evoenergy

Annual Planning Report 2020

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Approval

Date	Name	Position	Signature
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Disclaimer

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This report is prepared by Evoenergy in its capacity as the Transmission Network Service Provider and the Distribution Network Service Provider in the Australian Capital Territory (ACT).

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Review date

It is intended that in compliance with the regulatory requirements this report will be updated annually and the next report will be published by 31 December 2021. However, if Evoenergy identifies that material changes are required, Evoenergy may amend this document at any time. Amendments will be indicated in the version control table.

Table of contents

Introducing Evoenergy

Evoenergy is licensed by the Independent Competition and Regulatory Commission (ICRC) to provide transmission, distribution, and connection services in the ACT. Evoenergy is both a Distribution Network Service Provider and a Transmission Network Service Provider registered with the Australian Energy Market Operator (AEMO).

We are a regulated service provider subject to commonwealth and jurisdictional laws and statutory instruments including *National Electricity Law* (NEL), *National Electricity Rules* (NER), *Utilities Act 2000*, *Utilities Technical Regulations Act*, industry codes, technical codes, and regulations. The NER require Evoenergy to undertake annual planning review and prepare the Annual Planning Report.

Our "poles and wires" network is supplied predominantly by power imported from interstate. There is an increasing amount of generation embedded within Evoenergy's network. Evoenergy's primary focus is on the provision of a safe, reliable, and quality electricity supply in a prudent and efficient manner. We are an asset manager certified for compliance with *ISO 50001 Asset Management Standard*. Safety and risk management are key considerations of our business decisions. Whenever practicable, risk management is integrated with investment decisions and considers the life cycle of assets and least cost solutions.

Purpose of this report

The purpose of the Annual Planning Report (APR) is to inform other network services providers, market participants, consumers and interested parties of near-term constraints impacting Evoenergy's network, and factors impacting long-term demand forecasts and network reliability.

The report also addresses network capacity limitations, asset renewal, power quality and reliability in relation to transmission lines, zone substations and distribution network. The identified limitations are opportunities for non-network solutions including embedded generation and demand-side management. The report addresses ten-year planning requirements for the transmission network and five-year planning requirements for the distribution network.

This APR has been prepared to comply with the *NER Clause 5.12.2 Transmission Annual Planning Report (TAPR);* and *Clause 5.13.2 and Schedule 5.8 Distribution Annual Planning Report (DAPR).*

Executive summary

Transforming our business for the future

In recent years the electricity industry has been changing at an unprecedented pace with increased uptake in Distributed Energy Resources (DER) driven by improvements in affordability, advances in technology and the rise of customer desire for energy independence. Within the Evoenergy jurisdiction the ACT Government has a strong focus on their climate change strategy, aiming for net zero emissions by 2045. Aligning with this, the federal government as well as private sector have been accelerating and crystallising strategies around net zero emissions targets. These have been key factors in Evoenergy's recent strategy refresh as we work towards these goals using a set of innovation and optimisation initiatives while operating within our regulatory and legislative requirements.

A sustainable business, energising our evolving community.

A key component of the Evoenergy strategy is the transition to a contemporary Distribution System Operator (DSO), enabling Evoenergy to effectively facilitate a two-way energy market for customers that enables efficient utilisation of customer and network assets, to both generate electricity and access new energy products.

Evoenergy also aims to diversify our energy system through integration of non-network solutions, minimise the carbon and environmental footprint of our network operations and build network resilience to the changing climate. It is also important to understand the implications of, and road map to, a zero emissions future for the electricity network, gas substitution with electrical energy and how this will impact our customers throughout the transition process.

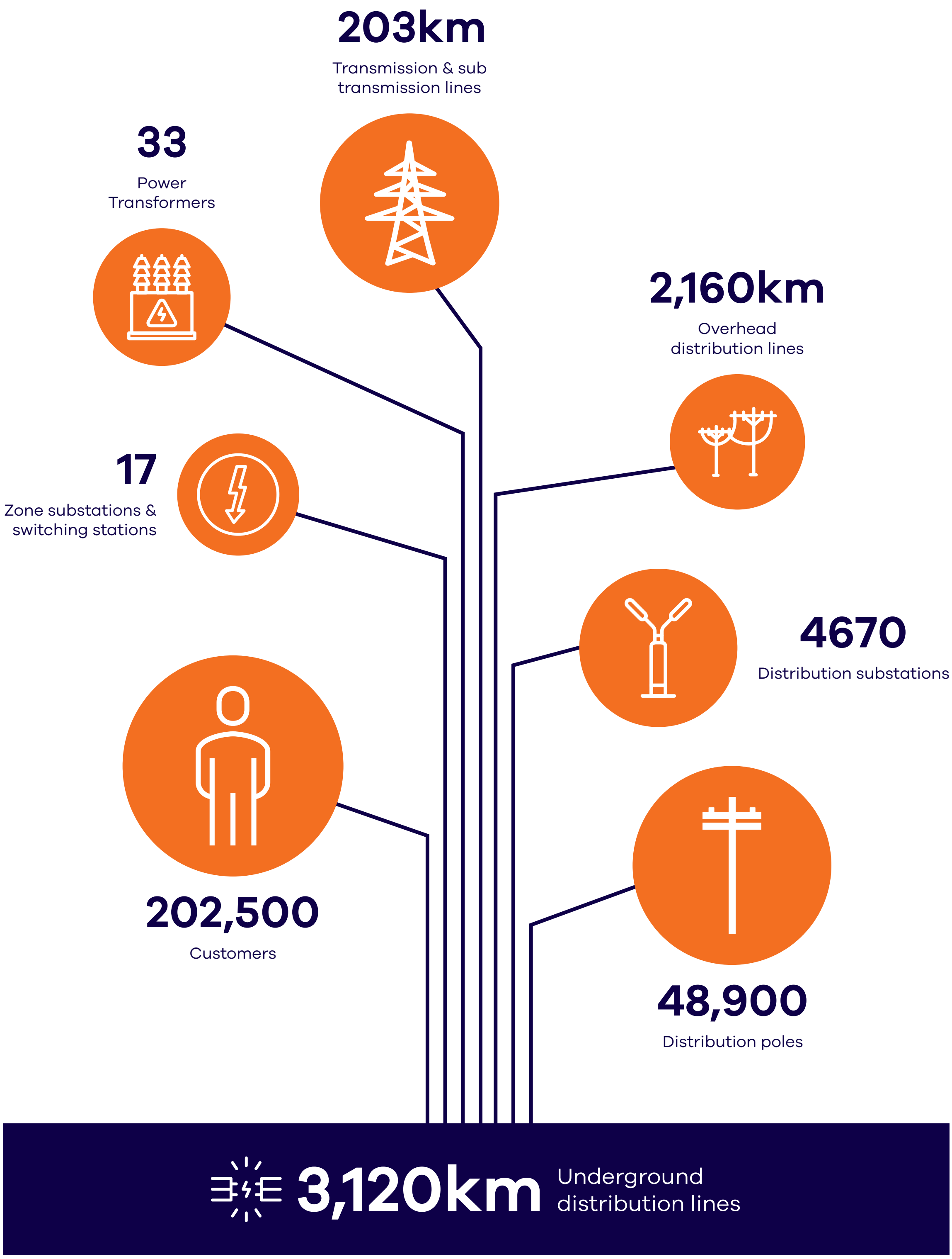
COVID19 & Black Summer bushfires

Throughout this report, as we discuss what we have achieved in the past year, this is overlayed by unprecedented events as Evoenergy, as with all businesses, has adapted and responded in new and innovative ways.

This year has been a year like no other. From December 2019, the ACT was blanketed in thick smoke from bushfires in NSW. Evoenergy had to rapidly adjust work plans to ensure our workforce was kept safe while maintaining a safe and reliable electricity supply to our customers. In January 2020, while still grappling with the impacts of hazardous air quality from surrounding fire, the ACT was hit by two bushfires. The first was a small but destructive fire in the Beard/Pialligo region which damaged our 66 kV lines and left Fyshwick Zone Substation and many customers without supply for over 24 hours. The second fire was the Orroral Valley Bushfire which devastated over 85,000 hectares of the Namadgi National Park and Tidbinbilla Nature Reserve as well as causing significant damage to private property. During this time most non-urgent planned work on the network was cancelled and Evoenergy crews were mobilised for both preventative and rectification work. Work was also impacted by the 15 Total Fire Ban days across January and February.

Just as the region began the recovery process after the Black Summer bushfires, COVID19 spread across the world. Like most workplaces, Evoenergy rapidly implemented changes to the way we operate, including work from home arrangements where possible and splitting field crews into geographically separated teams where a "bubble" style separation could be maintained.

Evoenergy snapshot



Key planning focus areas

Our network planning is aligned with Evoenergy's strategy and Energy Networks Association's (ENA) Electricity Network Transformation Roadmap.

Safety

Evoenergy recognises the importance of safety in the delivery of our services. Safety underpins everything we do and is our primary consideration when we plan, design, construct and operate our assets. Evoenergy has safety obligations under a number of legal instruments including acts, regulations, codes and guidelines. We do not compromise when it comes to safety as it relates to the community, environment and our workforce.

In 2020 Evoenergy launched a refreshed safety strategy, headlined by our new safety motto – *Powered by Safety.*

POWERED
BY **SAFETY**

Evoenergy has also completed significant work on developing and integrating Formal Safety Assessments (FSAs) into key areas of the business. These FSAs quantify mitigated risks against the five primary objectives of technical regulation: public safety, worker safety, loss of supply, environment and property.

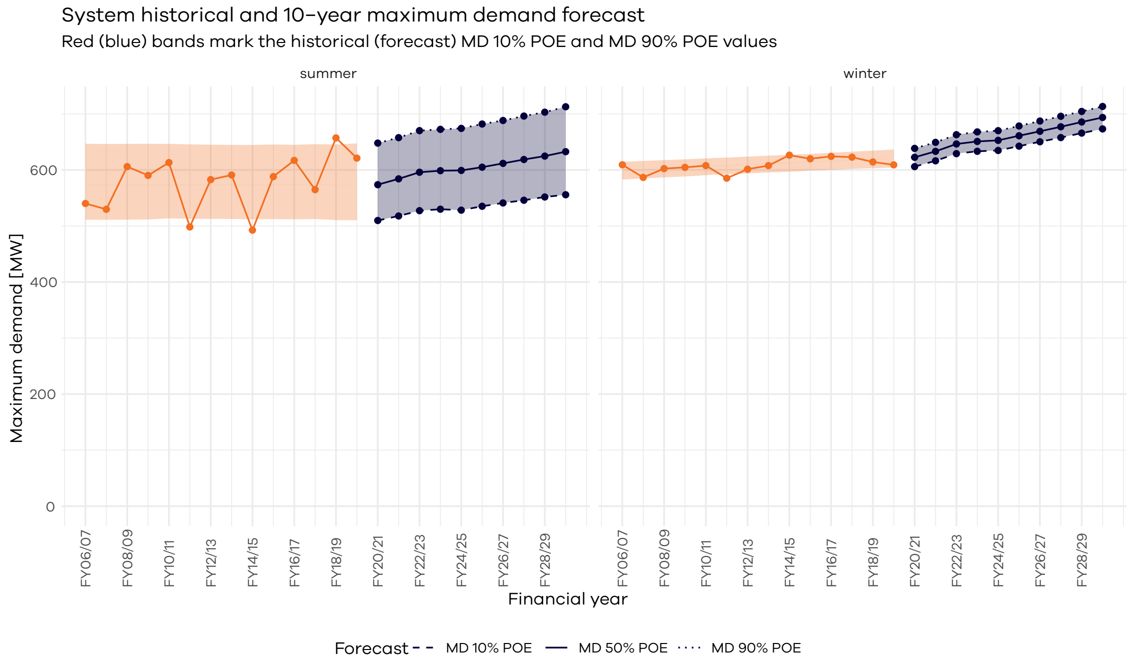
System level demand

In 2020, forecast peak demand for network-delivered energy shows organic growth in peak summer demand is expected to stay fairly steady. The increase in peak winter demand due to organic growth over the next ten years is expected to be approximately 3%. Despite this low organic growth, both summer and winter peak demand is expected to increase at a faster rate due to significant growth in data centre load.

A key feature of peak demand has been the relative volatility of peak summer demand over the last ten years culminating in the highest recorded peak in 2019 of 657 MW with the second highest recorded peak of 621 MW in 2020. This highlights the impact of changing weather conditions and the impact on cooling loads during the summer period. In contrast to the summer demand, the peak winter demand has been more stable but is forecast to increase, reflecting the impact of organic growth on heating loads during the winter period. The 2020 system peak winter demand was 609 MW.

These trends are illustrated in the following historical and 10 year maximum demand forecast 2020.

Figure 1. Summer and winter historical demand and forecast with probability of exceedance forecast (PoE)



The importance of forecast peak demand is the impact of potential unserved energy (and energy at risk) which determines when network capacity should be augmented to underpin the security and reliability of supply. Chapter 5 and Appendix E –provide more information on demand forecast methodology and outcomes for the system and distribution substations.

The shift in energy sources

As Evoenergy sees an increase in uptake of Distributed Energy Resources (DER) as well as other generation such as solar farms, bio-generation and grid batteries we anticipate that a higher proportion of demand will be supplied within the ACT rather than imported via TransGrid. There is even the potential for the ACT to become a net exporter to TransGrid in the future during times of minimum demand. Modelling for these situations is still in early stages however gaining a better understanding of minimum demand and demand components is important for Evoenergy's shift towards a distributed system operator.

In addition to this Evoenergy anticipates further load growth will be driven by ACT Government Zero Emissions Government Framework driving emission reductions in the natural gas network and transport. An option is electrification and is expected to drive a significant increase in peak demand, particularly in winter however the pathway will become clearer when the ACT Government sets transition targets.

Localised constraints

While Evoenergy's relatively flat demand profile means that it does not face system-wide security issues, it does face localised capacity constraints over the next 5–10 years. These constraints correspond mostly to the areas which are experiencing or are forecast to experience high levels of residential and commercial growth. Consequently, Evoenergy has identified a number of limitations within the zone substations and distribution network.

These constraints are summarised in Table 1, however the following constraints are of particular note.

Molonglo Valley demand constraints

Evoenergy is currently in the final stages of the Regulatory Investment Test for Distribution (RIT-D) process for constraints in the Molonglo Valley due to significant growth as a result of new greenfield residential developments. As part of this process Evoenergy identified that a non-network solution, such as a network scale battery, could be used to defer the required construction of a zone substation. Evoenergy is currently working with a proponent to implement a battery energy storage system (BESS) at the site of the future Molonglo Zone Substation.

Gold Creek demand constraints

The maximum demand in the Gungahlin District is forecast to continue to increase over the next ten years with continual growth in greenfield areas as well as high density residential and commercial developments. There is currently insufficient redundant capacity at Gold Creek Zone Substation for short but increasing periods of time and minimal coincident opportunity to transfer load to neighbouring zone substations. Evoenergy is currently considering two viable network options for this constraint, a third transformer at Gold Creek Zone Substation and a new zone substation located in the commercial suburb of Mitchell. It is anticipated that this constraint will go through the RIT-D process during which additional analysis will be completed, including a non-network options report.

Overview of constraints

Table 1. Existing and emerging limitations of the transmission network and distribution network

Location	Network Element	Constraint	RIT	MVA required	Consult	Decision	Required	Estimated cost
Gungahlin Town Centre	Feeder	Capacity	No	5.9	Dec-19	Mar-20	Mar-21	$2.9m
Dickson – Dooring St	Feeder	Capacity	No	4.1	Dec-19	Jun-20	Dec-21	$3.8m
Braddon – Donaldson St	Feeder	Capacity	No	1.7	Jun-22	Dec-22	Jun-24	$2.5m
Molonglo Valley	Zone Substation & Feeders	Capacity	Yes	9.1	Mar-20	Jun-20	Dec-21	$13.7m
Strathnairn	Feeder	Capacity	No	5.9	Jun-20	Dec-20	Jun-22	$2.4m
Pialligo	Feeder	Capacity	No	8.0	Dec-20	Mar-21	Jun-23	$4.8m
Belconnen Town Centre	Feeder	Capacity	No	7.1	Dec-20	Jun-21	Dec-22	$1.3m
Fyshwick	Feeder	Capacity	No	-	Jun-21	Dec-21	Jun-23	$5.5m
Mitchell / Gold Creek	Zone Substation	Capacity/ Voltage	Yes	12	Dec-21	Jun-22	Jun-24	$6.2m
North Canberra	Transmission	Voltage	No	-	Jun-21	Dec-21	Jun-24	TBC
Strathnairn	Zone Substation	Capacity	Yes	2024-29 period				
Gilmore	Zone Substation	Capacity	Yes	2024-29 period				

Note 1: RIT – The National Electricity Rules require Regulatory Investment Test for projects above $6 million

Note 2: The cost in this table for the option as determined in preliminary analysis or Project Justification Report. Projects may be subject to further options analysis and detailed cost estimation.

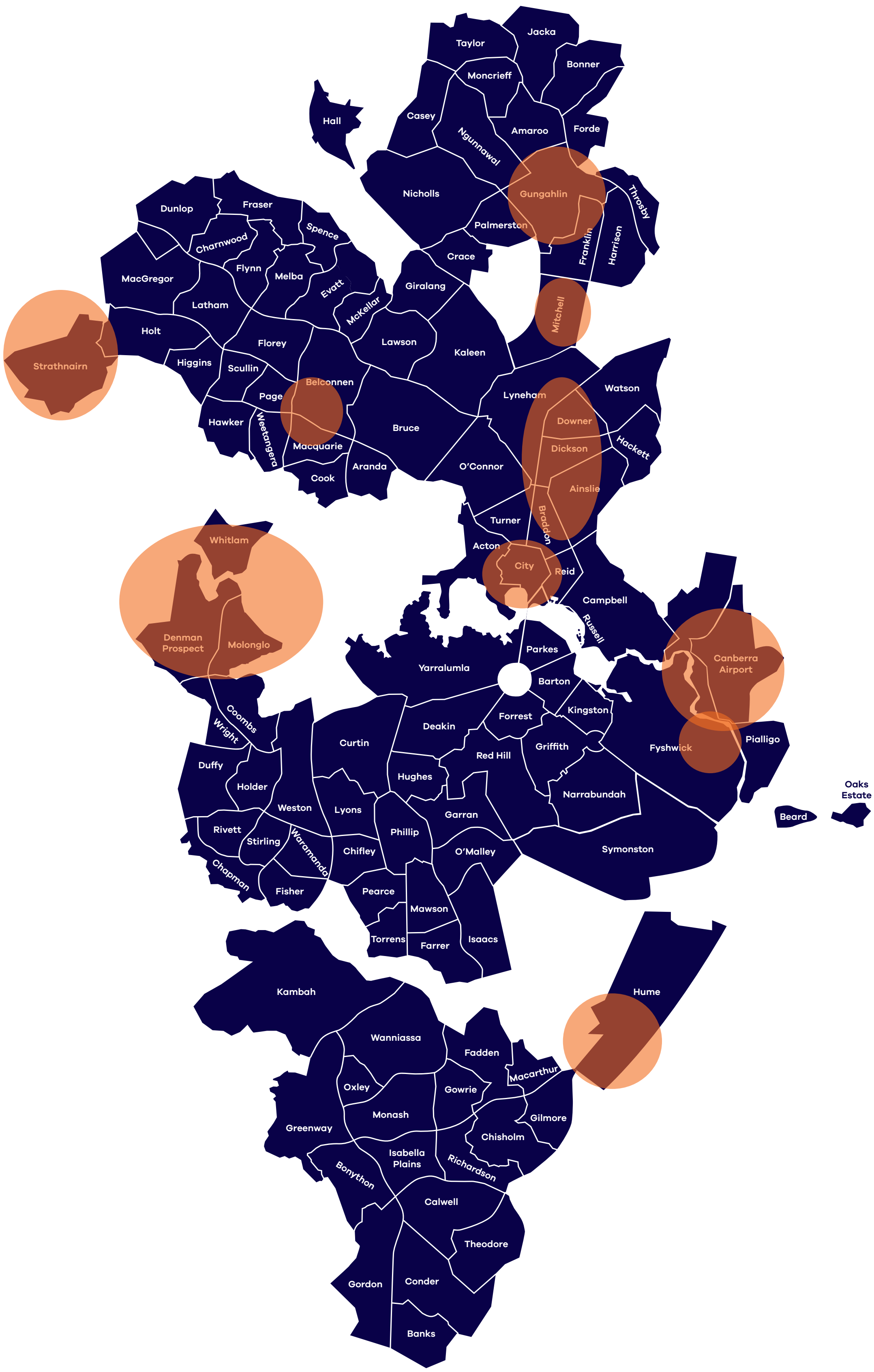
In addition to these localised capacity constraints, the make-up of electricity demand is changing in the ACT—specifically around customers driving localised growth in electricity demand, where electricity is sourced, and the impact that is having on network utilisation and performance.

Electricity connections grew by 3,686 in the 2019/20 financial year with load growth driven by:

- Urban infill development – the ACT Government 2018 Planning Strategy states that it aims for 70% of new housing to be within the existing urban footprint. This is also supported by the ACT Government land release program and development policies.
- Commercial/industrial growth is currently centred around Hume and Fyshwick industrial parks – with a significant proportion focused on large relatively stable loads as required, for example, data centres.
- Greenfield residential developments primarily in Gungahlin, Molonglo Valley and Ginninderry – with an increasing proportion of medium density developments.

Figure 2 provides an overview of the geographic locations where network limitations exist or are forecast to emerge due to urban in-fill, greenfield residential and commercial developments.

Figure 2. Overview – network limitations heat map



Network performance

Evoenergy continues to focus on the management of existing assets taking into account asset performance and risks relating to asset conditions, age and criticality. Our annual planning review process identified a need for several major asset retirements over the current regulatory period (2021–24). Chapter 6 summarises the major asset retirements identified during the regulatory review including timing and costs. In addition to these major asset retirements, Evoenergy runs a number of grouped programs for smaller assets including distribution poles, substations or switchgear. These programs are further discussed in Chapter 6.

Table 2. Identified retirements of major assets

Area	Network Element	Primary Driver	RIT-D	Estimated Cost ($ million)	Consult	Decision	Date Required
Woden Zone Substation	132 kV Circuit Breaker	Asset condition & performance	No	$0.35m	Feb 2019	Jun 2019	Jun 2021
Latham Zone Substation	Substation Switchboard	Asset condition & performance	No	$3.1m	Dec 2022	Jun 2023	Jun 2024
Wanniassa	Distribution Line Underground Cable	Asset condition & performance	No	$4.3m	Dec 2022	Jun 2023	Jun 2024
Fyshwick Zone Substation	66 kV Assets	Asset condition & performance	No	$2.1m	Jun 2021	Dec 2021	Jun 2024
Zone Substation	Provisional Power Transformer[1]	Asset condition & performance	No	$2.7m	Mar 2021	Jun 2021	Jun 2022

1 Not specifically a retirement but major system spare to provide contingency for unplanned zone transformer retirement.

Maintaining reliability

Evoenergy's reliability performance continues to be one of the best in Australia. We are subject to the Australian Energy Regulator's (AER) reliability performance targets for unplanned outages and jurisdictional ACT reliability targets for planned and unplanned outages. Our aim is to maintain reliability performance in line with our regulatory targets and incentive schemes. Our reliability strategy is published on the Evoenergy website. The focus of our reliability strategy is to target underperforming areas including worst-served customers and worst-performing distribution lines impacting large numbers of customers.

