network.

Primary assets supplying and at Fyshwick Zone Substation are approaching the end of their economic lives. The two 66 kV transmission lines from Queanbeyan to Fyshwick (3.6 km) were constructed in 1982 with wooden poles and Lemon 30/7/3.00 ACSR/GZ conductor. Most of the 52 x 66 kV poles have been nailed and will require replacement within the next 5-10 years. The steel core of the ACSR conductor is expected to corrode over time so the Lemon conductor will also require replacement in the near future with AAC, AAAC or similar type conductor. The 66 kV circuit breakers at Fyshwick are ASEA type; four are 1971 vintage and one 1985. These are nearing the end of their economic lives and will require replacement within the next 5-10 years.

Secondary assets such as 66 kV protection relays are also approaching the end of their economic lives.

Approximately $5.7 million will need to be expended over the next 5-10 years to upgrade / replace these 66 kV assets.

One of the original drivers for the establishment of East Lake Zone Substation in 2013 was to transfer the Fyshwick load to East Lake to enable Fyshwick Zone Substation to be retired and the 66 kV assets decommissioned. This is still an Evoenergy strategic objective which is proposed to be achieved by installing some high capacity express 11 kV feeders (i.e. feeders with no intermediate loads) from East Lake to Fyshwick, and converting Fyshwick to an 11 kV switching station only. Cables proposed are 11 kV 3c/400mm^2 Cu XLPE and these would replace the existing transformer incomer cables at the three Fyshwick 11 kV switchgear groups. These express cables would be rated at approximately 10.5 MVA each continuous, providing 31.5 MVA maximum capacity to Fyshwick and 21 MVA firm capacity. Other feeders would be run from East Lake to the Fyshwick and Majura areas (under separate projects), to reduce the maximum demand on the Fyshwick 11 kV switchboard to less than 21 MVA.

The proposed cable route length from East Lake to Fyshwick is approximately 2.7 km. Three spare 150mm diameter PVC conduits exist from East Lake Zone Substation approximately 1.8 km towards Fyshwick. Thus only 900m would be required to be directional drilled and have conduits installed to Fyshwick Zone Substation.

Estimated cost is $5.46 million. Proposed project completion is by June 2024.

The augmentation cost of this proposal exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in July 2021.

Figure 7.6 illustrates the condition of existing assets at Fyshwick 66/11 kV Zone Substation.

Figure 7.6 Fyshwick Zone Substation: Outdoor wooden pole strung busbars. Indoor 66 kV electromechanical protection relays

7.7.5 Decommissioning of Causeway 132 kV Switching Station

Causeway Switching Station located in the Kingston suburb at the eastern end of Lake Burley-Griffin, provides a point of 132 kV interconnection between City East, East Lake, Telopea Park and Gilmore zone substations. Connections to Causeway Switching Station comprise three 132 kV underground cable circuits to Telopea Park Zone Substation, a single circuit 132 kV overhead line to Gilmore Zone Substation, a single circuit 132 kV overhead line to City East Zone Substation, and a single circuit 132 kV overhead line to East Lake Zone Substation. Sections of these latter two lines traverse the Jerrabomberra wetlands nature reserve.

The site of Causeway Switching Station is surrounded by new apartment buildings and there is a desire by the Suburban Land Agency (SLA) to redevelop the switching station site for similar residential purposes. The SLA has requested Evoenergy to convert the 132 kV overhead lines in the vicinity of Causeway to underground cables and decommission the switching station. The proposed scope of works is as follows:

- Install three 132 kV cable circuits comprising one single core cable per phase (each circuit 3 x 1c/630mm^2 Cu XLPE) from East Lake Zone Substation through the Jerrabomberra wetlands to Causeway Switching Station to through-joint to the existing Causeway–Telopea Park cable circuits. This route includes directional drilling under the Jerrabomberra Creek. This will create three 132 kV underground cable circuits all the way from East Lake to Telopea Park, each rated at 127 MVA. These existing circuits are currently transformer feeders as there is no 132 kV bus at Telopea Park Zone Substation. It is proposed to retain them as transformer feeders.

- The East Lake–Causeway 132 kV circuit is currently approx 1.4 km underground cable connected to approx 1.6 km overhead line. The cable section will be reconnected to the City East line and the overhead section demolished. This will create a new East Lake–City East 132 kV circuit rated at 220 MVA.

- The Causeway–Gilmore 132 kV circuit is currently all overhead. A 132 kV underground cable circuit comprising twin single core cables per phase (6 x 1c/1600mm^2 Cu XLPE) will be installed approx 2.9 km from East Lake Zone Substation to connect to the existing overhead line at a new three concrete pole UGOH structure to replace pole no T87 at the corner of Canberra Ave and Monaro Highway. This will create a new East Lake–Gilmore 132 kV circuit rated at 457 MVA.

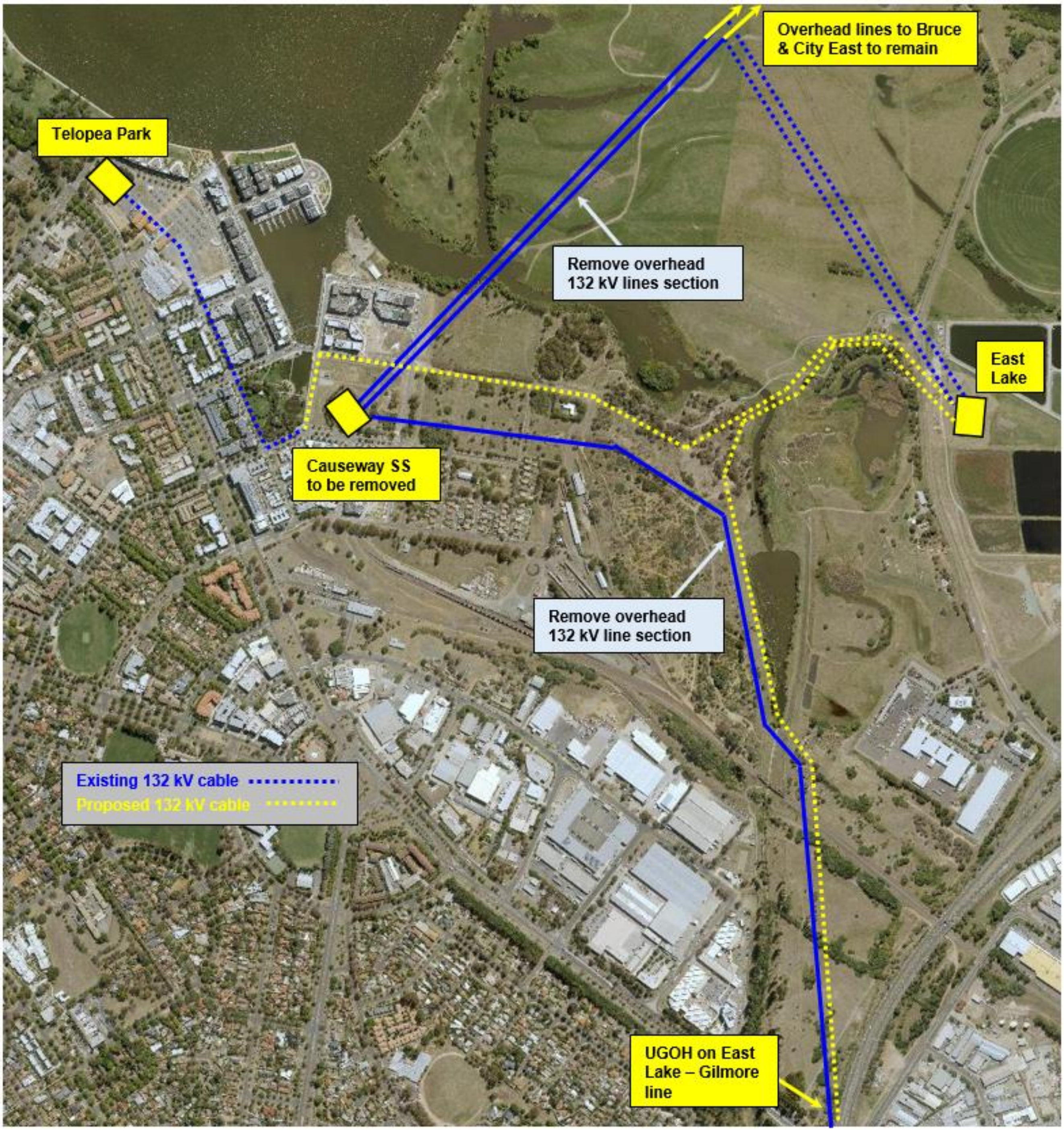
- Causeway Switching Station will be subsequently decommissioned and dismantled.

Figure 7.7 shows the existing Causeway 132 kV Switching Station.

Figure 7.7 Causeway Switching Station

The overhead to underground conversion works including decommissioning of Causeway Switching Station will be funded by the developer. Proposed project completion is by December 2020. Figure 7.8 illustrates this proposed development.

Figure 7.8: Causeway Switching Station – Proposed 132 kV Cabling



7.7.6 Supply to Gungahlin Town Centre

The maximum demand in the Gungahlin Town Centre East area is forecast to increase by approximately 16.6 MVA over the next five years with the development of new residential suburbs at Throsby, and Kenny, along with several commercial and residential developments in the Gungahlin Town Centre area, including commercial, retail and residential developments, Canberra Metro Traction Power Station (TPS), medical centre, and other community facilities.

Some of this load can be met by fully utilising the existing 11 kV network in the area and by transferring loads between feeders and between zone substations. This will still leave a shortfall of capacity required to the area by June 2020.

Network and non-network options have been evaluated including a new 11 kV feeder from Gold Creek or Belconnen zone substation, demand side management and embedded generation.

Evoenergy has considered two network options to supply the Gungahlin Town Centre area as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct new 11 kV cable feeder from Belconnen Zone Substation	$5.10 m	Not Preferred
2	Network	Construct new 11 kV cable feeder from Gold Creek Zone Substation	$3.90 m	Preferred

Option 1 involves the installation of a new 11 kV cable feeder from Belconnen Zone Substation to Valley Ave, Gungahlin. There are no spare 11 kV feeder circuit breakers at Belconnen Zone Substation so the new feeder would have to be connected in parallel with an existing feeder. The length of this feeder would be approximately 12.3 km. This is not the lowest cost option and is not preferred.

Option 2 involves the installation of a new 11 kV cable feeder from Gold Creek Zone Substation to Valley Ave, Gungahlin. There is a spare feeder circuit breaker available at Gold Creek Zone Substation. The length of this feeder would be approximately 5.3 km.

This option has the lowest cost and highest NPV and is preferred.

Estimated cost is $3.90 million and proposed project completion is by June 2020.

The augmentation cost of the most expensive option exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in January 2019.

7.7.7 Supply to Mitchell

Mitchell is a light industrial and commercial suburb in the Gungahlin District. Peak demand at Mitchell is forecast to grow by 12.3 MVA by 2022. The objective of this project is to provide capacity to the growing industrial load in the Mitchell area. There is insufficient spare capacity in existing 11 kV feeders to the area. Evoenergy has considered two options to supply this load as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct three new 11 kV cable feeders from Belconnen Zone Substation to Mitchell	$7.25 m	Not Preferred
2	Network	Construct three new 11 kV cable feeders from Gold Creek Zone Substation to Mitchell	$5.71 m	Preferred

Option 1 involves the installation of three new 11 kV cable feeders from Belconnen Zone Substation to the Mitchell area. The length of these feeders would be approximately 8.1 km. This is not the lowest cost option and is not preferred.

Option 2 involves the installation of a three new 11 kV cable feeders from Gold Creek Zone Substation to the Mitchell area. The length of these feeders would be approximately 6.3 km. Spare conduits will be installed along the feeder route to provide for future developments.

This option has the lowest cost and highest NPV and is preferred.

Estimated cost is $5.71 million. The project will be carried out in three stages, ie first cable by June 2021, second cable by June 2023, and third cable by 2024.

The augmentation cost of the most expensive option exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in July 2020.

7.7.8 Supply to Belconnen

There are several proposed developments in the Belconnen Town Centre area that will increase demand in the area over the next few years. Developments such as the Republic, a precinct of five proposed apartment buildings, is driving residential growth, and proposed development of the Belconnen Trades Centre is driving commercial and light industrial growth. There are also proposed development at the University of Canberra.

Load is forecast to increase by up to 18.6 MVA by 2022. There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered two options to supply this load as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct two new 11 kV cable feeders from Latham Zone Substation to Belconnen Town Centre	$7.66 m	Not Preferred
2	Network	Construct two new 11 kV cable feeders from Belconnen Zone Substation to Belconnen Town Centre	$3.27 m	Preferred

Option 1 involves the installation of three new 11 kV cable feeders from Latham Zone Substation to the Belconnen Town Centre area. The length of these feeders would be approximately 4.8 km. This option is not preferred

Option 2 involves the installation of three new 11 kV cable feeders from Belconnen Zone Substation to the Belconnen Town Centre area. The length of these feeders would be approximately 2.6 km.

This option has the lowest cost and highest NPV and is preferred.

Estimated cost is $3.27 million and proposed project completion is by June 2022.

The augmentation cost of the most expensive credible option exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in July 2020.

7.7.9 Supply to Tuggeranong Town Centre

The maximum demand in the Tuggeranong Town Centre area is forecast to increase by approximately 8.6 MVA by 2020 with the development of a number of mixed-use residential and commercial buildings adjacent to Lake Tuggeranong and in the West Greenway area.

There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered two options to supply the Tuggeranong Town Centre area as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct new 11 kV cable feeder from Wanniassa Zone Substation	$2.48 m	Preferred
2	Network	Construct new 11 kV cable feeder from Theodore Zone Substation	$6.77 m	Not Preferred

Option 1 involves the installation of a new underground 11 kV cable feeder from Wanniassa Zone Substation to the Tuggeranong Town Centre area. There is no spare 11 kV feeder circuit breaker at Wanniassa Zone Substation so a circuit breaker would be made available by paralleling two lightly loaded feeders. Wanniassa

Zone Substation has a continuous summer rating of 95 MVA with maximum demand around 80 MVA, so has spare capacity available for this development. The length of this feeder will be approximately 7.2 km. A spare conduit is available for approximately 6.9 km of this route. This option includes the installation of a new 11 kV cable feeder tie between the Sternberg and Matthews feeders.

This option has the lowest cost and highest NPV and is preferred.

Estimated cost is $2.48 m and proposed project completion is by December 2020.

Option 2 involves the installation of a new 11 kV cable feeder from Theodore Zone Substation to the Tuggeranong Town Centre area. There is a spare 11 kV feeder circuit breaker at Theodore Zone Substation. The length of this feeder would be approximately 8.1 km. There is no spare conduit available along any of this route. This is not the lowest cost option and is not preferred.

Viable proposals from third parties that can significantly reduce maximum demand of the Tuggeranong Town Centre development and enable Evoenergy to defer construction of the new 11 kV feeder are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 3.43 MVA by 2019, and 4.03 MVA by 2020, to enable the proposed 11 kV feeder project to be deferred.

The augmentation cost of the most expensive credible option exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in January 2019.

7.7.10 Supply to Canberra City North, Lyneham and Dickson

The maximum demand in northern Canberra City, Lyneham and Dickson suburbs is forecast to increase by up to 26.2 MVA by 2022 with major residential and commercial developments along with the ACT Government's light rail project and urban renewal program.

There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered two options to supply the Canberra City North, Lyneham and Dickson developments as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct new 11 kV cable feeder from City East Zone Substation to Donaldson St, Canberra North; construct new 11 kV cable feeder from Civic Zone Substation to Dooring St, Lyneham; and extend Haig feeder to Dickson area.	$7.90 m	Preferred
2	Non -network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves the construction of two new 11 kV feeders and the extension of an existing 11 kV feeder as follows:

- New 11 kV feeder from City East Zone Substation to Donaldson St by June 2020 to supply new developments in the Canberra City North area.
- New 11 kV feeder from Civic Zone Substation to Dooring St by June 2021 to supply new developments in the Lyneham area.
- Extension of existing 11 kV Haig feeder to Dickson by June 2022 to supply new developments in the Dickson area.

This option has the lowest cost and highest NPV and is preferred.

Estimated cost is $7.90 million and proposed project completion is by June 2022.

Viable proposals from third parties that can significantly reduce maximum demand of the Canberra City North, Lyneham and Dickson areas and enable Evoenergy to defer construction of the new 11 kV feeders are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 4.0 MVA pa from 2019 onwards, to enable the proposed 11 kV feeders project to be deferred.

The augmentation cost of the most expensive credible option exceeds $5 million so this project will be subject to the Regulatory Investment Test for Distribution (RIT-D). Evoenergy proposes to commence the RIT-D consultation process in January 2019.

7.7.11 Supply to Canberra CBD Central

The maximum demand in the Canberra Central Business District (CBD) is forecast to increase by up to 21.6 MVA by 2020 with major residential and commercial developments along with the ACT Government's City to the Lake long term urban renewal plan. The load in this area is typically summer peaking.

There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered three options to supply the Canberra CBD developments as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct new 11 kV cable feeder from Civic Zone Substation to London Circuit.	$1.28 m	Preferred
2	Network	Construct new 11 kV cable feeder from City East Zone Substation to London Circuit.	$3.26 m	Not preferred
3	Non-network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves the construction of a new 11 kV feeder from Civic Zone Substation to the Canberra CBD at London Circuit. The length of this feeder would be approximately 3.6 km.

This option has the lowest cost and highest NPV and is preferred.

Option 2 involves the construction of a new 11 kV feeder from City East Zone Substation to the Canberra CBD at London Circuit. The length of this feeder would be approximately 4.0 km. This option is not preferred.

Estimated cost is $1.28 million and proposed project completion is by June 2020.

Viable proposals from third parties that can significantly reduce maximum demand of the Canberra CBD area and enable Evoenergy to defer construction of the new 11 kV feeder are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 3.9 MVA pa from 2019 onwards, to enable the proposed 11 kV feeder project to be deferred.

7.7.12 Supply to Canberra CBD West

Canberra City west area is experiencing significant growth in terms of residential redevelopments (old detached houses being replaced by multi-storey apartment buildings), particularly in the Acton and Turner areas.

There is insufficient spare capacity in existing 11 kV feeders in the area.

It is proposed to install an 11 kV cable feeder to an existing11 kV switching station at Edinburgh St, Acton, from Civic Zone Substation. The length of this feeder will be approximately 3.3 km. The first section of this feeder (approximately 2 km) will be installed in a common trench with proposed new feeders to the Australian National University. Spare conduits will be installed along the feeder route to provide for future developments.

Estimated cost is $2.77 million and proposed project completion is by June 2019.

Viable proposals from third parties that can significantly reduce maximum demand of the Canberra City West area and enable Evoenergy to defer construction of the new 11 kV feeder are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 2.0 MVA pa from 2019 onwards, to enable the proposed 11 kV feeder project to be deferred.

7.7.13 Supply to Kingston Foreshore

The maximum demand in the Kingston Foreshore area is forecast to increase steadily over the next five years with major residential, commercial and community developments.

There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered three options to provide additional capacity to the Kingston Foreshore area as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct one new 11 kV cable feeder from East Lake Zone Substation to Kingston Foreshore area	$0.47 m	Preferred
2	Network	Construct one new 11 kV cable feeders from Telopea Park Zone Substation to Kingston Foreshore area	$2.10 m	Not Preferred
3	Non-network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves the construction of a new 11 kV feeder from East Lake Zone Substation to Kingston Foreshore area. The length of this feeder will be approximately 1.4 km. The feeder cable will be pulled through a spare conduit to be installed as part of the Causeway Switching Station Decommissioning project (refer section 7.5.5). This option has the lowest cost and highest NPV and is preferred.

Option 2 involves the construction of a new 11 kV feeder from Telopea Park Zone Substation to the Kington Foreshore area. The length of this feeder would be approximately 2.0 km. This option is not preferred.

Estimated cost is $0.47 million and proposed project completion is by December 2020.

Viable proposals from third parties that can significantly reduce maximum demand of the Kingston Foreshore area and enable Evoenergy to defer construction of the new 11 kV feeders are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 2.0 MVA pa from 2019 onwards, to enable the proposed 11 kV feeder project to be deferred.

7.7.14 Supply to Pialligo

The electricity demand in the Pialligo area near Canberra Airport is forecast to increase due to commercial development including the Brindabella Business Park and Fairbairn Business Park. The maximum demand of the area is forecast to increase by 11.2 MVA over the next 5 years.

There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered three options to provide additional capacity to the Pialligo area as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct two new 11 kV feeders from East Lake Zone Substation, and link Dairy North and Abattoir feeders	$4.28 m	Preferred
2	Network	Construct one new 11 kV feeder from East Lake Zone Substation, one new 11 kV feeder from Fyshwick Zone Substation, and link Dairy North and Abbatoir feeders	$4.88 m	Not preferred
3	Non-network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves the installation of two new 11 kV feeders from East Lake Zone Substation. One feeder from East Lake is proposed to be installed to the Brindabella Business Park near Canberra Airport to meet the growing customer demand. The length of this feeder will be approximately 3.2 km. The second feeder from East Lake will enable the overloaded Dairy North feeder to be split into two separate feeders – Dairy North and Dairy East. The proposed Dairy East feeder will supply the forecast demand of the Fairbairn Business Park. Additionally it is proposed to link the Dairy North and Abattoir feeders via a new 1.2 km long cable feeder tie. This will improve backup security to these two feeders and enable some load transfer from Dairy North to Abattoir feeder. This option has the lowest cost and highest NPV and is preferred.

Option 2 is similar to Option 1 except a new feeder would be installed to Brindabella Park from Fyshwick Zone Substation (instead of from East Lake). This option has a lower NPV and is not preferred.

Estimated cost is $4.28 million and proposed project completion is by June 2021.

Viable proposals from third parties that can significantly reduce maximum demand of the Pialligo area and enable Evoenergy to defer construction of the new 11 kV feeders are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 2.5 MVA pa from 2019 onwards, to enable the proposed 11 kV feeders project to be deferred.

7.7.15 Molonglo Valley 11 kV Feeders

The maximum demand in the Molonglo Valley is forecast to increase steadily to 50 MW over the next 30 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.

A new zone substation is to be constructed to supply the growing demand of the Molonglo Valley. The proposed Molonglo Zone Substation will be equipped initially with Evoenergy's 132/11 kV 14 MVA mobile substation by June 2021 (refer section 7.5.3).

The proposed new 11 kV feeders from Molonglo Zone Substation will supply the new suburbs and will eventually inter-tie with Civic, Woden, Belconnen and Latham zone substations, with the opportunity to offload these zone substations onto Molonglo Zone Substation.

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

Estimated cost for seven new 11 kV feeders is $6.71 million. Feeder installations will be carried out in stages as development and load increases.

7.7.16 Supply to Strathnairn

The development of the West Belconnen District is being carried out by a joint partnership between the ACT Government's Suburban Land Agency and Riverview Developments Pty Ltd. 11 kV feeders along with low voltage reticulation will be installed throughout the new suburbs of Strathnairn and Macnamara as they are developed. The maximum demand in the West Belconnen District is forecast to increase steadily to 45 MVA over the next 30 years as development proceeds. The development of this area will include 11,500 residential dwellings, plus commercial and community facilities. Maximum demand is forecast to grow initially at approximately 0.8 MVA per annum.

Evoenergy proposes to construct a new Strathnairn Zone Substation to supply this area with timing scheduled for approximately 2025-26.

There are two existing 11 kV feeders to this area, Macrossan and Latham feeders from Latham Zone Substation. Together they have approximately 1.4 MVA spare summer firm capacity only.

To meet demand until the Strathnairn Zone Substation is available it is proposed to extend the existing O'Loghlen feeder from Latham Zone Substation to Strathnairn. Load transfers will be made from this feeder to other adjacent feeders to provide sufficient spare capacity to meet the forecast demand.

In addition Evoenergy proposes to incorporate a demand management non-network solution to help manage demand within the capacity of the Macrossan, Latham and O'Loghlen feeders. This will include controlling the output and use of rooftop solar PV generation and battery storage systems via in-home demand management systems. These systems will be used to manage the combined load on the feeders to as low a level as possible.

Estimated cost for extending the O'Loghlen feeder to the first stage of Strathnairn is $2.17 million with proposed completion by December 2019. Estimated cost of the demand management solution is $1.88m.

Future feeders will be installed from the proposed Strathnairn Zone Substation in stages as development and load increases.

7.7.17 Supply to Griffith, Red Hill, Forrest and Narrabundah

The maximum demand in the Griffith, Red Hill, Forrest and Narrabundah area is forecast to increase steadily over the next five years with major residential developments. The maximum demand of the area is forecast to increase by 6.3 MVA by 2022.

There is insufficient spare capacity in existing 11 kV feeders in the area.

Evoenergy has considered three options to provide additional capacity to the Griffith, Red Hill, Forrest and Narrabundah area as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct one new 11 kV cable feeder from Telopea Park Zone Substation	$2.56 m	Preferred
2	Network	Construct one new 11 kV cable feeder from East Lake Zone Substation	$ m	Not Preferred
3	Non-network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves the construction of a new 11 kV feeder from Telopea Park Zone Substation to Griffith. The length of this feeder will be approximately 2.0 km. This option has the lowest cost and highest NPV and is preferred.

Option 2 involves the construction of a new 11 kV feeder from East Lake Zone Substation to Griffith. The length of this feeder would be approximately 3.4 km. This option is not preferred.

Estimated cost is $2.56 million and proposed project completion is by June 2021.

Viable proposals from third parties that can significantly reduce maximum demand of the Griffith, Red Hill, Forrest, and Narrabundah area and enable Evoenergy to defer construction of the new 11 kV feeder are welcome. It is estimated that such proposals would be required to provide an increasing reduction in maximum demand of approximately 2.0 MVA pa from 2019 onwards, to enable the proposed 11 kV feeder project to be deferred.

7.7.18 Installation of OPGW on 132 kV transmission lines

The existing Evoenergy SCADA telecommunications network is a mix of UHF digital radios (DDRN) and pilot wires, with some small scale use of optical fibre and microwave links. The network is extremely limited in capacity and does not provide adequate and timely real time SCADA information for effective Control Centre operations, with some analogue and digital changes taking several minutes to be reported.

The performance constraints of the network present a roadblock to realising the benefits of the SCADA system and this will only become more apparent with the implementation of the Advanced Distribution Management System (ADMS), where real time data is critical to correctly calculate the network state, load flows and correctly report network outages.

In addition to SCADA communications, the other critical application for communications is with Evoenergy's network protection. Increasingly some aspects of the protection systems will require communications to overcome protection performance and grading issues. In particular, the performance of the existing 132 kV network protection falls short of technical compliance with the current National Electricity Rules. These performance shortcomings are considered acceptable due to ‘grandfathering’ provisions within the Rules, but as network upgrades and augmentations occur the network protection will need to be brought into compliance with current standards.

Augmentations such as connecting generators to the network, or when the 132 kV network is upgraded or modified, are triggers for protection upgrades. Required protection upgrades may include the implementation of inter-tripping and line differential protection schemes and these are dependent on reliable and secure communications. In the future, the emergence of IEC 61850 as the industry standard substation automation and protection communications standard will require a very high level of reliability in the communications network.

The objective of this project is to replace existing communication networks with an optical fibre network that can deliver the speed, security, reliability and functionality required for the electricity network. It will be used to provide the communications bearer for the following systems:

- Zone substation protection signalling, including communications for inter-tripping and line differential protection.
- SCADA communications to zone substations, fault passage indicators, reclosers, switches and distribution substations.
- Security video and remote access management.
- Substation VoIP telephone.
- Corporate data services.
- Advanced metering infrastructure (AMI) communications.
- Inter station protection and control schemes.
- Intra station protection schemes utilising IEC 61850 and “GOOSE” messaging. Generic Object Oriented Substation Events (GOOSE) is a controlled model mechanism in which any format of data (status or analogue value) is grouped into a data set and transmitted within a time period of 4 milliseconds.
- Substation engineering access, for example remote access to protection relay fault records.
- Mobility communication to vehicles & deployed mobile tablets/computers.
- Network video, for example infrared cameras for switchyard fault detection.
- Monitoring and management of the communication network.

The optical fibre cables will follow each of Evoenergy’s 132 kV transmission lines, and will be strung on the same pole or tower structures.

Estimated cost is $5.25 million and the project will be implemented over a four year period from 2015 to 2018.

No non-network alternative to this project has been identified.

7.7.19 SCADA communications upgrade, optic fibre to distribution substations

The installation of fibre optic cables to individual distribution substations will be required in the following situations:

- Replacement of existing copper pilot cables with fibre due to failure of the metallic pilot.
- Additional business requirement such as chamber substation SCADA.
- Additional network protection requirements such as protection inter-tripping.
- Network automation requirements such as flop-over schemes for critical customers such as hospitals.
- High voltage customer and generator network connections.

It is proposed to roll out an optic fibre network to distribution substations over the next ten years at an annual estimated cost of approximately $407,000 pa.

No non-network alternative to this project has been identified.

7.7.20 Distribution System Limitations

Appendix F lists the proposed distribution augmentation projects and provides details of capacity and timing of non-network or demand management options required to defer the augmentation project.

7.8 Projects Subject to the Regulatory Investment Test

If the augmentation or replacement cost of a credible option for a proposal exceeds $5 million, we undertake a Regulatory Investment Test in line with the requirements of the NER (Section 5.16 for transmission RIT-T and Section 5.17 for distribution RIT-D). The purpose of the Regulatory Investment Test is to identify the credible option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the market. A preferred option may have a negative net economic benefit (that is, a net economic cost) where the identified need is for reliability corrective action. The RIT process considers all credible options that are technically and economically feasible, including non-network options.

Table 7.3 lists the projects proposed to commence in the five-year planning period that have a credible option augmentation or replacement component cost exceeding $5 million and will be subject to the RIT-D.

Interested parties are invited to participate in the planning process through the RIT-D consultation process.

Table 7.3: Projects Subject to the Regulatory Investment Test for Distribution

Proposed project	Identified Need	Estimated Cost	Start RIT-D
Supply to Gungahlin Town Centre	Load growth in the Gungahlin Town Centre area will require an additional 11 kV feeder to be supplied from Gold Creek Zone Substation.	$3.90 m	January 2019
Supply to Tuggeranong Town Centre	Load growth in the Tuggeranong Town Centre area will require an additional 11 kV feeder to be supplied from Wanniassa Zone Substation.	$2.48 m	January 2019
Establishment of Molonglo Zone Substation	The existing network will not be able to meet forecast demand from new residential developments in the Molonglo District due to supply capacity constraints.	$22.51 m	January 2019
Molonglo Valley 11 kV Feeders	Load growth in the Molonglo Valley will require additional 11 kV feeders to be supplied from proposed Molonglo Zone Substation.	$6.71 m	January 2019
Supply to Canberra City North, Lyneham and Dickson	Load growth in the Canberra City North, Lyneham and Dickson areas will require additional 11 kV feeders to be supplied from City East and Civic Zone Substations.	$7.90 m	January 2019
Supply to Mitchell	Load growth in the Mitchell area will require additional 11 kV feeders to be supplied from Gold Creek Zone Substation.	$5.71 m	July 2020
Supply to Belconnen	Load growth in the Belconnen Town Centre area will require additional 11 kV feeders to be supplied from Belconnen Zone Substation.	$3.08 m	July 2020
Decommission Fyshwick Zone Substation	Fyshwick Zone Substation has 66 kV primary and secondary approaching their end of life. It is more economic to convert Fyshwick to an 11 kV switching Station and supply it from East Lake Zone Substation.	$5.46 m	July 2021

Note the proposed Second Point of Supply to the ACT project (as described in Section 7.5.1) was part of a joint RIT-T completed in 2009 by Evoenergy and TransGrid for the program of projects required to provide a second point of supply to the ACT. Works are underway on this project and are expected to be completed by March 2020.

8. Demand Management

8.1 Overview of Demand Management

Demand management is deliberate action taken to reduce energy demand from the grid, rather than increasing supply capacity to meet increased demand.

Demand management seeks to influence energy consumption patterns as follows:

- The amount and rate of energy use.
- The timing of energy use.
- The source and location of energy supply.

Demand management is an important part of efficient and sustainable network operations. It can involve the voluntary reduction of customer electricity demand at peak times, network service provider controlled reduction of electricity demand, or the supply of electricity from generators or storage connected at customers' premises into the distribution network.

A demand management solution is referred to as a non-network solution and a demand management provider is referred to as non-network solution provider.

By reducing peak load on the grid, security of supply can be maintained without installing additional infrastructure and its associated expenditure.

Growth in demand across our network is uneven; negligible in some areas and rapidly growing in others. Drivers for demand growth include the development of new greenfield residential areas, urban renewal areas - where single level dwellings are demolished and replaced by multi-storey apartment buildings - and the development of energy-intensive businesses such as data centres.

Advances in smart metering and communications technology mean there are now a large number of methods to control energy loads, each becoming more affordable over time. A focus on peak load management, energy efficiency[12] and distributed generation will provide consumers high quality, low cost service into the future. Evoenergy also engages with consumers and non-network solution providers to identify demand management options in the pursuit of significant advances in demand management.

Effective application of demand management can defer the need to augment constrained parts of the network to meet demand growth. This reduces the cost of replacing ageing assets and leads to lower costs to customers. Evoenergy wants to maximise the benefits of non-network technologies such as solar PV generation and battery energy storage, and manage the use of new loads such as electric vehicle charging stations, to reduce daily system peaks and produce as smooth a load profile as possible. The future use of alternative energy sources such as natural gas, bio gas and hydrogen will also influence the demand on the electricity network.

8.2 Demand Side Engagement Strategy

Evoenergy's Demand Side Engagement Strategy (DSES) aims to:

- Support Demand Side Management (DSM) and provide opportunities for consumers and non-network service providers to participate in addressing network supply limitations.
- Develop and apply a transparent DSM process for network planning and development.
- Develop demand management tools and alliances to readily facilitate non-network options.

Potential non-network service providers and all customers are encouraged to participate in Evoenergy's demand management activities. It is important we ensure that a full range of solutions is considered and that emerging network constraints are resolved in a way that achieves optimal economical and technical outcomes for customers. Our DSES is published on our website[13]. Non-network service providers can register as an Interested Party[14] on our website and engage with Evoenergy to identify non-network solutions. Some demand

[12] https://www.evoenergy.com.au/residents/pricing-and-tariffs/peak-demand-tariffs/reducing-peak-demand
[13] https://www.evoenergy.com.au/emerging-technology/demand-management/demand-side-engagement
[14] https://www.evoenergy.com.au/emerging-technology/demand-management

management options will be able to generate a revenue stream, part of which will be accessible to the proponents of the demand solution.

8.3 Demand Side Management Programs

DSM programs are developed in a way that residential, commercial and industrial customers and third-party businesses such as demand aggregators and curtailment service providers can easily participate. These programs encourage customers to reduce their demand or use alternative energy sources for their energy needs when the network capacity is constrained.

Evoenergy has introduced initiatives under the AER's Demand Management Incentive Scheme (DMIS) that includes a Demand Management Innovation Allowance (DMIA). This capped allowance encourages distributors to investigate and conduct broad-based and peak demand projects.

Projects that have been, or are being funded under the DMIA include the installation of power factor correction equipment at strategic locations around the distribution network, a trial of small-scale batteries in residential customer installations, and the trial of a short-term, short-notice voluntary demand curtailment program.

Over the past year Evoenergy has conducted trials on the following DSM initiatives. These trials have proven the concept and it is hoped to scale these up over the next few years:

- SMS program – participating customers receive a text requesting they reduce energy demand for a specific period at times of peak demand.
- Load curtailment contracts with large customers. This an agreement with large customers to reduce their demand by known amounts during peak demand or system constraint.
- Virtual Power Plant – the stored energy from the residential battery systems of 600+ customers is remotely dispatched back into the grid at times of peak demand (refer to Section 9.4.2).

As well as the social benefit of looking after our shared network, demand management is a win-win situation when customers are compensated for their involvement and receive lower electricity charges on their bills over the long term. Benefits include:

- Sustainable electricity network costs - reduction in peak demand can potentially defer network upgrades, so that customers pay no more than necessary for a sustainable energy system.
- Increased reliability of service - if customers can switch off their non-essential load in response to a network request when there is a local or national supply shortage, we can maintain supply to customers' essential services.
- Payment for demand reduction - customers who participate in demand management programs may receive a payment for participation.

Evoenergy is partnering additional research and development projects, some of which may be funded through the DMIA. These will include a collaborative trial of demand management through a world-first virtual demand trading platform, peak load lopping utilising existing customer owned embedded generation, incentivising operation of residential batteries for grid support, and a broad scale residential demand shifting program utilising our newly developed customer information portal.

Beyond this we are developing a "smart suburb" in a new Canberra residential development, with smart meters providing customers with consumption data that they can use to reduce their electricity peak demand by making simple changes to how and when they operate a broad range of appliances and processes. As retailers roll out smart meters across the ACT this consumption data will become more valuable with the introduction of tariffs that include pricing signals to encourage customers to reduce demand at certain times of the day[15][16]. This will serve to reduce maximum demand on the network as well as provide financial benefit to customers.

Evoenergy is looking to the future and planning for an increasing number of electric vehicles in the ACT. The ACT Government has outlined plans in their action plan *The ACT's Transition to Zero Emissions Vehicles*[17] and

[15] https://www.evoenergy.com.au/business-and-government/pricing-and-tariffs/peak-demand-tariffs/shifting-to-demand-tariffs
[16] https://www.evoenergy.com.au/residents/pricing-and-tariffs/peak-demand-tariffs
[17] https://www.environment.act.gov.au/__data/assets/pdf_file/0012/1188498/2018-21-ACTs-transition-to-zero-emissions-vehicles-Action-Plan-ACCESS.pdf

expects that by 2021 all newly leased ACT Government passenger fleet vehicles will be zero emissions vehicles (where fit for purpose). As part of regular network innovation, Evoenergy is investigating the power-to-grid potential of vehicle battery storage.

Potential DSM programs are illustrated in Figure 8.1.

Figure 8.1: Potential DSM programs

Evoenergy's demand management staff consults with customers and customer groups to identify their expectations and drivers for DSM participation and what they can offer in terms of demand reduction or switching to alternative energy sources. We maintain a Register of Interested Parties for Demand Management, and we actively consult with those parties. Public consultations, awareness programs and trial programs also form part of our investigation process. Details of potential DSM programs to be investigated will be published on the Evoenergy website as they arise.

8.4 Demand Management Options

Our demand management strategy aims to identify demand management options and assess their potential to address network constraints for broad-based and specific, local issues. Options may reduce demand or supply the increasing demand from alternative sources. Some practical demand management options have been identified and categorised into the following groups.

8.4.1 Demand Reduction

The following schemes aim to reduce demand and may apply to residential, commercial or industrial situations.

- Demand response programs – we are currently investigating a number of options for these including simply asking customers to reduce demand at key times, directly controlling customer installations, working with demand aggregators who will provide the desired response, and creation of a demand response trading platform that will enable an open market.
- Power factor correction.
- Pool pump controls.
- Water heating load controls.
- Air conditioning controls.
- Under-floor heating controls.
- EV charging station control - discharging EV batteries into the home at peak demand times or simply controlling charging rates and charging times to avoid contributing to a new increased peak.
- Automated feeder load sharing - dynamically transferring load between feeders as their relative loading changes to relieve pressure during localised peak demand periods.
- Interruptible load controls and pricing.
- Critical load reduction controls and pricing
- Tariff realignment.
- Building management systems for office buildings and apartment blocks.
- Home energy management systems (HEMS) for managing the energy generation, storage and usage of individual dwellings.

8.4.2 Alternative Supply

The following demand management options are examples of where demand may be shifted by using alternative sources of supply.

- Fuel switching to gas to supply space heating, water heating, cooking appliances and evaporative cooling systems.
- Energy storage using battery banks, fuel cells and thermal storage systems.
- Alternative fuel sources such as rooftop solar hot water heating or ground-source heat pumps.
- Non-dispatchable embedded generation such as rooftop PV and micro-wind turbines.
- On-site dispatchable generation such as diesel generators, open cycle gas turbines, co-generation and tri-generation[18] systems.

Customers and non-network service providers will be able to respond to emerging demand management options or propose new, innovative demand management options through our demand side engagement activities.

8.5 Network Opportunity Maps

The Australian Renewable Energy Mapping Infrastructure (AREMI) is a website for map-based access to spatial data relevant to the renewable energy industry. The latest interactive maps of the Australian electricity grid to support more reliable, cleaner and local energy solutions were released on 31 October 2017. As an AREMI participant we have contributed data to generate these maps that highlight opportunities for demand management across our network area.

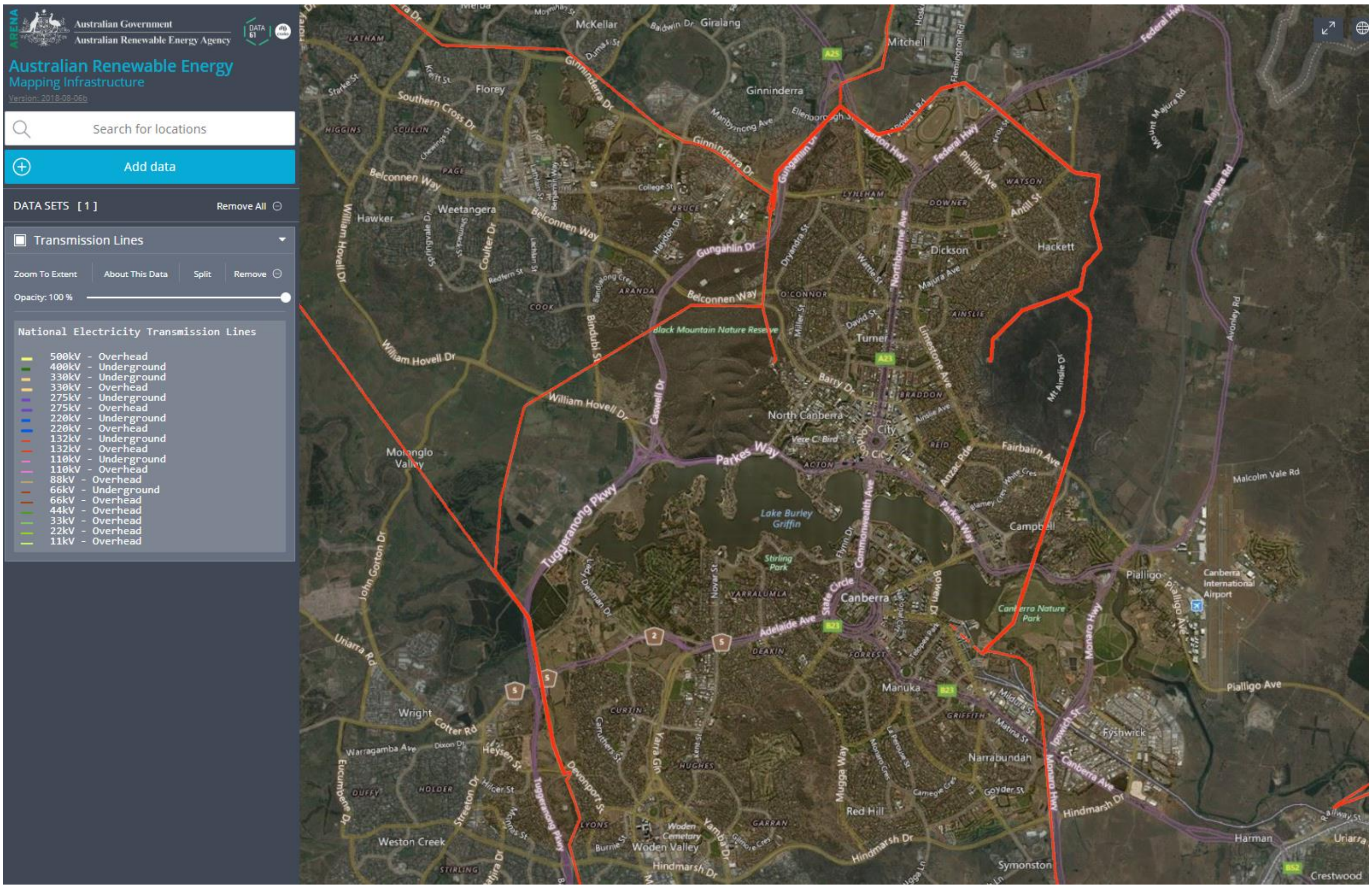
The Network Opportunity Maps provide detailed information to identify opportunities for distributed generation, energy storage and other non-network solutions to address network capacity constraints and reduce costs for customers. The free, publicly available online maps aim to provide the information required to underpin the development of vibrant markets for new energy services, and avoid spending more on electricity distribution infrastructure in the future.

[18] 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.

Alongside the 2017 released maps on the AREMI platform is the unveiling of a new "generator connection opportunity" layer that indicates how much new generation – such as solar and wind farms – can be connected to the grid in each geographical area. This resource will make it faster and easier to select the right location and size of clean energy projects. The Network Opportunity Maps are available on the AREMI site[19].

A sample view of the ACT is shown in Figure 8.2.

Figure 8.2: ACT Network opportunity map (from AREMI website)



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19 https://nationalmap.gov.au/renewables/

9. Emerging Technologies

9.1 Overview of Emerging Technologies

The generation, transmission and distribution of electrical energy is changing rapidly with new advances in technology. These emerging technologies are impacting on all parts of the supply chain, for example:

Generation – traditional hydro and thermal generation is being supplemented by wind and solar generation, and emerging technologies such as fuel-cells, biomass generation and geothermal generation. This is being driven by an international desire to reduce carbon emissions and expand the use of renewable energy sources. Large generating plants that are typically located distant from load centres are being supplemented with local embedded generation facilities located close to load centres.

Transmission – large capacity transmission lines are required to transport bulk energy from power stations to load centres. With the generation landscape changing to more local embedded generation, the need for such large transmission lines will decrease. Conductor types and shapes are changing, e.g. circular stranded copper and steel-cored aluminium conductors are being replaced by lighter aluminium alloy and composite-cored conductors with trapezoid-shaped strands to produce a smooth-bodied conductor that can operate at higher temperature and have lower wind drag than conventional conductors. The changes to conductor types as well as developments in materials science, are allowing a change in the size and shape of support structures from traditional lattice steel towers with suspension insulators to steel or concrete poles with cantilever insulators.

Distribution – areas of new development within the ACT such as greenfield estates are all reticulated with underground cables and underground pits where previously they would have featured surface-mounted pillars. Areas with high rooftop PV penetration are experiencing reverse power flow and voltage fluctuations that need to be managed. Energy storage systems such as batteries are becoming more efficient and affordable, and electrical appliances are becoming more energy efficient. New dwellings in particular are being constructed with high energy efficiency ratings, with energy generation, storage and usage controlled via a Home Energy Management System (HEMS). These advances have the potential to reduce maximum demands on distribution systems which will reduce the required capacity of these systems. The proliferation of instantaneous hot-water heating systems and electric vehicles may have the opposite effect, driving an increase in demand. Remote-controlled and automated devices are leading to smart networks (e.g. automatic load transfer), self-healing networks (e.g. automatic isolation of faults), and smart meters that allow customers to monitor and control their energy usage, will lead to an entirely different load profile on the network.

Evoenergy is keeping abreast of these emerging technologies and future network planning will embrace these technologies to shape our network and benefit our customers.

9.2 Distributed Energy Resources

Distributed Energy Resources (DER) include localised embedded generation and energy storage facilities provided by a variety of small grid-connected devices. Conventional power stations such as hydro and coal-fired power stations are centralised and often require electricity to be transmitted over long distances. DER systems however, are decentralised, use a variety of non-conventional fuels (typically renewable energy sources such as solar, wind, bio-gas or bio-mass), and are located close to the load they serve. They usually have capacities of less than 10 MW.

DERs are changing the way that distribution networks operate. Instead of the traditional energy flow from network to customer, the energy now often flows from the customer to the network. This reversal challenges the traditional design of the distribution network, but also provides opportunities to operate the network more reliably and efficiently.

Dealing with the increasing proliferation of DER presents new challenges to Evoenergy including coping with localised network overloads due to the thermal rating of existing equipment, increased voltage fluctuations due to varying DER power output, increased fault levels and protection coordination issues. Evoenergy is exploring ways to actively manage the network by utilising real-time control and communications systems to provide better integration of DER. In new areas with high penetration of distributed generation and storage, Evoenergy is installing On-Load Tap Changer (OLTC) distribution transformers (with integral voltage control relays) to manage fluctuating low voltage levels and is investigating the installation of voltage regulators to manage medium voltage (11 kV) levels. A voltage regulator controls voltage by changing its tap position. An alternative system is a DVAR (Dynamic Volt-Amp Reactive) system which controls voltage by injecting and absorbing reactive power dynamically. This is regarded as a centralised method of voltage control. In the future more decentralised methods may be adopted, such as controlling the output of individual inverters connected to the low voltage network and individual loads beyond the meter such as air-conditioning units using DREDs (Demand Response Enabling Devices).