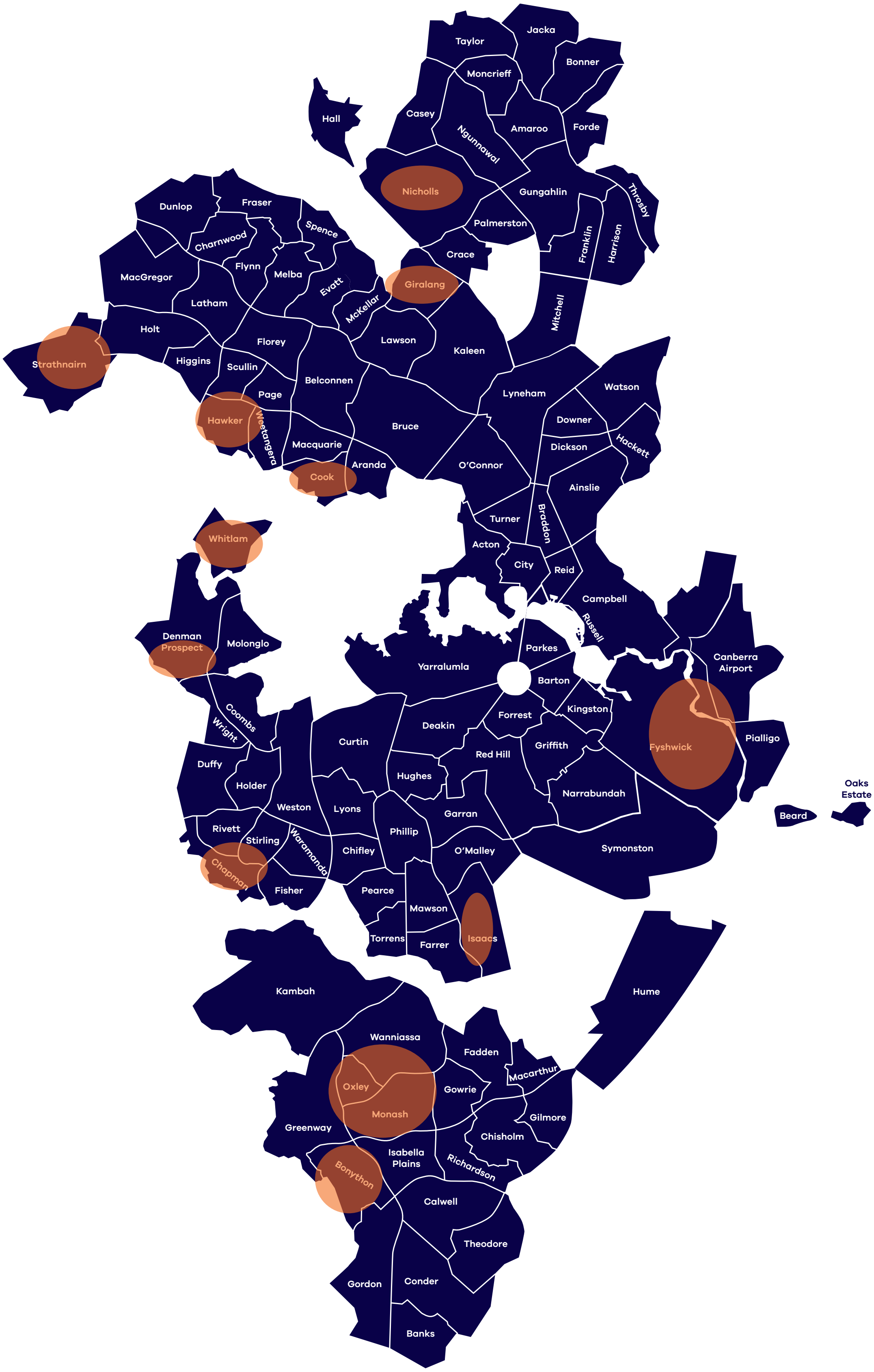
Power quality – voltage regulation

One of the most important planning considerations affecting forecast demand is the gradual shift from electricity generated and transmitted outside the ACT to embedded generation within the ACT, and unprecedented growth in "in front of the meter" and "behind the meter" generation. We have 43 MW of large-scale solar generation is currently embedded in the ACT network, with another 30 MW of new solar generation under consideration. There is continued strong growth in rooftop photovoltaic generation with around a quarter of all residential dwellings in the ACT now with photovoltaic installations. Over the 2019–20 financial year rooftop photovoltaic generation increased by close to 26.9 MW, which was the highest annual increase on record, with total PV capacity now over 145 MW.

This presents a key challenge for Evoenergy as this increase in embedded generation creates two-way energy flows and over-voltages in some locations. The voltage regulation limitations usually occur in the locations where the penetration of photovoltaics is high, causing power quality issues.

Figure 3 provides a heat map of the percentage of solar photovoltaic penetration per suburb.

Figure 3. Overview - rooftop photovoltaic generation heat map >25%



Gold Creek voltage constraints

In addition to the demand constraint, an emerging need has been identified at Gold Creek Zone substation to manage voltage regulation on the high voltage distribution network supplied from that zone substation. There is excessive leading reactive power being generated within the high voltage (HV) system in the Gold Creek Zone area which cannot be managed by the current zone transformer tap changing arrangement. Evoenergy is currently assessing options including:

1. Install two 11 kV fixed reactance shunt reactors
2. Install two 11 kV variable reactance shunt reactors
3. Seek non-network solution to manage reactive power such as network or community scale batteries, systemic reactive set point control of PV inverters or residential batteries.

Working with stakeholders on solutions

Solutions to constraints will fall into one of two categories—solutions over $6 million which are required to go through the regulatory investment test (RIT) process and solutions under $6 million which are not required to go through the RIT process. Depending on the solution, this may be a regulatory investment test for distribution (RIT-D) or a regulatory investment test for transmission (RIT-T).

Solutions that are required go through the RIT process will be analysed to determine if there may be a preferred non-network solution to the constraint. The findings of this analysis are published in a non-network options report which is publicly available on the Evoenergy website and communicated to our Demand Management Register[2] participants.

For solutions not required to go through the RIT process, Evoenergy will go through a non-network screening process. If it is determined that a non-network solution may be viable, Evoenergy will engage proponents through the Demand Management Register.

Customers may also approach Evoenergy with proposals, for example, if a customer would like to install a battery but would like to know where it would benefit the network and help to address current or future constraints, they can utilise the constraints summary in this report (see Table 1) or contact Evoenergy through demandmanagement@evoenergy.com.au.

Evoenergy is also working closely with government and other related stakeholders on initiatives such as the renewable energy auctions including grid level batteries, electric busses and utility master planning.

2 To sign up to the Demand Management Register please fill in the form at the bottom of this page: https://www.evoenergy.com.au/emerging-technology/demand-management

Chapter overview

Chapter 1:
Explains how interested parties can engage with Evoenergy. It discusses the four available paths for engagement with Evoenergy in relation to the non-network, demand management and network options.

Chapter 2:
Provides information on Evoenergy's physical network environment, regulatory environment and an overview of current factors and challenges impacting our network.

Chapter 3:
Provides Evoenergy's philosophy and approach to network planning and asset management.

Chapter 4:
Describes the current Evoenergy's reliability and power quality performance and planning outcomes.

Chapter 5:
Describes the electricity demand forecast for the system and zone substations.

Chapter 6:
Discusses management of the existing assets. Describes Evoenergy's asset retirement and renewals program planning outcomes for individual major assets and grouped assets.

Chapter 7:
Discusses network planning, including existing and emerging network limitations relating to the network capacity.

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 the operation in the changing business environment.

Appendices:
Provide additional and supporting data. The appendices are referenced in the individual chapters.

Chapter 1: Opportunities for interested parties

Evoenergy is operating in a rapidly evolving energy environment. We experience changes in technology, consumption patterns, customer preferences, energy policies and regulatory settings. This transformation is presenting both challenges and opportunities to Evoenergy, consumers and other stakeholders.

Close engagement with our stakeholders[3] is an integral part of our approach and being innovative, flexible, and adaptable business. We consult with stakeholders in relation to a range of matters relating to our business. For example, Evoenergy consults on preparation of regulatory submissions to the Australian Energy Regulator, resolving network constraints, tariff policy options and project development. Parties and groups impacted by projects are consulted in relation to environmental, social, economic, and governance concerns. Stakeholders contributing to regulatory submissions are consulted on policy options.

Evoenergy firmly believes in regular, structured engagement with stakeholders including providing feedback on stakeholder input or concerns. The consultation on general matters is often conducted according to the Stakeholder Engagement Strategy. For specific consultation matters additional plans or programs may also be developed.

A new Evoenergy's Stakeholder Engagement Strategy is due to be published before the end of 2020. That strategy together with the Demand Side Management Engagement Strategy are key reference documents governing engagement with our stakeholders.

This chapter focuses on engagement with consumers and interested parties when Evoenergy investigates network limitations and optimum solutions including non-network options.

3 One forum for engagement is the Energy Consumer Reference Council (ECRC) which includes broad representation of our customers and ACT community. We consult the ECRC on a range of matters including regulatory submissions, network development and network tariffs.

Figure 4. Four paths of engagement

Four ways our stakeholders can engage with Evoenergy on demand management or non-network options:

Path 1:

Participate in a **broad based program** as a consumer or solution provider. Broad based program incentivise consumers to reduce electricity demand.

Review the existing and planned broad based programs in the annual planning report.

Path 2:

Participate in a targeted program. Targeted programs aim to address network limitations in a particular area in the network (e.g. specific location or suburb).

Review the network limitations in the annual planning report.

Path 3:

Participate in a Regulatory Investment Test (RIT). RITs apply to projects above $6 million and are usually aimed at larger market participants.

Review Evoenergy projects subject to RIT in the annual planning report.

Path 4:

Provide a suggestion or comment. Receive correspondence on specific matters relating to network development.

To provide comment, register for a workshop or receive correspondence.

1.1 Engagement in broad-based demand management programs

As part of our planning processes and commitment to proactive engagement with our customers, we are developing several demand management programs designed to address broader groups of consumers and stakeholders. A number of current demand management initiatives are in the early stages of development and maturity and further information is available on the Evoenergy website[4]. Evoenergy will progress these initiatives further over short to medium term. Several programs have commenced to trial specific sectors and customer demographics within the ACT. The programs are summarised in Chapter 8 (Demand Management) of this report.

Broad based demand management programs

Broad based demand management programs are designed to address large groups of consumers and other stakeholders who can assist in peak demand reduction. For example, interrupting air-conditioning load or refrigeration for short periods of time can take place without a major inconvenience to consumers. Another example of broad-based programs are cost reflective or innovative tariffs which incentivise consumers to reduce demand. The programs may include proof of concept pilots and trials before the programs can be implemented.

Customer benefits

There are a number of possible benefits available to participants. The specific benefits may depend on the design of the particular program. Consumers can benefit from a reduction in electricity bill through using "time of use" or "demand tariffs". There are various types of monetary incentives which can be considered and tested including cash buy-backs, one off incentives, availability payments or event-based payments.

How to participate

If you would like to participate in a broad-based program including a pilot or a trial you can register via the website either as an energy consumer (end-user) or a business operating in the demand management space. You can also make suggestions relating to demand management or register to receive information on any of the future projects or programs.

You are not obligated to participate if you register, but your contribution is valuable to Evoenergy. In the future, we may ask you if you are interested in participating in one of the programs or pilot projects. We may publish a Request for Proposal (RFP) to submit proposed solutions and invite you to respond. As part of the engagement we will explain the network constraint, possible solutions and incentives which would be available to you. If you are a business operating in the demand management space we may invite you to discuss your demand side management proposal or provide additional information.

1.2 Engagement in a targeted initiative

As part of the network planning process, Evoenergy identifies existing and emerging electricity network limitations. Table 1 identifies limitations in relation to the distribution and transmission networks. The table identifies the type of constraint, location of constraint, level of constraint and its timing. As part of the network development process Evoenergy must resolve identified limitations either though network or non-network solution. The information is updated as new data becomes available.

Targeted solutions to constraints

Targeted programs focus on a reduction of demand in specific areas or pockets of the network where limitations were identified or the provision of other services such as voltage regulation, "solar soak" services or provision of contingency. The majority of limitations identified by Evoenergy in the 2020 planning review relate to the distribution line (feeder) capacity constraints, however there are also voltage and contingency constraints emerging.

Evoenergy endeavours to identify limitations as early as possible to allow sufficient time for consideration of a full range of solutions. If the limitation emerges late in the process (e.g. as the result of a late connection application from a large customer) the time available for consideration of all options may be limited. Consideration of non-network and demand management solutions is a mandatory part of Evoenergy's network planning process.

4 https://www.evoenergy.com.au/emerging-technology/initiatives

Customer benefits

There are a number of possible non-network solutions ranging from demand reduction to contracted embedded generation. The incentives can range from reductions in electricity bills to substantial contributions towards capital costs of solutions.

If a customer proposes a viable alternative which defers or eliminates a need for network investment, Evoenergy is likely to be interested in sharing the cost of investment. Under National Electricity Rules Evoenergy has an obligation to implement least cost options.

How to participate

Interested parties can register for targeted programs on the Evoenergy website[5]. There are no obligations on your part if you register[6]. You can also provide a suggestion or request information or updates on any program.

Evoenergy investigates identified network limitations and periodically updates data (e.g. load information) relating to the limitations. As part of the investigations, depending on the screening assessment of options, Evoenergy may issue a RFP to submit non-network solutions.

If you register for one or more targeted programs with Evoenergy, we will inform you of the relevant RFP, however you are not under any obligation to respond. The exact timing for a RFP may depend on the specific project requirements and available information. As far as practicable, for the distribution network limitations, we will endeavour to issue a RFP no later than 21 months before the limitation must be addressed and allow three to six months for selection of preferred solutions. For transmission system limitations we will generally endeavour to publish a RFP no later than 36 months before the network limitation must be addressed. Figure 6 provides a process overview including Evoenergy stakeholder engagement through demand side engagement strategy.

Our RFP will explain the network limitation, the timeline for resolution and possible solutions. The RFP will indicate what investment, capital contribution or incentive we are prepared to provide to external praties to resolve the issue.

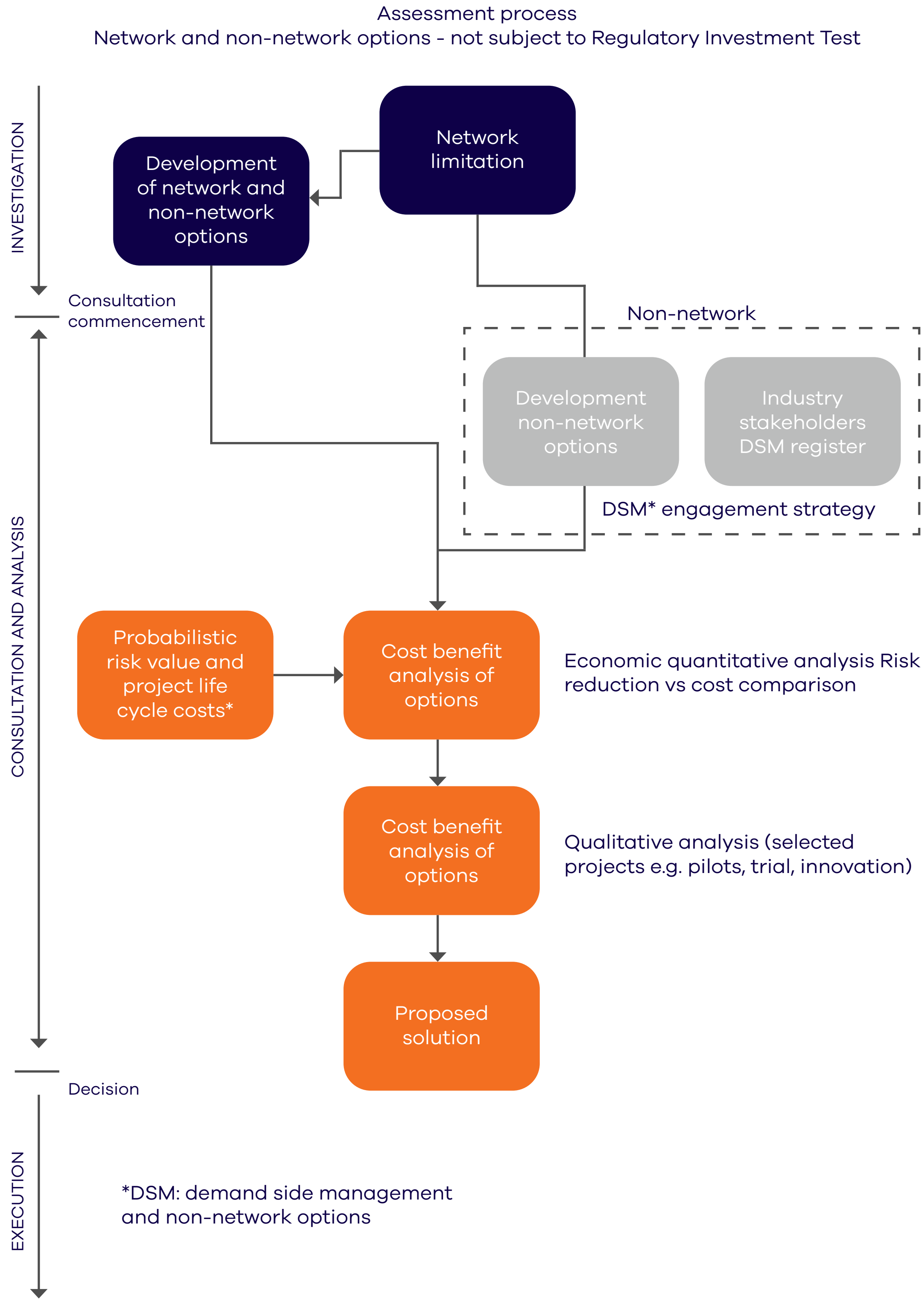
Distribution and Transmission projects above $6 million are subject to mandatory Regulatory Investments Test[7] (RIT) process. As described in the next section for RIT projects we will follow Australian Energy Regulator's guidelines for regulatory investment tests for distribution or transmission.

5 https://www.evoenergy.com.au/emerging-technology/demand-management

6 Strict privacy provisions apply: no marketing, no spam email, no sharing of information with third parties. Privacy policy available on the Evoenergy website, https://www.evoenergy.com.au/legal/privacy-policy

7 Projects above $6 million are subject to Regulatory Investment Tests.

Figure 5. Process overview – projects not subject to regulatory investment test



1.3 Engagement in a regulatory investment test

National Electricity Rules require Evoenergy to conduct a Regulatory Investment Test (RIT) on all investments above $6 million. The aim of the test is to consider the full suite of alternative solutions including network, non-network, and demand side management options. A RIT requires consultation and review of the proposal with external stakeholders, particularly National Electricity Market participants who may submit an alternative proposal. If optimised solution includes a mix of non-network and network elements, RIT rules oblige Evoenergy to implement such a solution.

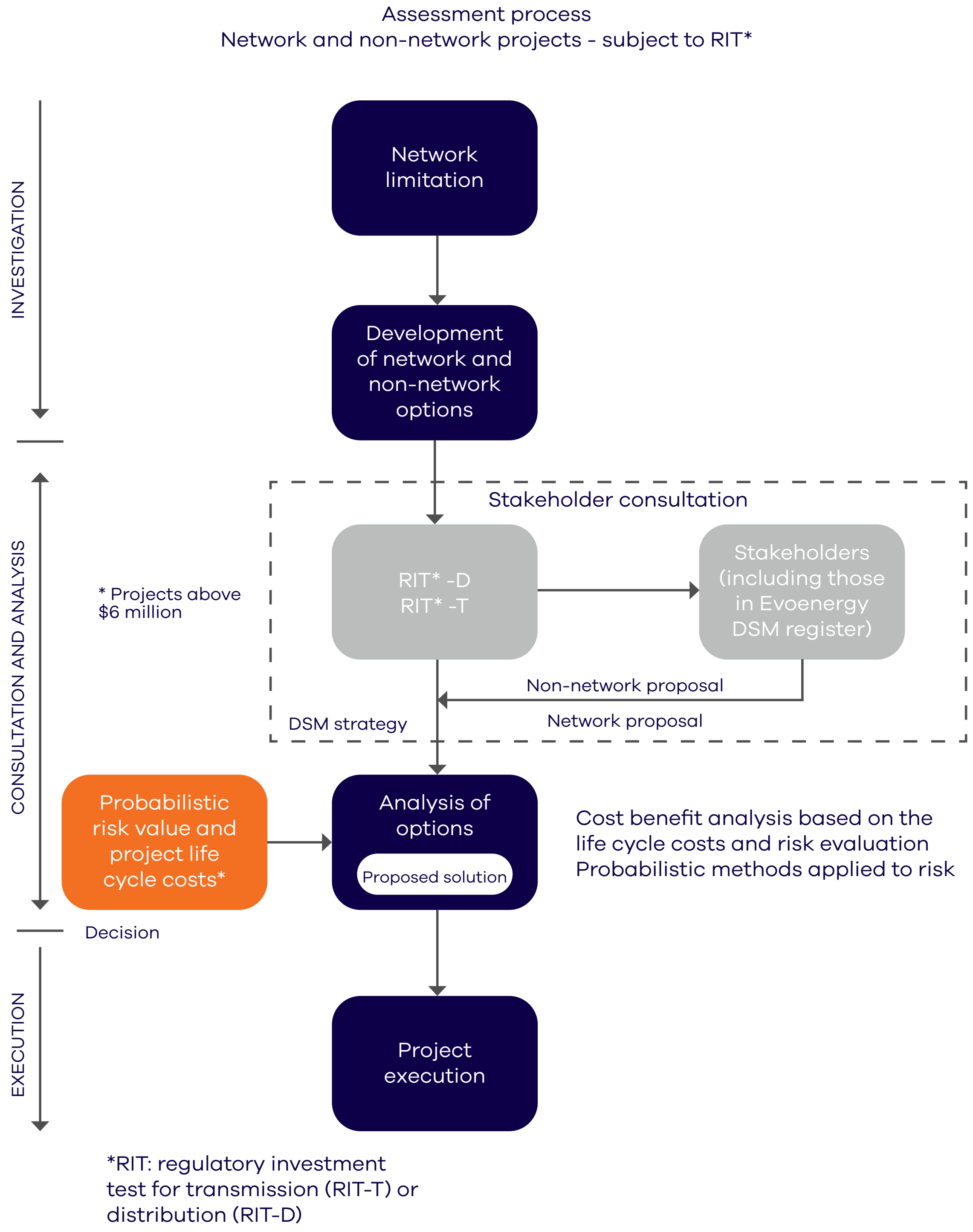
RIT Transmission (RIT-T) is conducted for transmission projects according to the process set out in AER's Application Guidelines. RIT for distribution projects (RIT-D) is conducted according to the process set out in AER's Application Guidelines for Regulatory investment test for distribution. For eligible projects, Evoenergy initiates RIT-D and RIT-T consultations after preliminary investigation of viable options and selection of proposed solution. The exact timing is governed by the requirements and complexity of the project. For distribution projects, Evoenergy aims to commence the RIT-D process at least 21 months before the network limitation must be resolved. For transmission projects, Evoenergy usually commences RIT-T process no later than 36 months prior to intended completion.

As part of the RIT process Evoenergy is required to publish a non-network options report (NNOR) detailing the analysis of the viability of non-network options when compared with the proposed network option(s). If it is determined that a non-network solution is potentially viable, Evoenergy can use the NNOR to call for submissions from non-network proponents.

Stakeholders who would like to participate in the process or be notified of future regulatory investment test can register their interest on the Evoenergy website[8].

8 To sign up to the Demand Management Register please fill in the form at the bottom of this page: https://www.evoenergy.com.au/emerging-technology/demand-management

Figure 6. Process overview – projects subject to Regulatory Investment Test



1.4 General feedback and suggestions

Evoenergy invites feedback and suggestions from all interested parties in relation to the contents of this report and other matters relating to network planning and development. This report and meeting papers from the Energy Consumer Reference Council (ECRC) are published on the Evoenergy website. The ECRC is a forum of Evoenergy's stakeholders representative of consumers, businesses, and the broader ACT community.

From time to time, Evoenergy conducts workshops, information sessions or sends out information on specific topics relating to the network development. You can register your interest to receive correspondence and notifications of future sessions using the form at the bottom of the Demand Management page on the Evoenergy website[9] or by emailing demandmanagement@evoenergy.com.au.

9 https://www.evoenergy.com.au/emerging-technology/demand-management

Chapter 2: About Evoenergy

This chapter provides the following information:

- Introduces Evoenergy as a licensed transmission network and distribution network provider.
- Provides an overview of the electricity network and the physical environment.
- Provides an overview of the regulatory environment.
- Discusses the main factors and trends which are currently impacting Evoenergy's planning approach and outcomes.

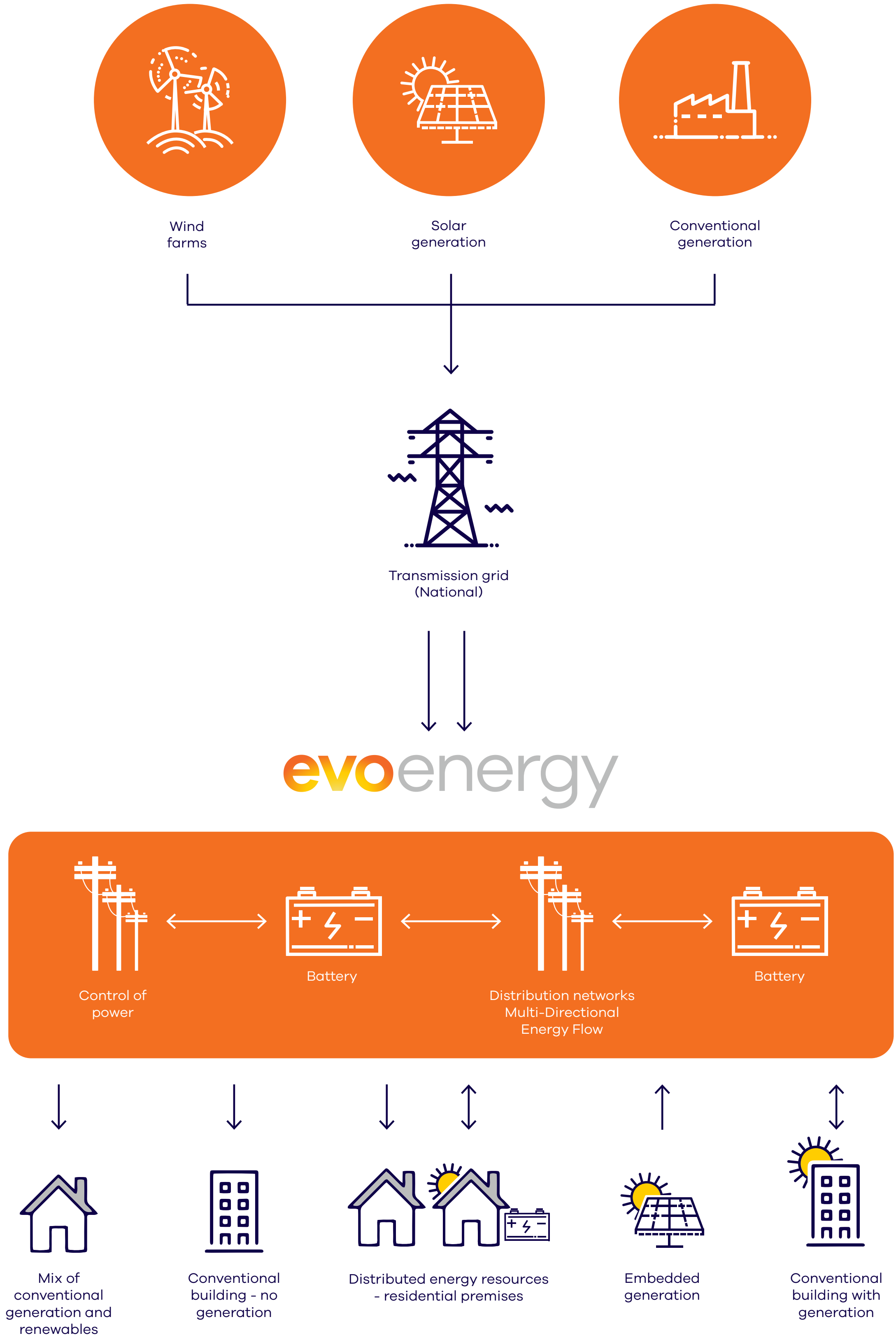
2.1 Introduction

Evoenergy is a utility licensed in the ACT to provide electricity transmission, distribution and connection services. Evoenergy also provides gas network services, which are outside the scope of this report. Evoenergy is a trading name of ActewAGL Distribution which is a partnership of Jemena Networks (ACT) Pty Ltd (wholly owned by Jemena Ltd) and Icon Distribution Investments (wholly owned by Icon Water Ltd). The licence was granted by the Independent Competition and Regulatory Commission (ICRC) in the ACT.

The licence and the licence conditions are available on the commission's website. In addition to the jurisdictional licence, Evoenergy is registered with the Australian Energy Market Operator (AEMO) as a Transmission Network Service Provider (TNSP) and a Distribution Network Services Provider (DNSP). Evoenergy also holds a gas distribution licence, but gas operations are outside the scope of this report. Appendix C – provides further details in relation to Evoenergy's structure and licensing.

Evoenergy's obligations cover all aspects of operation of transmission and distribution networks including customer connections, network planning, design, construction and maintenance. The figure below shows Evoenergy's position in the energy delivery chain which is increasingly impacted by changes in technology, consumer preferences and distributed energy resources.

Figure 7. Evoenergy within the energy delivery chain



2.2 Evoenergy's physical environment

Evoenergy provides electricity services over an area of 2,358 square kilometres to 204,000 electricity customers as of 30 June 2020, within the ACT. It also supplies electricity to around 90 customers in New South Wales.

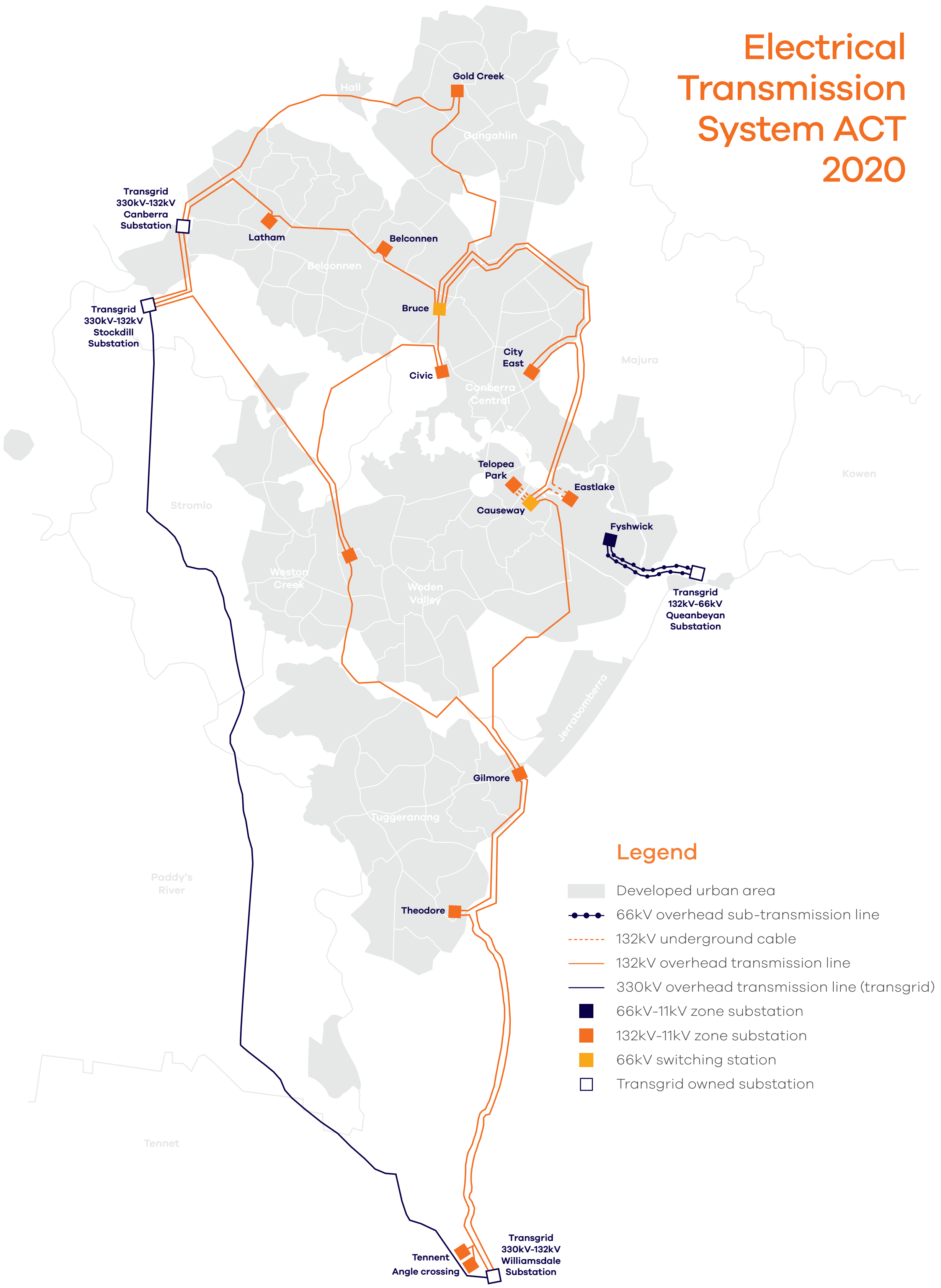
Evoenergy owns and operates the electricity network which includes 190 kilometres of transmission lines, sixteen 132 kV/11 kV zone substations and switching stations, around 4700 distribution substations, and over 5,200 km of distribution lines. More detailed statistical information on individual network asset numbers is provided in Table 18.

Figure 8 and Figure 9 below show the overview of the main components of the existing Evoenergy's transmission network including bulk supply points, zone substations and interconnecting lines.

Figure 8 is geographic representation of transmission lines and zone substations within the ACT. Evoenergy's network includes transmission and distribution substations, lines and cables supplying to a range of areas including high density urban centres, lower density suburban areas and rural areas. The lines cross developed urban areas and bushlands. Significant sections of overhead transmission lines and overhead distribution lines are located in bushfire prone areas. The vast majority of our low voltage distribution poles are located in residential backyards which is a unique feature of Evoenergy's network, and many sections of the network are heavily vegetated.

Appendix B – provides additional details on the network's physical assets including a number of transmission and distribution assets, lengths of lines and cables, the rating of the main transmission components and zone substations.

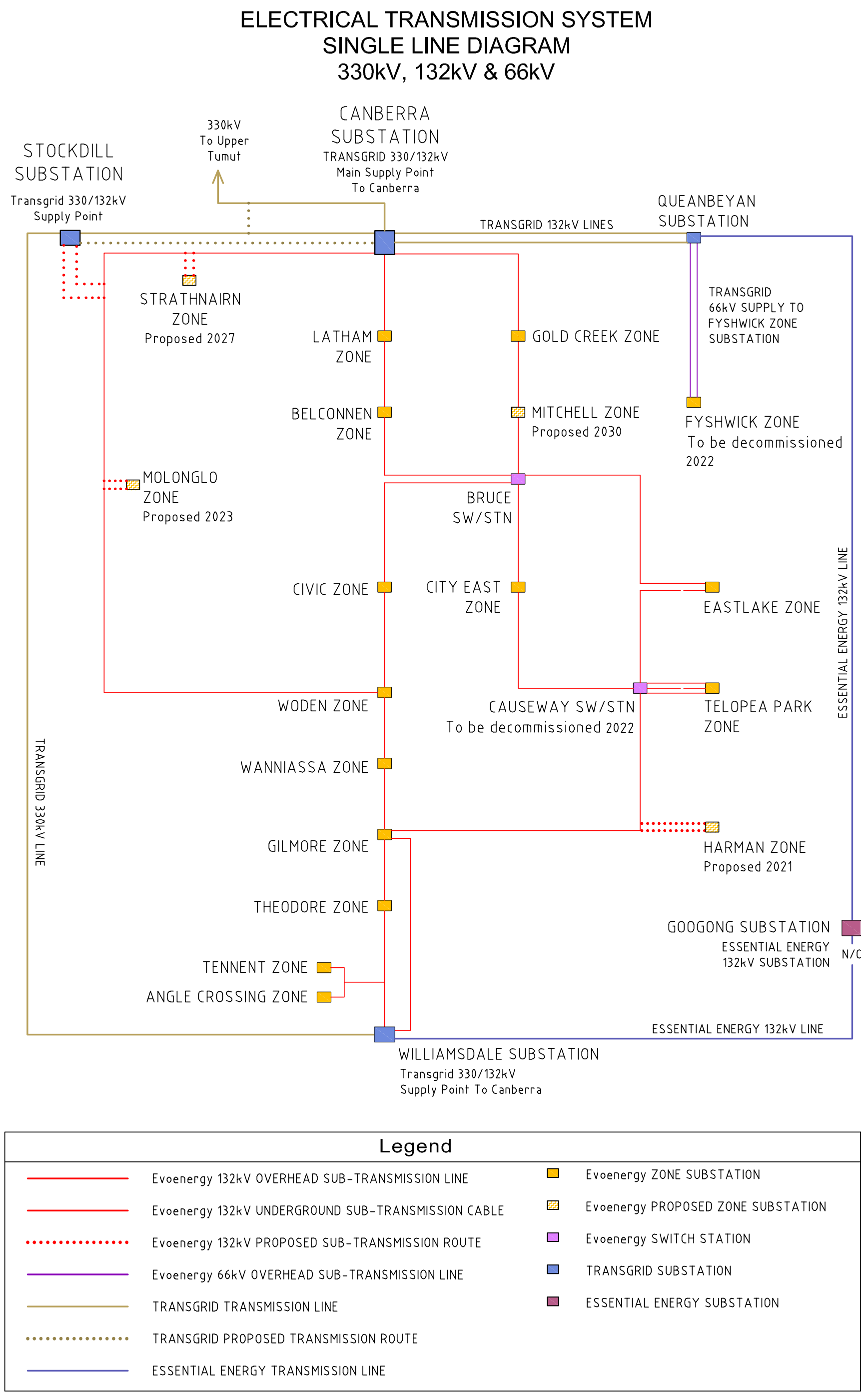
Figure 8. Evoenergy's transmission network – geographic representation



Details current as at November 2020.

The diagram below depicts existing and future Evoenergy's transmission network and TransGrid's 330 kV lines connecting Evoenergy's network through four bulk supply points (Canberra Substation, Stockdill Substation[10], Williamsdale Substation and Queanbeyan Substation) to the New South Wales transmission network. All the components marked for 132 kV, 66 kV and 11 kV voltage levels are operated by Evoenergy. The network consists of fourteen zone substations and two switching stations and the interconnecting transmission lines. The bulk supply substations and 330 kV lines are operated by TransGrid.

Figure 9. Evoenergy's existing and future transmission network - schematic representation



10 Stockdill was energised in December 2020

2.3 Regulatory environment

Evoenergy is a utility regulated by Commonwealth and jurisdictional legislative and regulatory instruments, which cover economic and technical regulation.

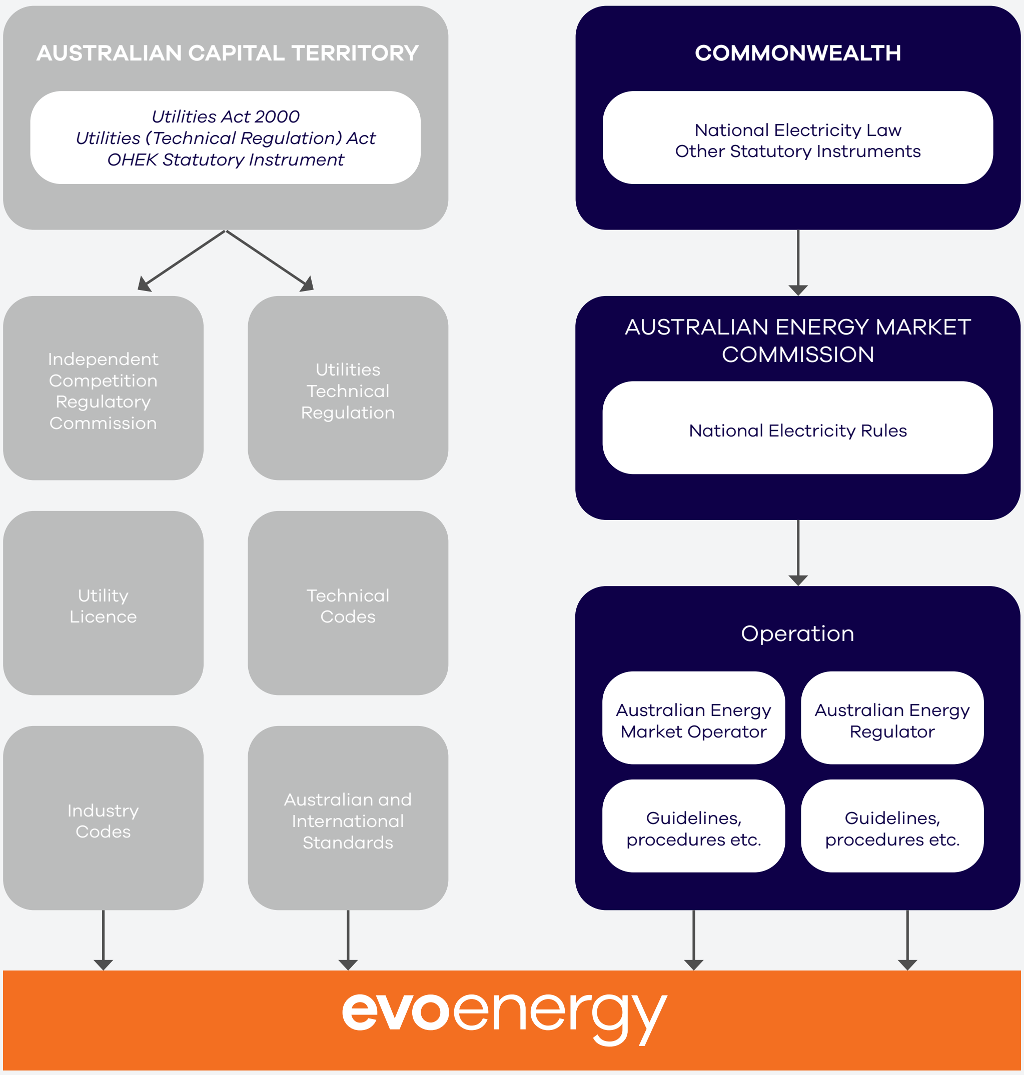
The way we plan our network is consistent with a range of obligations and regulatory instruments which support the National Electricity Objective (NEO):

"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 price, quality, safety and reliability and security of supply of electricity"

Our network planning process aims to achieve operational outcomes in line with the *NEO* including supply security, reliability, quality and safety. In addition, we plan and develop the network to fulfil obligations relating to price, investment efficiency and long-term interest of consumers. Therefore a consideration of technical and operational outcomes goes hand in hand with the economic and consumer interest when we make network investment decisions.

Figure 10 provides an overview of main elements of Evoenergy's regulatory environment as a licenced and registered utility. The regulated Evoenergy's "poles and wires" business is ring-fenced form other entities and activities which operate in competitive markets. National Electricity Rules (NER) and AER ring-fencing guidelines define the rules which apply to separation of a regulated business and non-regulated business activities.

Figure 10. Utility regulation framework – main elements



Apart from the main regulatory components presented in the above diagram, small parts of Evoenergy's network located outside the ACT are subject to New South Wales regulations with an oversight by the New South Wales Independent Pricing and Regulatory Tribunal. In addition, to the utility obligations, Evoenergy is also subject to a range of other legislative obligations which apply to a broader business and corporate community.

Appendix C provides a more detailed description of key regulatory instruments relevant to utility regulation, in particular those relating to asset management and network planning. The description covers National Electricity Law (NEL) and NER, ACT's Distribution and Transmission Supply Codes and regulatory incentive schemes administrated by AER. These components are relevant to planning outcomes documented in this report.

2.4 Factors impacting future network development

Network planning process requires us to consider a range of internal and external factors impacting the electricity network. External factors are driven by consumer preferences, consumption trends, demand, development trends and technology impacting security of supply, reliability, power quality and safety.

Evoenergy is cognisant of the following current external factors impacting electricity network planning and asset management:

- The ongoing high-level of growth in distributed energy resources in particular residential photovoltaic installations and medium size commercial installations, which create voltage regulation issues in some pockets within the network.
- Small growth in summer and winter demand at the network level and higher demand growth pockets in several locations in the ACT.
- Urban intensification including increase in growth in medium and high-density residential development, higher rates of commercial developments and new greenfield developments leading to localised network capacity constraints.
- The existing trends and the long-term policy settings including ACT Government energy policies such perpetual 100% renewable energy target and 2045 zero emissions target reinforcing need for changes to the way we operate the network.
- Impact of decarbonisation policies, gas substitution and electric vehicles policies which are part of the ACT government Zero Emissions Framework.
- The full potential of technology including advanced metering or energy storage to support the network is yet to be fully realised.

The next section discusses ACT Government energy polices and provides a long-term context for the existing trends impacting Evoenergy's network.

Government policies and long term context

Local renewable energy generation in the ACT was initially encouraged by Commonwealth renewable energy certificates, ACT feed-in-tariffs, and the ACT Government 100% renewable energy target and reverse renewable energy auctions. In recent years, Evoenergy's network has experienced unprecedented growth in both in front of meter and behind the meter generation.

We have 43 MW of large-scale solar generation currently embedded in the ACT network and there is around 30 MW of new solar generation under consideration. The strong growth in rooftop photovoltaic generation continued last year and now around a quarter of all residential dwellings in the ACT have photovoltaic installations. The installed capacity of residential photovoltaic installations has increased by just over 35% across the 2019–20 financial year. At the same time the average size of residential photovoltaic installation has increased from 2.5 kVA in 2010 to around 5.6 kVA for the new installations in 2019.

This growth has had an increasing impact on the network, particularly in relation to voltage regulation in areas where the penetration of photovoltaic is high. Figure 3 in the executive summary shows geographic areas of high PV penetration.

The ACT Government's energy policies point to the continuation of this trend. The ACT Government's policy includes the 100% renewable energy target which was met in 2019 and has been extended in perpetuity into the future. The 2019 ACT Government renewable auctions also mandated provision of network batteries a part of the offer.

A perpetual 100% renewable target means that future increases in the energy consumption will have to be matched by additional renewable generation. The rapid uptake of the distributed generation in the ACT is expected to continue, and as a result, we predict an increase in power quality challenges and electricity demand due to decarbonisation, gas substitution and electric vehicles.

The ACT Government energy policy includes Zero Emissions Government Framework with a long term net zero emission target set for 2045. The discussion paper on ACT Sustainable Energy Policy 2020–25 deliberates on a number of policy options to achieve the net zero emissions target. One of the key issues the discussion paper sets out to address is a long-term transformation of the transport sector which is the main contributor towards greenhouse gas emissions at around 60%. Most future transport scenarios, including fully-electric, hydrogen and hybrid vehicles point to the likely increases in electricity requirements and demand from the network. This report does not factor the impact of 2045 target which at the time of publication was subject to Government consultation.

The discussion paper also notes that the net zero emission would require "a transition away from using natural gas". Under this scenario and most scenarios, this would likely result in an increased electrical energy consumption. Development conditions specified by the ACT Government for several recently developed residential estates exclude gas reticulation.

Evoenergy is cognisant of many future scenarios which will require changes to the network solutions and network investments if the net zero emissions transport and natural gas substitution translate to increased electricity consumption. Ongoing close engagement with interested parties is essential to adapt and to address future challenges. We are committed to managing future uncertainty through adaptability and innovation.

Planning towards future network

Evoenergy responds to the changing energy industry landscape. 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 Distributed Network Supply Provider to a Distribution System Operator. 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.

Figure 11 provides and overview of the changing business environment influenced by our key stakeholders.

The ACT Government 100% renewable energy target and the net zero emissions target set for 2045 are key drivers of transformation. Rooftop solar PV are being encouraged by developers of large residential estates, and it is likely that battery energy storage and home energy management systems will be further encouraged in the near future. Production of bio-gas from waste vegetation material is also 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.

Figure 11. Towards the future network

On-grid residential customers

Increased independence from the grid. Use of advance metering to optimise energy use, remotely controlled appliances, solar generation and use of battery storage. Increasing collaboration with distributors on demand management. Some consumers sell energy to retailers or pier to pier.

Off-grid customers

Customers wholly independent from the network. Customers select micro-grid solutions.

Developers

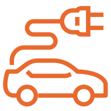
Increasing number of estates with compulsory renewable generation and battery storage. Estates requiring only limited support from the electricity network.

Government

Zero net emissions by 2045 target supports increasing penetration of distributed renewable energy resources and embedded generation.

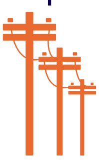
Commercial Customers

Increased focus on energy efficient building management systems to miminse energy use. Installation of renewable generation to offset consumption and increased collaboration with distributors on demand management.



Zero emission vehicle owners

Vehicle owners require charging stations located through the network. Increasing energy consumption from electric, hydrogen vehicles or hybrid technologies.



Demand management sector

Growing number of operators collaborate with distributors in demand management and non-network solutions. Embedded generators, demand integrators and virtual plant operators provide network support and demand management solutions.

The ACT's climate provides for future extensive solar power generation, though it 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 retirement or replacement. Such assets include urban backyard overhead low voltage lines. With growing in-fill housing developments, these backyard lines are becoming increasingly difficult to access and maintain. The long-term strategy plan provides strategic direction for the efficient utilisation of existing assets.