DER coupled with demand management presents opportunities to defer or avoid expenditure on network assets by providing alternative power supplies to the network. Evoenergy seeks to manage the increasing prevalence of DERs connected to its network without the need for extreme control means such as generation curtailment, i.e. automatic disconnection of distributed generation in order to manage power flows and voltage levels.

Evoenergy's transmission and distribution network has grown from its inception in 1915 to an extensive overhead and underground network covering the ACT. Many assets are approaching the end of their economic lives. Increasing proliferation of DERs is forecast to decrease energy and demand growth on the network over the planning period. As demand growth decreases or flattens the requirement for network augmentation works decreases. Asset replacement is becoming a greater investment driver than network augmentation. Evoenergy is investigating ways to reduce future asset replacement costs such as retiring under-utilised assets, and the increasing use of DERs is regarded as a means to achieve this.

9.4 Battery Energy Storage

Small battery energy storage systems (BESS) are becoming more popular for domestic use (associated with rooftop PV generation) as technology improves and costs reduce. Larger battery energy storage systems are used by some utilities for peak shaving and load balancing, day to night shifting of renewable PV energy, and reducing the fluctuations in PV generation output caused by passing clouds or wind power output caused by changing wind conditions.

As at 31 October 2018, there are approximately 800 residential battery storage systems in service in the ACT of average capacity 12 kWh.

The battery industry is changing rapidly with several different battery technologies available, such as lithium-ion, zinc-bromine, lead-acid, nickel-cadmium, and sodium-sulphur. Lithium-ion batteries are recommended for high power applications and lead-acid batteries for high capacity applications. Lead-acid batteries cannot be charged at the same rate as lithium-ion batteries, but their discharging behaviour is equivalent. Lead-acid batteries are a proven technology; their main advantages continue to be their low price, high availability and simplicity. Lithium-ion batteries offer high energy density and are low maintenance. Zinc-bromine batteries offer high energy density, have 100% depth of discharge capability on a daily basis, and last longer than other battery types.

9.4.1 Network Battery Trial

Network batteries have been utilised by other entities in Australia (both commercial entities and regulated utilities) for purposes similar to what is outlined above. These include the South Australian Produce Market micro-grid and Endeavour Energy's West Dapto Battery.

Evoenergy is exploring the benefits of large distributed energy resources (DER) installations for commercial customers. This includes developing a pilot for managing energy consumption, commercial demand management and energy control equipment – activities falling outside of the regulated utility space. However, Evoenergy is in a unique position as a network battery installation at the Greenway depot can offer a model for both the commercial market and for grid support through deferring feeder augmentation.

This project will outline the commercial and strategic need to install a network battery at the Greenway depot. Installing a network battery will deliver the following benefits:

- Building internal expertise and experience within Evoenergy in relation to managing the consumption of a commercial customer, managing the operation of a network battery and commissioning of network batteries – by both professional engineering and electrical trade staff.
- Reduction in the overall energy costs at the Greenway depot.
- Demonstration of the viability of DER installations for large industrial and commercial customers.
- Demonstration of the viability of a network battery to defer network augmentation.
- Demonstration of the viability of a network battery in future subdivisions with high DER penetration
- Investigation of optimal network battery control schemes to lower peak demand and operate in the wholesale energy and FCAS markets.
- Ability to advise large customers interested in similar DER installations.
- Enhancing of Evoenergy's reputation within the ACT.

The project is proposed to run alongside the Greenway Energy Performance Project (GEPP), an all-inclusive project encompassing energy efficiency measures, PV generation and other administrative measures to cut energy costs. For GEPP to be proven as a complete energy solution model, some level of storage must be used to absorb excess PV during solar peaks and reduce demand. This has the benefit of cutting peak usage and further reducing overall energy costs.

It is proposed that the Greenway depot refurbishments will incorporate the installation of the network battery and the PV system proposed in the GEPP project. By 'piggy-backing' off much of the civil works of the refurbishment, the final civil costs associated with the installation of the network battery could be reduced.

9.4.2 Virtual Power Plants

A virtual power plant consists of a combination of several small scale distributed energy resources, such as rooftop PV generators and battery energy storage systems that can be controlled to act in a similar way to a large conventional power plant to minimise system demand in a local area. As Evoenergy transforms in to a distribution system operator it will need to either develop new tools internally or integrate with external experts.

Evoenergy is collaborating with Reposit Power to trial a virtual power plant (VPP), enabled through residential battery storage. Virtual Power Plants are collections of Distributed Energy Resources (DERs), such as residential solar panels (PV) and batteries (nodes) that can be aggregated and controlled in real time to help meet the demand needs of a distribution network.

Reposit Power's VPP Fleet system allows Evoenergy to dispatch a pricing signal to over 300 Canberra residential batteries offering to reimburse each household with GridCredit for each kWh discharged from its battery. The battery control system instantly accepts or declines the signalled offer, the decision made based on the battery discharge capacity and the value of the GridCredit compared to other uses for the charge.

The objectives for Evoenergy's participation in the VPP trials were to:

- Prove that a VPP can be used to help reduce peak demand on the distribution network,
- Test if the Reposit Power's VPP Fleet system is capable of coordinating residential batteries to provide grid support, and
- Observe the practicality of third-party service engagement for network support.

The initial VPP trials were conducted over an 11 week period between 24th November 2017 and 7th February 2018. The trials were designed to test a VPP comprised of over 300 residential batteries to prove the viability of the VPP as a peak demand management tool.

The trials were a success –VPP successfully delivered in excess of 2 MW of grid support over the 2017-18 summer. The batteries even managed to charge given a short window for preparation (25 min, 10 min and 5 min respectively). Each trial resulted in a very positive acceptance rate of 96%, 95% and 98%.
The first three trials have provided Evoenergy with the following:

- Proof that a VPP can be used to help reduce peak demand on the distribution network.
- Confirmation that the Reposit Power's VPP Fleet system is capable of coordinating residential batteries to provide grid support.
- Demonstration that a third-party service engagement is a practical and effective means of supporting Evoenergy's distribution network.
- Identification of the need to continue the integration of similar dynamic data services, such as Solcast for solar modelling and IoT devices for network state estimation.

Evoenergy has more to learn in order to operate in an increasingly DER and battery storage rich environment, and to this end, has purchased access to Reposit Power's fleet management system and customer network data from their growing fleet of residential batteries. The Demand Management team will continue to analyse data from these avenues, as well as future trials, and compile a collection of relevant data extracted from the Reposit Power API.

9.5 Ginninderry Energy Pilot Project

Ginninderry Estate is a large new residential estate being developed in the West Belconnen area, with new suburbs to be named Strathnairn and Macnamara. Ultimately home to approximately 30,000 residents over the next 30-40 years, Ginninderry aims to showcase world leadership through its planning, design, construction and post-occupancy performance (liveability) – acting as a model for other developments to follow. As part of that aspiration, the Ginninderry Joint Venture has chosen to explore the renewable energy future for the development – through the use of solar photovoltaic (PV) systems, energy management and battery storage technologies.

In the first stage of the development, solar PV systems (ranging in size from 2 – 5 kW) are incentivised on all buildings (including single residential, townhouse, multiunit and community facilities) with the ultimate aim that the buildings within Ginninderry become a distributed energy network. This includes the exploration of the potential for extensive residential (behind the meter) and centralised battery storage systems.

The Ginninderry JV has sought permission from the ACT Government's Environment, Planning and Sustainable Development Directorate (EPSDD) for a Territory Plan Waiver to allow Stage 1 of the development to be built without gas reticulation to its residents – making it the first ACT neighbourhood to be fully electric with 100% of dwellings having PV systems. While the Territory Plan Waiver will mean that gas reticulation is not mandatory for Stage 1, Evoenergy may still chose to install a gas reticulation network through Stage 1.

The Ginninderry Energy Pilot Project (EPP) aims to assess the real time implications/outcomes from an electricity-only neighbourhood with a very high penetration of rooftop PV systems. The EPP will cover the planning, design and construction/installation of the relevant infrastructure, and post-occupancy data collection in respect of the performance of the residential energy systems and their interaction with the electricity grid within Stage 1 of Ginninderry.

The first stage of approximately 1,150 dwellings will include rooftop PV systems on all dwellings, demand management systems, and solar or heat pump hot water heating system. All dwellings will be fitted with smart meters. Residential scale battery storage systems are also encouraged. Network scale batteries could also be trialled, along with other innovative devices such as "On-Load Tap Changer" (OLTC) distribution substations, HV and LV voltage regulators.

The EPP aims to assess the on-ground effects of the electricity-only neighbourhood including:

- how homes and precinct controls can manage and mitigate peak demand
- how a precinct can manage power quality to comply with all regulatory standards
- the impact on peak demand of an all-electricity, high PV penetration residential area
- what additional measures or devices are required at a network level to manage 100% rooftop PV penetration
- what is the impact on reliability and security of supply
- how future developments could design for lower peak demands, and high PV and battery penetration
- how residents respond to an electricity-only suburb
- how ancillary service benefits from network-scale batteries could be realised

The EPP will also conduct research providing both a modelled analysis of the expected impact as well as a baseline comparison of current residential energy use in the ACT. Power system modelling has indicated that 100% PV penetration will likely cause undesirable voltage fluctuations due to the difference between the extremes of peak export in the summer months and the peak consumption period in the winter months (which is further exacerbated by the customers not having access to gas supply). These fluctuations can be managed by adjusting the transformer 'taps' to keep the voltage in the acceptable range or disconnecting / curtailing PV export. Since limiting or curtailing power generation export defeats the purpose of investing in a solar PV system, it has been proposed that automatic On-Load Tap Changer (OLTC) substations are installed during Stage 1 and other technologies to be trialled in subsequent stages.

Once the construction / installation of the relevant infrastructure is completed, the Ginninderry EPP will provide vital real-time information to the Ginninderry Joint Venture and Evoenergy to inform future stages of Ginninderry and other developments exploring emerging energy options for neighbourhoods and communities.

The EPP is the outcome of two years of work between the Ginninderry JV, Evoenergy, energy retailers, product suppliers, research institutions, ACT Government and energy consultants to explore options for a best practise residential energy solution. It is projected that in the coming few years, the majority of new detached dwellings in the ACT will feature rooftop PV installations. These home PV systems will exist alongside EV charging stations, solar farms on the city fringe, in-home batteries and a range of other localised energy generation, management and storage systems. With these will come the demand for more agile network management, new tariff structures, and new commercial models. The EPP is a collaboration that seeks to address these issues in a collective way – bringing together the Government, energy utility, research institutions, interested parties (developers and product suppliers) and residential interests and concerns.

9.6 Electric Vehicles

9.6.1 Electric Light Rail

The ACT Government is undertaking the construction of a light rail system (known as Capital Metro) which will feature electric passenger trams running on purpose-laid tracks, the first stage of which runs from Central Canberra City approximately 10 km northwards to Gungahlin town centre. This first stage is due to be commissioned in early 2019 and includes two main traction power stations that require an 11 kV 5.2 MW supply to each, plus a depot / control centre that requires an 11 kV 1.2 MW supply. Power is transformed and converted to DC at the traction power stations from where it supplies the railway catenary wires which are energised at 750 V DC.

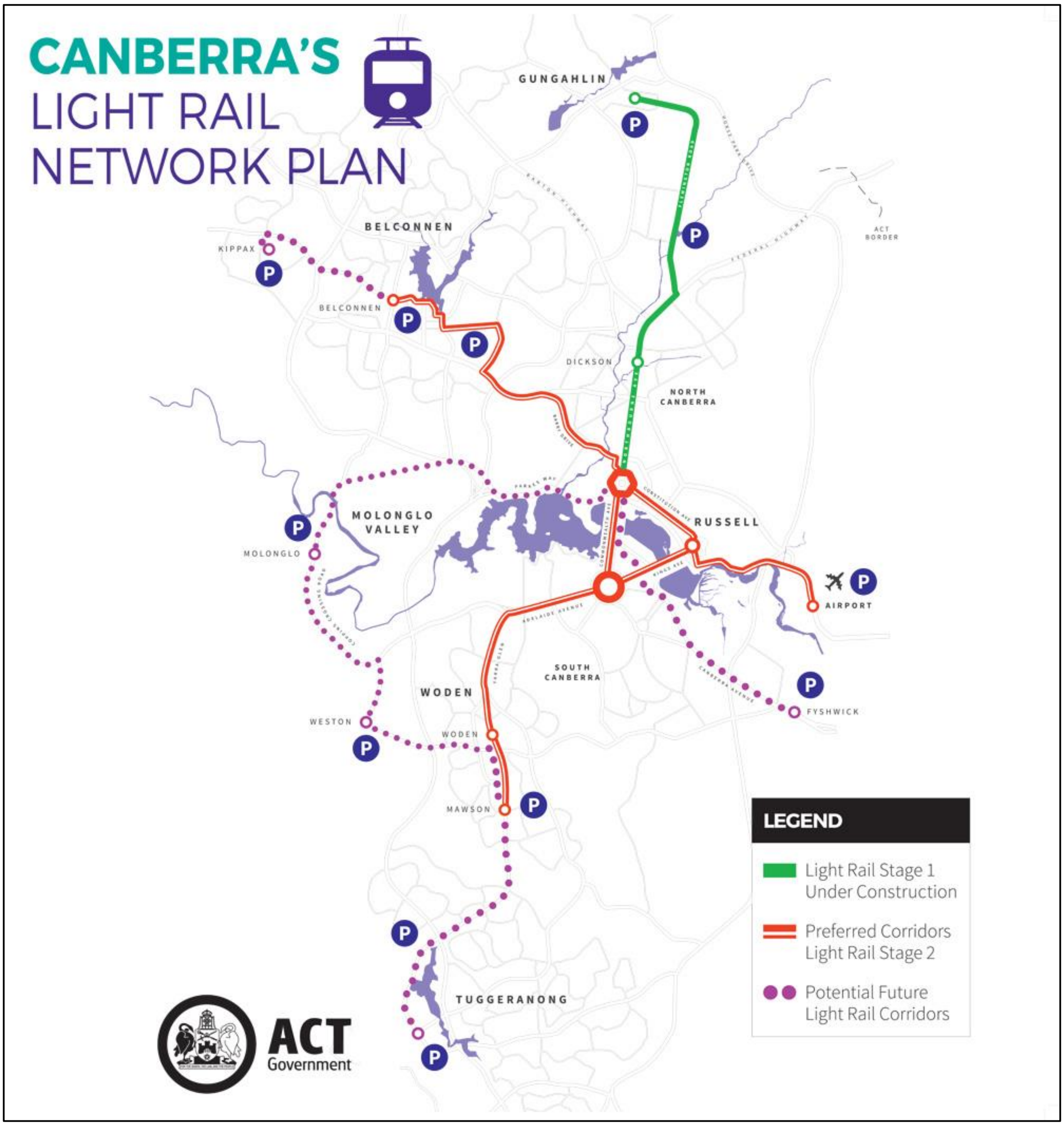
Stage 2 from Canberra CBD to Woden is at preliminary design stage.

Evoenergy is working with Capital Metro to monitor and mitigate the effects of stray currents emanating from the light rail network. Further expansion of this network is planned for the future, shown indicatively in Figure 9.1.

Evoenergy has replaced two 132 kV transmission line suspension spans that crossed the light rail corridor at Flemington Road with termination spans, to meet rail code requirements.

Photo source Transport Canberra

Figure 9.1: Light Rail Network Plan (*source Transport Canberra*)



9.6.2 Electric Vehicles (cars, trucks, bicycles)

There are few privately-owned electric vehicles (EV's) on the streets of the ACT at present but it is anticipated that their prevalence will increase significantly in coming years as costs decrease and battery range increases. Globally EV's are forecast to increase to 15% of the motor vehicle population by 2030. As travelling distances within the ACT are relatively short compared with other states, coupled with the ACT Government's plan for the territory to be carbon-emission-neutral by 2050, it is anticipated that the uptake of EV's in the ACT will exceed this. Penetration of EV's in the ACT could well be 30% by 2030. This will serve to offset the reduction in energy demand caused by embedded generation and storage systems.

Evoenergy is trialling twelve publicly accessible electric vehicle charging stations across the ACT. To date three rapid chargers type Tritium Veefil Level 3 have been installed. These have a capacity of 50 kW and can fully charge a car within 30 minutes. In addition nine fast chargers type eBee Level 2 have been installed. These have a capacity of up to 22 kW and can fully charge a car in 2-6 hours. As part of this trial, Evoenergy is investigating the following:

Roaming: Network infrastructure to enable inter jurisdictional roaming that allows ACT EV charging network members to travel outside of the ACT and charge at any inter jurisdictional charge point - regardless of the network provider, hence, mitigating range anxiety.

Open Charge Point Protocol (OCPP): The initial rollout of charger hardware and software infrastructure was based on OCPP 1.5, allowing for standardised network integration with a range of third party EV charging hardware providers. This protocol is now being converted to OCPP 1.6 which will provide load levelling capability. In addition Evoenergy is actively promoting OCCP 1.6 adoption with other network providers to simplify interoperability and roaming capability between inter jurisdictional systems. This protocol also allows dynamic allocation of available capacity, load levelling and management of hardware that will ensure our network is up to date with the latest technology available. Evoenergy has representation on the OASIS[20] Open Charge Point Protocol Technical Committee and has actively engaged with this development.

Load levelling: Allowing Evoenergy or other commercial operators to run a cluster of chargers without exceeding the maximum available load of a distribution substation.

Bi-directional chargers: Allowing Evoenergy to use energy stored in the EV's battery at peak times and charge the EV's battery at off-peak times to help optimise load on the network. EV's with this capability are expected to be introduced to the Australian market by mid-2019.

To avoid electric vehicle charging stations creating new peak demands on distribution feeders or substations, intelligent controls will be required to distribute charging throughout the day and maintain system voltage within regulation levels. Ideally public charging stations will be sited to meet customer needs and at locations on the electricity network where they will not create loading issues. If sufficient charging stations are installed in public places such as shopping centres and workplace carparks, this would minimise the impact of EV owners plugging in to recharge their vehicles upon arriving home from work which could overload residential LV and HV feeders. EV charging during the middle part of the day would assist with absorbing excess rooftop solar PV generation.

Expansion of EV charging network: Evoenergy is working with various local councils to establish a network of EV charging stations between Canberra and Batemans Bay, Sydney and Thredbo, to encourage the use of EV's to popular destinations near the ACT.

Electric buses: Transport Canberra is currently trialling an all-electric bus, which takes approximately 7 hours to fully charge via a 400V 3-phase 130 Amp charger. A fully charged bus has a range of approximately 450 km. Transport Canberra is hoping to introduce 120 such electric buses to its Canberra fleet by mid-2019, and proposes to construct a new electric bus depot at Woden to house, charge and maintain this fleet. Maximum demand of this depot is expected to be approximately 3.8 MW.

Autonomous vehicles and plugless chargers: In the future it is expected that electric vehicles will be driverless. As well as providing increased safety to passengers, this will increase their appeal and could potentially increase the electrical demand to charge their batteries – eg a driverless EV could provide a 24 hours per day taxi service, stopping only to recharge itself when required. Plugless chargers that work by parking an EV above an induction pad are expected to enter the Australian market in the near future and will enhance the convenience and ease to charge an EV. In the future it is expected that plugless EV chargers will be located in public car parking spaces and operate in tandem with parking meters.

[20] OASIS is a non-profit consortium that drives the development, convergence and adoption of open standards for the global information society. https://www.oasis-open.org.

9.7 Micro-grids

A micro-grid is a small power system with generation and consumption occurring locally. Micro-grids can function autonomously ('island mode') or connected to the distribution network. Energy sources can include PV, wind, diesel generators, fuel cells and micro-hydro amongst many others. Around the world micro-grids, can be found in scales varying from a single residential house or industrial/production site to a complete power system island. A micro-grid can balance generation and demand with or without energy storage and is capable of operating with or without connection to the electricity distribution network. A micro-grid can have lower transmission losses because the energy is generated and consumed in close proximity.

Evoenergy is currently investigating the viability of micro-grids within its network with proponents of such schemes. To date none of the proposed schemes has proven to be viable but we continue to assess schemes as the technical and financial barriers reduce and regulatory barriers are clarified.

9.8 Dynamic Rating of Transmission Lines and Power Transformers

Static ratings of transmission lines and power transformers are based on probabilistic weather conditions and equipment loadings. Ratings of network assets are determined by their maximum allowable operating temperature. Weather and loading conditions are dynamic hence static ratings may not accurately reflect the load transfer capability of these assets at any particular point in time. Dynamic rating of transmission lines is done by assigning conductor current ratings in real time taking into account the heating effects of the electrical current, ambient air temperature, solar radiation and reflected radiation, and the cooling effects of wind and emitted radiation, so that the conductors do not heat to such an extent that they sag below allowable ground clearances.

Weather stations are installed at various points along a transmission line to measure such data in real time and transmit it to the Control Centre's computer where it is analysed and a dynamic current rating assigned to the transmission line. This allows the network operator to apply load to a line based on its dynamic rating which enables increased power flows above its static rating when weather conditions are favourable. This permits such assets to be fully utilised without the risk of overloading.

The same principle can be applied to zone substation power transformers to enable them to be operated above their normal continuous name-plate rating when conditions are favourable.

Evoenergy currently does not have dynamic rating capability on its network, but is investigating it as a possible future development as system load changes.

9.9 Smart Networks

9.9.1 Smart Networks

Emerging technologies such as embedded generation, energy storage, electric vehicles, and smart street lighting networks, are rapidly changing the electricity distribution industry. To improve the supply-demand balance and meet all power quality standards, Evoenergy will need to monitor and control load and generation flows at the domestic customer level. In order to do this, a reliable and secure means of communicating with customers will be required along with means to remotely control load and generation flows.

Evoenergy's Advanced Distribution Management System (ADMS) is being developed to provide real time information allowing for network switching decisions and the realisation of self-healing network principles. A self-healing system will detect and isolate a fault on the network and automatically restore power to as much of the network as possible until repairs have been carried out.

Evoenergy is investigating the installation of additional smart devices such as voltage regulators, dynamic volt-amp reactive compensators (D-VARs), auto-reclosers, intellirupters and sectionalisers on its distribution network to improve quality, security and reliability of supply.

9.9.2 Denman Prospect Smart Network Trial

Denman Prospect is a new residential suburb currently under development in the Molonglo Valley to the west of Canberra City. Stage 1 will comprise 400 dwellings that will all be equipped with 3 kW rooftop solar PV generation panels, and it is anticipated that some will also feature battery storage systems. This will be the first residential estate in the ACT and one of the first in Australia with 100% PV penetration.

To support this Evoenergy has identified an opportunity to establish an industry leading multi-utility smart network including smart metering for electricity, gas and water. Evoenergy is also developing a customer portal to provide customers with up to date access to their electricity and gas consumption to pass on the benefits of smart metering to customers.

Evoenergy recognises that a smart grid is much more than just smart meters and includes grid sensors, distribution automation equipment, monitoring and control devices for renewable resources, load control devices, in-home energy management devices and smart charging stations for electric vehicles. We understand that emerging technologies such as embedded generation, energy storage, electric vehicles, and smart street lighting networks, are rapidly changing energy usage and the electricity distribution industry.

The Denman Prospect Smart Network Trial will specifically investigate issues related to data collection and trial devices for intelligent street lighting and electric vehicle charging. This will be achieved through the following investments and activities:

- Install and pilot a radio mesh network for communications supporting a multi-utility smart network platform.
- Trial the ability of Evoenergy's network control software, ADMS, to use real time data and respond dynamically.
- Install and trial electricity demand management of customers' devices including PV inverters and battery storage systems, and remote control of smart street light luminaires and electric vehicle charging stations.
- Provide a network gateway at each house to enable:
    - Monitoring and capture of solar generation data in real time.
    - Monitoring and control of demand data and power quality data in real time.
- Trial of gas and water metering with our partners.

This project creates a communications 'umbrella' to enable smart meter data reads, demand management control, smart street lighting control and electric vehicle charger management. This complements Evoenergy's existing fibre optic communication networks as well as our Digital Data Radio Network and Trunked Mobile Radio communication networks which encompasses numerous towers in and around the ACT.

Evoenergy is in the process of installing smart meters in Denman Prospect as part of a pilot phase. The pilot will allow us to test whether the meters can talk to the communications canopy, and whether we can read this information back at a central point. We will also be testing whether we can communicate effectively with the market. Our intention is to demonstrate a multi-utility solution with electricity, gas and water smart meters.