The following sections discuss how specific observed trends impact security or supply, reliability, and quality. These factors were taken into account when developing network plans and this report.

Main factors impacting security of supply and demand

Security of supply relates to the available capacity to supply the existing and projected electricity demand. The available network capacity must be sufficient to cater for peak demand under normal conditions and credible contingency conditions (e.g. a failure or outage of a network component).

The capacity and demand on the main components of the network is considered during the planning process. The demand forecast is prepared for the systems, zone substation and specific distribution system parts experiencing capacity constraints. Demand for electricity is driven by a number of factors including population growth, economic activity, energy efficiency, consumer consumption patterns, new commercial and residential developments and larger point loads. The distributed energy resources located behind the meter reduce the transportation of energy through the network. The energy consumption and demand can be also influenced by the electricity tariffs levels and structures. More importantly, demand is sensitive to weather conditions, in particular the maximum and minimum temperatures.

Evoenergy observations and findings:

The projected demand at the system level is relatively flat (Chapter 5), and no new major security concern has been identified at the system level to be addressed by Evoenergy. Previously identified constraints are being addressed by joint planning with TransGrid through a construction of Stockdill bulk supply substation and interconnecting lines due to be commissioned in 2020 (see 7.6.1 for further detail). Evoenergy liaises with TransGrid to manage transmission voltage regulation constraints at zone substations at the time of low network load which coincided with high PV generation during the day or low consumption at night.

Identified network limitations (Table 1) relating to the zone substations capacity and distribution system are localised to the areas experiencing higher growth. These limitations must be addressed either through network augmentation or demand side management solutions.

Factors impacting reliability

The reliability of the supply is measured though the number and duration of electricity supply interruptions experienced by network customers (Chapter 4). The reliability of supply is impacted by a condition of network assets and factors outside Evoenergy's control such as weather or accidental damage. Not all assets equally impact supply reliability. The probability of failure and consequences of failure are different for different assets, depending on the location and function in the network. Health of some network components is critical to the electricity supply, and we optimise maintenance activities according to the age, health, and criticality of the assets.

Reliability performance is measured against the target set by the ACT Distribution Supply Standards Code for all outages (planned and unplanned) and a target for unplanned outages set by the Australian Energy Regulator as part of the Service Target Performance Incentive Scheme (STPIS).

Evoenergy observations and findings:

Evoenergy's reliability for unplanned outages is one of the best in Australia[11] and our intent is to maintain reliability performance within the existing regulatory targets. Our work program is oriented towards maintenance of reliability levels and targeting improvements in specific areas of concerns, including the worst performing feeders and worst served customers. For more details on network

11 AER 2019 distribution network service provider benchmarking report – November 2019 (2020 version not yet available)

reliability performance refer to Chapter 4.

Evoenergy is cognisant of some assets that pose an increasing reliability risk (e.g. underground distribution cables or distribution switchboards). The management of existing assets including maintenance and renewal seeks to prioritise and address these risks. The management of existing assets is discussed in Chapter 6.

Factors impacting power quality and other technical parameters

Power quality relates to the standard voltage and current experienced by customers connected to the electricity network. Power quality can be measured and expressed through a range of parameters including voltage levels, voltage and current harmonics, voltage stability and power factors. Departures form the standard may have adverse impact on customer equipment. Customer equipment may also contribute to poor power quality and impact other consumers connected to the network. The departures from the standard can be transient, temporary or permanent which impacts power quality to various degrees. Poor power quality may adversely impact consumers for example through appliance overheating, disconnections or light flicker. In more severe cases, poor power quality can cause appliance damage or shorten the life of appliances.

Distributed energy resources such as photovoltaics have a potential to impact power quality and reliability.

Evoenergy observations and findings:

Currently, our main power quality initiatives focus on the impact of photovoltaic distributed generation. As demonstrated by voltage regulation constraints in some parts of the network, we are reaching hosting capacity limits which needs to be assessed on individual basis.

In network locations with high concertation of photovoltaic generation, we experience increased incidence of voltage regulation constraints. At times of high energy production and a low consumption, the reverse power flow may increase voltage levels beyond the normal operating limits. High voltages may cause automatic disconnection from the network of PV installations. The limitations impact the low voltage distribution network and, at times, distribution substations. The voltage regulation issues which will have to be managed are set to increase in line with the growing penetration of distributed generation.

Chapter 4 and Appendix F – discuss network reliability performance and measures.

Chapter 3: Asset life cycle management

This chapter provides an overview of Evoenergy's asset management and planning approach that underpins development of our work programs to meet the need for a safe, reliable, and quality electricity supply.

Optimising the value of investments is at the core of Evoenergy network planning and asset management philosophy. Evoenergy asset management decisions recognise the transformation of electricity network and role of the network provider due to changes in consumer preferences and technologies. The approach is designed to support prudent and efficient investment and promote innovation.

The key characteristics of Evoenergy asset management approach include:

- Planning and asset management processes aiming to maximise the benefits over the life cycle of assets.
- Employing and testing innovative solutions whenever cost effective and practicable.
- Integration of risk management and probabilistic planning into asset management investment decisions.
- Mandatory consideration of non-network and demand management solutions.
- Exploiting synergies between planning of the network needs and management of the existing assets.
- Philosophy of continuing improvement applied to asset management processes, components, and systems.
- Certification for compliance with *ISO 55001 for Asset Management*.

Appendix D – provides further description and details of Evoenergy's approach to the management of the existing assets and planning of the network.

Certification of Asset Management System to ISO 55001

ISO 55001 states the specification for an integrated, effective management system for asset management which maximizes value derived from the use of assets. Evoenergy has adopted *ISO 55001* as the reference for measuring asset management continuous improvement and compliance.

JAS-ANZ accredited auditor assessed that Evoenergy attained the certification against the requirements of *ISO 50001 Asset Management standard*. Evoenergy intends to maintain that certification.

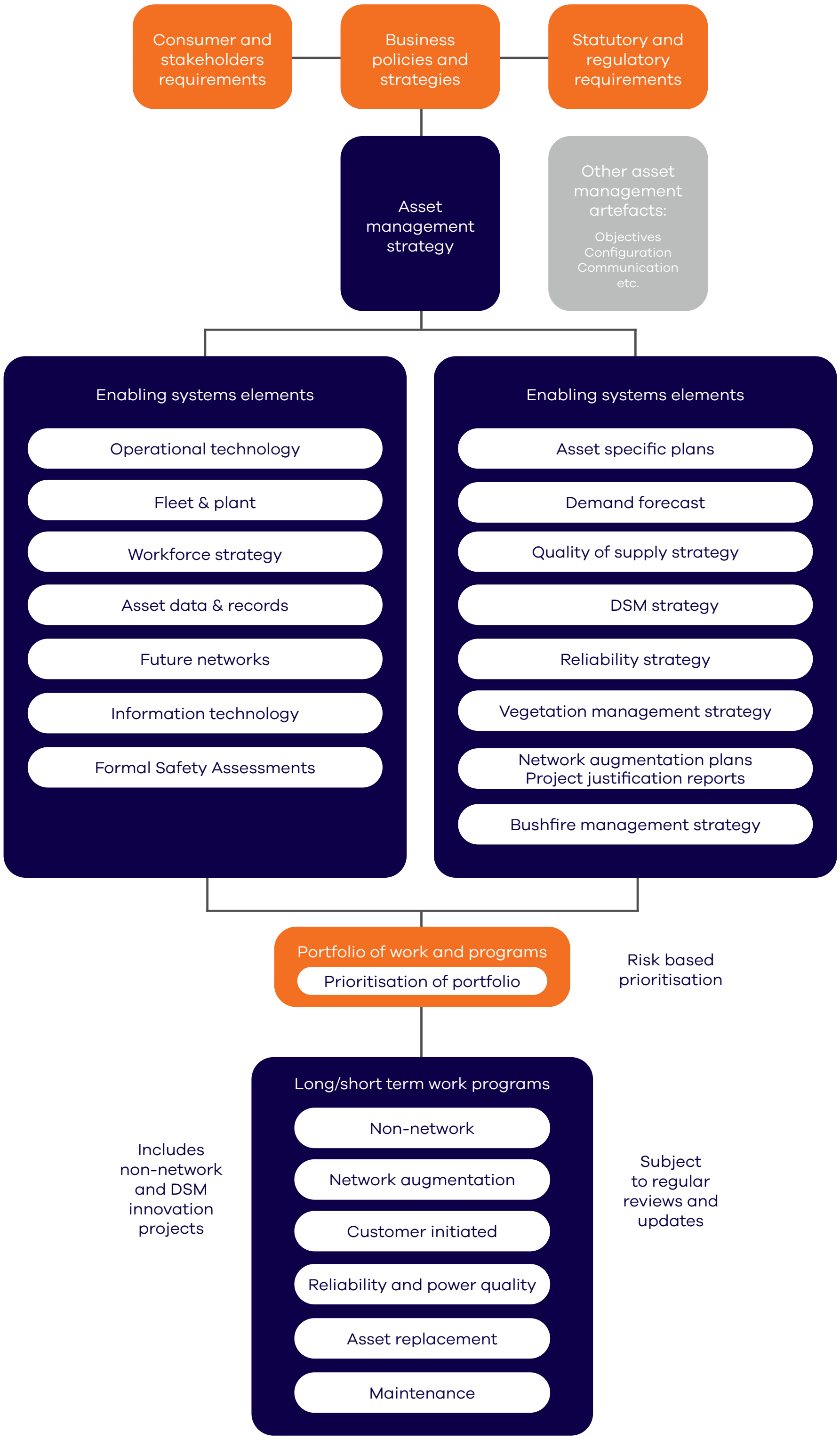
3.1 Asset management approach and components

The asset management and network planning outcomes are achieved by applying methodologies which include:

- Development of network investment and maintenance programs through a bottom up analysis of network and asset needs including performance, safety, load growth, security, asset health and criticality.
- Exploration of demand management and non-network solutions through engagement with the consumers and industry stakeholders.
- Application of rigorous probabilistic risk assessment methods to operational risk analysis and network investments.
- Application of Risk Centred Maintenance methodology to the development of asset maintenance programs in accordance with asset performance, health, and criticality.
- Optimising programs across asset categories by using a risk based top-down review to achieve the desired level of risk mitigation at least cost.

Figure 12 provides an overview of the main Asset Management and Network Planning artefacts relevant to the development of the network programs relating to asset augmentation, replacement and maintenance. The asset management processes are discussed further in Appendix D – The network planning outcomes are discussed in Chapter 6 for the existing assets and in Chapter 7 for planning of the network.

Figure 12. Asset management and network planning – overview of key artefacts



3.2 Network planning methodology

Evoenergy applies its network planning process to address existing and emerging network limitations and performance issues. The primary objective of network planning is to ensure sufficient security, quality, and reliability of supply at the lowest possible cost. Evoenergy's network planning processes considers the network performance and capacity against future network needs based on the projected demand forecast for the main network components such as transmission lines, zone substations and distribution lines.

As a starting point, deterministic methodology is used to identify parts of the network where demand may exceed supply capacity. The network is designed with a limited redundant capacity margin in the critical parts of the network to cater for credible contingency events. This deterministic methodology is usually referred to as the "n-1" criteria. The Advanced Distribution Management System (ADMS) network analysis tools use demand forecast to analyse and identify network limitations including capacity and power quality constraints. Synergies with asset replacement and retirement program are considered and captured at the same time. The identified constrains are further assessed through application of probabilistic planning methods.

3.3 Risk based probabilistic planning

Risk management is fundamental to all Evoenergy's investment decisions. Although the methodology may vary for different asset classes, the risk management is integrated with asset management decisions and network planning. Network investment is designed to mitigate existing or emerging risks. As far as practicable, the risk reduction from various solutions is assessed for each investment option. This method forms the basis for the business case and the Net Present Value (NPV) calculation. Projects driven by compliance requirements are often assessed on the Net Present Cost (NPC) basis rather than NPV basis.

Figure 13 provides a high-level overview of the risk based approach to investment decisions. It shows that risk assessment and as far as practicable valuation of risk is a critical step in investment decisions. Unbiased consideration of non-network and network solutions is a mandatory step in the process.

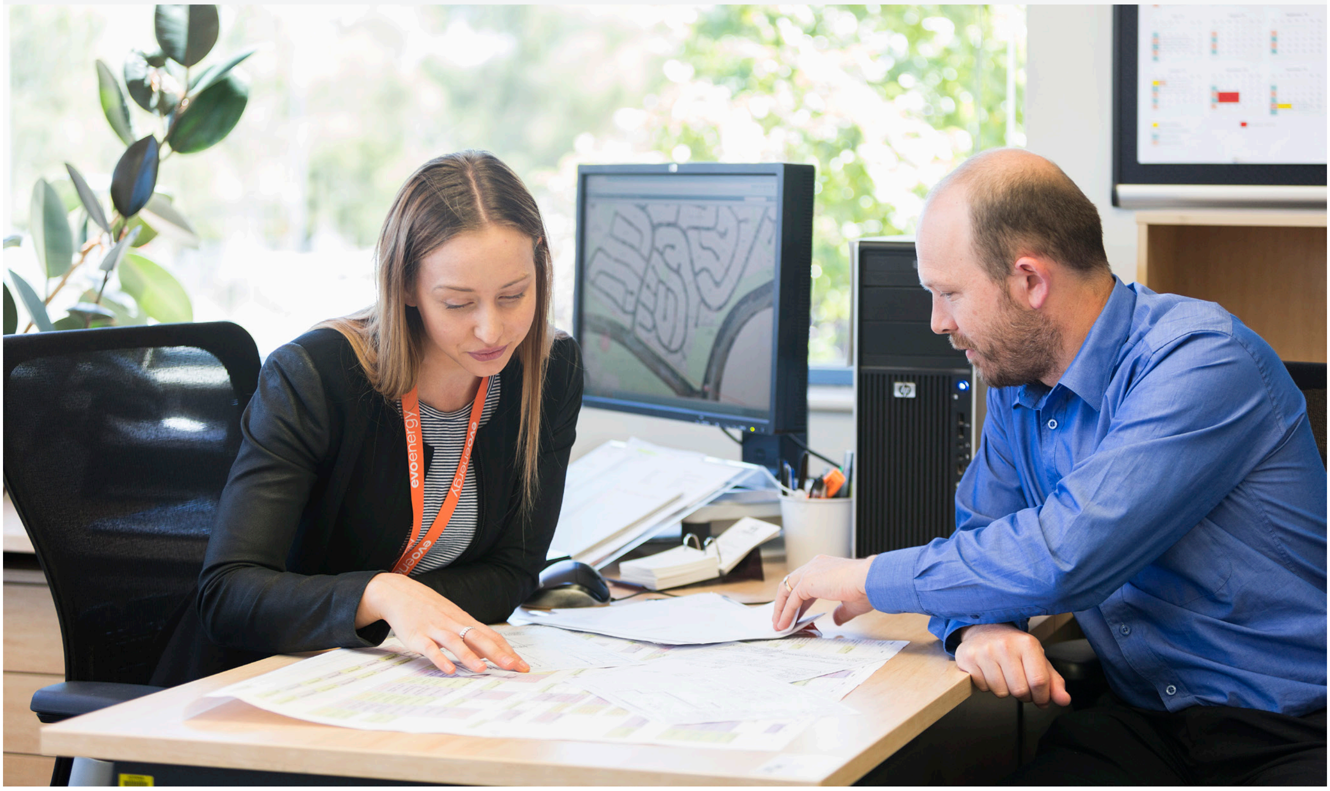
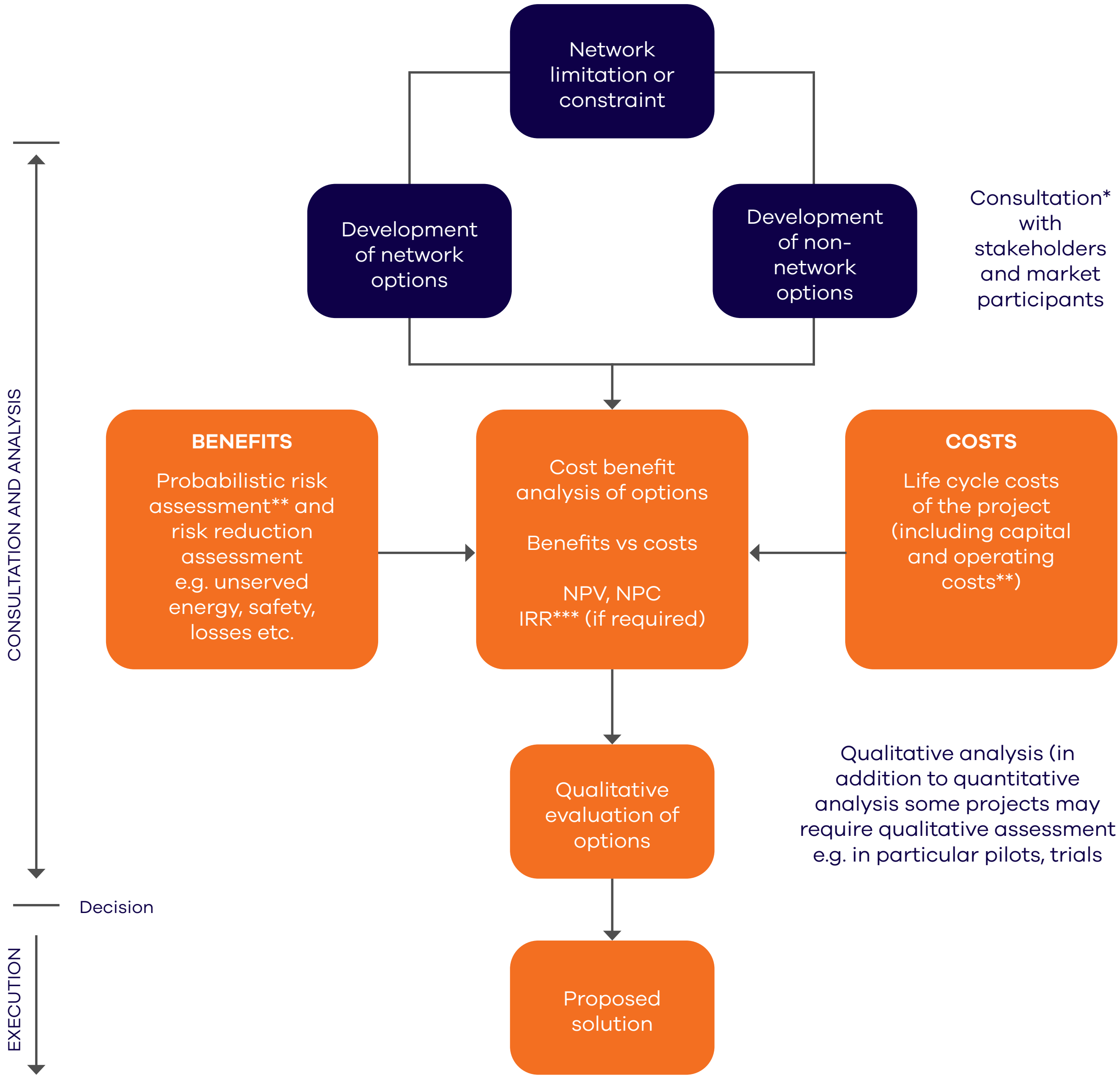


Figure 13. Overview – probabilistic risk-based investment decisions



*As per Evoenergy demand management engagement strategy
** risk assessment and life cycle costs are applied as far as practicable, whenever appropriate market benefits are considered
***IRR definition – internal rate of return

For the identified network limitations, the probabilistic planning methods are used to quantify the existing and emerging risks. As far as practicable, the methodology is applied to network capacity constraints and asset renewal projects. This risk is often related to the risk of supply interruptions (reliability). It is expressed as the value of "unserved energy" corresponding to probability of supply interruption and consequences of interruptions for credible network events. These supply interruption consequences are assessed from an economic perspective. The valuation is based on the value of energy to the consumer. The unit value of reliability to consumers for each unit of energy ($ / kWh), known as the value of customer reliability, is published by the AER[12].

Apart from the risk of supply interruption, typical risk assessment may include safety, environmental and financial risks. The value of risk expressed in monetary terms allows for the comparison of the market benefits with the corresponding investment costs. Risk reduction in that comparison is considered as a benefit. Evoenergy developed improved asset management model which uses probabilistic risk methodology to asset renewal decisions. The model has been recently reviewed and employed within Powerplan application to preparation of Asset Specific Plans. The approach is consistent with the AER's applications notes on asset replacement planning[13].

Projects for which the risk is not easily quantifiable or projects driven by compliance may use alternative methods. Typically, project driven by compliance or innovative projects (including pilots and trials) would lend themselves to alternative assessment methods.

Appendix D – provides more details on Evoenergy asset management approach.

3.4 Management of existing assets

Evoenergy's approach to the management of existing assets aims at optimising the investment over the life cycle of the assets. Asset retirement and renewal are closely coordinated and integrated with the network augmentation plans to exploit synergies and capture savings. The foundation of the asset management approach is operational risk assessment based on the analysis of asset condition, performance, and criticality. Asset criticality takes into account the operational function of the asset and consequences of failure. The analysis includes variety of data and information collected as part of network operations including asset monitoring, testing and inspections. The performance and failure rates of specific assets or asset classes are factored into asset management whenever available.

Evoenergy asset maintenance philosophy complements asset retirement and renewal approach. Risk centred maintenance is discussed in the next section.

The main output from the process are Asset Specific Plans (ASPs) for all network asset classes and groups. The ASPs include planned asset retirement, renewal, and maintenance. ASP are the results of the bottom up analysis based on the available asset data.

An additional step is to optimise the investment across asset classes. The top down analysis across ASPs ensures that investment dollars are allocated to the assets where the overall benefits (e.g. risk reduction) are greatest.

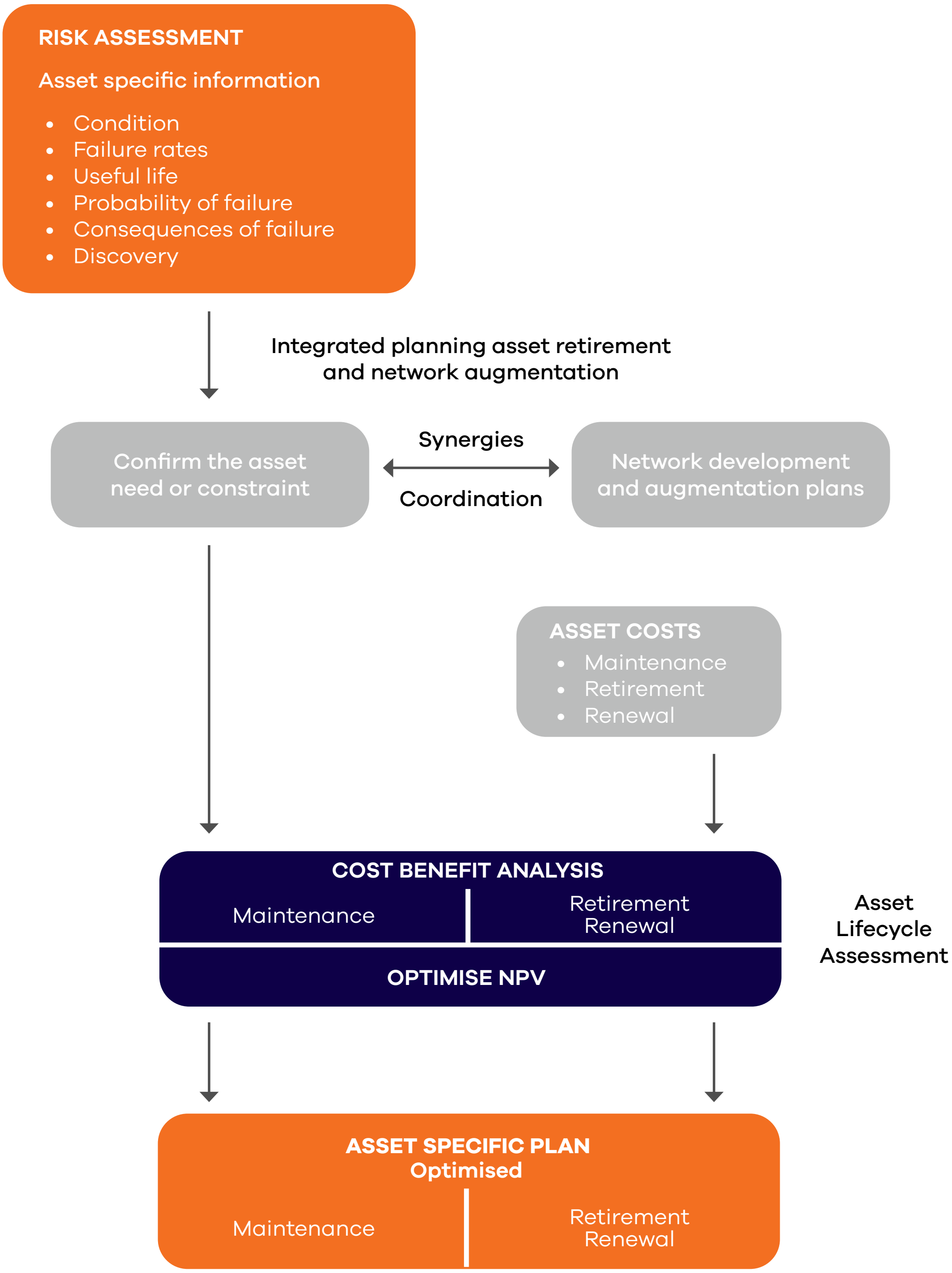
Appendix D – provides additional details and commentary on the Evoenergy asset management approach. Chapter 6 discusses outcomes of the planning review for the asset retirement and renewal.

Figure 14 shows an overview of the life cycle optimisation process.

12 VCR values are sourced from: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability

13 AER January 2019. Industry practice application note. Asset replacement planning.

Figure 14. Optimising asset retirement and renewal – an overview



3.5 Asset maintenance

Evoenergy maintains its assets according to the principles of risk centred maintenance. The governing factor in risk centred maintenance analysis is the impact of a functional failure at the equipment level dependent on the criticality of the asset.

The process of developing a risk centred maintenance program depends on selecting scheduled tasks that are both applicable and effective for a given asset. Risk assessment is integrated into the process. For some asset classes, the rick centred maintenance methodology is extended to Failure Mode Effect Analysis (FMEA) which considers in more detail root causes and consequences of failures. The fact that failure consequences govern the decision process makes it possible to use a structured decision approach, both to establish maintenance requirements and to evaluate proposed tasks. As far as practicable the cost of maintenance and asset replacement are optimised over the life of the asset. Overall, the maintenance tasks tend to be weighted towards the assets where failure might have greater safety, environmental, reliability or economic consequences.

The net result of the decision process is an optimised planned maintenance program that is based at reliability characteristics of the equipment in the operating context (function and criticality) in which it is used.

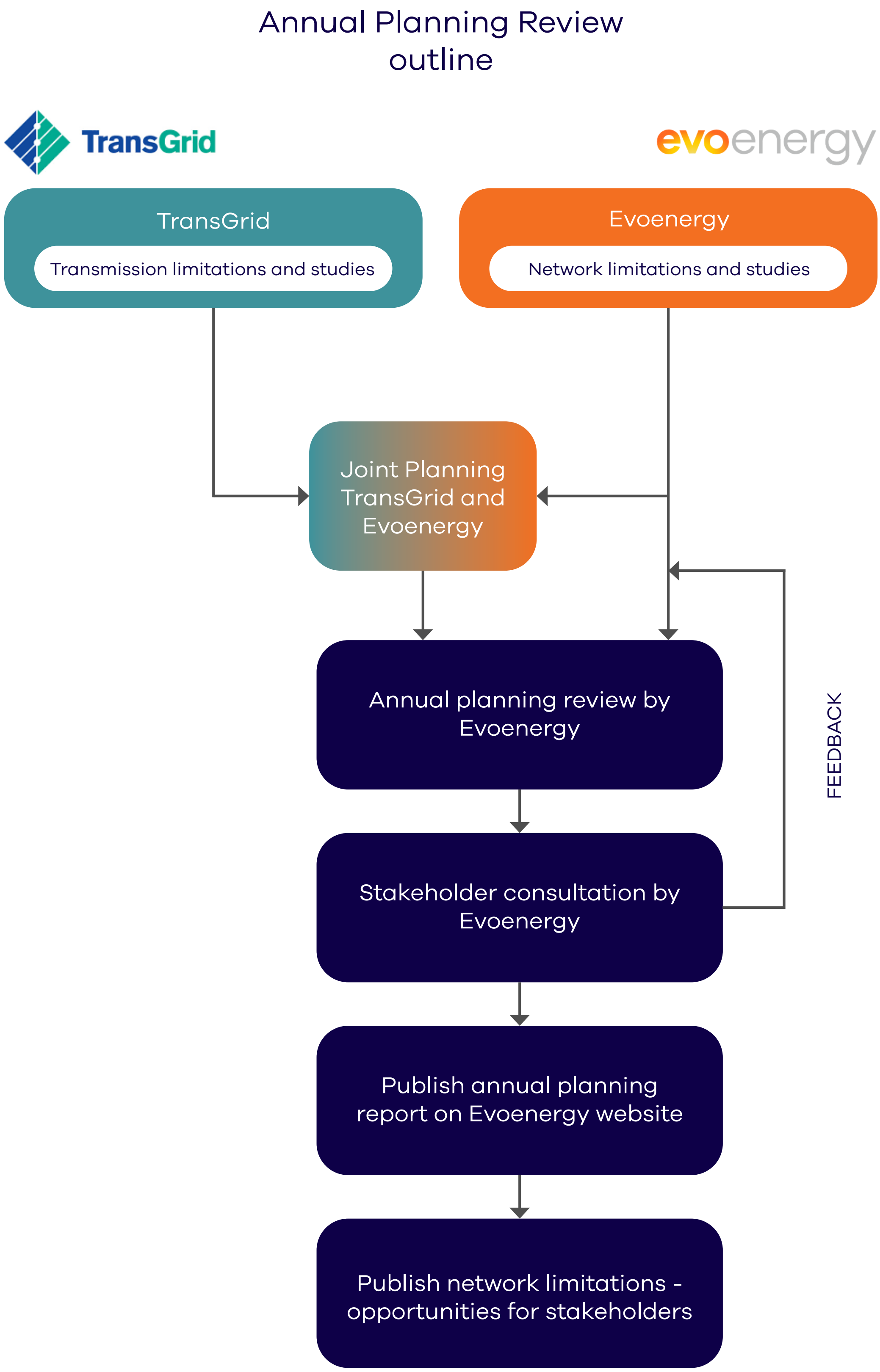
3.6 Annual planning report

Evoenergy documents the approach and outcomes of network planning in its APR. The prioritised solutions are rolled into the network asset management and development programs and are periodically reviewed and updated. The report's planning horizon is five years for the distribution network and ten years for the transmission network. The projects which are likely to be subject to regulatory investment test are included in this report.

The APR also describes how we engage with our stakeholder to explore the full range of non-network and demand management solutions.

Figure 15 on the next page provides an overview of the planning review process including joint planning with TransGrid, the operator of the transmission network in NSW with which ACT network connects.

Figure 15. Annual planning review – outline of the process



Chapter 4: Network performance

This chapter discusses network reliability and power quality performance. Network performance refers to the level of service Evoenergy provides to its customers in terms of availability and quality of supply. This section identifies challenges and presents our plans to maintain network performance.

4.1 Network reliability

Network reliability performance is measured by the frequency and duration of supply interruptions to customers. Our strategy is to maintain the overall network reliability performance and implement set initiatives targeting specific improvements.

In the past 5 years, network reliability performance has remained consistent with minor departure from the AER's Service Target Performance Incentive Scheme (STPIS) supply reliability targets for the duration of outages (SAIDI). Our network reliability performance and forecast performance is shown in Figure 16 and Figure 17.

Figure 16. SAIDI- unplanned interruptions per customer (minutes per customer per year)

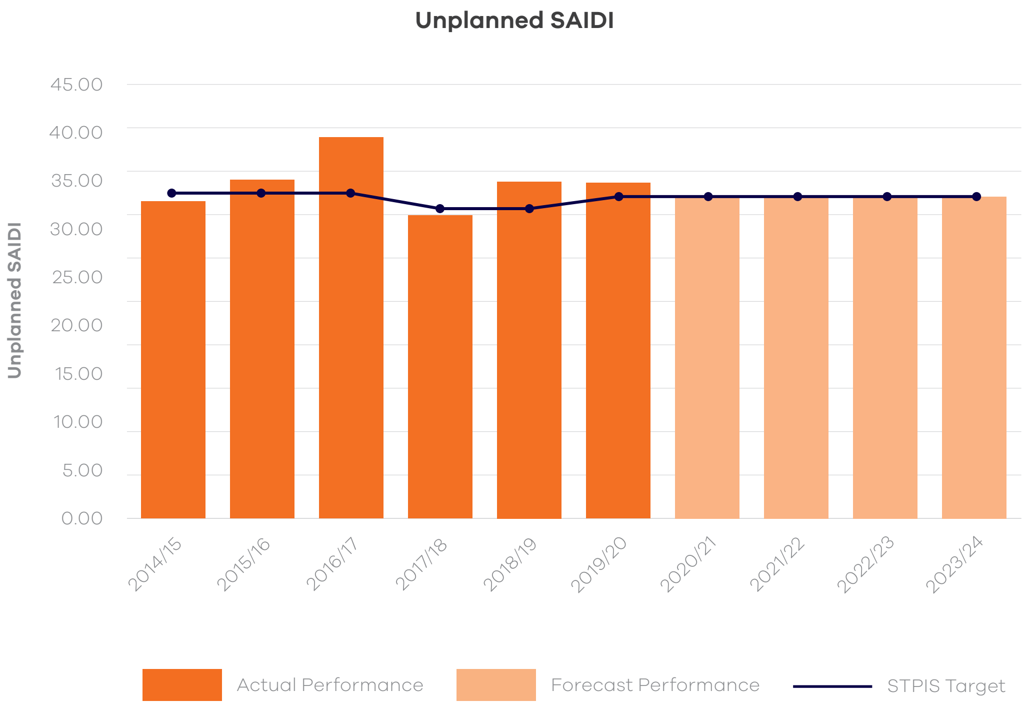
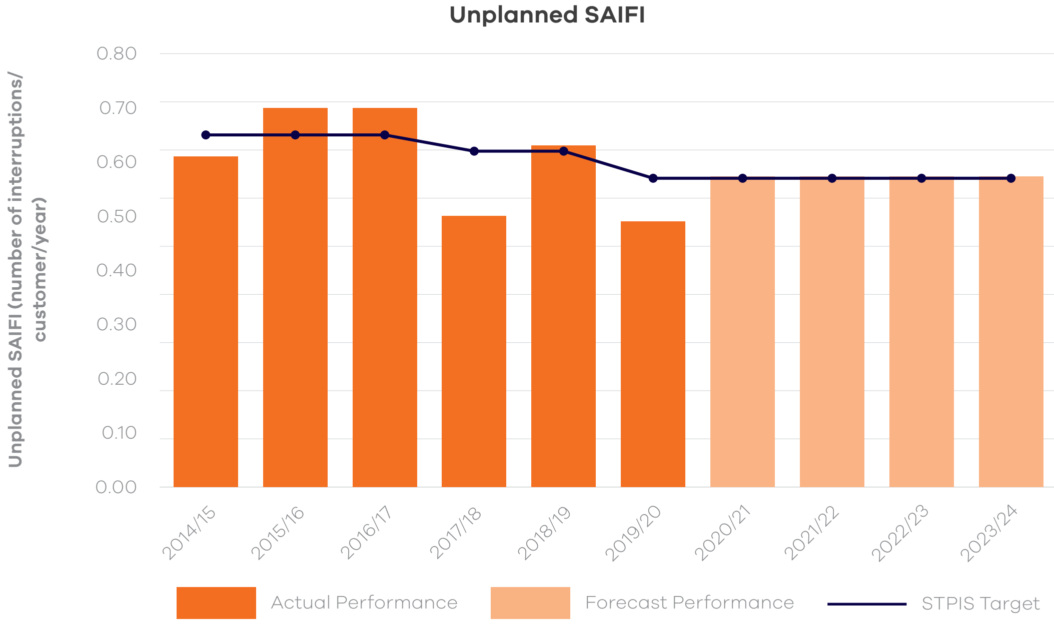


Figure 17. SAIFI- unplanned interruptions per customer (number of interruptions per customer per year)



Appendix F – contains detailed network performance and comparison to AER and local jurisdictional targets.

4.1.1 Reliability – what are the main challenges

The overall network reliability performance for unplanned outages is one of the best in Australia. Network reliability performance is continually monitored to identify emerging trends of poor network performance by worst performing feeders and worst served customers.

Duration of outages

Our customers value fast restoration when outages occur. This was expressed by customers when Evoenergy consulted with customers through our ECRC. The majority of our customers prefer faster restoration compared to fewer outages.

Evoenergy's average duration of unplanned outages per customer (SAIDI) has slightly increased over the last 10 years. Evoenergy's reliability strategy aims to address this trend.

Worst served customers and worst performing lines

Some customers (worst served customers) experience poorer performance compared to the network average. The customers may be impacted by planned and unplanned outages. Evoenergy monitors planned and unplanned outages for all customers and identifies customers who experience the reliability well below average.

For those customers, the root cause(s) of supply interruptions are analysed to determine credible solutions.

Power quality

Our reliability strategy extends to minimising interruptions to customers grid connected PV inverters. Power quality, specifically LV voltage regulation is affecting customers grid connected PV inverters causing outages to those PV inverters. This is addressed through our power quality strategy however is related to the reliability our customers experience.

Integration with asset management and maintenance

Areas of the network experiencing poor reliability are investigated to determine the cause of poor performance and solutions analysed to improve reliability. There are selected parts of the network in which the reliability performance is well below average and needs to be addressed through asset maintenance, redesign or renewal measures. Furthermore, reliability of some assets such as older underground distribution cables is being closely watched and tested. The increased risk of failure of old underground distribution cables is addressed through the asset renewal program discussed in Chapter 6.

Large sections of Evoenergy networks are located in bushlands, backyards and other heavily vegetated areas. Vegetation management and maintenance of clearances between vegetation and network assets is an important preventive measure designed to maintain reliability and safety of operations.

4.1.2 Reliability – what we have achieved in the last year

Evoenergy's network reliability improvement initiatives implement economic options to reduce supply interruptions to customers. Our reliability initiatives have focused on the fast and safe restoration of supply as it was outlined in the previous section as one of our reliability challenges. In 2019/20 we took a number of steps to address reliability issues:

- Installed remote controlled automatic reclosers on one (1) overhead feeder to minimise customers affected by faults and reduce supply restoration time to customers on healthy sections.
- Installed FPIs in new ground mount substations (padmount substations) to reduce outage restoration time.

4.1.3 Reliability – planning outcomes

Reliability strategy and tactics

Our overall strategy is to maintain existing levels of reliability for customers and make improvement to match customer's value of reliability.

Our reliability plan uses the following tactics to maintain network performance for customers:

- **Prevent** outages from occurring
- **Minimise** the number of customers affected when faults occur and
- **Fast and safe** restoration of supply to customers.

Appendix F – contains a full list of prevention, minimisation and restoration tactics considered by Evoenergy.

Our reliability program of work continues to focus on the fast and safe restoration of supply. These initiatives include:

- Installing remote controlled automatic reclosers on our overhead network to minimise customers affected by faults and reduce the duration of outages for customers on healthy sections. In 2020/21 this program is planned on eight (8) overhead feeders.
- Installation of remote-control switchgear with fault indication on underground networks to reduce the duration of outages. In 2020/21 this program is planned on one (1) underground feeder.
- Installation of Distribution Fault Analysers on our overhead network to reduce outages to customers. This is achieved by detecting imminent faults allowing network repairs before faults occur causing an outage. In 2020/21 this is program is planned on two (2) overhead feeders.
- Utilise network augmentation opportunities to optimise network load and connected customers to reduce the frequency and impact of faults when they occur.

Our medium-term strategy includes evolution to automatic network switching to restore supply to customers when a fault occurs. This strategy further utilises value from our deployment of remote-control switchgear and network monitoring by using Fault Location Isolation and Supply Restoration (FLISR) functions with centralised control from our Advanced Distribution Management System (ADMS). For further information about this initiative refer to the Chapter 9 which discusses use of more advanced technologies.

4.2 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* stipulates power quality standards imposed on Evoenergy by ACT technical regulations. Evoenergy's Service and Installation Rules describe the applicable power quality design and operating criteria that must be met by our customers. 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) and may increase life of electrical appliances.

The objective is to maintain power quality to provide a safe and secure source of electricity to our customers.

Appendix G – provides more details on the power quality standards, obligations, and parameters.

4.2.1 Power quality – what are the main challenges?

This section discusses main challenges which Evoenergy is facing with respect to power quality.

Evoenergy is experiencing increasing voltage regulation issues in the low voltage network. The Bulk of the current challenges relate to increasing penetration of the distributed photovoltaic (PV) generation within Evoenergy network, particularly rooftop photovoltaics. The growth in embedded generation continues at a high rate, with the 35% increase in installed capacity in the last year alone after a similar increase in the previous year. As a result, some parts of the low voltage network are increasingly subject to reversed power flows. The latest planning review confirmed that that voltage regulation is the most important power quality challenge that Evoenergy is currently facing. Evoenergy is experiencing increasing numbers of voltage regulation incidents particularly in locations where the penetration of the PV generation is high or generation clusters exists. Evoenergy assesses that hosting capacity limits for PV generation will be increasingly challenged in the future in various network locations. Gold Creek Substation is one such area which requires special attention. Supply in Gold Creek requires effective coordination of voltage regulation at the TransGrid's Canberra Substation, Evoenergy's Gold Creek Zone Substation and the distribution system to effectively manage voltage regulation problems (section 4.2.2).

In addition to the voltage regulation concerns Evoenergy is taking steps to resolve existing issues relating to voltage unbalance in some parts of the low voltage network. The methods to address voltage unbalance in a structured and systematic way are being explored by Evoenergy. The Power Quality Strategy is discussed in more detail in the section 4.2.3 below.

The integrity of neutral connections in the system may be impacted over time by aging assets, loose connections, and corrosion. Evoenergy undertakes immediate rectification works once these faults are known. However, there is potential for hazards to remain undetected. Neutral to earth voltage is being monitored by Evoenergy at times when reactive and pro-active measurements are conducted in the system with the use of the portable monitoring and measurement devices.

4.2.2 Power quality – what we have achieved during the last year?

During the last year Evoenergy conducted proactive power quality monitoring programs, investigated, and resolved a number of network power quality issues and researched and trailed new methods.

Evoenergy investigated and resolved the following power quality enquiries from customers who reported power quality issues including:

- 159 high voltage level issues associated with solar PV installations.
- 99 other instances relating to the level of voltage.
- 31 low voltage level complaint.

In addition to the investigations of the power quality enquiries, Evoenergy took the following steps to manage power quality in the network:

- Tested 100 randomly selected sites during the year for voltage level, voltage unbalance, voltage fluctuations and harmonics.

- Commenced an ongoing program of testing photovoltaic installations with an annual target of 20% of sites.
- Adjusted off load tap position in 84 distribution substations to improve voltage regulation.
- Commenced monthly reporting on the power quality monitoring at 147 substations in which monitoring devices have been installed and mapped in the ADMS.
- Implemented with TransGrid a reduction of the reference voltage setting (from 136 kV to 132 kV) at the Canberra Bulk Supply Substation to address voltage regulation constraints at Gold Creek Substation. The voltage regulation within Gold Creek Substation supply area is discussed in more detail in the section below.

Gold Creek Zone Substation

An emerging need has been identified at Gold Creek Zone substation to manage voltage regulation on the high voltage distribution network supplied from that zone substation. The voltage on the high voltage network is regulated by on load tap changers to maintain a set point automatically adjusted as a function of the transmission voltage, the distribution system real power loading and the power angle of the load.

For long and regular periods of each late night/early morning and mid-afternoon periods on sunny days the zone substation transformers operate at the tap range limit without further ability to regulate voltage. This is occurring mainly in spring, summer, and autumn and to a lesser extent on sunny days in winter.

There is excessive leading reactive power being generated within the high voltage (HV) system in the Gold Creek Zone area. The high voltage network supplied by Gold Creek Zone Substation is predominantly underground cables. The leading reactive power is mainly being caused by the capacitive effect of lightly loaded high voltage cables due to lower overnight load or solar power generation during daylight periods. During these periods, the HV voltage floated above the set-point due to lack of tapping range.

In October 2019 Evoenergy raised a project with TransGrid to assess and modify the transmission voltage setting at Canberra 330 kV Substation to provide greater headroom in voltage regulation at Gold Creek Zone.

In April 2020 TransGrid lowered the transmission system voltage regulation set-point at the Canberra 330 kV Substation from 136 kV to regulate at nominal 132 kV. This change reduced the period of time where Gold Creek Zone substation has no further regulation.

The zone substation power transformers leading up to April 2020 operated at the maximum end of the voltage regulation range greater than 50% of the day generally from midnight until 5:30 am and again from midday to 3:00 pm.

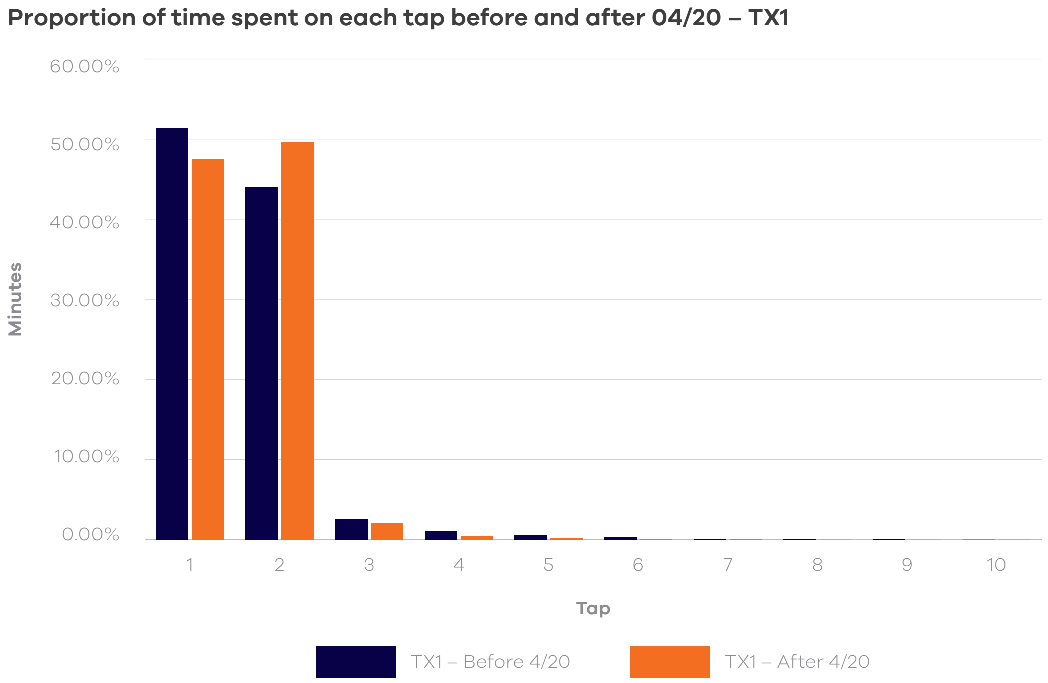
After April 2020 the zone substation power transformer operation at the maximum end of the voltage regulation range reduced to 20% of the day for overnight and less so during day.

With the expected growth of solar penetration and increased cables lengths to connect future residential development in the Gold Creek area it is forecast by spring 2022 that situation will return to pre-April 2020 conditions.

The following options are being considered to enhance Gold Creek Zone Substation voltage regulation by spring 2022:

1. Install two 11 kV Fixed reactance shunt reactors
2. Install two 11 kV variable reactance shunt reactors
3. Seek non-network solution to manage reactive power such as network or community scale batteries, systemic reactive set point control of PV inverters or residential batteries.

Figure 18. Voltage regulation at Gold Creek Zone Substation



4.2.3 Power quality – planning outcomes

During the year, Evoenergy has reviewed and updated Power Quality Strategy which was subject to consultation with the technical regulator at the time of preparation of this Annual Planning Report. The new draft strategy sets out projects and initiatives designed to manage power quality issues including those identified during the review.

The main existing and new initiatives covered by the draft strategy confirm continuing focus on the management of Power Quality in general and voltage regulation in particular. The suite of measures includes proactive monitoring, participation in national surveys and investigation of specific power quality issues. The main components are summarised below.

Proactive monitoring

The Power Quality Strategy includes proactive monitoring program (compliant with *AS 61000.4.30 – Testing and measurement techniques – Power quality measurement methods)* covering one hundred randomly selected sites and twenty percent of mid-sizes distributed photovoltaic installations.