9.10 Smart Meters

Evoenergy has been managing the supply, installation, maintenance and metering data management of metering infrastructure for over 100 years. Since 2003 Evoenergy has been operating in the NEM as a Responsible Person and an accredited Metering Provider and Metering Data Provider, and currently provides metering services for over 200,000 customer metering points. Evoenergy's managed services include metering for domestic and commercial customers within the ACT.

The Power of Choice (PoC) rules implemented by the AEMC on 1 December 2017 requires all new and replacement meters to be Type 1-4 meters (smart meters) and be provided by independent Metering Coordinators acting for retailers. The PoC will enable customers to have a greater ability to manage their power usage and costs through choosing demand-side management (DSM) products and services that may better suit their needs, and can assist DNSPs to reduce capital and operating costs. New meters will be smart meters that are specified by the relevant retailer.

This rule change redefines who will have the overall responsibility for the provision of metering services. The role and responsibilities of the Responsible Person must be undertaken by a new type of Registered Market Participant – a Metering Coordinator. Metering Provider and Metering Data Provider are retained as separate accredited roles; however a Retailer will now be required to appoint the Metering Coordinator to coordinate suitably qualified parties to conduct metering services for its retail customers.

Smart meters enable energy consumption data to be available to both customers and utilities on a real time basis via two-way communications networks. This will assist the customer and the service provider with demand management initiatives, to respond to price signals and automatically control or shift demand during high demand periods, and facilitate future retail contestability.

Some of the potential uses of smart meters are as follows (refer section 4.11.1 for further details):

- Outage management
- Support and enhance network modelling functionality of ADMS
- Improved network forecasting and planning
- Reduced network investment
- Power quality monitoring
- Reduced manual meter reads
- Remote connection and disconnection of customers
- Demand management
- Support smart network initiatives, e.g. battery storage and embedded generation

9.11 Remote Area Power Supplies

Evoenergy's network is primarily urban, but there are some long overhead 11 kV distribution feeders in rural areas that supply remote small loads only. These feeders are under-utilised and as they age, their maintenance costs increase. Vegetation management is also costly, particularly where a feeder traverses a bushfire prone area.

Evoenergy is currently evaluating options to install Remote Area Power Supplies (RAPS) to supply loads at the ends of two such long rural feeders. Options being considered for these RAPS consist of a mixture of solar PV generation, battery energy storage, with back-up diesel generators and demand management options. The two RAPS being investigated are at:

Gudgenby Homestead:

The ACT Department of Parks, Conservation and Lands owns and operates this facility within the Namadgi National Park. Current supply to this site is via a single phase overhead 11 kV line (Matthews feeder) approximately 7 km long. The line runs through a bushfire prone area. Evoenergy is proposing to replace this overhead 11 kV line with a hybrid RAPS system at the Gudgenby Homestead comprising solar PV panels, batteries and a diesel generator, coupled with a demand management system.

Photo: Gudgenby Homestead

Corin Dam:

Icon Water owns and operates this facility within the Namadgi National Park. Current supply to this site is via a three phase overhead 11 kV line (Reid feeder) approximately 9.5 km long. Investigations are continuing to specify the most appropriate RAPS system at this location.

Photo: Corin Dam

At both sites following installation and commissioning of the RAPS, the overhead 11 kV feeder line sections connected to these sites will be decommissioned and dismantled.

Evoenergy is investigating the feasibility and economics of establishing RAPS at other similar sites.

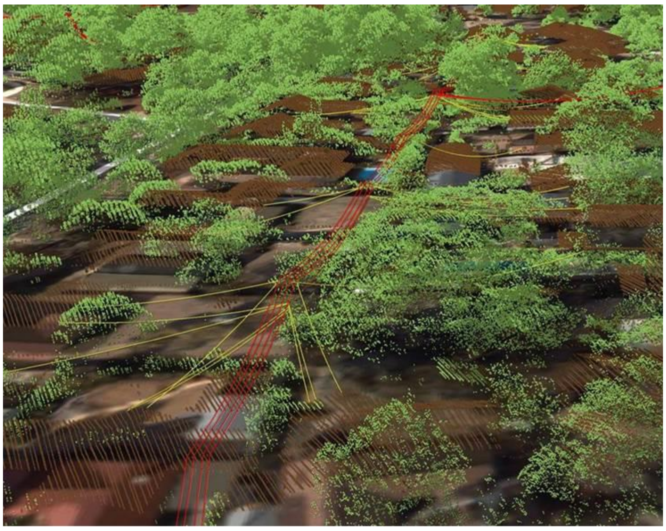
9.12 Drones and LIDAR Technology

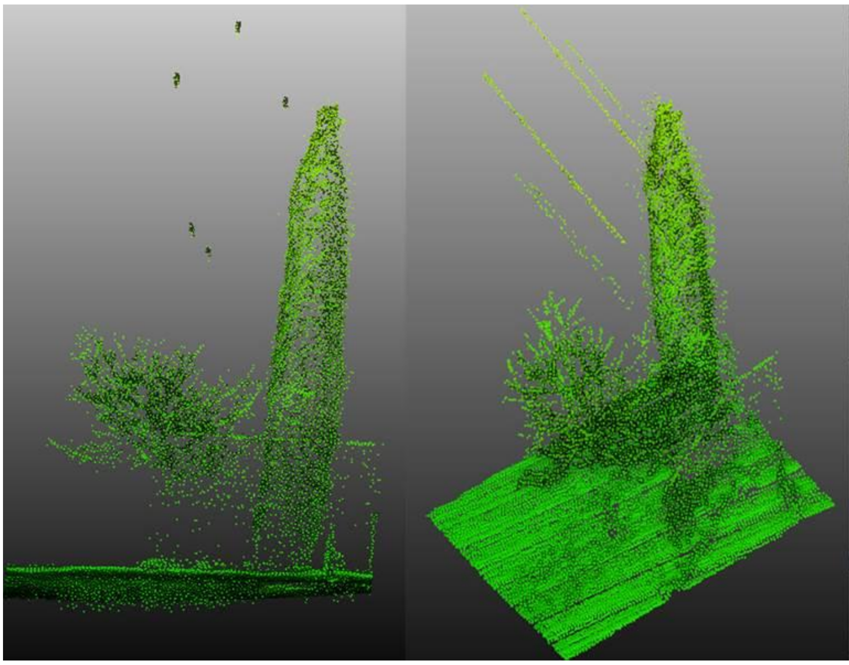
Providing “Energy for the Future” means that Evoenergy will strive to adopt new technologies and evolve practices in the ever changing landscape of the distribution business. For the last four years, vegetation management has been managed through helicopter inspections. The inspections involve a helicopter performing LIDAR (Light Detection and Ranging) scans of our network to identify where vegetation has grown within a safe clearance zone of our power lines.

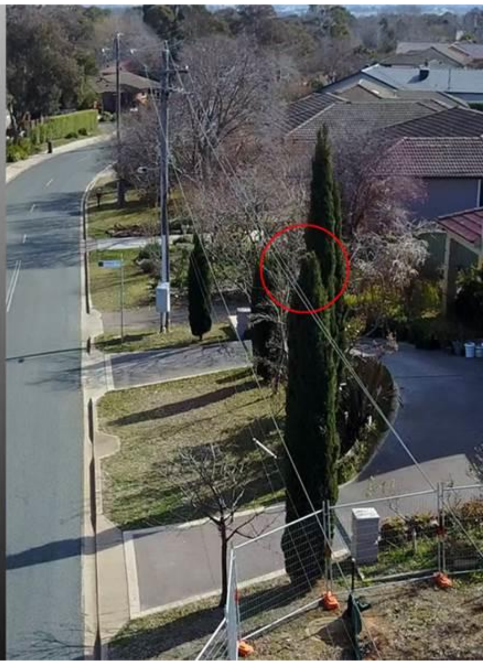
During 2018, LIDAR-enabled drones flew multiple sections of power lines capturing data on vegetation, conductors, poles and structures. The level of detail and data that a is captured by the LIDAR scan and photography of a drone flying at 30m above the ground is far greater than that of a helicopter flying at 300m above the ground. This facilitates an improved defect identification and defect location accuracy. As many low voltage lines in urban areas are installed in property on backyards, the use of drones removes the need for inspection personnel to access residential properties disrupting the customer.

The results from the trial are promising with Evoenergy to further operationalise the use of drones to perform LIDAR scans to inspect and detect vegetation near power lines and other assets. We look forward to further testing the feasibility of the technology by scanning larger areas of our network in 2019 and using the data to maintain vegetation clearance, identify network defects to keep the network safe and reliable while improving our customer service and satisfaction at the same time.

Evoenergy has also engaged in a trial using drones to perform pole top, pole equipment, transmission tower and vegetation inspections. Inspection methods include photographic and thermal imagery. The pole top photography captured is used to identify defects on the pole top, cross-arm, insulators, and conductors while the thermal imagery is used to capture any hotspots that may be present indicating defective equipment. Images of the asset that are captured during the inspection provide a pictorial history of the asset that can assist in the long term management of particular assets. Transmission tower inspections were carried out by taking multiple photo images of the tower, insulators, and conductors. This removes the need to climb transmission structures and results in safer work practices. Evoenergy is currently considering the regular use of drones to inspect transmission towers and distribution poles.







9.13 Intellirupters

Evoenergy is trialling the use of pulse closing Intellirupters on overhead 11 kV feeders as an option to replace or supplement traditional reclosers. A recloser automatically opens and recloses upon the passage of a high level fault current. The high level of fault current passage during the reclose operation can cause localised heating of line conductors and generation of sparks that could potentially start a grass-fire or bushfire. This is a concern in the ACT especially during extremely dry summer months. An Intellirupter sends a low energy pulse of current down the line to detect if the fault has cleared before initiating a reclose operation. This significantly reduces the amount of current during reclosing and thus reduces the possibility of a resulting bushfire. This also reduces the possibility of damage to cable sections of a feeder. Evoenergy is developing a “bushfire algorithm” as part of this trial that will detect very low energy earth faults and operate the Intellirupter to isolate or clear such faults. Such faults are typically caused by vegetation contacting overhead conductors and if not detected and cleared, could cause localised heating that could lead to a bushfire.

9.14 FLISR (Fault Location, Isolation and Supply Restoration)

11 kV feeders can experience faults due to natural effects, human error, or equipment failures, causing customers to experience service interruptions. Locating these faults, limiting the total number of customers that are impacted by these faults, and quickly restoring power to customers are issues that Evoenergy faces continually.

Evoenergy is developing the use of field devices such as fault passage indicators and utilising its ADMS network control system to include FLISR (Fault Location, Isolation and Supply Restoration) as part of its overall progression towards a smart and self-healing network.

The FLISR process includes the following steps/applications:

1. Fault Location: Locating the part of the feeder with the faulted network element (e.g. faulted cable or overhead section) using appropriate methods. These methods make use of all deployed equipment in the distribution system capable of fault detection and location.
2. Fault Localisation: Locating the part of the feeder with the faulted element using remotely and/or manually controlled switching devices. This step is used for feeders without deployed equipment for fault location, such as fault indicators and fault measurements.
3. Element (Fault) Isolation: This step isolates the faulted element from the remaining (healthy) part of the feeder.
4. Service Restoration: Re-supplying (healthy) de-energized sections on the faulted feeder via switch orders.
5. Return to Normal State: Returns the network to the state before the fault occurred.

To maintain reliable service, the ADMS FLISR application provides the optimal plan of control actions for detecting, locating, and isolating faults and restoring power on a distribution feeder.

Using the FLISR application, operators can efficiently use existing field equipment in order to minimise the duration of the outage, and thus minimise the impact to customers, and improve SAIFI, SAIDI, and related indices.

Automatic (Closed Loop) Mode – FLISR can be run in a fully automated mode. Fault Location is executed without operator interaction when a permanent fault on a feeder is detected. Fault Location execution is followed by automatic execution of Element Isolation and Service Restoration, in sequence.

FLISR is a collection of tools used for detection, location, and isolation of faults and restoration of supply for de-energized customers. FLISR can be used in manual, semi-automatic, and automatic mode. Each application that is part of the FLISR solution is also available as a separate application.

Fault Location (FL) supports detecting the location of the fault. It calculates the locations where faults could have occurred by analysing the fault pattern along with available real-time information acquired from field devices, including fault indicator outputs, fault magnitude at various locations on the feeder, and protective relay trippings.

Element Isolation (EI) determines which switching operations are required to isolate selected elements, using defined types of equipment for isolation.

Supply Restoration (SR) is used for determining the optimal plan of switching actions for restoring supply to the de-energized parts of the distribution network.

Large Area Restoration (LAR) determines the plan for restoration of the supply of large parts of the distribution network, which remained de-energized after a fault occurrence on a zone substation supply transformer or MV busbar at a zone substation or after isolation of an element for maintenance at a zone substation.

9.15 Evoenergy Hydrogen Test Facility

Evoenergy and the Canberra Institute of Technology (CIT) have partnered to build a first-of-its-kind hydrogen test facility at CIT's Fyshwick campus.

While many gas distribution companies are embarking on hydrogen-related projects, ours will be the first facility in the country to look at testing 100% hydrogen on existing materials, equipment and work practices, in preparation for application to the existing gas distribution network.

This Australian-first initiative will allow us to gain a clear understanding of the impact of introducing hydrogen to existing infrastructure. It will move us one step closer to rolling out a viable renewable gas source on a large scale.

It is essential the impact of introducing hydrogen to the existing network is understood as this will have a major impact on any modifications or replacements that may be required to accommodate its use in the natural gas distribution system. Proving the viability of hydrogen as a clean gas energy source will have a profound impact on customers, as further beneficial hydrogen developments would likely follow. And hydrogen as a proven energy source aligns with the ACT Government's "green energy" target to reduce emissions to zero by 2045. Both Evoenergy and CIT will use the facility to train plumbing students in these new technologies, to equip tradespeople with skills well into the future.

Project phases

The facility will be launched progressively in 3 phases over 12 months:

- Phase 1: Testing existing Australian network components, construction and maintenance practices on 100% hydrogen application.
- Phase 2: Testing hydrogen as a broader energy storage source to support coupling the electricity network to the gas network.
- Phase 3: Appliance testing (eg. testing hydrogen and mixed gases in existing appliances such as Hot Water systems).

9.16 Gas-Plus Smart Home

Evoenergy is currently working with a local family who has built a home in Googong that is majority powered by gas, the first of its kind to be built and trailed in Australia.

The project provides a new understanding of gas usage in ACT region homes and is an opportunity to develop smart-home systems that includes gas energy. The purpose of the Googong Gas-Plus Smart Home trial is to gather gas consumption data from a number of different household appliances to understand usage patterns, the efficiency of gas in the Canberra climate, individual appliance efficiencies, and to facilitate the advancement of natural gas appliance smart-home solutions. These culminate to provide a better understanding of the role of natural gas in the ACT.

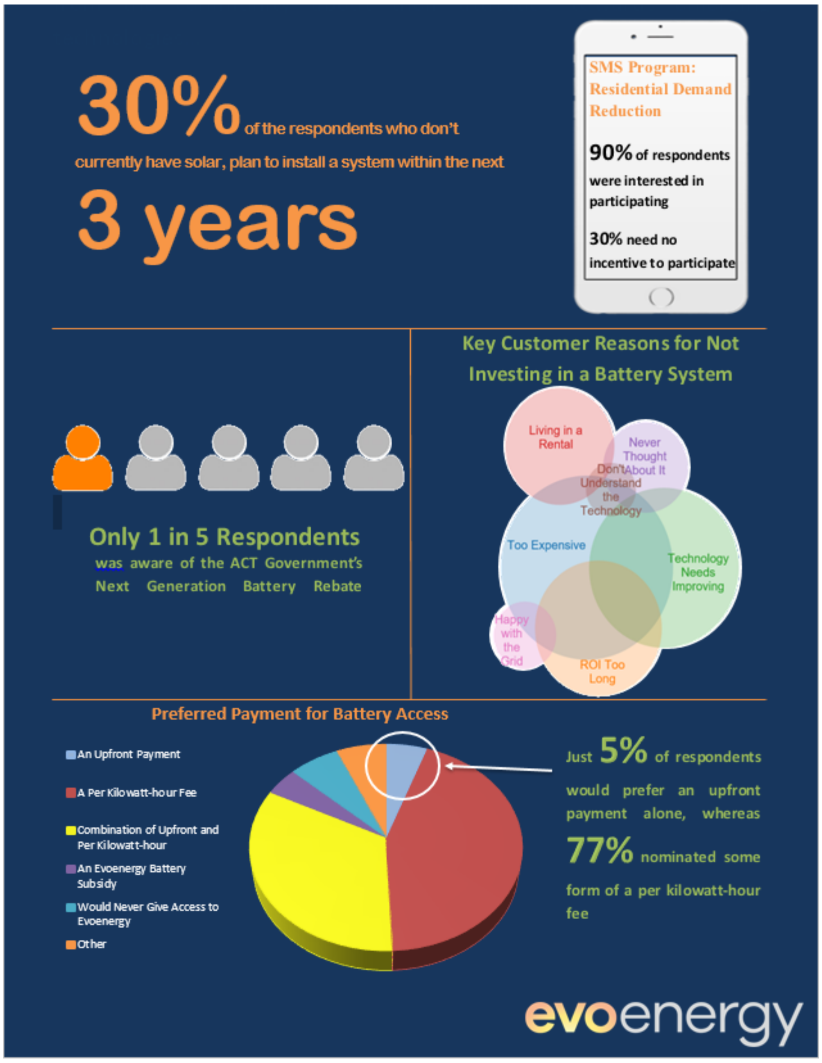
Transforming the gas network into one with a renewable future is in line with a longer plan to balance energy securities, reduce greenhouse gas emissions, and improve affordability. Understanding customer usage and appliance efficiency under the real Canberra climate is important for educating the community and assisting the deployment of new technologies that will drive the decarbonisation journey of gas in Evoenergy networks.

The project involves partnership between Evoenergy, appliance manufacturers – Seeley and Rinnai and the Australia National University (ANU). An advanced communication and data management system (DMS) has been installed into the home capturing real-time, accurate energy usage data for individual appliances and the home's external and internal climate condition. The trial provides a platform for:

- New systems to be tested for gas appliance manufacturers with accurate data being collected in a real-use environment for the ACT region.
- The currently unreleased Seeley CW3 dual system (heating and cooling) has been installed into the Googong Smart Home. Once the CW3 is in use Data on gas, electricity, and water use provided to the manufacturer for observation and analysis.
- Data acquired through the trial can be used to reinforce efficiency calculations.
- The energy data acquired in the trial will provide direction for gas suppliers, appliance manufacturers, with individual appliance and overall gas usage made clear over seasonal and daily timeframes.
- Research & Development

9.17 Future Network Survey

In June 2018, Evoenergy ran a Future Network Survey to gauge the opinion of customers on a range of topics and the community's attitude towards emerging technologies. With over 600 responses the findings were statistically significant and they confirm the results observed in our previous trials, e.g. when asked about their willingness to participate in an SMS demand response program, 90% of respondents were interested in participating, some even without the promise of an incentive. This is consistent with our earlier trial of SMS Demand Response in 2017, which saw a 75% response for the two events held. These numbers are promising for the viability of such a program in the ACT.



Appendix A: Glossary of Terms

Term	Definition
ACT	Australian Capital Territory
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGGREGATOR	A party that facilitates the grouping of DER to act as single entity in the market
APR	Annual Planning Report
BESS	Battery Energy Storage System
BSP	Bulk Supply Point
CAIDI	Customer Average Interruption Duration Index
CESS	Capital Expenditure Sharing Scheme
DER	Distributed Energy Resource
DMIS	Demand Management Incentive Scheme
DMP	Demand Management Process
DNSP	Distribution Network Service Provider
DR	Demand Response
DSES	Demand Side Engagement Strategy
DSM	Demand Side Management
DSMP	Demand Side Management Planning
DSO	Distribution System Operator
DUOS	Distribution Use of System
ENA	Energy Networks Australia
EOI	Expression of Interest
FLISR	Fault Location, Isolation and Supply Restoration
HV	High voltage
ICRC	Independent Competition and Regulatory Commission
MVA	Mega Volt Amperes
MW	Mega Watts
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
NPV	Net Present Value
NTFP	National Transmission Flow Path
NTNDP	National Transmission Network Development Plan
N-1	Security Standard where supply is maintained following a single credible contingency event
OPGW	Optical Ground Wire
PFC	Power Factor Correction
PoC	Power of Choice

Term	Definition
PoE	Probability of Exceedance
PV	Photovoltaic
QOS	Quality of Supply
RDSE	Register of Demand Side Engagement
RIT-D	Regulatory Investment Test for Distribution
RIT-T	Regulatory Investment Test for Transmission
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control And Data Acquisition
STPIS	Service Target Performance Incentive Scheme
TNSP	Transmission Network Service Provider
TOU	Time of Use
TUOS	Transmission Use of System
Utilities Act	ACT Utilities Act 2000
UTR	Utilities Technical Regulator
VoIP	Voice Over Internet Protocol
VPP	Virtual Power Plant
WAN	Wide Area Network

Appendix B: Bulk Supply Point Load Forecasts

Tables B.1 and B.2 show the summer and winter maximum demand forecasts for the three TransGrid owned bulk supply point substations Canberra, Williamsdale and Queanbeyan. Table B.3 lists the seasonal diversity factor for each BSP. Tables B4 and B5 show the impact of emerging technologies on system forecasts.

Table B.1: TransGrid bulk supply point substations summer maximum demand forecast

Summer	Canberra		Queanbeyan		Williamsdale		Stockdill	
Year	POE 50	POE 10	POE 50	POE 10	POE 50	POE 10	POE 50	POE 10
2019	386	432	27	28	174	195	0	0
2020	379	429	29	30	171	194	0	0
2021	252	283	29	30	171	192	126	142
2022	249	280	29	30	169	189	125	140
2023	252	283	29	30	171	191	126	141
2024	250	280	29	30	170	189	125	140
2025	246	279	29	31	167	189	123	139
2026	247	278	30	31	167	188	124	139
2027	248	279	30	31	168	189	124	140
2028	248	280	31	32	168	190	124	140

Table B.2: TransGrid bulk supply point substations winter maximum demand forecast

Winter	Canberra		Queanbeyan		Williamsdale		Stockdill	
Year	POE 50	POE 10	POE 50	POE 10	POE 50	POE 10	POE 50	POE 10
2019	445	469	23	24	196	207	0	0
2020	448	469	24	25	198	207	0	0
2021	298	312	25	25	198	207	149	156
2022	297	312	26	26	197	207	148	156
2023	296	309	27	27	196	205	148	155
2024	293	308	27	28	194	204	146	154
2025	293	308	28	29	194	204	147	154
2026	293	309	29	30	194	205	147	155
2027	295	310	30	30	195	205	147	155
2028	294	307	31	31	195	204	147	154

Table B.3: TransGrid bulk supply point substations seasonal diversity factor

Season	Canberra	Queanbeyan	Williamsdale	Stockdill
Summer	88%	95%	100%	88%
Winter	95%	82%	86%	95%

Table B.4: 10-year System summer forecast by structure change technologies

Summer	TG less EV		Plus EV (TG Import)		Plus Large Solar& Bio Gen (Operational demand)		Plus Battery		Plus Rooftop Solar		Plus Energy Efficiency	
Year	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10
2019	539	600	539	600	557	618	557	619	595	657	597	660
2020	530	598	530	598	547	615	548	615	593	664	599	671
2021	528	592	529	593	548	611	548	611	596	660	607	673
2022	523	585	524	585	540	602	540	603	589	655	606	674
2023	528	590	529	591	546	610	546	610	593	664	613	686
2024	525	584	526	586	544	607	544	606	592	658	615	683
2025	517	582	519	584	535	600	534	599	586	655	610	682
2026	518	580	521	584	537	602	536	599	590	655	616	685
2027	518	581	522	586	539	602	536	599	588	661	616	693
2028	516	581	523	589	537	606	532	600	586	652	615	685

Table B.5: 10-year System winter forecast (Neutral Scenario) by structure change technologies

Winter	TG less EV		Plus EV (TG Import)		Plus Large Solar& Bio Gen (Operational demand)		Plus Battery		Plus Rooftop Solar		Plus Energy Efficiency	
Year	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10
2019	610	643	610	643	616	648	617	649	621	655	628	661
2020	615	644	616	644	620	648	623	651	627	656	639	668
2021	615	643	615	644	620	649	622	651	627	657	645	676
2022	612	643	613	644	617	649	620	651	625	656	646	678
2023	611	638	612	639	616	644	619	646	624	653	647	678
2024	605	635	607	637	612	645	614	645	618	651	644	678
2025	605	635	608	638	613	644	615	645	620	648	647	677
2026	604	636	609	641	613	647	614	647	620	650	650	681
2027	606	636	613	643	618	648	617	646	623	651	655	684
2028	601	628	611	638	616	646	612	639	616	644	649	679

Appendix C: Zone Substations Load Forecasts

Figures C.1.1 – C.13.2 illustrate the 10-year summer and winter maximum demand forecasts for the thirteen zone substations: Belconnen, City East, Civic, East Lake, Fyshwick, Gilmore, Gold Creek, Latham, Telopea Park, Tennent, Theodore, Wanniassa and Woden.