Proactive monitoring measures also include installation of permanent monitoring PQ devices at selected distribution substations. To date monitoring devices have been installed at 147 distribution substations and funds have been approved by the Australian Energy Regulator to install additional devices in up to 1000 substations during the current regulatory control period (2020-2024). However, presently Evoenergy is re-considering the appropriate mix of monitoring measures between permanent monitoring at distribution substations and leveraging of data captured by advanced revenue meters; and the Advanced Distribution Management System (ADMS)

As a result, the following initiatives have commenced to set the future direction.

Data Driven Distributed Energy Resources (DER) Management Pilot

This is a proof of concept pilot to investigate benefits, increased capability, and improved management of Distributed Energy Resources through the use of advanced revenue metering data. The pilot includes small number of distribution substations and covers predictive power flow, predictive system parameters such as voltage and an automated "worst case" scenario calculation.

Smart metering data

An initial financial analysis of smart meter data versus programmed rollout of the distribution substation monitoring identified that investment in the substation monitoring is a preferred solution. However, this position is being reviewed by Evoenergy and the access to the smart meter data is subject of the consultation with the technical regulator. The Evoenergy Distribution System Operator Strategy (currently under development) will include the consideration of use of smart metering data as part of comprehensive strategy for distribution transformers voltage regulation which is intended to address impact of the Distributed Energy Resources on the network.

Line drop compensation

To complement updated distribution transformer tap setting methodology, Evoenergy intends to investigate improvements to the Line Drop Compensation operation at zone substations. The intention is to determine real time float voltage settings using advanced algorithms based on system parameters which in addition to the current magnitude will account for active and reactive power impact on the network regulation.

PQCA national survey and benchmarking

As part of the pro-active approach to power quality management, Evoenergy participates in the Power Quality national survey managed by the University of Wollongong. The survey allows Evoenergy to monitor power quality compliance within the network as well as relative performance against other Australian utilities. The recent annual reports indicate a positive trend in overall material improvement in Evoenergy voltage regulation performance with lower number of incidents outside the envelope.

Investigations of power quality issues and complaints

Evoenergy investigates all instances of identified power quality issues and power quality complaints. At present, most issues impact of the distributed generation on voltage regulation. Depending on the results of investigations, Evoenergy employs usually one of the following solutions to resolve the voltage regulation issue:

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

Standards

The requirements for the connection of rooftop generation in a way which mitigates likelihood of over-voltages are being reviewed. To manage voltage regulation, Evoenergy has published requirements for the connection of embedded PV installations which include variable invertor power factor settings and curtailment of output depending on the voltage levels which assist in management of the voltage regulation in the network.

Appendix G – provides a more detailed description Evoenergy's power quality obligations.

Power quality issues associated with embedded generation

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 distribution transformers fitted with an on-load tap changer (OLTC) voltage regulation capability at Denman Prospect and several other suburbs with a high PV penetration. The preliminary technical results from the trials are positive. Full cost benefit assessment will be required before broader application of OLTC transformers in the Evoenergy network.

Another trial currently in progress is the Ginninderry Energy Pilot Project which aims to assess the real time implications/outcomes from an electricity-only neighbourhood with a very high penetration of solar PV systems and includes a trial of residential batteries. For more information on this project please see section 9.5.

Chapter 5: System load and energy demand, and the supply-demand balance

5.1 Introduction

This chapter describes a ten-year forecast of maximum summer and winter electrical load demands for zone substations, bulk supply points and the whole of system. These forecasts are used by Evoenergy to identify constraints in the network. The forecast is a key input into the planning process described in Chapter 7.

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.

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.

Appendix E – contains more details on the demand forecasts and methodology.

ACT Government energy policies

The demand forecast is increasingly impacted by energy efficiency measures, behind the meter small scale and larger scale embedded generation, advances in technology, economic factors, and consumer preferences. In the long term, the demand in Evoenergy will be also increasingly driven by the government energy policies such as ACT's zero emission 2045 target as well as incentives and mandates driving customers to change from natural gas to electric appliances and preventing new connections to the natural gas network (e.g. in greenfields developed by the Suburban Land Agency). These targets would require carbon dioxide emitting energy sources for transportation and gas to be transferred or substituted by alternative energy sources such as electricity. The overall impact on the network is expected to be significant but varied from location to location depending on the structure of the existing load, consumption trends and distributed energy resources.

Evoenergy has a strategic initiative in progress to produce improved modelling of a zero emissions future. The initiative aims to work with the ACT Government to inform prudent planning for a comprehensive and practical zero emissions roadmap.

5.2 System demand

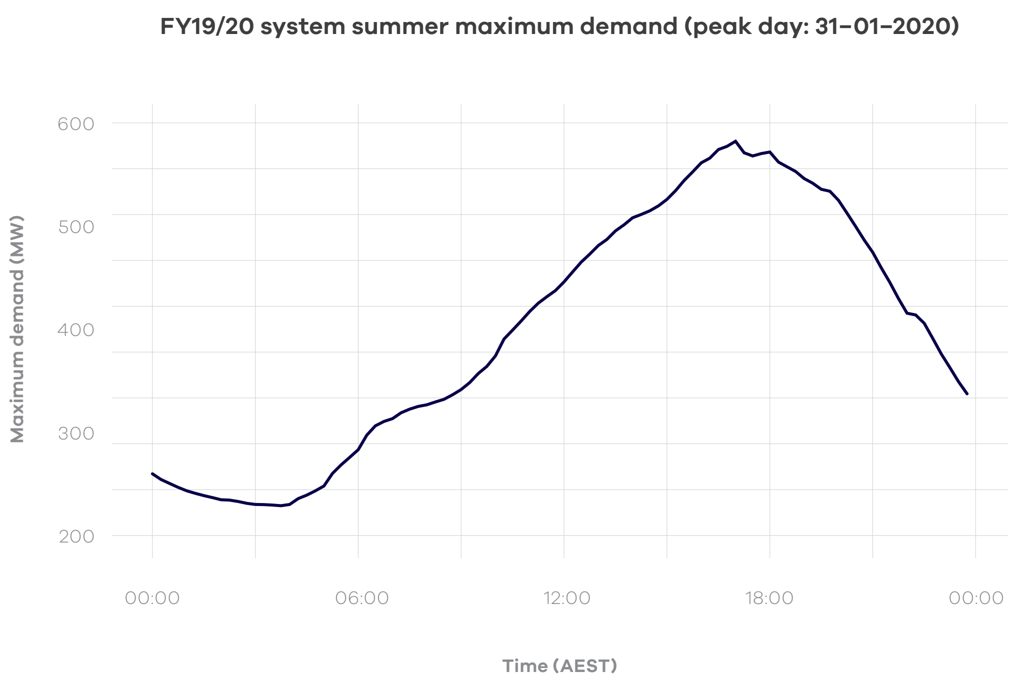
5.1.1 Historical demand

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

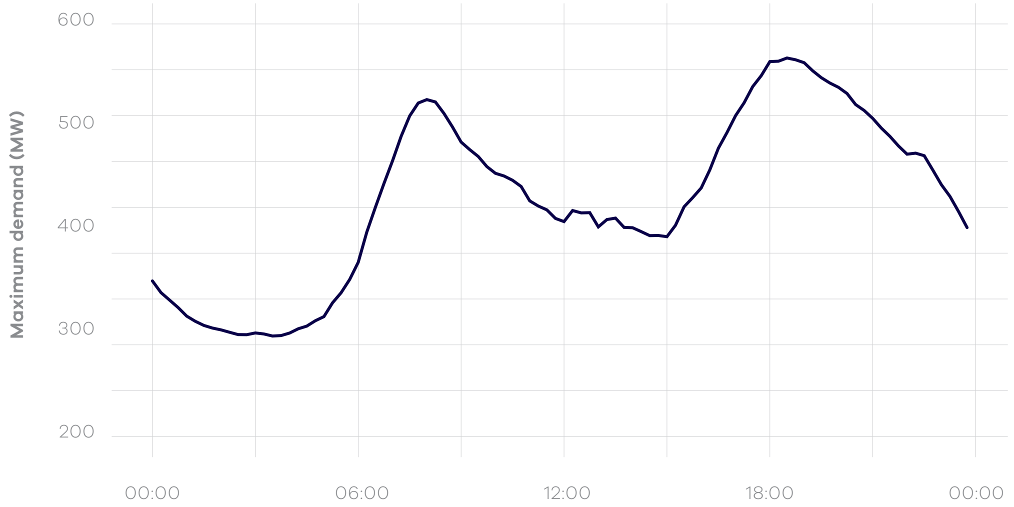
- Summer maximum demand is weather dependent. For example, summer 2012 and 2015 maximum demands fell below 500 MW due to mild weather conditions and summer 2019 maximum demand rose above 650 MW due to persistent widespread heat, exceptional heatwaves, and below-average rainfall.
- The highest historical summer peak in real power was 657 MW (2018/9) and the highest winter demand was 626 MW (2014/15). The higher summer peak demand indicates that summer loading conditions (when the ambient temperatures are higher and network equipment ratings lower) can be a major driver behind emerging network constraints.
- The historical winter maximum demand has been less variable than summer maximum demand. This is largely due to less variability in weather conditions.
- The hottest day of Summary 2019-20 was recorded on Saturday 4 January 2020 where it reached 44°C, however the system peak demand of **621 MW** occurred at 5:30 pm (AEDST) on Friday 31 January 2020 as a result of sustained heatwave conditions. The maximum temperature on this day as 41.9°C
- In the 2019-20 winter period the coldest day was Saturday 24 August 2019 where a low of –5.2°C was reached. The peak winter demand of **609 MW** occurred at 6:00pm (AEST) on Friday 9 August 2019 which had a maximum temperature of 8.7°C after several days of cold weather.
- In comparison to 2019, actual summer maximum demand showed a 4% decrease and actual winter maximum demand a 1% decrease. The actual maximum demand variation appears to be mostly a function of the temperature and weather conditions. The actual summer demand is above the 2019 and 2020 middle (50% POE) forecast and in winter slightly below the forecast.

The figures below show the daily demand curve for summer and winter days with distinctly different profiles for summer and winter.

Figure 19. 2020 summer and winter maximum demand day load profiles.



FY19/20 system winter maximum demand (peak day: 09–08–2019)



5.1.2 System summer and winter maximum demand forecast

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

Evoenergy calculates load forecasts based on 10%, 50% and 90% probability of exceedance. Network planning is based on the medium 50% POE forecast and an additional capacity allowance to cater for credible network contingencies. Evoenergy's maximum and minimum demand forecasts for the ten year period 2021–30 are presented in Figure 20.

There is a forecast increase in demand which exceeds the trend from historical data. This is due to predicted significant increases in data centre load, particularly the construction of Harman Zone Substation which is a customer-initiated project which will be purpose built to supply a large data centre.

System forecast

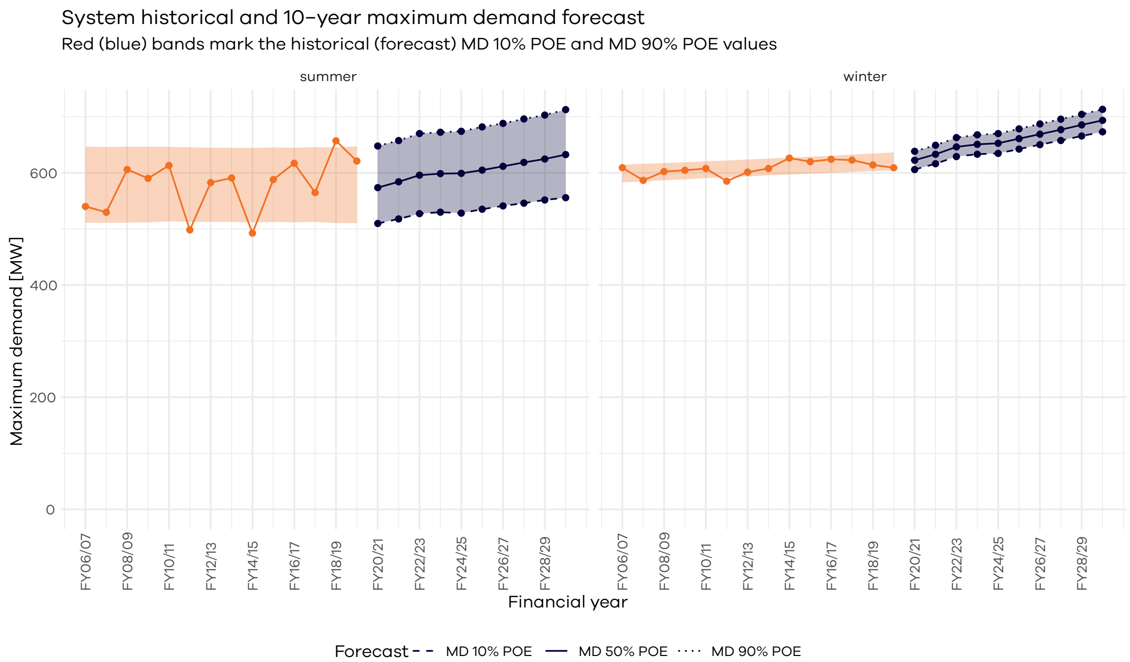
10-year forecasts based on historical system data estimate an insignificant **change in peak summer demand of -0.1 MW per annum[14] and a change in peak winter demand of 1.7 MW per annum[15].**

Based on recorded 2020 peak demand values, this corresponds to an expected change of **+0% over the next 10 years in peak summer demand, and +3% over the next 10 years in peak winter demand.**

The higher uncertainty of the summer forecast is due to the summer demand being very volatile due to the high variation in weather conditions, whereas winter weather conditions are generally more stable.

The overall projected demand growth is low. No new capacity limitations are expected at the system level.

Table 3 provides summer and winter forecast demand (MW) numerical values for three



probability of exceedance levels to complement Figure 20.

Table 3. 10-year summer and winter maximum demand (MW) forecast.

Year	Summer			Winter		
	POE90	POE50	POE10	POE90	POE50	POE10
2021	509	574	647	606	623	638
2022	518	583	657	616	633	650
2023	528	595	669	629	646	663
2024	530	598	673	633	651	668
2025	529	599	673	635	653	670
2026	534	605	682	642	661	679
2027	540	612	690	650	669	688
2028	546	619	695	658	677	696
2029	550	626	704	666	686	705
2030	555	631	712	673	694	713

Some of the summer system demand forecast highlights are:

- Historically, the summer maximum demand has fluctuated significantly due to weather conditions. This is why the spread between 90% PoE and 10% PoE of summer forecasts are much wider than the winter forecasts in Figure 20.
- Both summer and winter maximum demand is forecast to have relatively low growth over the next 10 years however this increase may be accelerated with higher uptake of electric vehicles and the outcome of ACT Government policy decisions related to zero emissions targets.

5.1.3 System summer and winter minimum demand forecast

In AEMO's 2020 Electricity Statement of Opportunities[16] it is forecast that minimum operational demand in NSW (which includes the ACT) will decline steadily at an average rate of -1.9% per annum between 2021 and 2045. This is attributed to projected growth in distributed PV capacity throughout the forecast horizon. Evoenergy is currently working to better understand minimum demand forecasting modelling.

In the 2020 Electricity Statement of Opportunities AEMO has also forecast the reduction in demand as a result of rooftop PV, non-scheduled PV generation, other non-scheduled generation and energy efficiency. Evoenergy is considering how best to incorporate this type of modelling into maximum and minimum demand forecasts.

Figure 21 shows the projected minimum demand in the system over the 10 year period. The forecast curves indicated forecasted minimum demand which needs to be satisfied from TransGrid's transmission network. Evoenergy is required to prepare the minimum forecast for grid stability assessment.

It should be noted that minimum demand forecasts at the connection points with the TransGrid network have not been provided as part of the annual planning report this year. This is because Evoenergy is currently in the process of reviewing minimum demand modelling methodology. We expect the TransGrid TAPR template to be provided in mid-December 2020 and the full set of minimum demand forecasts will be provided in accordance with that template.

Minimum demand

Minimum demand is analysed for both day and night[17]. This is because daytime minimum demand is significantly impacted by distributed generation resources, particularly solar photovoltaics whereas the night-time demand is impacted by organic growth.

The total capacity of rooftop PV has grown by around 35% during the last year. Continual growth in PV installations has led to a decreasing day time minimum demand. If this trend continues, we can expect a net system export in approximately 17 years (-4, +8).

Management of the network will become more challenging as synchronous conventional generation is replaced with asynchronous wind, large-scale PV and rooftop PV generation which are subject to intermittency. At times asynchronous sources of generation could exceed the demand. The challenges relate to how the system behaves during disturbances, and how much generation can be dispatched in order to match supply and demand. Power quality issues that could result from an increase in asynchronous generation include voltage regulation, voltage stability, and frequency stability due to a lack of system inertia, and low fault levels which could impact protection schemes.

17 Day/night separation is in agreement with AEMO's new point forecasting methodology

16 AEMO 2020 Electricity Statement of Opportunities available here: https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2020/2020-electricity-statement-of-opportunities.pdf?la=en

Figure 21. 10-year whole-system summer and winter minimum demand forecast.

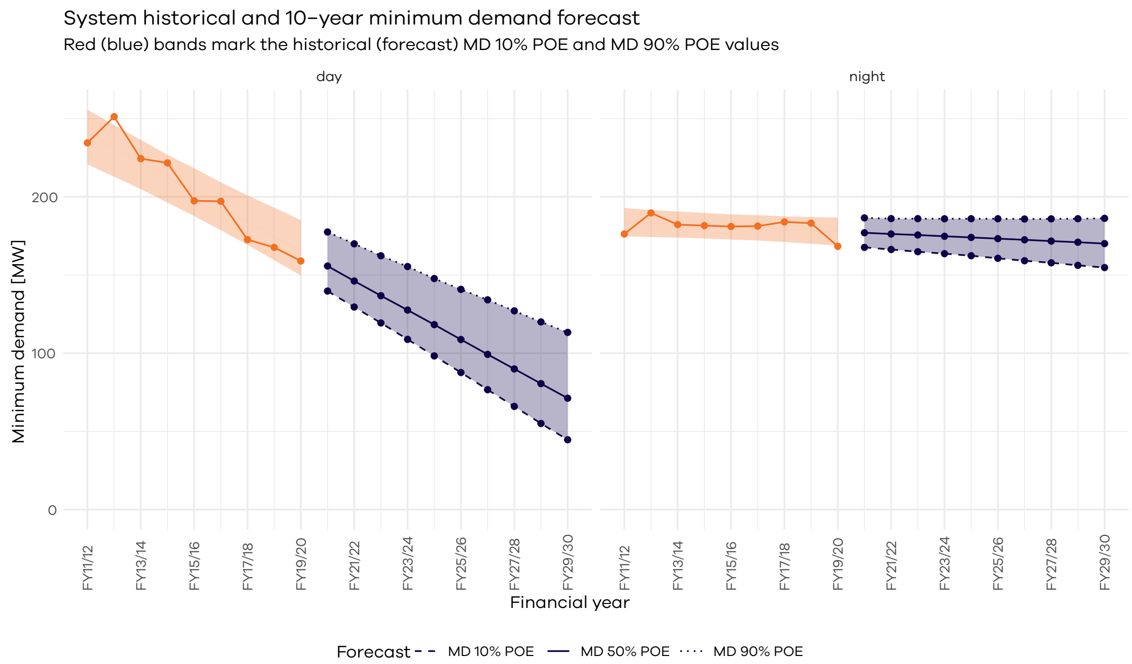


Table 4 provides minimum demand (MW) numerical values to complement the minimum forecast Figure 21.

Table 4. 10-year whole-system day and night minimum demand forecast (MW).

Year	Day			Night		
	POE90	POE50	POE10	POE90	POE50	POE10
2021	140	156	178	168	177	187
2022	130	146	170	166	176	186
2023	119	137	162	165	176	186
2024	109	128	155	164	175	186
2025	98	118	148	162	174	186
2026	88	109	141	161	173	186
2027	77	99	134	159	173	186
2028	66	90	127	158	172	186
2029	55	81	120	156	171	186
2030	45	71	113	155	170	186

5.2 Zone Substation Load Forecasts

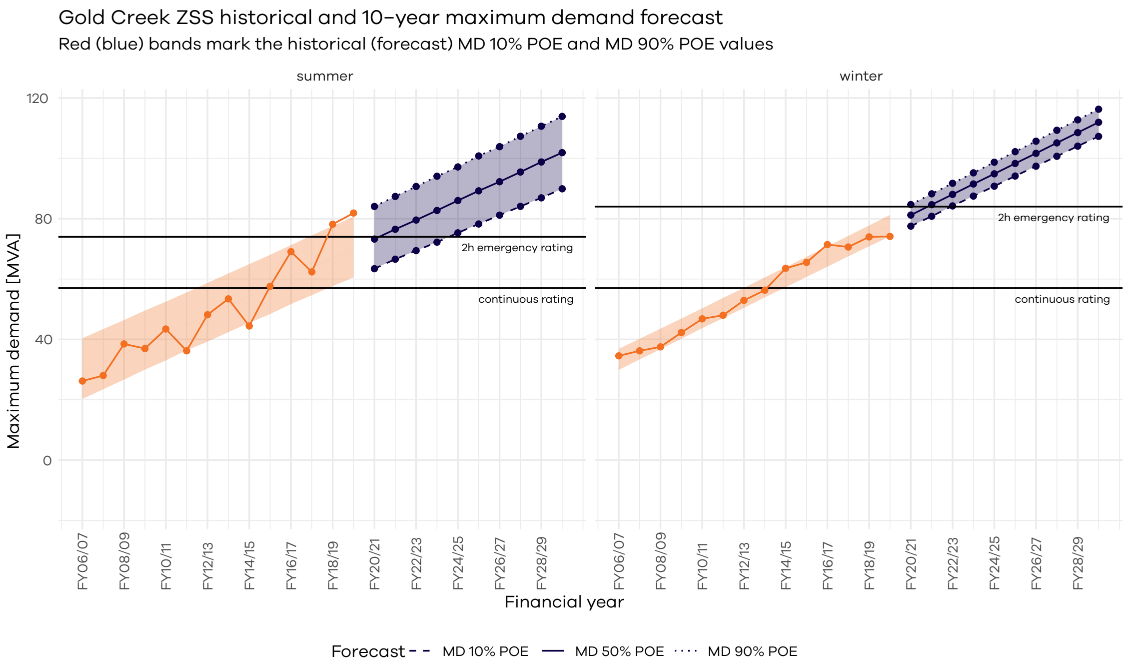
This section provides the highlights of the zone substation demand forecast. The figures below show summer and winter ten year forecast for selected zone substations shown against substation two-hour emergency rating. Appendix E – contains the full set of forecast graphs and figures for zone substations.

5.2.1 Gold Creek Substation

Zone substation limitation

Updated forecasts indicate that the winter 50% POE forecast is expected to exceed two-hour emergency ratings during the 2023/24 financial year. Evoenergy plans to begin the detailed options analysis process, including non-network options analysis, potentially resulting in a RIT-D process in the 2021 calendar year. See section 7.9.1 for more detail.

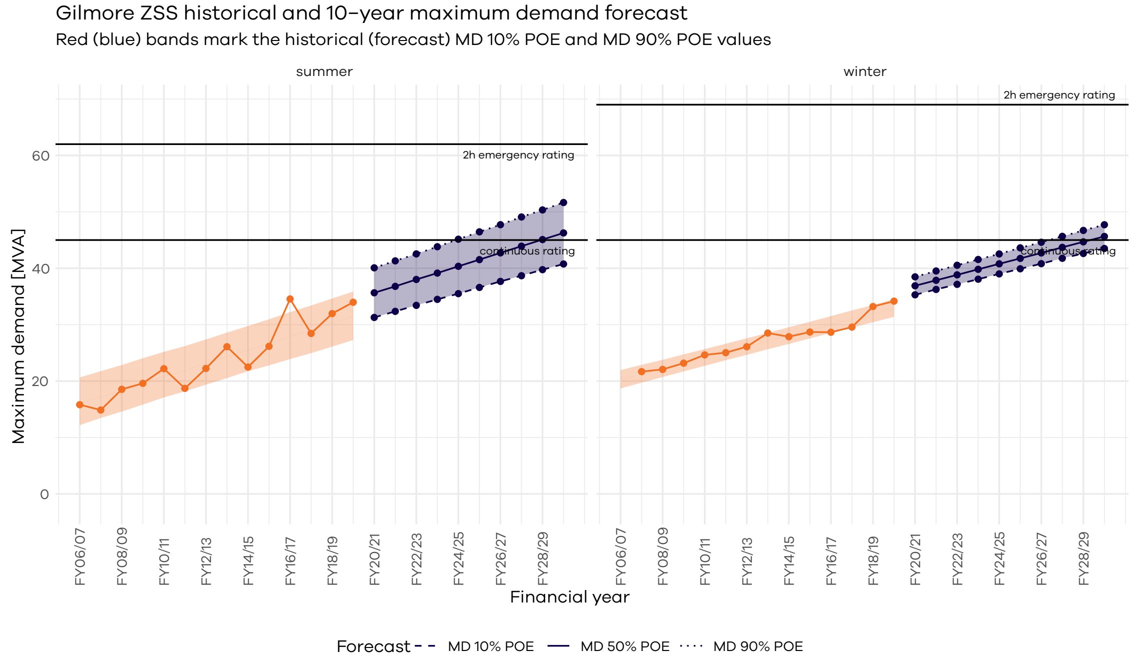
Figure 22. Gold Creek Substation 10-year forecast.