Figure C.1.1: Belconnen Zone Substation summer maximum demand forecast

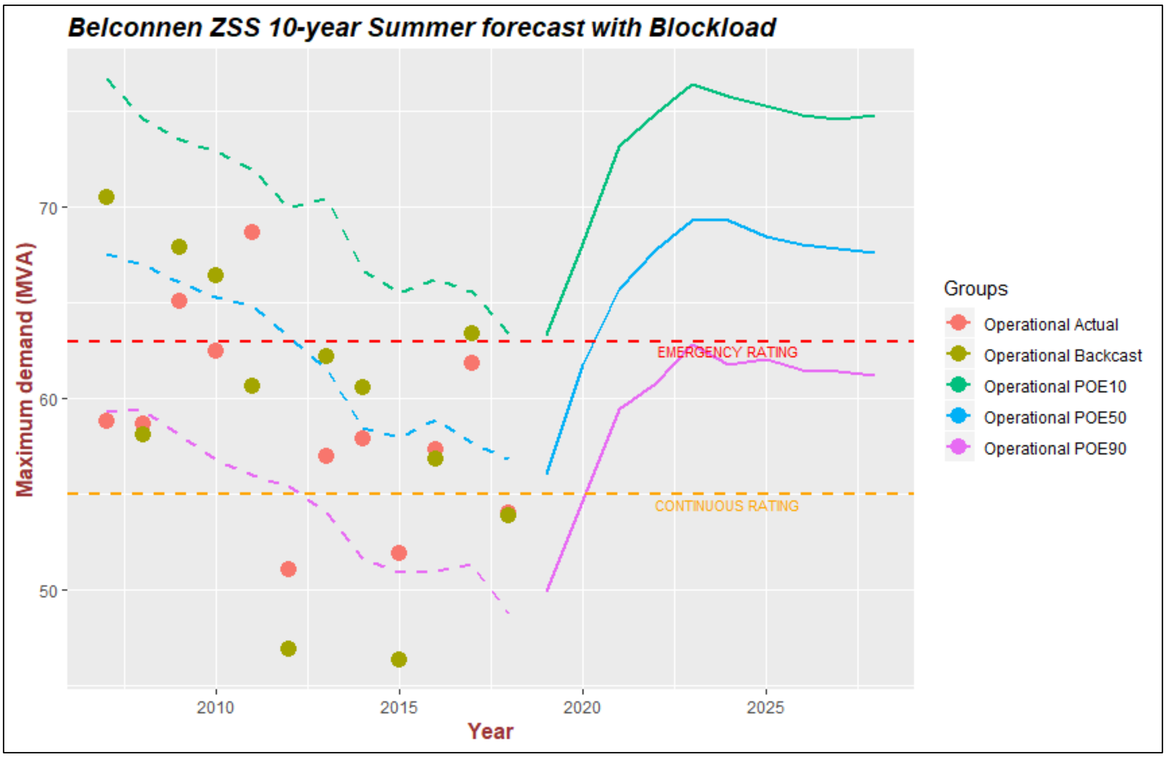


Figure C.1.2: Belconnen Zone Substation winter maximum demand forecast

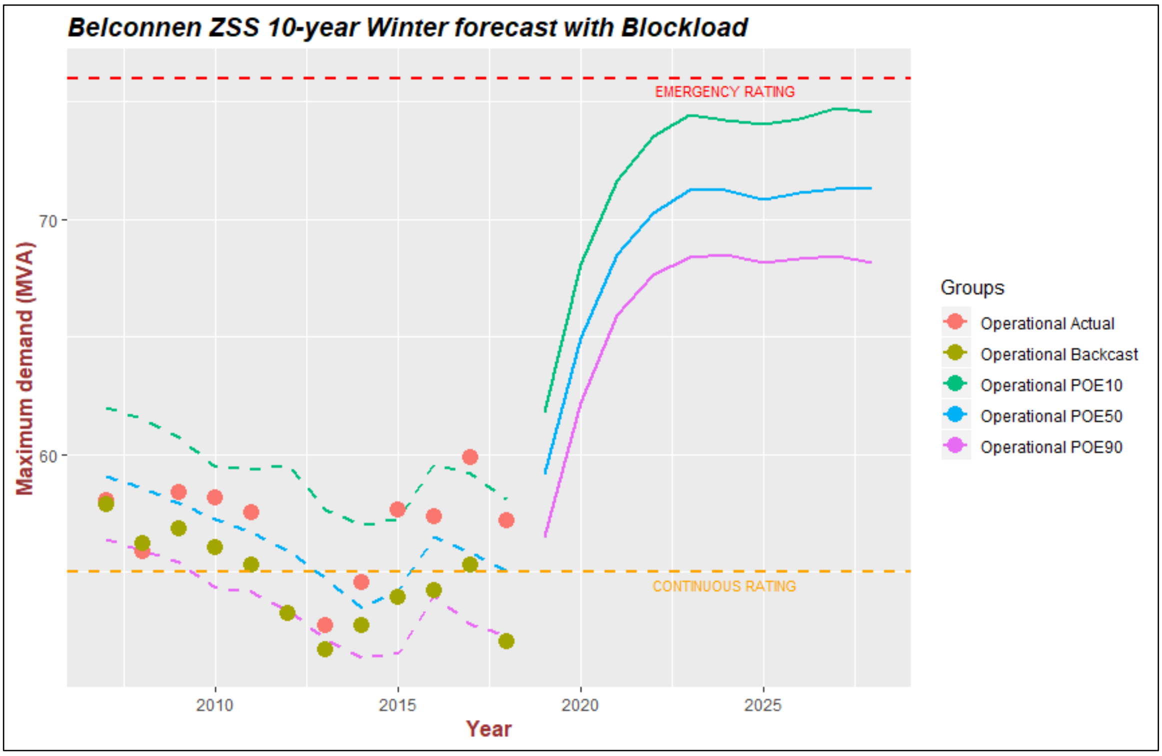


Figure C.2.1: City East Zone Substation summer maximum demand forecast

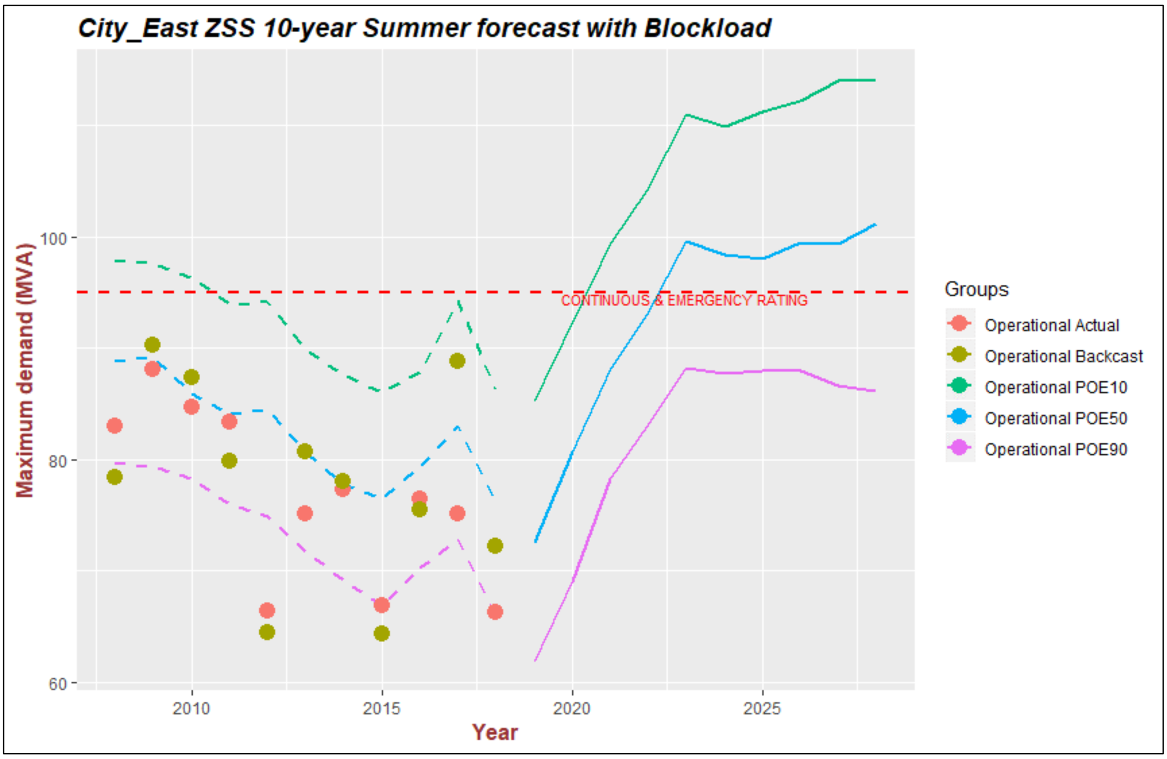


Figure C.2.2: City East Zone Substation winter maximum demand forecast

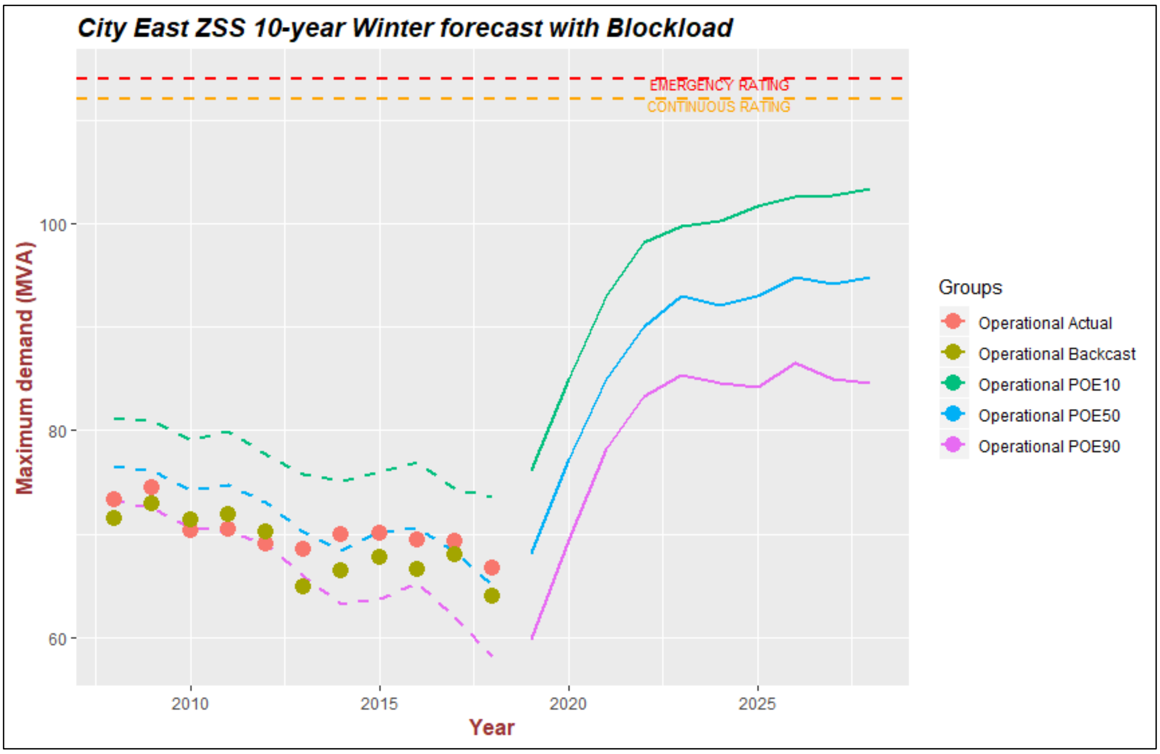


Figure C.3.1: Civic Zone Substation summer maximum demand forecast

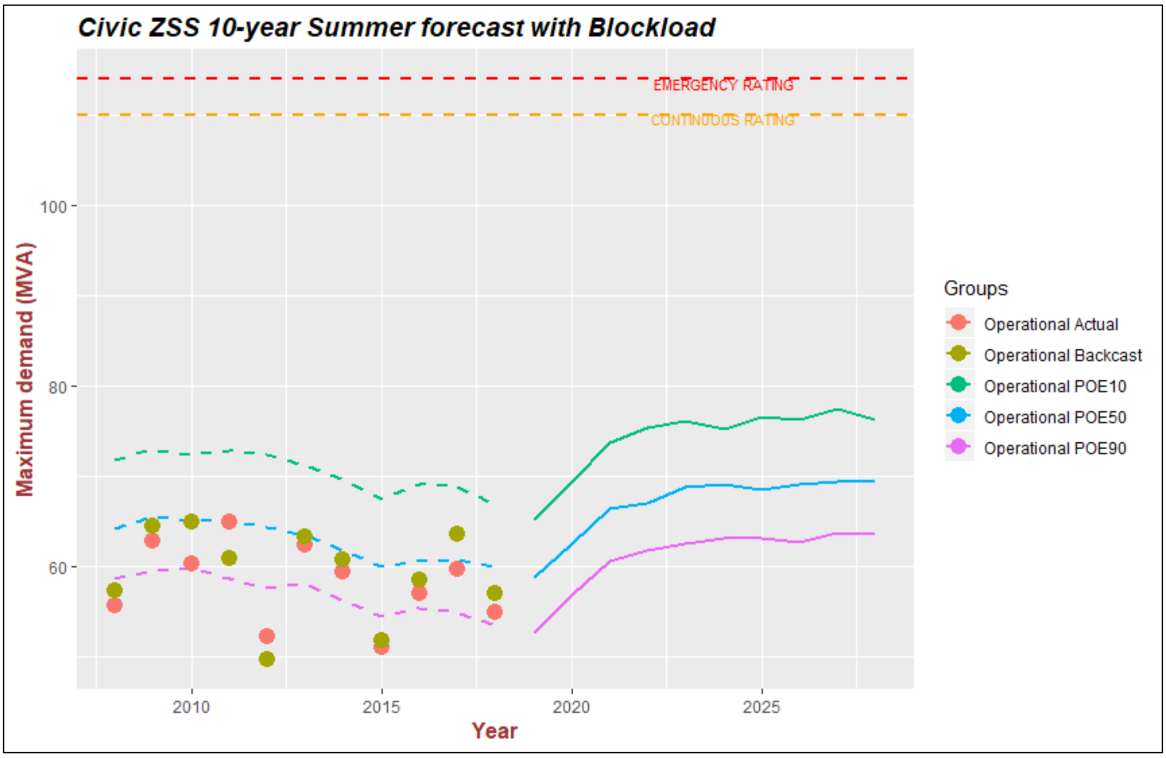


Figure C.3.2: Civic Zone Substation winter maximum demand forecast

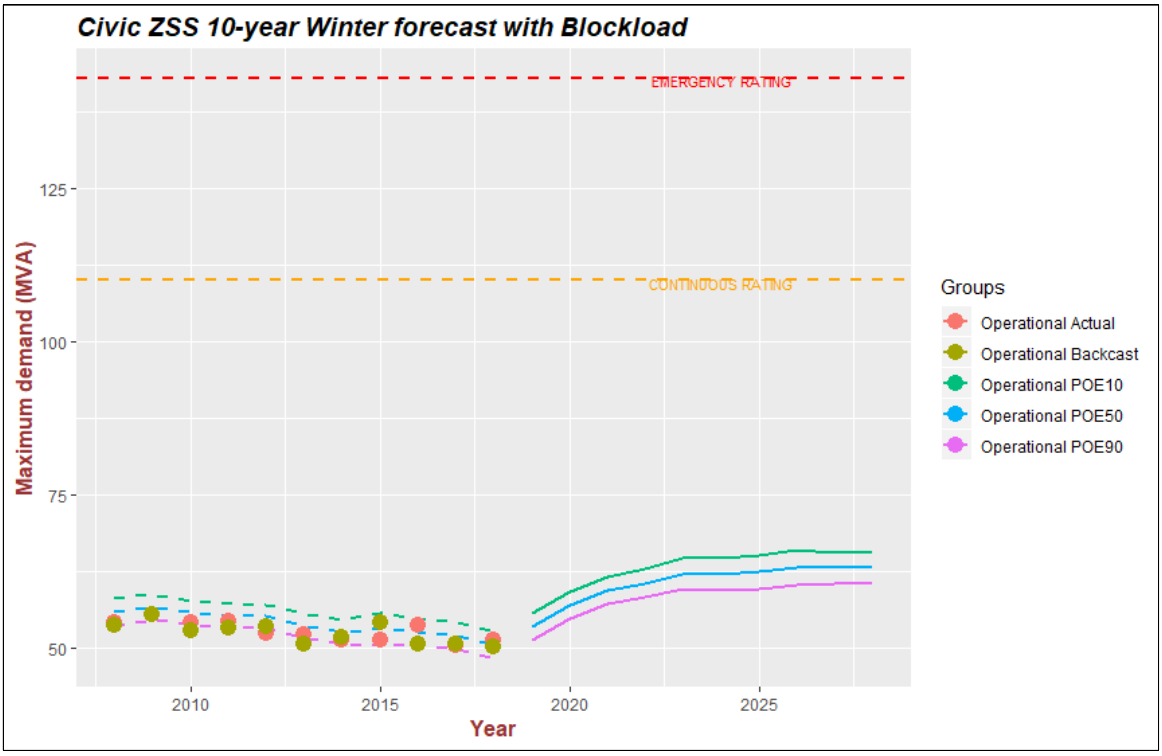


Figure C.4.1: East Lake Zone Substation summer maximum demand forecast

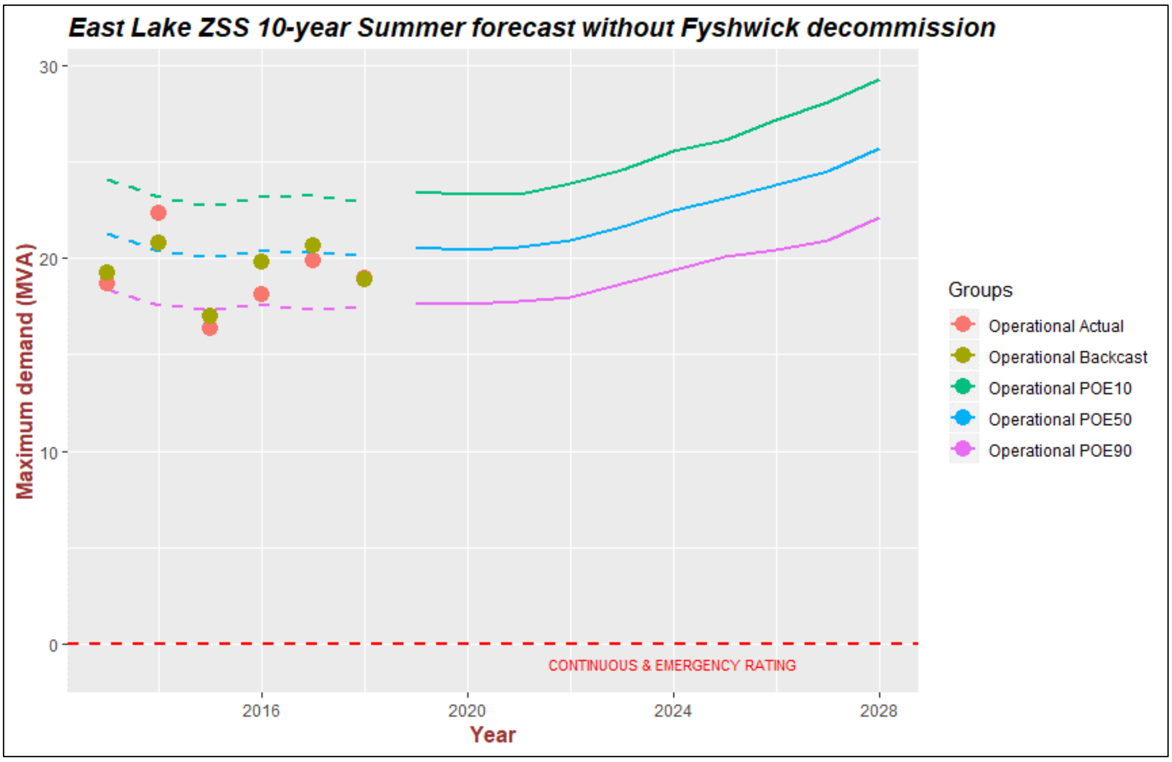


Figure C.4.2: East Lake Zone Substation winter maximum demand forecast

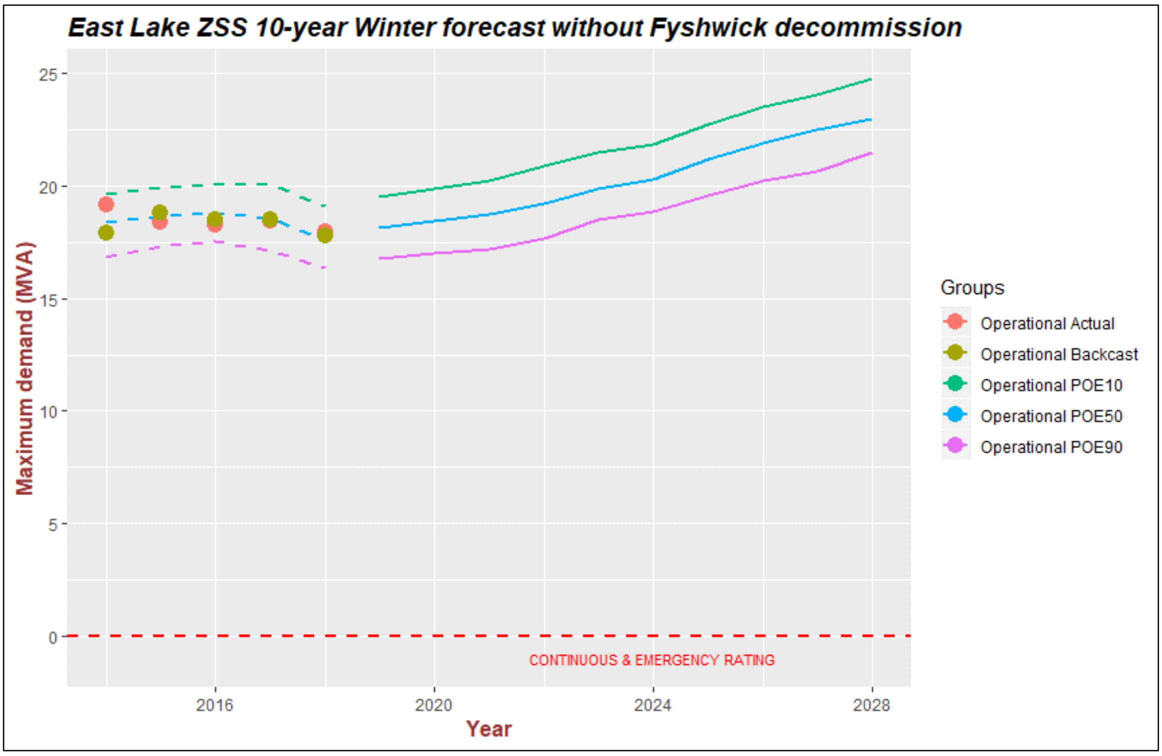


Figure C.5.1: Fyshwick Zone Substation summer maximum demand forecast

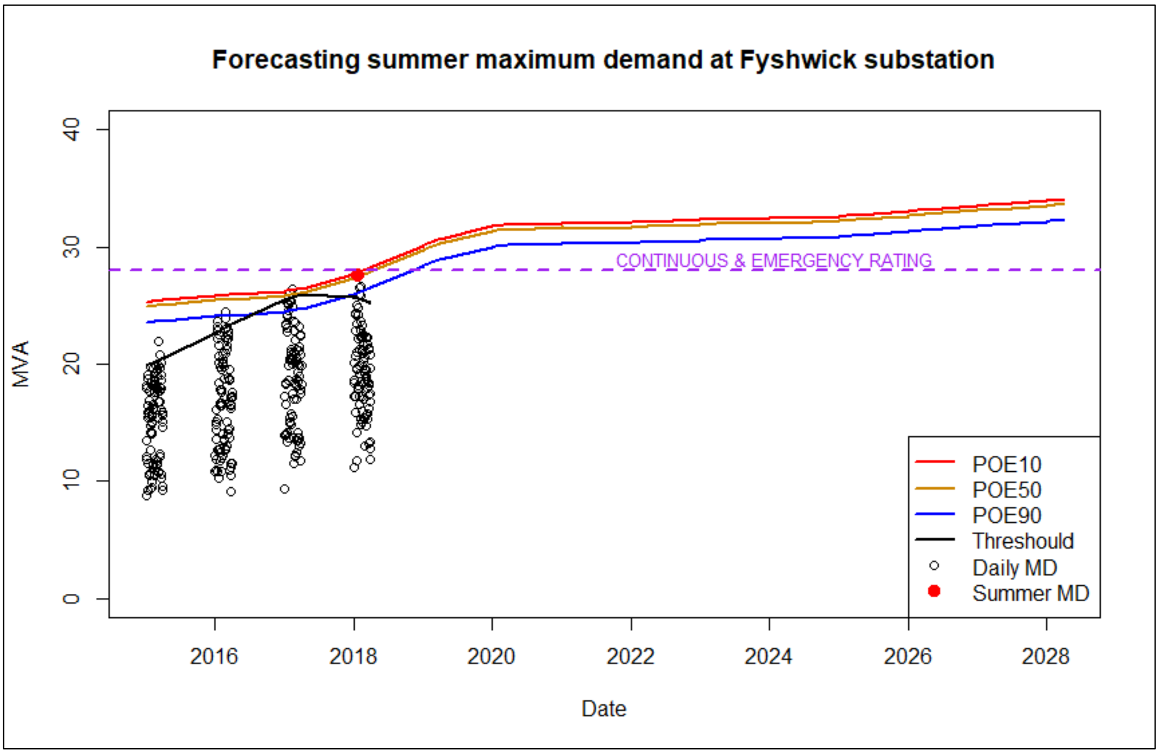


Figure C.5.2: Fyshwick Zone Substation winter maximum demand forecast

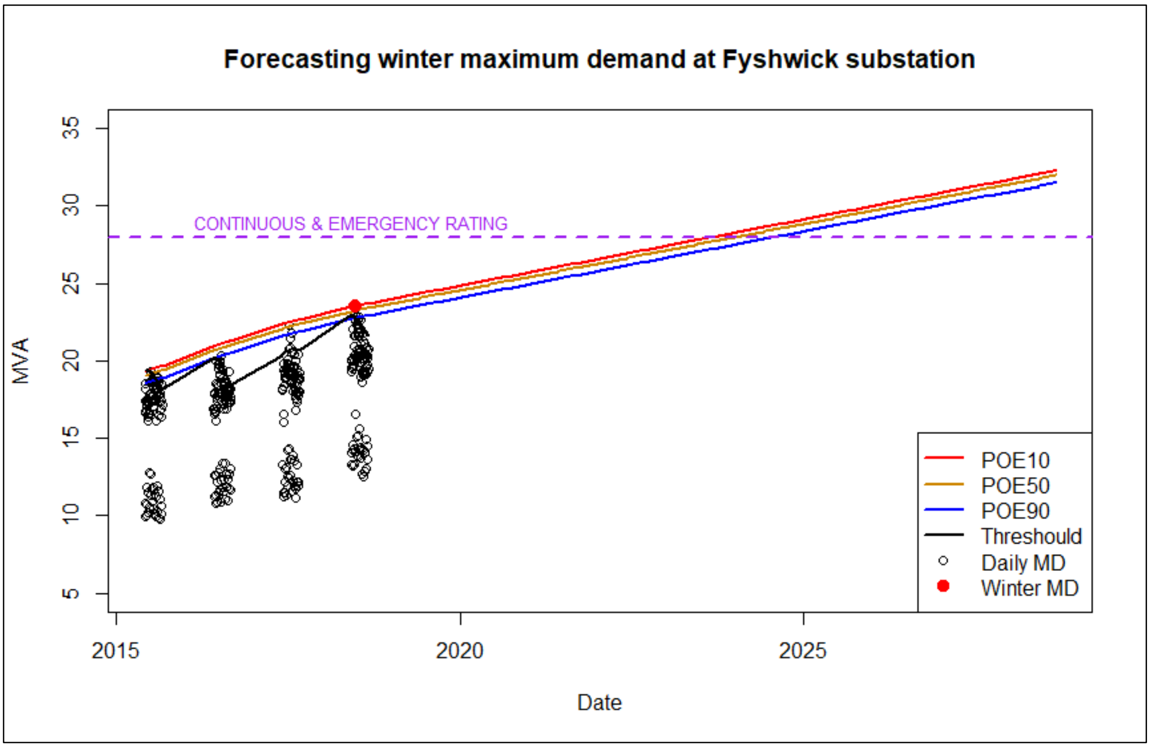


Figure C.6.1: Gilmore Zone Substation summer maximum demand forecast

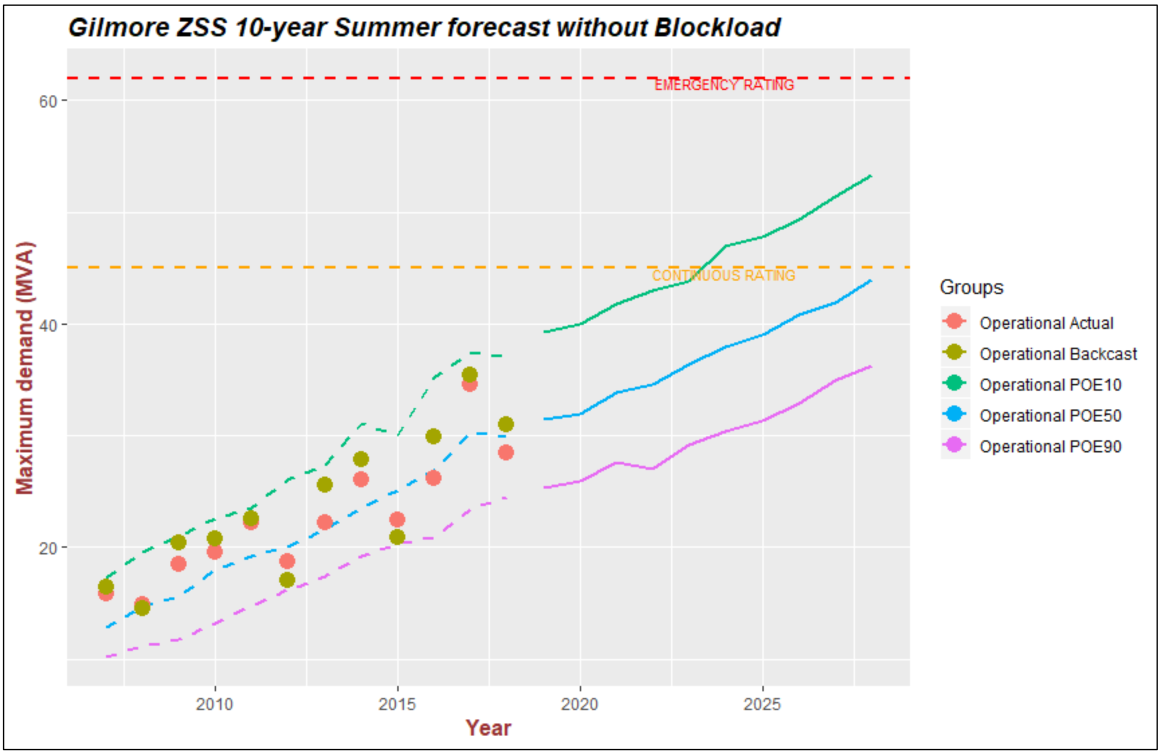


Figure C.6.2: Gilmore Zone Substation winter maximum demand forecast

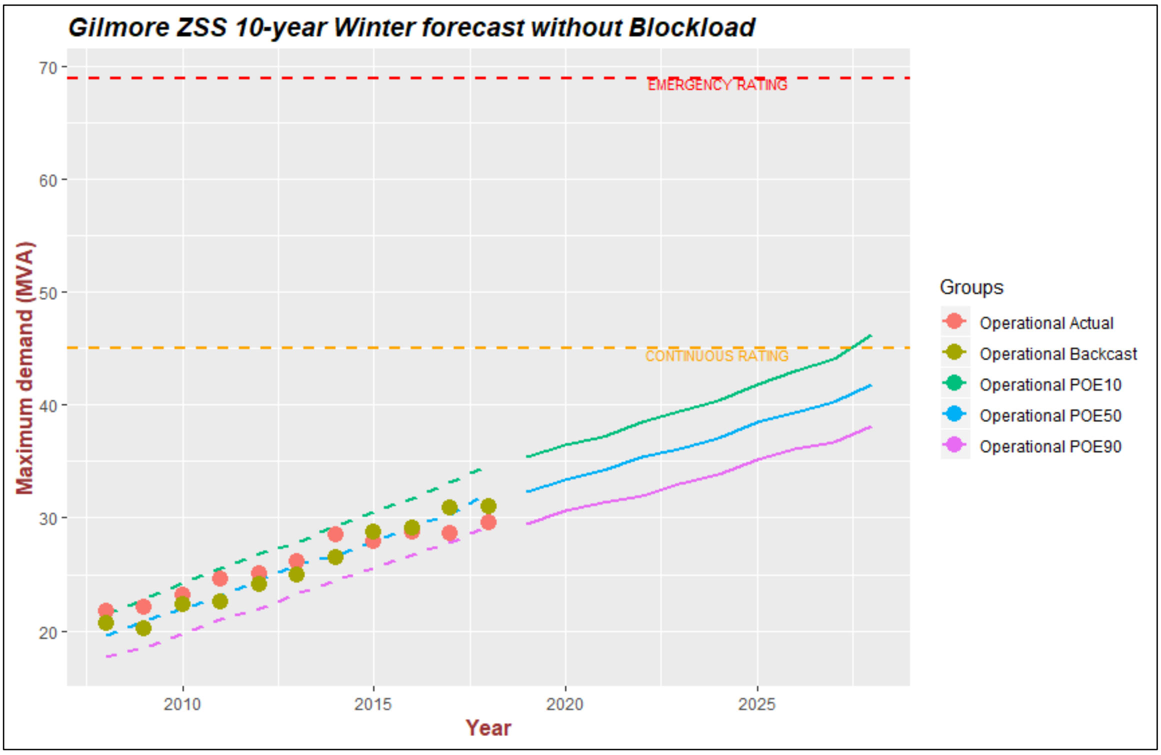


Figure C.7.1: Gold Creek Zone Substation winter maximum demand forecast

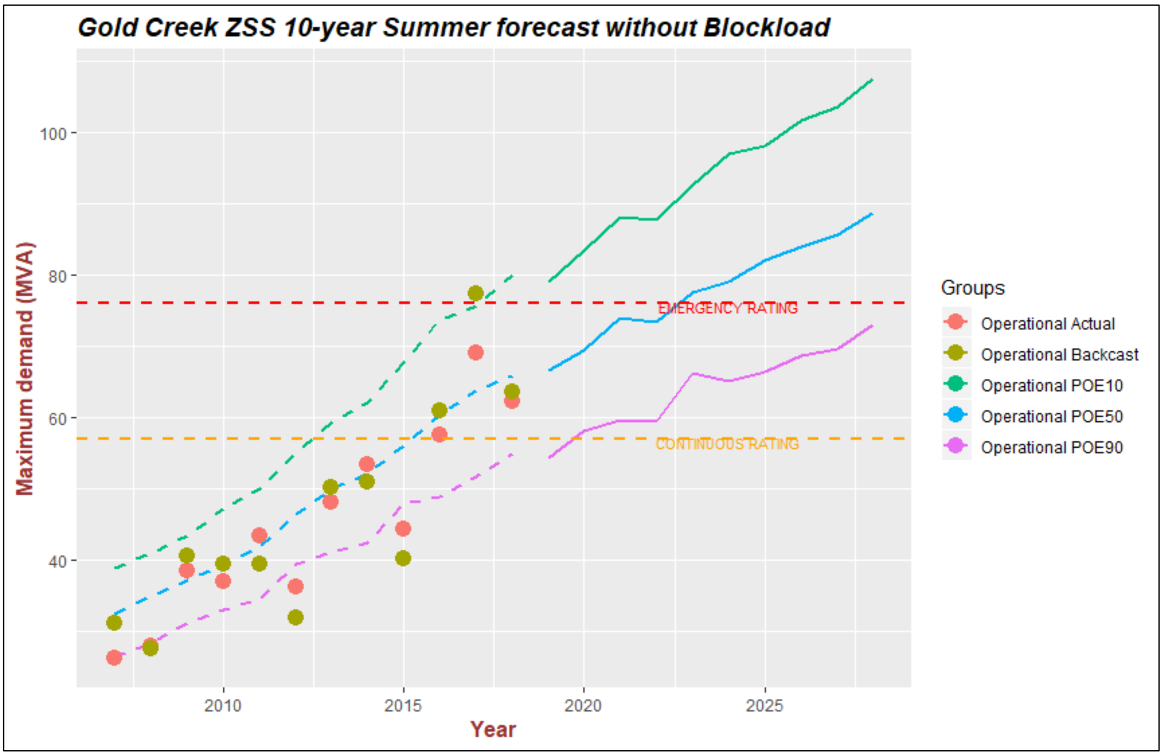


Figure C.7.2: Gold Creek Zone Substation summer maximum demand forecast

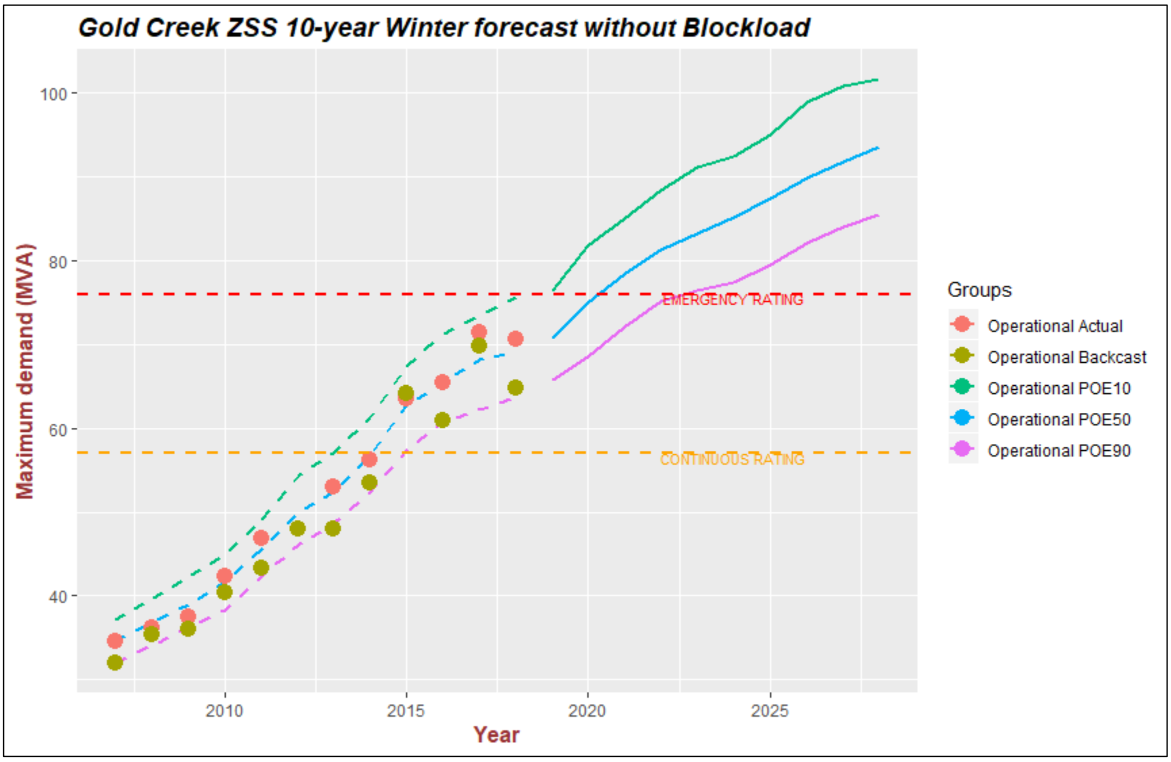


Figure C.8.1: Latham Zone Substation summer maximum demand forecast

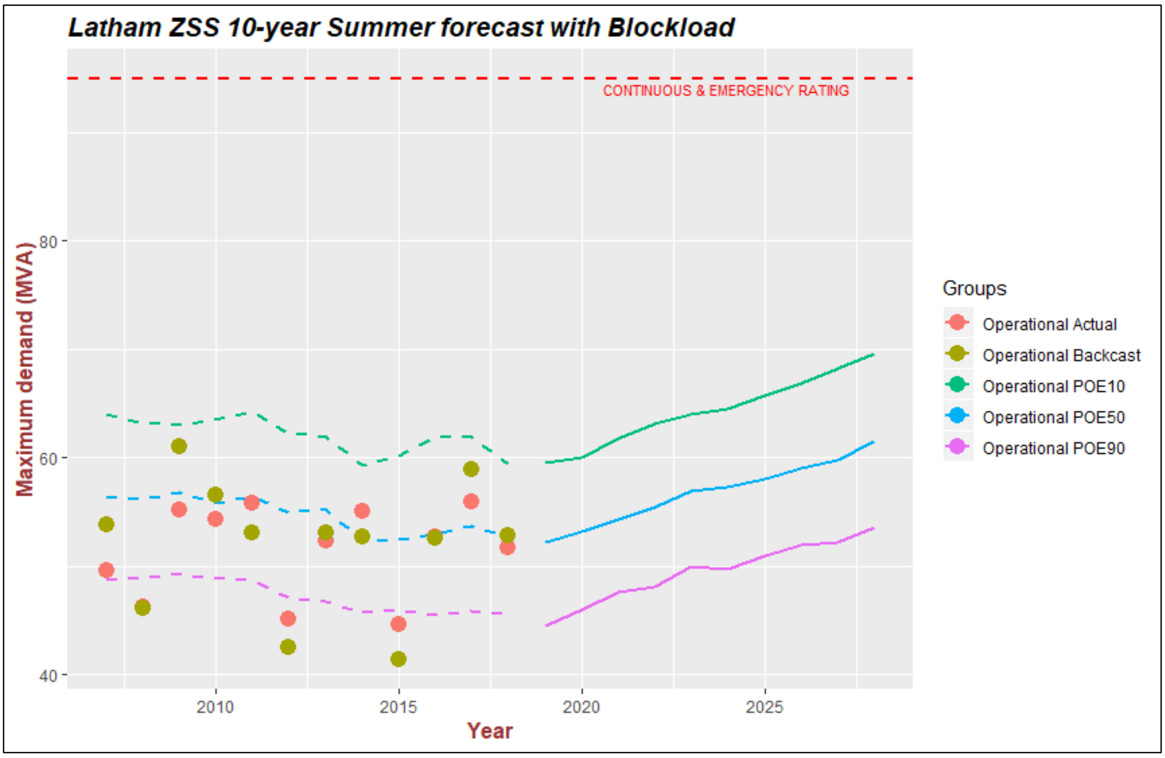


Figure C.8.2: Latham Zone Substation winter maximum demand forecast

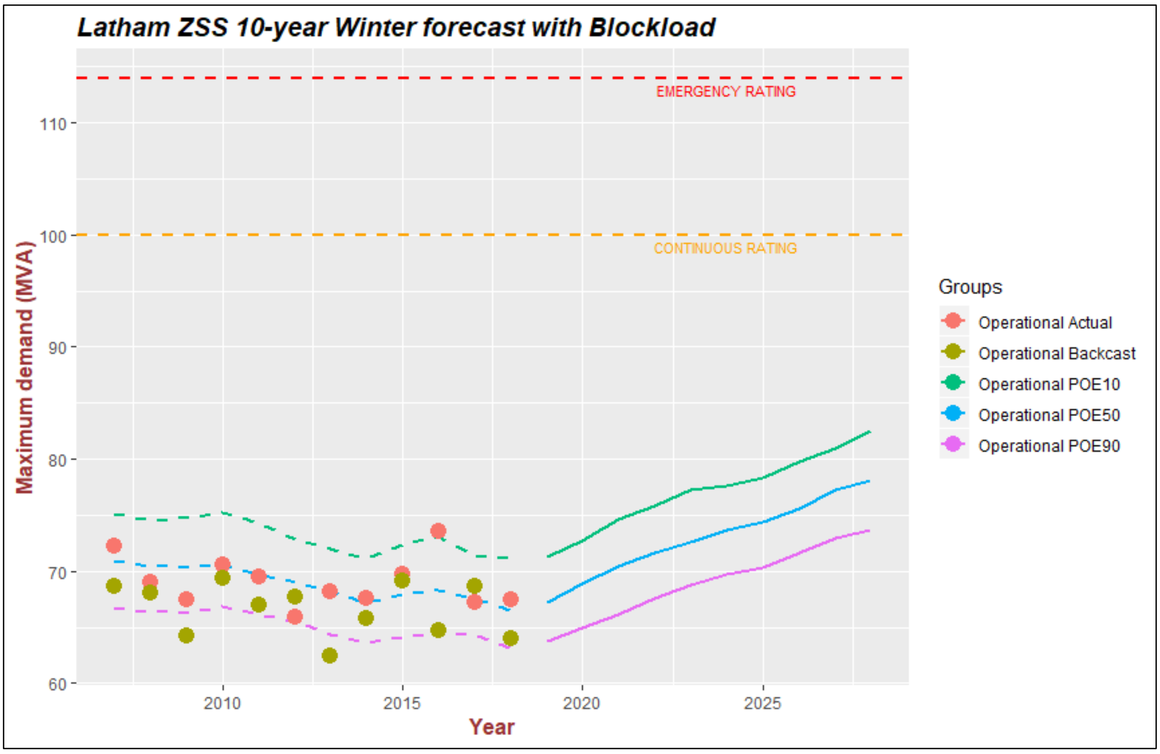


Figure C.9.1: Telopea Park Zone Substation summer maximum demand forecast

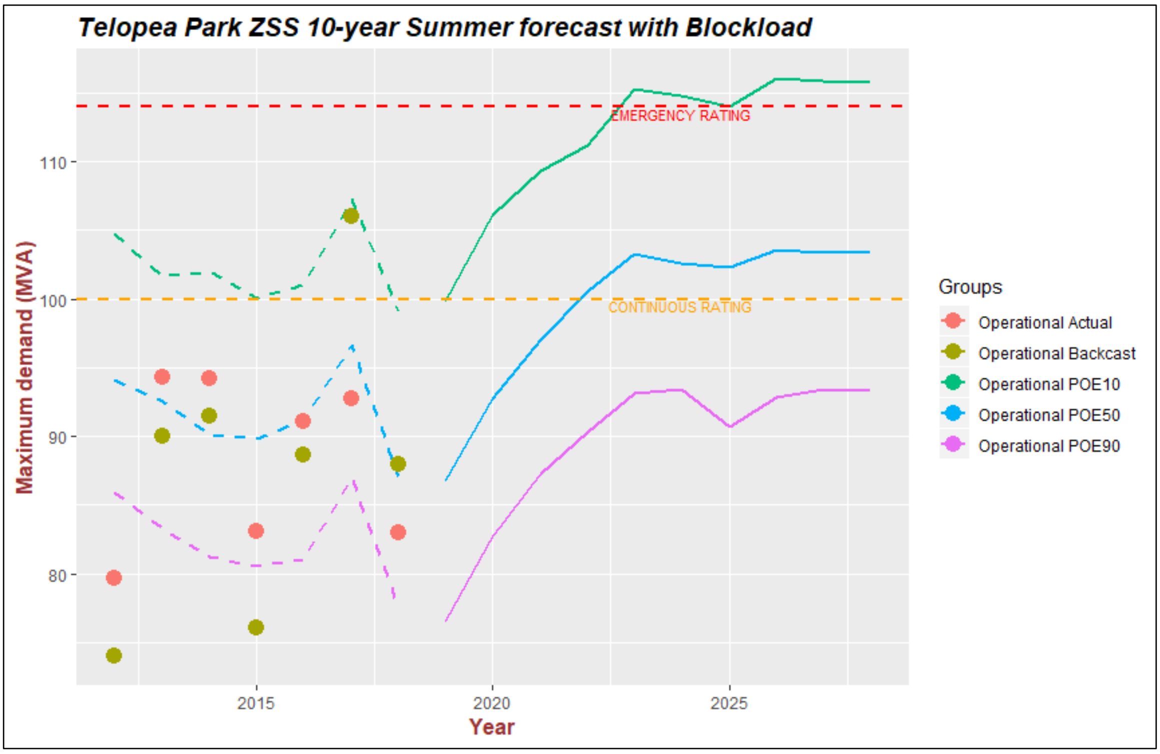