5.2.2 Gilmore Substation

Gilmore Zone Substation (ZSS) forecast (Figure 23) is expected to have the biggest load growth (probability adjusted total of 16 MW) in the next 5 years due to the expansion of commercial load in the Hume area, primarily the data centres. It is forecast that the demand will exceed the continuous rating in the 2024-29 regulatory period. This additional load along with the aged assets in the zone substation indicate that additional investigation is required at this substation. This is covered in further detail in section 7.9.2.

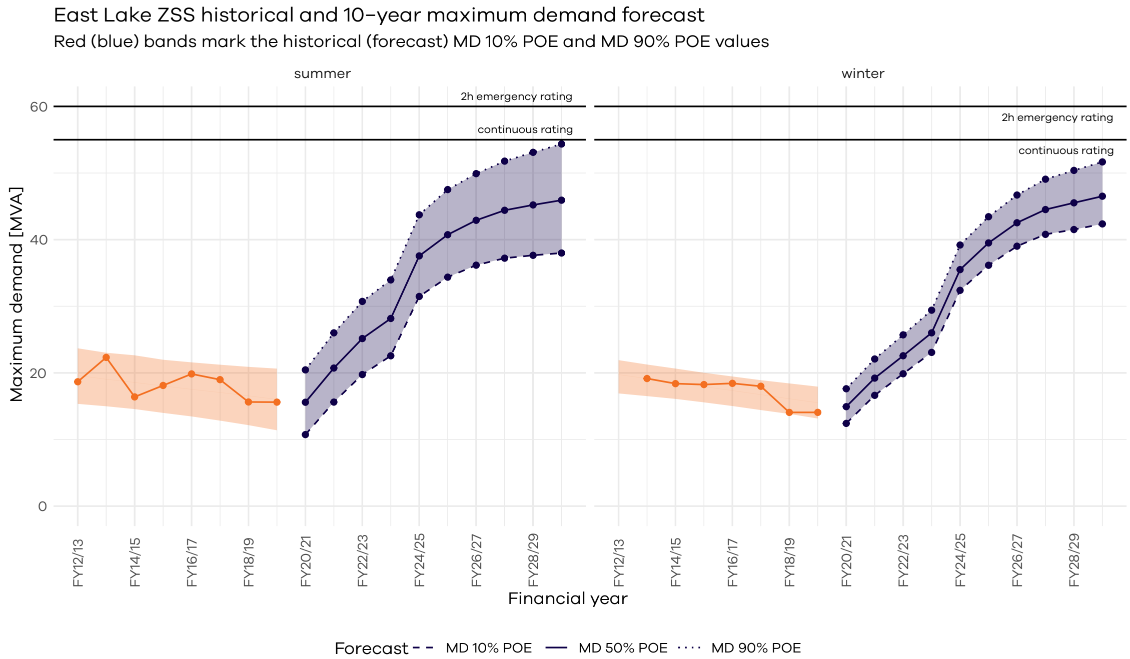
Figure 23. Gilmore Substation 10-year forecast



5.2.3 East Lake Substation

In the forecast shown in Figure 24 we see a steep increase in demand at East Lake Zone Substation. The drivers for this are two-fold. One driver is the increase in commercial load from customers in the Fyshwick, Causeway and Canberra Airport areas, in particular data centres. The other driver is the decommissioning of Fyshwick Zone Substation by 2024. All the load currently supplied by Fyshwick Zone Substation will need to be supplied by East Lake Zone Substation by 2024. Please see sections 7.8.6 for further detail. It is not anticipated that additional augmentation of East Lake Zone Substation will be required within the 10-year planning horizon.

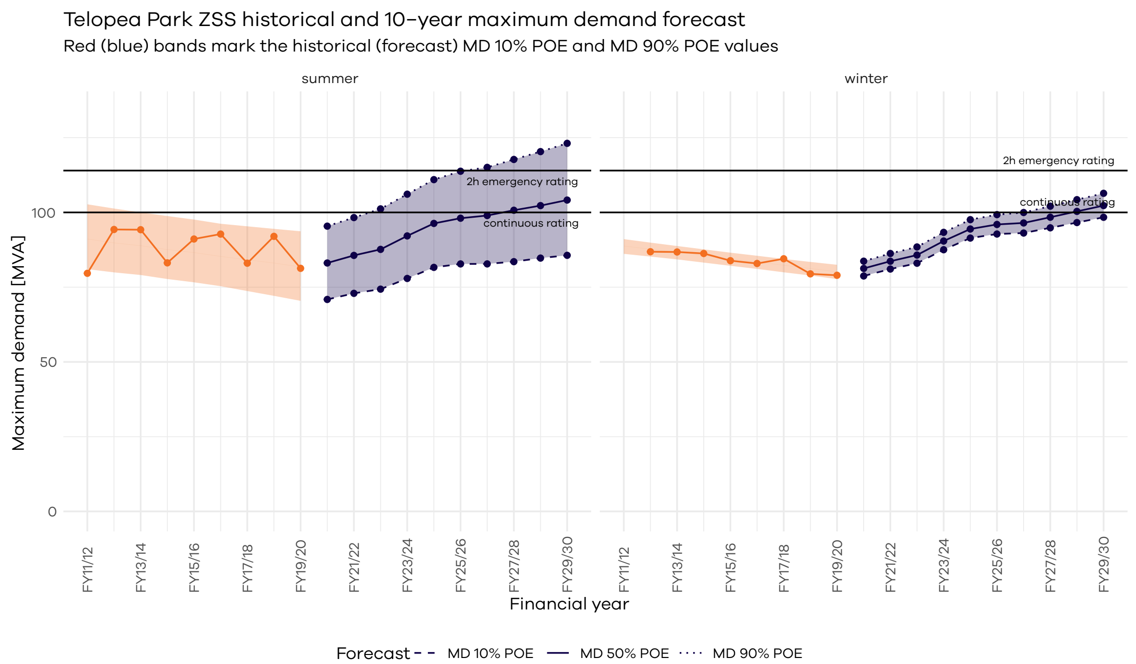
Figure 24. East Lake Substation 10-year forecast



5.2.4 Telopea Park Substation

Telopea Park Zone Substation is forecast to exceed the summer two-hour emergency rating in the later part of the 2024-29 regulatory period. Because this expected increase in demand is based on anticipated customer block loads which are subject to some uncertainty, Evoenergy will review this forecast in the next period and update the planning outcomes accordingly.

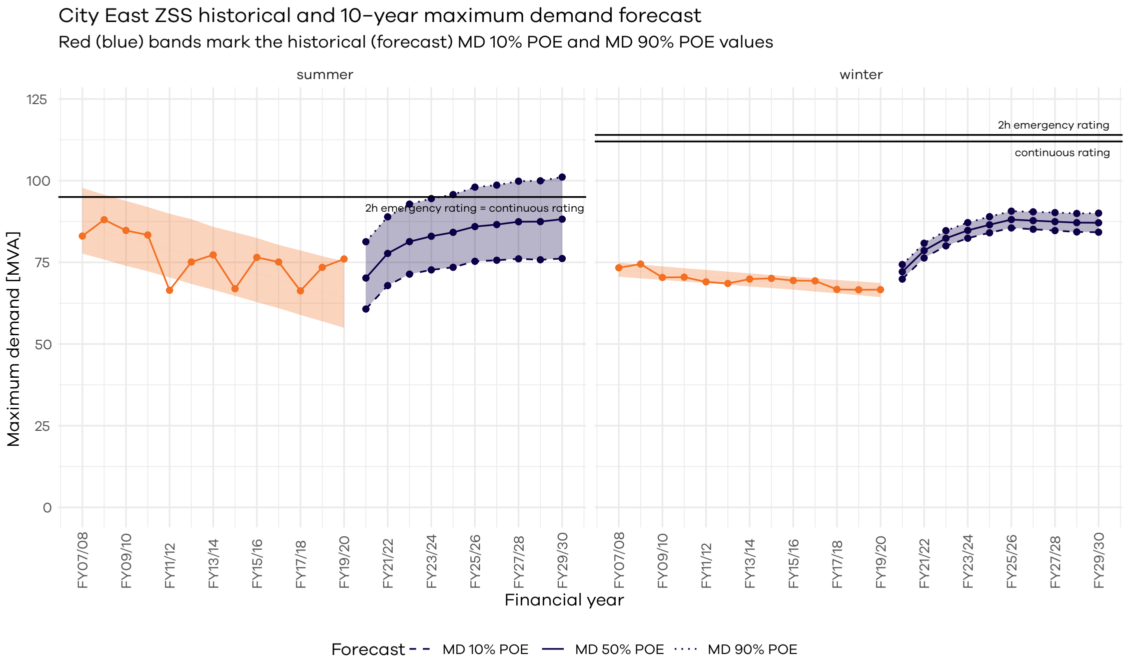
Figure 25. Telopea Park Substation 10-year forecast.



5.2.5 City East Substation

City East Zone Substation is forecast to potentially exceed the Summer two-hour emergency rating in the middle of the 2024-29 regulatory period. Because this expected increase in demand is based on anticipated customer block loads which are subject to some uncertainty, Evoenergy will review this forecast in the next period and update the planning outcomes accordingly. The proximity of City East Zone Substation to the proposed site of Mitchell Zone Substation provides an opportunity to utilise the future Mitchell zone substation to alleviate load constraints at City East Zone Substation so this has not been identified as a key constraint.

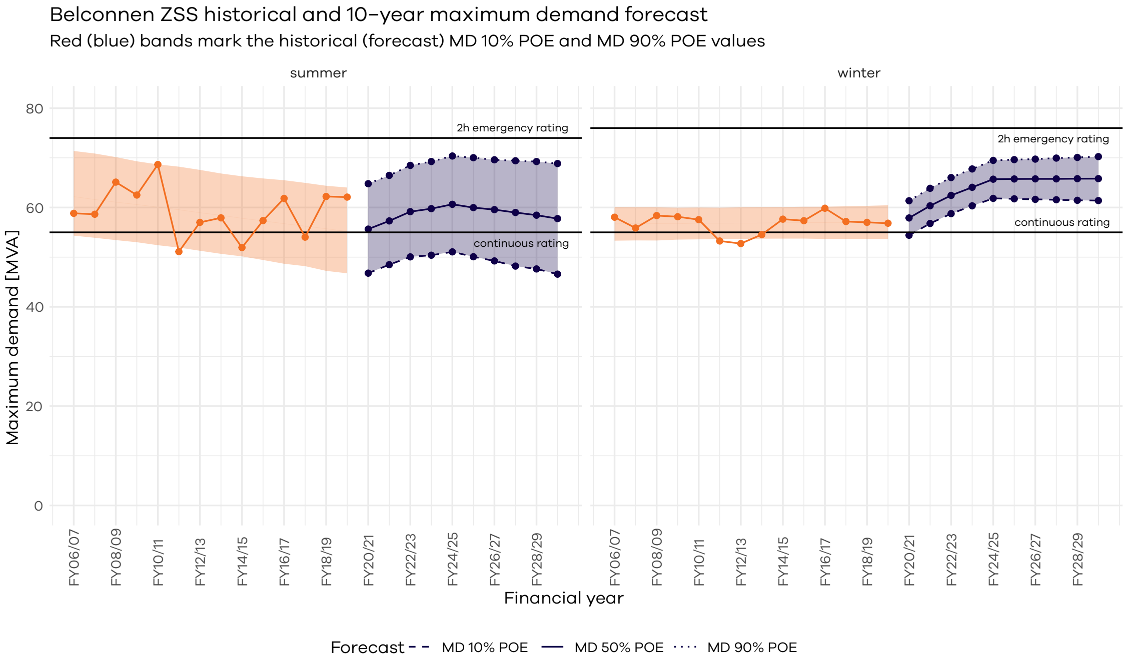
Figure 26. City East Substation 10-year forecast



5.2.6 Belconnen Substation

Belconnen Zone Substation has been consistently operating above the continuous rating during both the summer and winter peak demand periods for several years. Despite this there is minimal load growth expected during the 10-year planning horizon so it is not forecast that the zone substation will operate above the emergency 2-hour rating. For this reason, this zone substation has not been identified as having any critical load constraints.

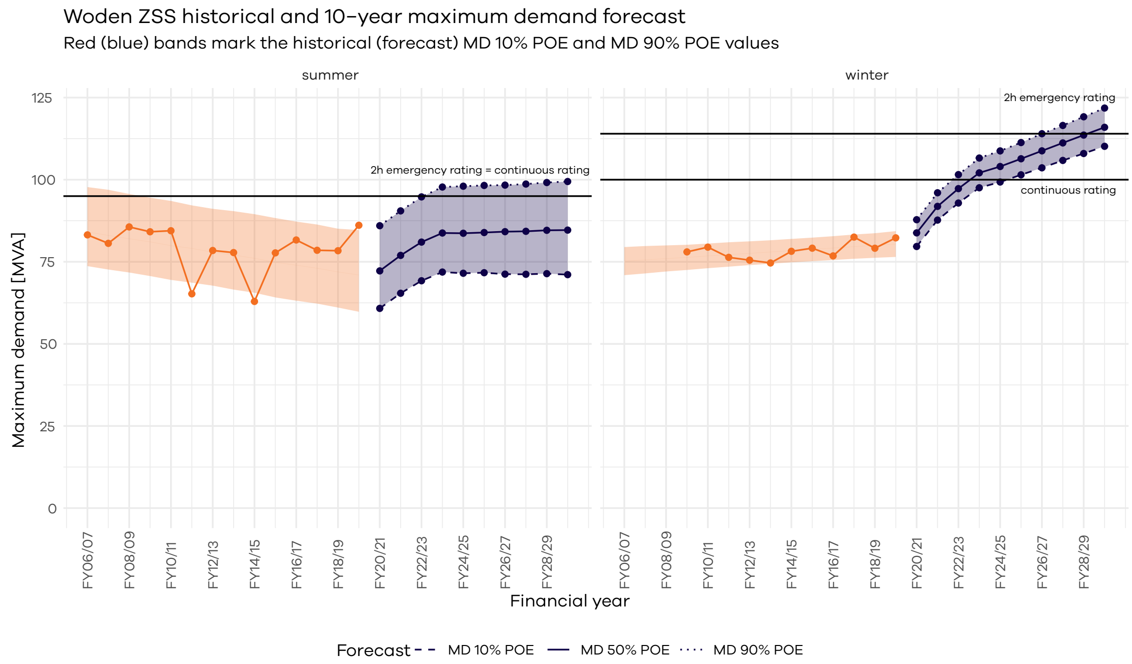
Figure 27. Belconnen Substation 10-year forecast



5.2.7 Woden Substation

There is significant load growth expected in the area currently supplied by Woden Zone Substation due to major residential development in the Molonglo Valley. This load growth will initially be supplied by the proposed Molonglo battery and then the Molonglo Zone Substation. For further detail on this project and the associated RIT-D please see section 7.6.2.

Figure 28. Woden Substation 10-year forecast.



5.3 Load Transfer Capability

Table 5 and Table 6 show the load transfer capability (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. This is based on the thermal capacity of the feeders.

Table 5. Load Transfer Capability (MVA) between Evoenergy's Zone Substations in summer

Zone Substation		To												
		Belconnen	City East	Civic	East Lake	Fyshwick	Gilmore	Gold Creek	Latham	Telopea Park	Tennent	Theodore	Wanniassa	Woden
From	Belconnen		9.7	14.2					15.1					
	City East			26.5	3.5					18.7				
	Civic	7.4	19.0						6.1	7.8				1.5
	East Lake		3.1							13.5				
	Fyshwick		0.5		16.1		2.5			1.4				
	Gilmore									3.7		3.8	19.3	
	Gold Creek	11.9		2.9					3.7					
	Latham	11.9		9.4										
	Telopea Park		19.0	8.0	13.0		3.1						8.3	8.9
	Tennent													
	Theodore						5.2						11.5	
	Wanniassa						17.8			3.5		10.0		8.9
	Woden			4.5						11.4			23.2	

Figure 6. Load Transfer Capability (MVA) between Evoenergy's Zone Substations in winter

Zone Substation (From \ To)	Belconnen	City East	Civic	East Lake	Fyshwick	Gilmore	Gold Creek	Latham	Telopea Park	Tennent	Theodore	Wanniassa	Woden
Belconnen		7.6	13.4				9.9	14.8					
City East	2.4		33.9	4.4					23.5				
Civic	11.4	23.0					3.5	7.1	9.8				1.5
East Lake		6.1			0.9				9.9				
Fyshwick		3.9		36.4		1.1			1.7				
Gilmore					0.9				3.5		5.2	25.1	
Gold Creek	19.2		2.7					3.3					
Latham	19.2		10.4				1.4						
Telopea Park		23.3	8.3	17.7	0.9	2.7						9.4	22.4
Tennent													
Theodore						5.3						10.5	
Wanniassa						23.3			3.1		14.9		31.7
Woden			4.9						12.8			28.8	

Chapter 6: Managing existing assets

Evoenergy manages network assets for optimisation on a whole of life cycle basis network investment and therefore maximise value for our customers. Asset retirement and renewal decisions are designed to maximise asset utilisation and optimise asset life. A coordinated approach is applied to planning, designing, constructing, operating, maintaining, renewing, and decommissioning our assets. Our Asset Management System is certified against *ISO 55001*, an internationally recognised standard for asset management.

Risk management is integrated with Evoenergy's asset management decisions. Asset retirement and maintenance decisions are made to manage risk based on health, age, and criticality of assets. Whenever practicable, the whole-of-life asset costs including maintenance are considered to optimise the timing of asset renewal/ replacement. Risk centred maintenance philosophy underpins out maintenance regime. Two dominant risk categories in terms of assessed value of risk are reliability and safety.

Furthermore, asset retirement or renewal decisions are coordinated with network development plans to identify possible savings. Asset renewal decisions also support power quality strategy and reliability strategy. This chapter provides information on the primary system assets, the electronic and communications systems (referred to as secondary systems) and information technology applications which are essential to the support of network management and operations.

Chapter 3 provides an overview of the Evoenergy's asset management approach and Appendix D – includes information on certification of the Evoenergy's Asset Management system against *ISO55001*.

6.1 Primary systems

6.1.1 Existing assets - what are the main investment drivers?

Network assets are being continually monitored and the asset management plan reviewed as new information becomes available in relation to asset condition, performance or failure rates. The assets are being maintained, inspected, tested, and monitored to identify and mitigate risk, and address existing and emerging asset needs. The data is analysed in the development of Asset Specific Plans (ASPs).

The key observations and drivers reflected in the planning outcomes discussed in this chapter include:

- Continuing focus on aging network assets particularly to identify increased risk of failure of critical assets
- The risk profiles of some key asset groups are revised upwards (e.g. underground distribution cables and zone substations switchboards)
- Reliability risk remains a dominant driver for investment for most asset classes
- For selected asset classes (e.g. switchboards, earthing), the dominant risk driver is safety of people or property

6.1.2 Asset Specific Plans

Evoenergy prepares asset specific plans in alignment with the asset management policy, strategy, and objectives. Our ASPs address groups of assets and are grouped by asset type, for example, Evoenergy's Distribution Poles ASP summarises our strategy and plan to coordinate asset management for our distribution pole fleet.

To maximise value for customers from our assets over the entire asset lifecycle, our ASPs consider:

- **Asset Class Overview** – describes the asset type, its function, population of assets and data sources available to develop the plan.
- **Service and Performance** – outlines the service and performance requirements and monitoring needed to meet the asset management objectives.
- **Asset Failure Modes** – applies risk centred maintenance to our assets assessing how assets can fail, the likelihood and consequences of failing to forecast the risk associated with our assets.
- **Asset Class Strategy** – outlines the optimal asset class lifecycle strategy and alternative options considered.
- **Asset Health and Expenditure** – forecast expenditure (CAPEX and OPEX) for the optimal asset class lifecycle strategy and future health of our assets.

Evoenergy's assets are managed by the ASPs listed in Table 7.

Table 7. Asset Specific Plans (ASP)

Asset Specific Plan (ASP)	Asset Group(s)	Asset Qty	Average Age
Distribution Overhead Network			
Poles	**Total**	**48,889**	**35**
	Concrete Pole	11,358	20
	Fibreglass Pole	4,104	7
	Timber Pole	27,160	48
	Steel Pole	5,900	21
	Stobie Pole	355	73
Pole Substations	**Total**	**1,390**	**36**
	Pole Substation	1,390	35
Overhead Lines and Pole Hardware	Total	2,162 km	52
	Overhead HV Conductors	980 km	49
	Overhead LV Conductors	1,182 km	52
Overhead Switchgear & Automation	**Total**	**8,016**	**40**
	Gas Switch	115	15
	HV Link	1,521	53
	Surge Diverter	2,709	35
	Fault Passage Indicator	498	36
	Drop-out Fuse	1,602	30
	Auto-Recloser	37	18
	Air Break Switch	1,524	48
	Load Break Switch	6	40
Overhead Service Conductors	**Total**	**2,374 km**	**39**
	Overhead Service Cable	2,374 km	39

Asset Specific Plan (ASP)	Asset Group(s)	Asset Qty	Average Age
Distribution Underground Network			
Distribution LV Switchboard Assembly	**Total**	**4,056**	**25**
	LV Circuit Breaker	1,028	19
	LV Switchboard	3,028	28
Underground LV Cables	**Total**	**5,175 km**	**30**
	Underground Service Cable	3,680 km	31
	Underground LV Cable	1,495 km	29
LV Pillars	Total	18,788	39
	LV Pillar	15,441	25
	Point of Entry Cubicle	3,347	53
Earthing	**Total**	**12,895**	**35**
	Substation Earth	7,150	28
	Overhead Asset Earth	5,729	41
Distribution Substation/ Switching Station Sites	**Total**	**3,313**	**28**
	Padmount Substation	2,476	27
	HV Switching Station	342	34
	Chamber Substation	490	29
	Stockade Substation	5	34
Distribution HV Switchboard Assembly	**Total**	**768**	**47**
	HV Circuit Breaker	471	26
	HV Switchboard	141	56
Ground Mounted Transformers	**Total**	**3,843**	**28**
	Ground Transformer	3,843	28
Underground HV Cables	Total	18,128	52
	Underground HV Cable	1,623 km	49
	Underground HV Feeder	240	55
Ring Main Units	**Total**	**3,791**	**39**
	Ring Main Unit	3,791	39
LV Pits	**Total**	**427**	**92**
	LV Underground Pit	413	95
Earthing Distribution	**Total**	**16**	**28**
	Earth Mats	16	28

Asset Specific Plan (ASP)	Asset Group(s)	Asset Qty	Average Age
Zone Substations			
132 kV & 66 kV Air Insulated Switchgear	**Total**	**730**	**35**
	132 kV & 66 kV Circuit Breakers	68	27
	132 kV & 66 kV Current Transformers	288	24
	132 kV & 66 kV Isolators	149	38
	132 kV & 66 kV Voltage Transformers	89	30
	132 kV & 66 kV Earth Switches	37	36
	132 kV Surge Diverters	99	53
Zone 11 kV Switchboard Assembly	**Total**	**461**	**33**
	11 kV Oil Circuit Breakers	129	43
	11 kV Vacuum Circuit Breakers	243	25
	11 kV Earth/Test Trucks	58	35
	11 kV Switchboards	31	30
Power Transformer Assembly	**Total**	**156**	**35**
	Power Transformers	33	33
	Power Transformer 132kV & 66kV Bushings	93	35
	Online Tap Changers	30	36
Other Transformers	**Total**	**52**	**35**
	Auxiliary Transformers	23	33
	Neutral Earthing Transformers	29	37
Gas Insulated & Mixed Technology Switchgear (GIS & MTS)	**Total**	**105**	**6**
	132kV GIS/MTS Voltage Transformers	12	7
	132kV GIS/MTS Earth Switches	11	7
	132kV GIS/MTS Circuit Breakers	11	7
	132kV GIS/MTS Isolators	18	7
	132kV GIS/MTS Current Transformers	3	7
Backup Generator Auxiliary	**Total**	**28**	**14**
	Generator Auxiliary	14	12
	Automatic Transfer Switches	14	15
Transmission Network			
Overhead Transmission Lines	**Total**	**1496**	**37**
	Concrete Pole	857	27
	Timber Pole	419	42
	Overhead conductors	197 km	36
	Steel Tower	201	44

Asset Specific Plan (ASP)	Asset Group(s)	Asset Qty	Average Age
Underground Transmission Lines	**Total**	**6**	**11**
	Underground cables	6	11

6.1.3 What we have achieved during the year

During the last year, Evoenergy asset replacement focused mainly on the grouped programs for smaller assets. No major asset replacements were undertaken during the period.