Figure C.9.2: Telopea Park Zone Substation winter maximum demand forecast

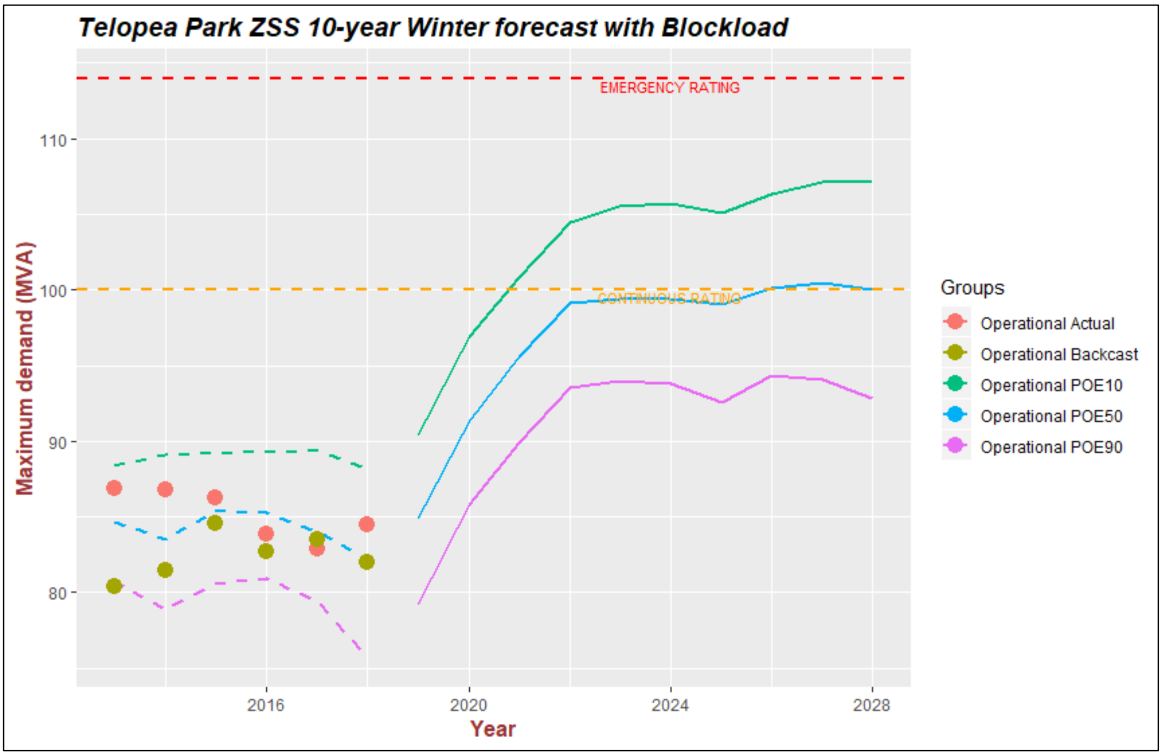


Figure C.10.1: Tennent Zone Substation summer maximum demand forecast

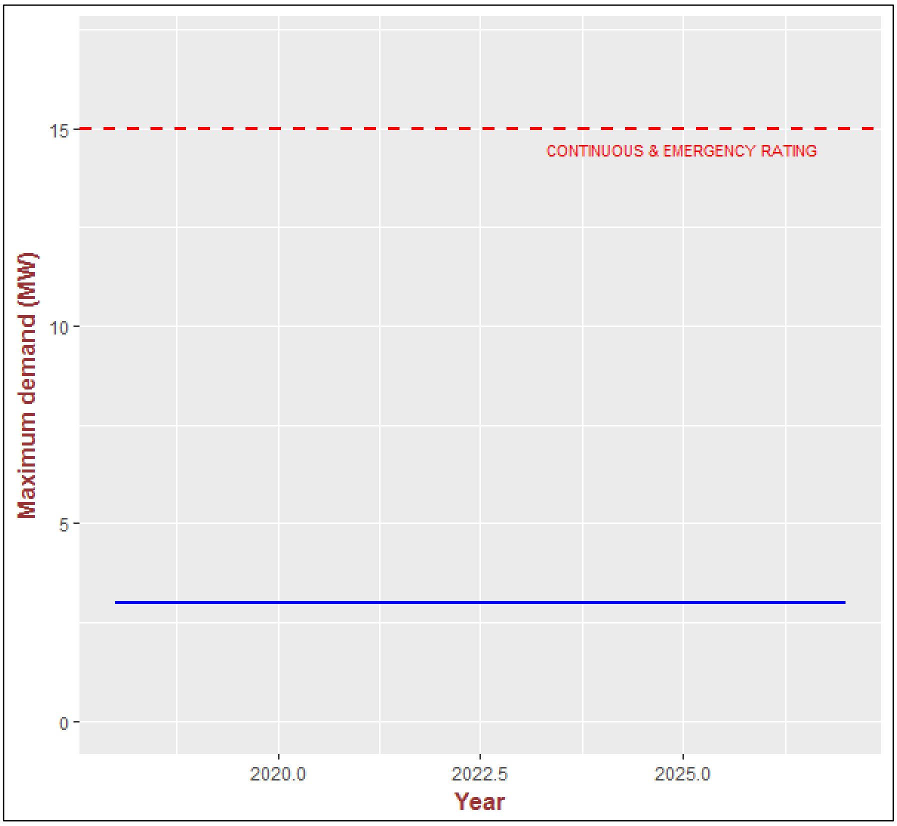


Figure C.10.2: Tennent Zone Substation winter maximum demand forecast

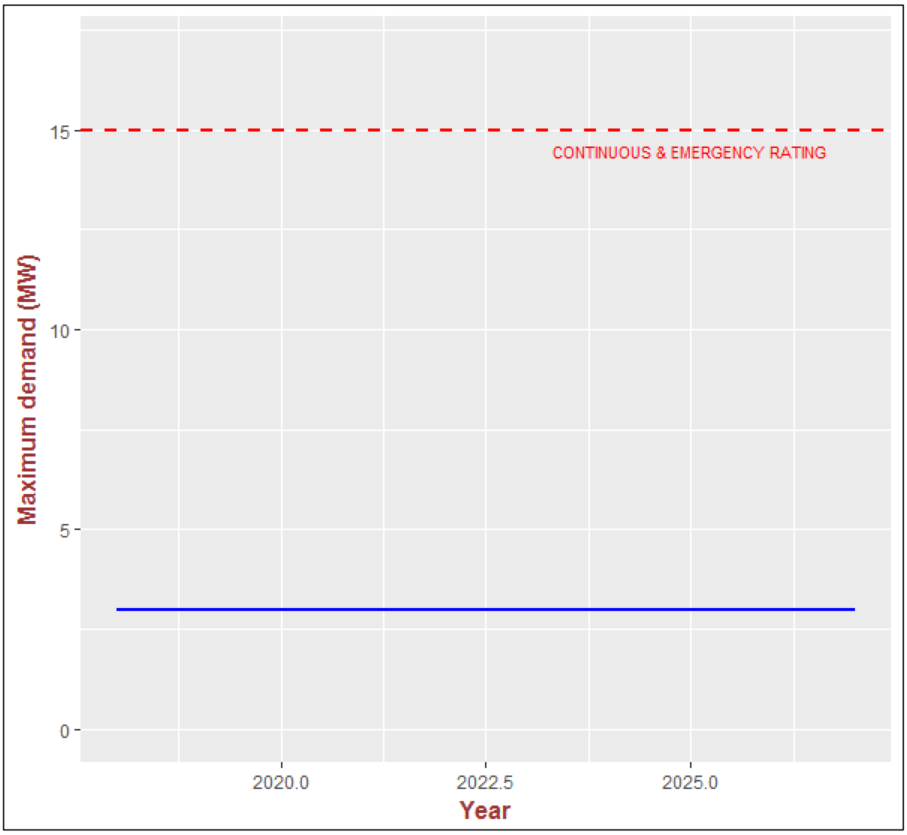


Figure C.11.1: Theodore Zone Substation summer maximum demand forecast

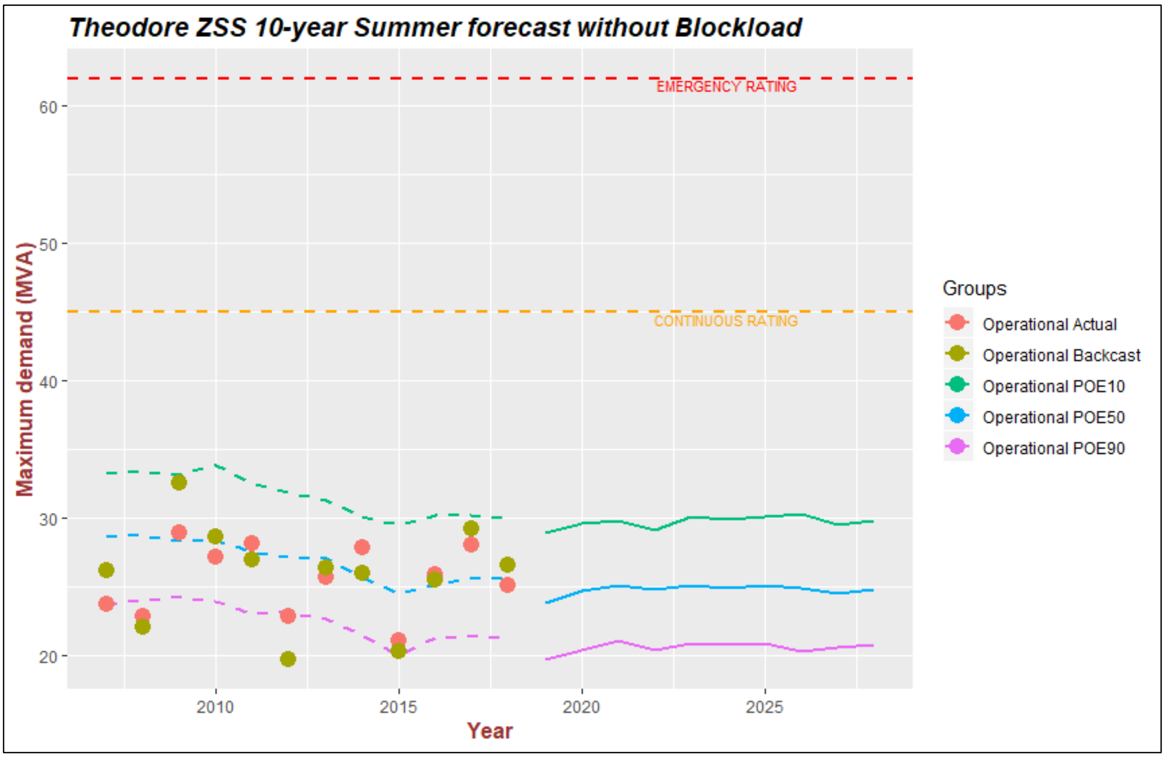


Figure C.11.2: Theodore Zone Substation winter maximum demand forecast

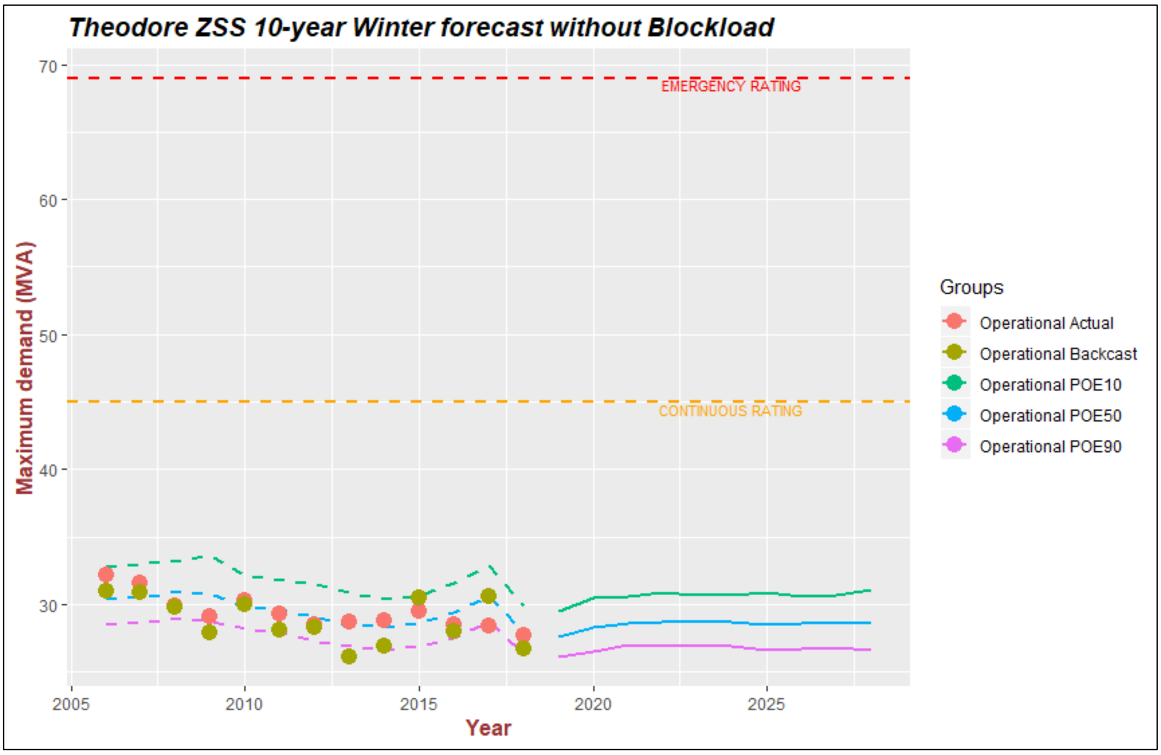


Figure C.12.1: Wanniassa Zone Substation summer maximum demand forecast

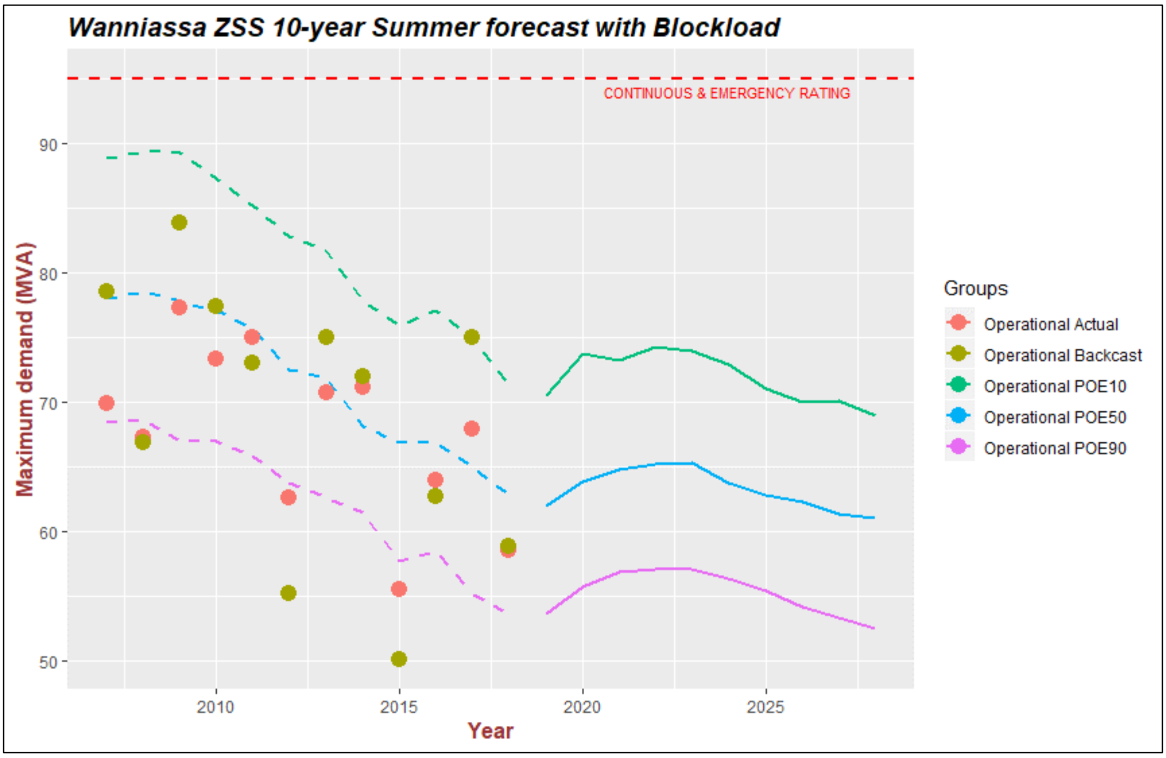


Figure C.12.2: Wanniassa Zone Substation winter maximum demand forecast

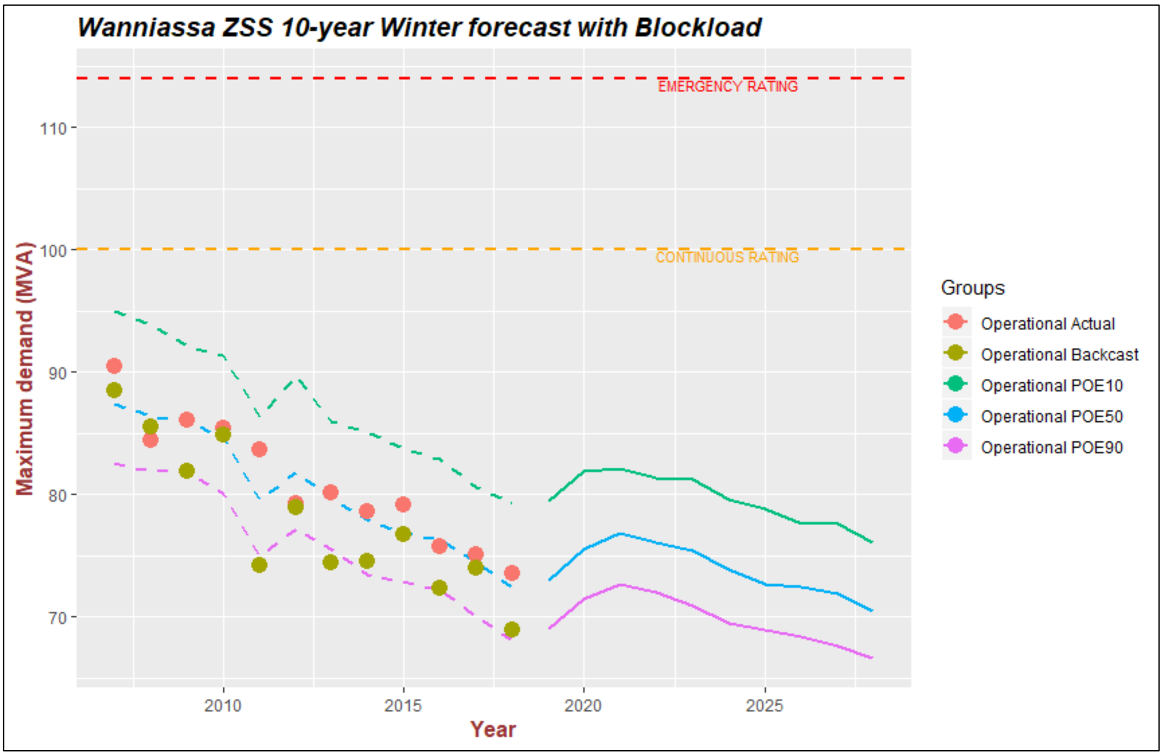


Figure C.13.1: Woden Zone Substation summer maximum demand forecast

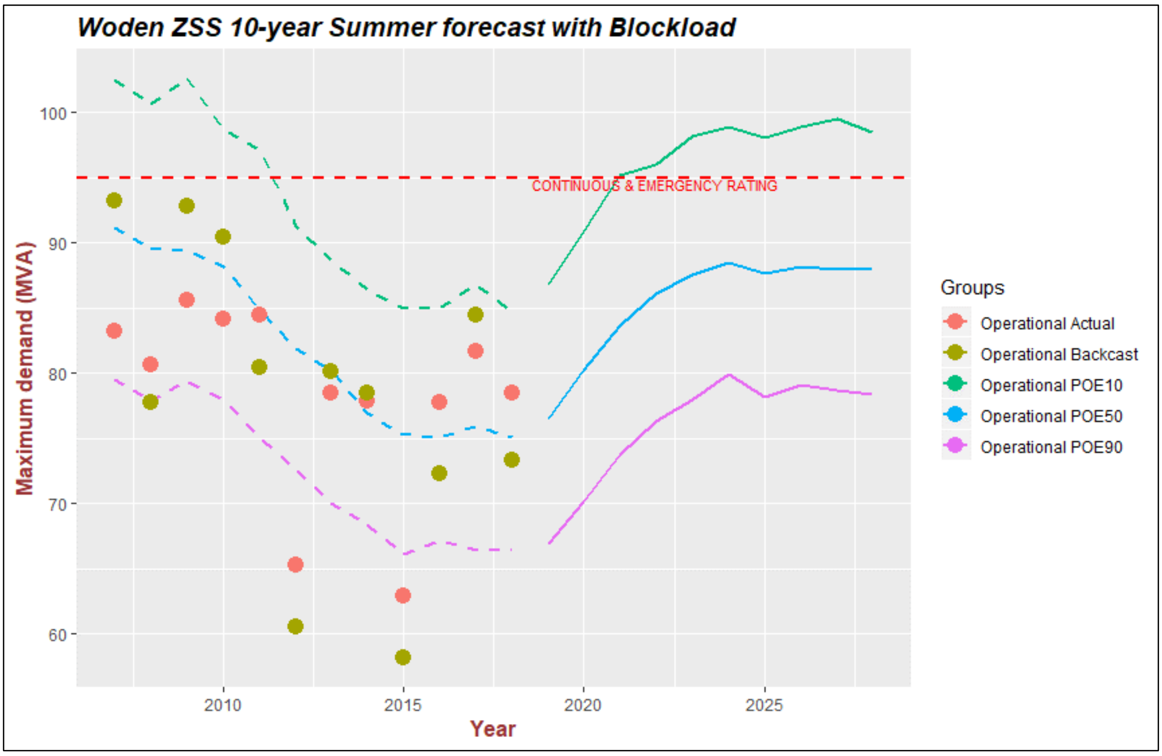
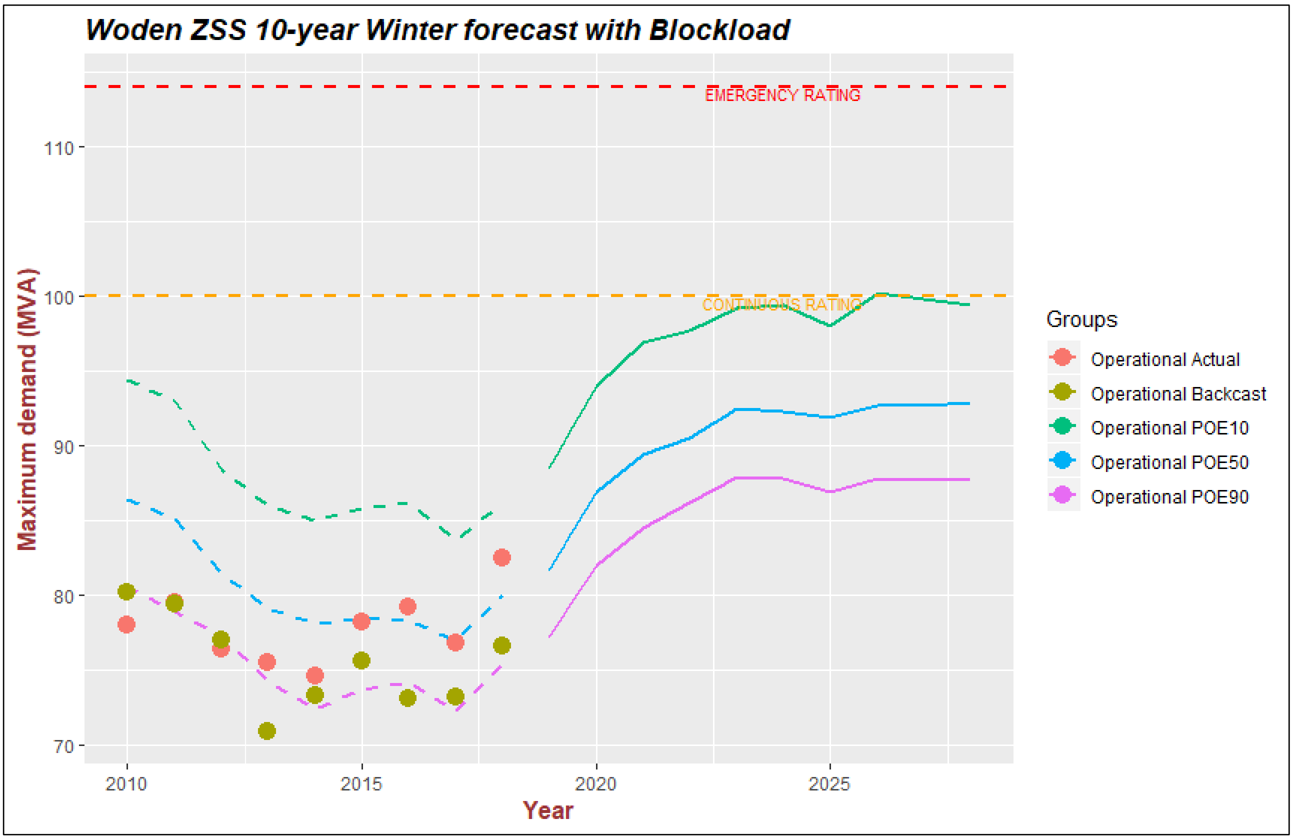


Figure C.13.2: Woden Zone Substation winter maximum demand forecast



Appendix D: Transmission Line Ratings

LINE			CURRENT RATING (AMPS)			
			Summer Day (35ºC ambient temperature)		Winter Day (15ºC ambient temperature)	
From	To	ID No	Continuous	Emergency	Continuous	Emergency
132 kV						
Belconnen	Bruce	A-21	1934	2916	2514	3277
Belconnen	Latham	A-20	1955	2958	2545	3325
Bruce	City East	A-54	967	1463	1259	1644
Bruce	Civic	A-11	1934	2926	2518	3289
Bruce	East Lake	A-45	967	1122	1122	1122
Bruce	Gold Creek	A-30	1934	2916	2514	3277
Canberra	Gold Creek	A-3	1934	2916	2514	3277
Canberra	Latham	A-2	1955	2958	2545	3325
Canberra	Woden	A-1	1955	2958	2545	3325
Causeway	City East	A-50	968	1458	1257	1638
Causeway	East Lake	A-46	968	1122	1122	1122
Causeway	Gilmore	A-44	1935	2916	2514	3277
Causeway	Telopea Park 1	A-51	390	390	390	390
Causeway	Telopea Park 2	A-52	390	390	390	390
Causeway	Telopea Park 3	A-53	390	390	390	390
Civic	Woden	A-10	1955	2958	2545	3325
Gilmore	Theodore	A-43	968	1458	1257	1638
Gilmore	Wanniassa	A-41	968	1458	1257	1638
Gilmore	Williamsdale	97F	968	1458	1257	1638
Tennent	Tennent Tee	97H/5	968	1458	1257	1638
Wanniassa	Woden	A-40	1990	3002	2586	3374
66 kV						
Fyshwick 1	Queanbeyan 1	0844	583	865	750	970
Fyshwick 2	Queanbeyan 2	0845	583	865	750	970

Appendix E: Small Scale (≤ 200 kW) PV Generation by Feeder

Small scale rooftop solar PV generation installations as at 31 October 2018:

Zone Substation / Feeder	No. of Sites	Installed Capacity (W)
BELCONNEN	**1,844**	**6,794,295**
Battye	4	28,363
Baldwin-Joy Cummins	247	806,565
Benjamin-Laurie	245	834,095
Cameron South	23	57,844
Chuculba	159	581,989
Eardley	50	159,808
Haydon	107	417,668
Maribyrnong	34	199,718
McGuinness-Bellbird	159	666,192
Meacham-Bean	303	1,140,022
Shannon	184	638,838
Swinden-Lampard	65	236,215
William Slim	265	1,026,979
CITY EAST	**1,386**	**5,433,320**
Braddon	1	27,523
Chisholm	101	345,172
Constitution	3	138,480
Cowper	104	353,938
Duffy	145	524,832
Ebden	242	842,727
Electricity House	5	193,637
Fairbairn	5	20,520
Ferdinand	127	482,072
Haig	14	51,470
Ijong	6	20,929
Mackenzie	221	807,104
Masson	3	8,736
Northbourne	9	31,807
Quick	17	106,168
Stott	211	711,840
Wakefield	92	468,853
Wolseley	82	297,513
CIVIC	**979**	**4,117,894**
Belconnen Way North	140	490,675
Belconnen Way South	219	877,007
Black Mountain	129	475,090
CSIRO	5	162,281
Dryandra	198	727,716
Hobart Long	2	13,519
Hobart Short	4	252,437

Zone Substation / Feeder	No. of Sites	Installed Capacity (W)
McCaughey	16	55,996
Miller	224	846,289
Nicholson	33	131,424
Wattle	10	85,461
EAST LAKE	**38**	**518,467**
Dairy North	8	46,530
Dairy South	17	285,357
Isa	5	75,165
Lyell	8	111,415
FYSHWICK	**60**	**644,109**
Abattoir	17	101,617
Airport	1	90,156
Gladstone	5	19,582
Newcastle	1	5,409
Tennant	25	192,995
Whyalla-Pialligo	12	234,350
GILMORE	**1,122**	**4,453,250**
Alderson	15	320,847
Beggs	93	356,050
Edmond	165	572,774
Falkiner	123	458,937
Findlayson	130	478,072
Jackie Howe	166	598,824
May Maxwell	134	428,185
Monaro	2	5,409
Penton	49	185,292
Rossman	130	467,648
Tralee	6	133,840
Willoughby	109	447,370
GOLD CREEK	**3,423**	**13,692,962**
Anthony Rolfe	100	957,941
Barrington	260	930,847
Birrigai	200	832,452
Magenta-Boulevard North	333	1,287,827
Ferguson	369	1,194,482
Gribble	21	131,673
Gungahlin	75	543,533
Flemington	1	67,617
Lander	334	1,277,493
Lexcen	233	936,986
Ling-Hughes	202	696,734
Hamer	244	825,690
Nona	255	864,908
Riley	105	404,799
Saunders	250	964,342

Zone Substation / Feeder	No. of Sites	Installed Capacity (W)
Wanganeen	142	624,449
Wellington-Gurrang	173	715,644
West	126	435,546
LATHAM	**3,519**	**12,830,385**
Bowley	265	971,299
Conley	122	428,735
Copland	141	453,177
Elkington	192	722,252
Fielder	48	246,591
Florey	162	552,808
Homann	162	715,985
Latham	154	533,689
Lhotsky	456	1,562,893
Low Molonglo East	40	149,742
Low Molonglo West	35	147,863
Macrossan	322	1,007,052
Markell	205	955,616
Melba	150	584,161
O'Loghlen	202	755,873
Paterick	90	343,115
Powers	115	376,756
Seal	166	569,802
Tillyard	164	532,903
Verbrugghen	116	463,427
Weir	212	756,645
TELOPEA PARK	**859**	**4,080,376**
Belmore-King Edward	34	231,568
Blackall	4	144,250
Cunningham	196	748,606
Empire	128	472,658
Forster	55	300,483
Giles	49	205,082
Jardine	2	14,064
KF1	35	319,226
Kurrajong	1	2,840
Monash	8	27,610
NSW Cres	14	95,660
Ovens	11	62,221
Power House	57	181,322
Queen Victoria Terrace	2	144,250
Riverside	1	2,083
Strzelecki	74	289,743
Sturt	66	252,205
Telopea Park East	8	86,113
Throsby	114	500,393

Zone Substation / Feeder	No. of Sites	Installed Capacity (W)
THEODORE	**1,816**	**6,596,408**
Banyule	173	559,179
Callister	330	1,202,203
Chippindall	209	765,613
Eaglemont	277	1,110,448
Fairley	188	754,084
Lawrence Wackett	202	653,688
Lethbridge	165	672,750
Morison	184	586,793
Templestowe	89	291,651
WANNIASSA	**3,546**	**12,531,153**
Ashley	128	449,440
Athllon	175	545,981
Bissenberger-Hawkesbury	400	1,450,864
Brookman	143	563,852
Conolly	130	419,683
Erindale	3	20,952
Gaunson	111	407,631
Gouger	101	378,173
Grimshaw	492	1,294,083
Hawker-Pridham	203	694,421
Hemmings	114	376,991
Lambrigg	86	346,519
Langdon	175	634,120
Longmore	195	662,857
Mannheim	115	407,208
Marconi	164	531,812
Matthews	196	850,165
Muresk	236	936,496
Reid	203	741,927
Pitman-Rowland	6	71,160
Sainsbury	81	350,533
Sternberg	2	30,383
Symers	89	365,902
WODEN	**3,103**	**12,509,983**
Bunbury	249	991,673
Carruthers	158	627,483
Cooleman	104	380,287
Corinna	1	26,695
Cotter 11kV	280	1,347,192
Curtin North	165	607,096
Daplyn	148	465,805
Deakin No 1	103	394,626
Deakin No 2	38	180,656
Devonport	34	114,538

Zone Substation / Feeder	No. of Sites	Installed Capacity (W)
Easty	4	106,294
Follingsby	216	902,258
Hilder	218	902,189
King	10	56,137
Lyons West	229	731,676
McInnes	155	604,050
Phillip North	5	35,003
Streeton	415	1,590,752
Tidbinbilla 22 kV	4	64,182
Theodore	145	669,811
Weston East	153	497,332
Wilson	195	773,256
Yarralumla	74	440,993
TOTAL	**21,695**	**84,202,602**

Appendix F: Power Quality Performance Standards

Schedule 5.1 of the NER lists the Network System Standards that are to be achieved by Network Service Providers (NSPs). Evoenergy's network planning strategy complies with these reliability and performance requirements when considering network developments and aims to meet the following power quality performance levels.

Steady State Voltage:

Steady state phase-neutral low voltage at the customer's point of supply is measured to ensure the V1%, V99% and V50%, (phase-to-neutral and phase-to-phase) as per AS/NZS 61000.3.100.

Table F1: Voltage tolerance limits

Voltage Boundary	AS 600038	AS 61000.3.100
Nominal Voltage	230 Volts	230 Volts
Upper Limit	+10%	+10%
Lower Limit	-6%	-6%
$V_{99\%}$ / V_{MAX}	253 Volts	253 Volts
$V_{1\%}$ / V_{MAX}	216 Volts	216 Volts
$V_{50\%}$ +	244 Volts	244 Volts
$V_{50\%}$ -	225 Volts	225 Volts
Utilisation Limit (+10% / -11%)	-	424 Volts (Phase-to-Phase Maximum) 253 Volts (Phase-to-Neutral Maximum)
	-	392 Volts (Phase-to-Phase Minimum) 204 Volts (Phase-to-Neutral Minimum)

Voltage Fluctuation (Flicker):

Table F2: Voltage fluctuation:

COMPATIBILITY LEVELS FOR FLICKER IN LV SYSTEMS	
P_{st}	1.0
P_{lt}	0.8

Notes to Table F2:

1. Compatibility levels are not defined for MV, HV and EHV systems in the Australian Standards.
2. P_{st} refers to "short term severity level" and is determined for a 10-minute period.
3. P_{lt} refers to "long time severity level" and is calculated for a two-hour period. It is derived from the values of P_{st} for 12 consective10-minute periods.

PLANNING LEVELS FOR FLICKER IN MV, HV & EHV SYSTEMS		
	MV	HV / EHV
P_{st}	0.9	0.8
P_{lt}	0.7	0.6

Voltage Dips:

Table F3: Voltage Dip Voltage Tolerances

DIPS DOWN TO % NOMINAL VOLTAGE	MAX NO. OF DIPS PER YEAR (PER POINT OF SUPPLY) URBAN	MAX NO. OF DIPS PER YEAR (PER POINT OF SUPPLY) RURAL
< 30	2	6
30 – 50	20	40
50 – 70	20	40
70 – 80	25	50
80 – 90	200	300

Voltage Difference between Neutral to Earth:

Table F4: Voltage Difference between Neutral to Earth Limits

VOLTAGE DIFFERENCE BETWEEN NEUTRAL TO EARTH
< 10 Volts (5 minute average at the point of supply)

Voltage Unbalance:

Evoenergy's objective is to limit voltage unbalance to less than the compatibility levels for low voltage networks in AS/NZS 61000.2.2, and the indicative planning levels for medium and high voltage networks in TR IEC 61000.3.13.

Table F5: Compatibility Levels for Voltage Levels in LV and MV Systems

MAXIMUM NEGATIVE SEQUENCE VOLTAGE (% OF NOMINAL VOLTAGE)
2%

Notes to Table F5:

1. Up to 3 % may occur in some areas where predominately single-phase loads are connected.
2. Compatibility levels are not defined for HV and EHV systems.

Harmonic Distortion:

Table F6: Compatibility levels for Individual harmonic voltages in low voltage networks

ODD HARMONICS, NON-MULTIPLE OF 3		ODD HARMONICS, MULTIPLE OF 3		EVEN HARMONICS	
Harmonic order (h)	Harmonic voltage (%)	Harmonic order (h)	Harmonic voltage (%)	Harmonic order (h)	Harmonic voltage (%)
5	6	3	5	2	2
7	5	9	1.5	4	1
11	3.2	15	0.4	6	0.5
13	3	21	0.3	8	0.5
17 ≤ h ≤ 49	2.27x(17/h)-0.27	21 ≤ h ≤ 45	0.2	10 ≤ h ≤ 50	2.27x(17/h)-0.27

The corresponding compatibility level for the total harmonic distortion is: THD = 8% (LV) and 3% (HV).

Appendix G: Distribution System Limitations

The following tables are included to comply with the requirements of the NER Section 5.13.3 and to provide information to the proponents of non-network solutions or demand-side management to meeting or deferring identified constraints on Evoenergy's distribution network.

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.17207º S, 149.11647º E
Location of constraint (end)	35.18862º S, 149.14571º E
Asset ID	Gold Creek - Valley feeder
Network Element	Distribution Feeder
Residential customers affected	2,000
Residential customers affected	1.00%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 16.6 MVA
Voltage level	11 kV
Maximum Load at risk	2018-2024; 5.5 MW
Energy at risk	2018-2024; 26,280 MWh
Preferred network investment	New underground 11 kV feeder Gold Creek Zone Substation to Valley Rd, Gungahlin
Preferred network investment capital cost	$3,900,000
Preferred annual network investment operating cost	$39,000
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2020
Demand reduction required to defer investment by 1 year	2.0 MVA
Annual Deferral Value	$296,652
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	**Information**
Constraint primary driver	Capacity
Location of constraint (start)	35.17207º S, 149.11647º E
Location of constraint (end)	35.20911º S, 149.13846º E
Asset ID	Gold Creek – Mitchell 3 x feeders
Network Element	Distribution Feeders
Residential customers affected	0
Residential customers affected	0%
Asset rating	2019-2024; 21.9 MVA (3 x 7.3 MVA)
Forecast Demand	2019-2024; 12.3 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 12.3 MW
Energy at risk	2019-2024; 3,601 MWh
Preferred network investment	Three new underground 11 kV feeders Gold Creek Zone Substation to Mitchell
Preferred network investment capital cost	$5,710,000
Preferred annual network investment operating cost	$57,100
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2021, June 2023, June 2024
Demand reduction required to defer investment by 1 year	3.2 MVA
Annual Deferral Value	$438,721
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.23326º S, 149.08432º E
Location of constraint (end)	35.23639º S, 149.06706º E
Asset ID	Belconnen – Belconnen Town Centre 2 x feeders
Network Element	Distribution Feeders
Residential customers affected	3,000
Residential customers affected	1.50%
Asset rating	2019-2024; 21.9 MVA (3 x 7.3 MVA)
Forecast Demand	2019-2024; 18.6 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 8.5 MW
Energy at risk	2019-2024; 102 MWh
Preferred network investment	New underground 3 x 11 kV feeders Belconnen Zone Substation to Emu Bank, Belconnen
Preferred network investment capital cost	$3,270,000
Preferred annual network investment operating cost	$32,700
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2022
Demand reduction required to defer investment by 1 year	2.0 MVA
Annual Deferral Value	$251,247
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A
Historic asset rating	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.38376º S, 149.09575º E
Location of constraint (end)	34.41910º S, 149.07216º E
Asset ID	Wanniassa - Limburg feeder
Network Element	Distribution Feeder
Residential customers affected	2,000
Residential customers affected	1.00%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 8.6 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 2.1 MW
Energy at risk	2019-2024; 586,280 MWh
Preferred network investment	New underground 11 kV feeder Wanniassa Zone Substation to Limburg Way, Tuggeranong
Preferred network investment capital cost	$2,480,000
Preferred annual network investment operating cost	$24,800
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	December 2020
Demand reduction required to defer investment by 1 year	3.4 MVA
Annual Deferral Value	$190,548
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.26934º S, 149.14976º E
Location of constraint (end)	35.27697º S, 149.13308º E
Asset ID	City East – Donaldson feeder
Network Element	Distribution Feeder
Residential customers affected	0
Residential customers affected	0%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 13.1 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 6.3 MW
Energy at risk	2019-2024; 5,000 MWh
Preferred network investment	New underground 11 kV feeder City East Zone Substation to Donaldson St, Canberra City North
Preferred network investment capital cost	$3,950,000
Preferred annual network investment operating cost	$39,500
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2020
Demand reduction required to defer investment by 1 year	4.0 MVA
Annual Deferral Value	$303,494
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.27010º S, 149.10899º E
Location of constraint (end)	35.25838º S, 149.13363º E
Asset ID	Civic – Dooring feeder
Network Element	Distribution Feeder
Residential customers affected	0
Residential customers affected	0%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 13.1 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 6.3 MW
Energy at risk	2019-2024; 5,000 MWh
Preferred network investment	New underground 11 kV feeder Civic Zone Substation to Dooring St, Lyneham
Preferred network investment capital cost	$3,950,000
Preferred annual network investment operating cost	$39,500
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2021
Demand reduction required to defer investment by 1 year	4.0 MVA
Annual Deferral Value	$303,494
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.31082º S, 149.14272º E
Location of constraint (end)	35.32226º S, 149.13498º E
Asset ID	Telopea Park – Stuart feeder
Network Element	Distribution Feeder
Residential customers affected	1,000
Residential customers affected	0.50%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 6.3 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 2.5 MW
Energy at risk	2019-2024; 150,658 MWh
Preferred network investment	New underground 11 kV feeder Telopea Park Zone Substation to Stuart St, Griffith
Preferred network investment capital cost	$2,560,000
Preferred annual network investment operating cost	$25,600
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2021
Demand reduction required to defer investment by 1 year	2.0 MVA
Annual Deferral Value	$196,695
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.31521º S, 149.16432º E
Location of constraint (end)	35.31444º S, 149.15070º E
Asset ID	East Lake – Eyre feeder
Network Element	Distribution Feeder
Residential customers affected	2,000
Residential customers affected	1.00%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 18.4 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 4.8 MW
Energy at risk	2019-2024; 5 MWh
Preferred network investment	New underground 11 kV feeder East Lake Zone Substation to Eyre St, Kingston
Preferred network investment capital cost	$1,020,000
Preferred annual network investment operating cost	$10,200
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	December 2020
Demand reduction required to defer investment by 1 year	2.0 MVA
Annual Deferral Value	$78,371
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.31521º S, 149.16432º E
Location of constraint (end)	35.31705º S, 149.18976º E
Asset ID	East Lake – Pialligo 2 x feeders
Network Element	Distribution Feeder
Residential customers affected	1,000
Residential customers affected	0.50%
Asset rating	2019-2024; 14.6 MVA (2 x 7.3 MVA)
Forecast Demand	2019-2024; 11.2 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 9.7 MW
Energy at risk	2019-2024; 523 MWh
Preferred network investment	New underground 2 x 11 kV feeders East Lake Zone Substation to Pialligo Ave, Pialligo
Preferred network investment capital cost	$4,280,000
Preferred annual network investment operating cost	$42,800
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2021
Demand reduction required to defer investment by 1 year	2.50 MVA
Annual Deferral Value	$328,849
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.22545º S, 149.03212º E
Location of constraint (end)	35.23325º S, 148.99891º E
Asset ID	Latham – O'Loghlen feeder
Network Element	Distribution Feeder
Residential customers affected	2,000
Residential customers affected	1.00%
Asset rating	2019-2024; 6.7 MVA
Forecast Demand	2019-2024; 5.0 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 5.0 MW
Energy at risk	2019-2024; 686 MWh
Preferred network investment	Extend 11 kV underground O'Loghlen feeder to Strathnairn
Preferred network investment capital cost	$2,170,000
Preferred annual network investment operating cost	$21,700
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	December 2019
Demand reduction required to defer investment by 1 year	1.0 MVA
Annual Deferral Value	$166,730
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.26926º S, 149.05260º E
Location of constraint (end)	35.27373º S, 149.04849º E
Asset ID	Civic – Black Mountain feeder
Network Element	Distribution Feeder
Residential customers affected	1,000
Residential customers affected	0.50%
Asset rating	2019-2024; 5.5 MVA
Forecast Demand	2019-2024; 3.0 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 3.0 MW
Energy at risk	2019-2024; 3,893 MWh
Preferred network investment	Extend 11 kV underground Black Mountain feeder to John Gorton Drive, Whitlam
Preferred network investment capital cost	$451,415
Preferred annual network investment operating cost	$4,514
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2020
Demand reduction required to defer investment by 1 year	1.0 MVA
Annual Deferral Value	$34,684
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.26926º S, 149.05260º E
Location of constraint (end)	35.28199º S, 149.12557º E
Asset ID	Civic – London feeder
Network Element	Distribution Feeder
Residential customers affected	1,000
Residential customers affected	0.50%
Asset rating	2019-2024; 7.3 MVA
Forecast Demand	2019-2024; 48.2 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 6.5 MW
Energy at risk	2014-2024; 384 MWh
Preferred network investment	New underground 11 kV feeder Civic Zone Substation to London Circuit, Canberra CBD
Preferred network investment capital cost	1,280,000
Preferred annual network investment operating cost	$12,800
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2020
Demand reduction required to defer investment by 1 year	3.9 MVA
Annual Deferral Value	$98,347
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.27080º S, 149.05753º E
Location of constraint (end)	35.27373º S, 149.04849º E
Asset ID	Molonglo – Molonglo Valley 7 x feeders
Network Element	Distribution Feeders
Residential customers affected	5,000
Residential customers affected	2.50%
Asset rating	2019-2024; 51.1 MVA (7 x 7.3 MVA)
Forecast Demand	2019-2024; 23.6 MVA
Voltage level	11 kV
Maximum Load at risk	2019-2024; 13.7 MW
Energy at risk	2019-2024; 37,205 MWh
Preferred network investment	New underground 7 x 11 kV feeders Molonglo Zone Substation to John Gorton Drive, Molonglo
Preferred network investment capital cost	$6,710,000
Preferred annual network investment operating cost	$67,100
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2021 – June 2024
Demand reduction required to defer investment by 1 year	1.9 MVA
Annual Deferral Value	$515,555
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A

Field Name	Information
Constraint primary driver	Capacity
Location of constraint (start)	35.26926º S, 149.05260º E
Location of constraint (end)	35.26926º S, 149.05260º E
Asset ID	Molonglo Zone Substation (Stage 1)
Network Element	Zone Substation
Residential customers affected	5,000
Residential customers affected	2.50%
Asset rating	2019-2024; 14 MVA
Forecast Demand	2019-2024; 23.6 MVA
Voltage level	132/11 kV
Maximum Load at risk	2019-2024; 13.7 MW
Energy at risk	2019-2024; 37,205 MWh
Preferred network investment	New 132/11 kV zone substation at Coulter Drive, Molonglo
Preferred network investment capital cost	$8,340,000
Preferred annual network investment operating cost	$83,400
Preferred network investment cost accuracy	+10%
Preferred network investment cost accuracy	-10%
Proposed timing	June 2021
Demand reduction required to defer investment by 1 year	1.9 MVA
Annual Deferral Value	$640,794
Load transfer capability	0 MVA
Emergency generation	0 MVA
Historic use of existing emergency response	N/A
Historic load trace	N/A