Table 8 provides a summary of Evoenergy's asset replacement completed during the last year.

Table 8. Completed asset replacement program

Asset Specific Plan (ASP)	Task	Number of Replacements
Distribution Overhead Network		
OH Switchgear and Automation	Replace Overhead Gas Switch	3
	Replace Surge Diverter	51
Poles	Replace Pole	247
Pole Substations	Replace Single Pole Substation	5
	Replace Two Pole Substation	1
Distribution Underground Network		
Distribution Substations / Switching Station Sites	Replace Padmount	6
LV Pillars	Replace Pillar	73
Underground LV Cables	Replace LV Pothead	30
	Replace Service Pothead	14

Corin Dam and Gudgenby Lines

As part of the asset management process, Evoenergy identified two long 11 kV rural lines with high numbers of aging assets which required significant investment to maintain safety and reliability as well as mitigate bushfire risk, but where only small numbers of customers were supplied. During options analysis it was identified that a remote area power supply (RAPS) would be the best solution for these sites. Two RAPS were implemented at Gudgenby Homestead and Cottage and Corin Dam across 2018 and 2019. The goal was to run these RAPS for 1-2 years with the lines de-energised to ensure reliability was maintained prior to decommissioning of the lines. During the Orroral Valley bushfire these de-energised lines were damaged and retirement of the poles and associated overhead lines was accelerated. Evoenergy was able to decommission 16.5 km of 11 kV overhead lines as part of this project. Further detail is provided in section 9.2.

Figure 29. Poles burnt in the Orroral Valley bushfire

6.1.4 Asset retirement - planning outcomes

This section summarises planning review findings related to the existing network assets. The review identified number of network constraints which relate to asset condition and criticality. The review amended previous plans and reprioritised planned asset retirements based on the most recent asset data and the corresponding risk assessment. Evoenergy's plans to retire assets are determined on the basis of assets reaching the end of their economic life in accordance with the *National Electricity Rules (NER) schedule 5.8 (b1)*. The section addresses requirements of major assets and separately asset groups.

Retirements of major assets

Table 9 below summarises review outcomes which relate to transmission and distribution with the value above $200 000 (as per *NER, schedule 5.8(b2)*). Evoenergy ASPs apply a ten year planning horizon for the transmission and distribution assets. The table summarises specific assets set for retirement over the next five years. The specific constraints will be subject to further investigations and when appropriate consultations with interested parties with respect to non-network and demand side management solutions. The plans are regularly reviewed and updated to account for the most recent asset performance, condition monitoring and testing information.

table. 9 Identified retirements of major assets

Area	Network Element	Primary Driver	RIT-D	Estimated Cost ($ million)	Consult	Decision	Date Required
Woden Zone Substation	132 kV Circuit Breaker	Asset condition & performance	No	$0.35m	N/A	Mar 2020 complete	Jun 2021
Fyshwick Zone Substation	66 kV Assets	Asset condition & performance	No	$2.1m	Jun 2021	Dec 2021	Jun 2024
Latham Zone Substation	Substation Switchboard	Asset condition & performance	No	$3.1m	Dec 2022	Jun 2023	Jun 2024
Wanniassa	Distribution Line Underground Cable	Asset condition & performance	No	$4.3m	Dec 2022	Jun 2023	Jun 2024
Zone Substation supply security	Provisional Power Transformer[18]	Asset condition & performance	No	$2.7m	Mar 2021	Jun 2021	Jun 2022

Interested parties are invited to propose alternative solutions to our asset retirement plan including options to defer investment. Parties considering an alternative investment option to this replacement plan should contact Evoenergy for specific details and up to date information. Chapter 1 provides information on how interested parties can engage with Evoenergy.

Woden 132 kV Circuit Breaker Replacement

This project proposes replacement of an old minimal oil live tank circuit breaker with a new SF6 dead tank circuit breaker. The circuit breaker has exceeded its useful design and operational life and is known to exhibit operational issues. A detailed

18 Not specifically a retirement but major system spare to provide contingency for unplanned zone transformer retirement.

condition assessment has been performed on this circuit breaker, the main contacts are in unacceptable poor condition requiring replacement and the mechanism requires major overhaul. The existing circuit breaker is uneconomic to repair.

Replacing the circuit breaker will improve the safety and reliability of a zone substation that feeds the Woden area and Canberra Hospital.

Decommissioning of Fyshwick Zone Substation 66 kV Assets

Fyshwick Zone Substation was constructed and commissioned in 1982. It was a least-cost construction which included second-hand transformers. It is supplied radially from TransGrid's Queanbeyan 132/66 kV Substation via two single-circuit wooden pole 66 kV sub-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 reinforced and will require replacement within the next 5 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 years. Oil water contamination is likely to impact these units as there are issues with leaking seals due to deterioration. There are no spare units available and Evoenergy is unable to sufficiently maintain the units to extend their life.

Secondary assets such as 66 kV protection relays are also approaching the end of their economic lives and a risk assessment has shown a high risk of mal-operation which has significant reliability impacts.

Approximately $9.7 million will need to be expended over the next 5 years to upgrade / replace these 66 kV assets.

It has been estimated that the decommissioning of the 66 kV assets will cost $2.09 million.

Figure 30 illustrates the condition of existing assets at Fyshwick 66/11 kV Zone Substation.

Figure 30. Fyshwick Zone Substation: Outdoor wooden pole strung busbars. Indoor 66 kV electromechanical protection relays

Latham Zone Substation Switchboard Replacement

Latham zone substation was commissioned in 1971 and supplies over 25,000 customers in the Belconnen district. The original oil filled 11 kV indoor metal clad switchgear remains in service and is approaching the end of its economic service life.

This 11 kV switchgear is increasing in risk to Evoenergy, our customers and the community. The switchgear contains oil-filled circuit breakers designed in the 1970s which have a history of breakdowns causing unplanned outages to customers. The condition these assets continues to deteriorate resulting in increasing risk to the health and safety of Evoenergy staff, and reliability of supply to customers.

An intrusive asset condition assessment and partial discharge testing of the Latham switchboards is planned for 2021. This will inform assessment of the asset risk and confirm the need for replacement.

Subject to condition assessment and partial discharge testing results, it is proposed to replace one 11 kV switchboard at Latham Zone Substation with modern equivalent at an estimated cost of $3.1 million in 2024.

Wanniassa Distribution Line Underground Cable

Reid feeder, an 11 kV underground feeder from Wanniassa zone substation, supplies over 1,200 customers in the Tuggeranong district. This feeder was installed in 1976 and has experienced eight cable faults in the past 10 years.

The 11 kV underground feeder is comprised of PILC and XLPE cable continuing to deteriorate in condition, resulting in more frequent failures and outages for customers. As the failure rate increases, customers experience more frequent unplanned outages and Evoenergy's overall network performance is affected.

Two options have been considered to manage the network reliability risk associated with the 11 kV underground feeder from Wanniassa zone substation;

Option 1 – Do nothing

Option 2 – Replace 11 kV underground cable

The preferred technical and economic option is option 2, replace 11 kV underground cable from Wanniassa zone substation at an estimated cost of $4.3 million. This replacement is planned for 2024 however a maintenance programs continues to monitor this asset's condition, enabling Evoenergy to manage this risk.

Provisional 132 kV Power Transformer

Transformer condition is dictated by the remaining integrity of the internal paper insulation. Generally, the remaining strength, or inversely the 'degree of polymerisation' (DP), of the paper is strongly linked to the remaining life of the transformer.

To determine these levels of insulation, Evoenergy estimates the DP of the paper from furan analysis of the oil. Once this has reached a certain threshold, Evoenergy performs intrusive sampling of the in-tank paper for laboratory assessment.

Due to the designed capacity of the zone substations, if a single transformer at a Zone Substation shows poorer condition, this is less critical than if multiple transformers show poorer condition. Based on these assessments, there are three zone substation sites which are considered to have higher risk and impact of a transformer failure. The sites are Gilmore, Telopea Park and Theodore Zone Substations.

Considering the above, and the estimated 12-18 month lead time of a new transformer, it is prudent to be prepared with the purchase of a spare provisional power transformer in 2021 with delivery in 2022.

This project has synergies with the Power Transformer Dissolved Gas Analysis Unit project summarised in section 6.2.7.

Grouped asset retirement plan

This section describes our grouped asset retirement plans. These plans include groups of asset retirements of the same type where individual asset replacement costs are less than $200,000 in accordance with *NER schedule 5.8 (b2).*

Our grouped asset retirement plan is predominantly asset replacement with like for like replacement with modern equivalent solutions.

Although most asset retirements require replacement, the option to decommission the asset is also assessed. Evoenergy has been successful at decommissioning assets which have reached retirement by augmenting the network with non like-for-like solutions at a lesser cost. For example, distribution substations may be decommissioned where the LV and HV network can be augmented without the need for the substation and retain adequate network reliability.

Our grouped asset retirement plan, as determined in our 5 year Program of Works (POW), is shown in Table 10. Sections 6.1.5, 6.1.6 and 6.1.7 provide further commentary on respective programs.

Table 10. Identified group asset retirements

Asset Specific Plan (ASP)	2021		2022		2023		2024		2025		Total	
	Qty	Cost ($m)	Qty	Cost ($m)	Qty	Cost ($m)	Qty	Cost ($m)	Qty	Cost ($m)	Qty	Cost ($m)
Ground Assets												
Distribution HV Switchboard Assembly	7	0.39	7	0.39	7	0.39	7	0.39	7	0.39	35	1.93
Distribution LV Switchboard Assembly	5	0.83	3	0.50							8	1.33
Distribution Substation/ Switching Station Sites	6	0.92			1	0.10	9	1.25	4	0.53	20	2.80
LV Pillars	61	0.33	511	2.76	94	0.51	14	0.08	30	0.16	710	3.83
UG HV Cables			1	1.61	1	2.69					2	4.30
UG LV Cables	3	0.21									3	0.21
Overhead Assets												
OH Lines and Pole Hardware	240	0.90	240	0.90	240	0.90	240	0.90	240	0.90	1,200	4.50
OH Switchgear & Automation	26	0.24	34	0.35	34	0.35	34	0.35	34	0.35	162	1.63
Overhead Transmission Lines	5	1.04									5	1.04
Pole Substations	9	0.55	8	0.38	9	0.41	8	0.38	8	0.38	42	2.12
Poles	320	4.20	320	4.20	320	4.20	320	4.20	320	4.20	1,600	20.99

6.1.5 Distribution overhead network

This section provides a brief explanation of each grouped program listed in the above table.

Overhead Lines and Pole Hardware

Evoenergy's overhead lines and pole hardware replacement program comprises largely pole top replacements. Pole tops include crossarms, insulators and hardware, and they are replaced when these components are defective, but the pole structure is in good condition with years of service life available.

Overhead Switchgear and Automation

Asset replacement in the overhead switchgear and automation program is primarily defect driven. This program replaces auto-reclosers, air break switches, drop-out fuses, HV links and surge arrestors that fail in-service or are defective. This is usually due to wear and tear, or damage caused by lighting, wind or vegetation.

Pole Substations

Pole substations are replaced when the reach to their end-of-serviceable life. Replacement drivers include poor condition of the supporting pole or pole top, and transformer defects such as oil leaks. This program includes replacement of single and two-pole substations. Two-pole substations are of early design (built between 1952 and 1966) constructed using many steel brackets and bolts. These structures are experiencing high levels of corrosion. Thus, most replacements in this program are two-pole substations.

Poles

The distribution poles replacement program is a risk-based replacement or refurbishment program. Asset risk is determined from an assessment of the assets' likelihood and potential consequence of failure. This assessment is undertaken following the ground or aerial inspection programs to determine asset condition.

6.1.6 Distribution ground network

Distribution LV switchboard assembly

Distribution LV switchboard assembly includes LV switchboard panels and LV circuit breakers in distribution substations. The driver for this replacement program is predominantly operational risk. This replacement program currently focuses on replacing LV switchboards containing Capstan Links. This type of switchboard was installed in Evoenergy's network prior to 1975 and has exposed live components. An inspection program developed by Evoenergy is under way with the planned completion in early 2021. The inspections together with risk assessment will inform the priorities for the Evoenergy replacement program. The Capstan Link switchboard replacement program also includes replacement of the LV switchboards which have LV CBs containing asbestos material.

Distribution substation/switching station sites

The distribution substation and switching station replacement program includes ground mounted substation and switching station replacements. The program is driven by asset condition and corresponding risk assessment. The condition of switchgear and transformers are the key components which are included in that assessment. Some substations include older HV or LV legacy switchgear designed to standards which were subsequently superseded with the new technical requirements. Some of this equipment may result in increased operational risk either in terms of reliability or operator safety. Types of switchgear which typically fit into these categories includes Reyrolle, Yorkshire, J&P, Statter, Long and Crawford, and MI Australia. The operational reliability is reduced for the switchgear which is no longer supported by manufacturers and therefore cannot be adequately maintained. To mitigate the existing operational risks prior to replacement with modern equivalents, Evoenergy has put in place operating and maintenance restrictions is selected locations.

Distribution substations may also be nominated for planned replacement due to defective transformers.

LV pillars

The LV pillar replacement program replaces aged pillars in poor condition and assets shared with Canberra and City Services (TCCS). The shared asset arrangement involves some LV pillars being contained within streetlight columns - these are referred to as "Pregnant Columns". The LV Pillars that have been prioritised for replacement are Henley Pillars and Pregnant Columns.

Underground LV cables

LV cables replacement is designed to mitigate risk relating to the failure of LV cables. Some failures may result in a loss of neutral conductor connection. During the 2020/21 FY most replacements were reactive after a failure of LV cable. However, Evoenergy is in the process of implementing a condition monitoring and testing program which will provide additional data in terms of the asset failure rates, life span and risk including safety. On the basis of the test results Evoenergy intends to develop a structured risk-based approach to LV cable replacements.

Underground HV cables

Evoenergy's distribution network includes a number of HV cables whose age exceeds an original design life span. These cables are usually Paper Insulated Lead Cables (PILC). They are often present in some of Canberra's older suburbs such as Yarralumla, Reid, Griffith, Barton, Civic, Turner, Reid and Deakin. Evoenergy has identified these cables as a potential operational risk. Evoenergy is progressively evaluating risks associated with these cables. An external service provider was contracted to conduct on-line and off-line testing and condition assessment using a number of specialised technical methods. The enhanced testing program will be used to identify priority for HV cable replacements within Evoenergy network.

6.1.7 Transmission network

The transmission poles replacement program is a risk-based replacement or refurbishment program. Asset risk is determined from an assessment of the assets' likelihood and potential consequence of failure. This assessment is undertaken following the ground or aerial inspection programs to determine asset condition.

6.1.8 Asset de-rating

NER Schedules 5.8 (b1) and (b2) require Evoenergy to report on asset retirements and de-ratings. Table 9 summarises identified retirement of assets above $200,000. Table 10 identifies programs for grouped small asset renewals and replacements.

During the last year Evoenergy did not de-rate any distribution or transmission assets.

6.1.9 Vegetation management

Vegetation management is an important part of Evoenergy operations which promotes safety and reliability of network assets.

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 ACT Government department Transport Canberra City Service (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 has also installed several pulse-close intelligent reclosing devices with a "bushfire algorithm" designed to detect high impedance "lines down" events to help to prevent bushfires due to vegetation on lines.

6.2 Secondary systems

Secondary systems support operation of the primary network assets. This section addresses the following key secondary systems:

- Supervisory Control and Data Acquisition (SCADA) system which enables network operation, control or switching, monitoring and data acquisition.
- Telecommunication system which supports network protection, SCADA, telephony, video, and corporate data services
- Protection systems which enable fault clearing, isolation and protection of network equipment, and enhance safety of operations.

This section provides information on the current challenges, main secondary system projects progressed or completed over the last year, and projects proposed for the forthcoming period.

The future programs are developed within the Evoenergy Asset Management framework. Chapter 3 and Appendix D – describes the Evoenergy Asset Management Framework and the approach to asset management. Appendix H – includes additional description of the network technical parameters and systems.

6.2.1 Secondary assets - what are the main challenges?

Evoenergy is regularly monitoring network secondary assets and assessing operational risks, compliance requirements, and future network needs. Compliance requirements are derived from the NER, technical codes, and Australian standards.

The main current challenges and drivers of the Evoenergy investment in secondary systems are:

- Compliance with the NER requirements in relation to the fault clearance times and duplicate systems for transmission assets
- Concerns in relation to reliability of some of the existing protection assets in zone substations
- The need to replace old damaged and failing pilot cables used for 11 kV feeder unit protection and SCADA communications
- The need for increased speed, capacity, and reach of the telecommunication systems to support our operations
- Protecting secondary assets from cyber security threats.

6.2.2 SCADA

SCADA is a key component of the overall electricity network and is the source of field data and control for the ADMS and other operational systems. Zone substations and controllable distribution assets are critical elements of the electricity network, and SCADA has traditionally been applied to these areas. SCADA is increasingly being utilised to provide additional data for monitoring, control, and asset condition monitoring.

From 2020, Evoenergy is adopting IEC 61850 digital substation technology as part of secondary systems renewal programs. Further information on the IEC 61850 Substation Automation System approach can be found in section 9.1. SCADA renewal works for 2021-2025 include:

Implementation of an IEC61850 substation automation system at Woden, Telopea Park, Belconnen, and Wanniassa Zone Substations including a new SCADA Remote Terminal Unit (RTU) and Human Machine Interface (HMI).

6.2.3 Protection

Protection assets are located within Evoenergy zone substations, switching stations, and distribution substations, and are used to isolate faulty electrical equipment within the substations, connected transmission lines, and distribution feeders. The protection systems ensure reliable and safe operation of the network by isolating faulty sections of the network. The correct operation of the protection systems limits impact of faults on the system stability and potential damage to network infrastructure.

Evoenergy has identified the need to replace a number of protection relays that have reached end-of-life. These relays are integral to the safety and secure performance of the network.

While asset condition remains the primary driver supporting protection replacement projects, there are additional benefits from the installation of modern numerical relays including automated condition monitoring, distance to fault measurement, comprehensive power measurement, and combined protection and control in one device.

Evoenergy's 2021-25 protection renewal program includes the following:

- Upgrade protection and install 132 kV line differential protection using the new OPGW network (Latham ZSS, Wanniassa ZSS, Woden ZSS, Belconnen ZSS)

- Condition-based replacement of 11 kV feeder protection (Woden ZSS, Belconnen ZSS and Telopea Park ZSS, City East ZSS)
- Condition-based replacement of transformer protection (Woden ZSS, Belconnen ZSS and Telopea Park ZSS, City East ZSS)
- Voltage Regulation System Upgrades at zone substations.

6.2.4 Telecommunication systems

Evoenergy's telecommunication systems 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.

Evoenergy has installed Optical Ground Wire (OPGW) within our network to replace aged communications bearers, such as radio. This involved replacing the existing overhead earth wire on 132 kV transmission lines with hybrid OPGW cables to provide optical fibre communications capability. Over the coming years, this fibre will be used to meet the following regulatory and business requirements, as protection is upgraded at each Zone:

Upgrading our 132 kV transmission line protection systems to meet current NER network performance standards, ensuring regulatory compliance, and safety for the community

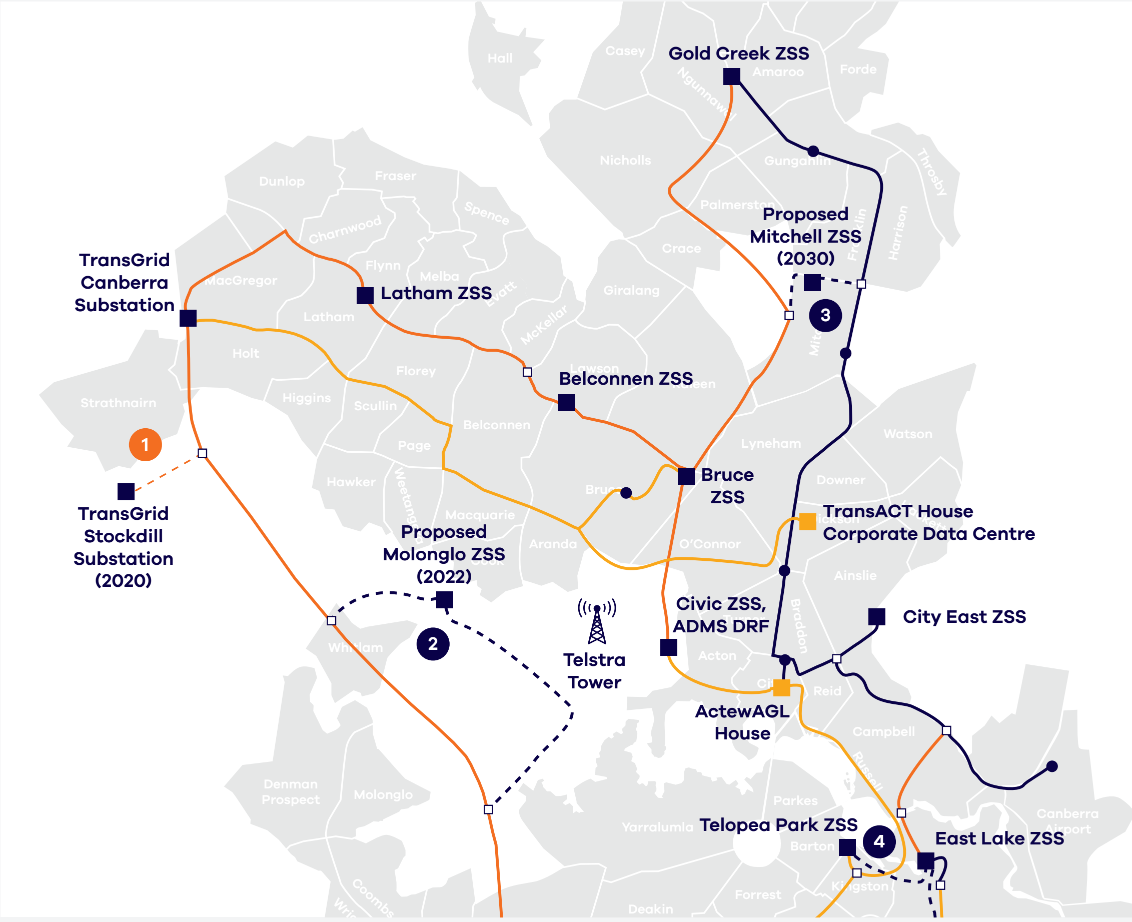
Providing communications for security monitoring of substations and other operational communication services.

Other telecommunications upgrade programs include:

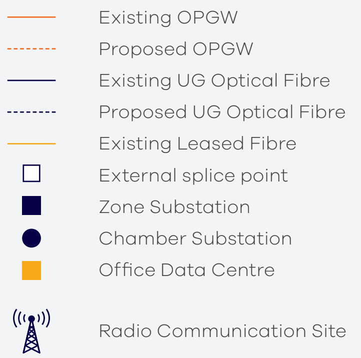
- Replacement of aging copper pilot cables with Optical Fibre cables. Pilot cables are used for 11 kV feeder protection and SCADA communications. This is necessary for providing safety and reliability in the 11 kV network.
- Progressive replacement of radio equipment in the SCADA Digital Data Radio Network (DDRN) and migrate radio systems to the 4G network. This program will replace SCADA data radios as they reach the end of their serviceable life.

Figure 31 and Figure 32 depict the proposed communications network program.

Figure 31. Fibre optic network – north ACT



Legend



Current OPGW Projects

1 New TransGrid Stockdill Substation (2020) OPGW TransGrid Canberra, Stockdill to Woden

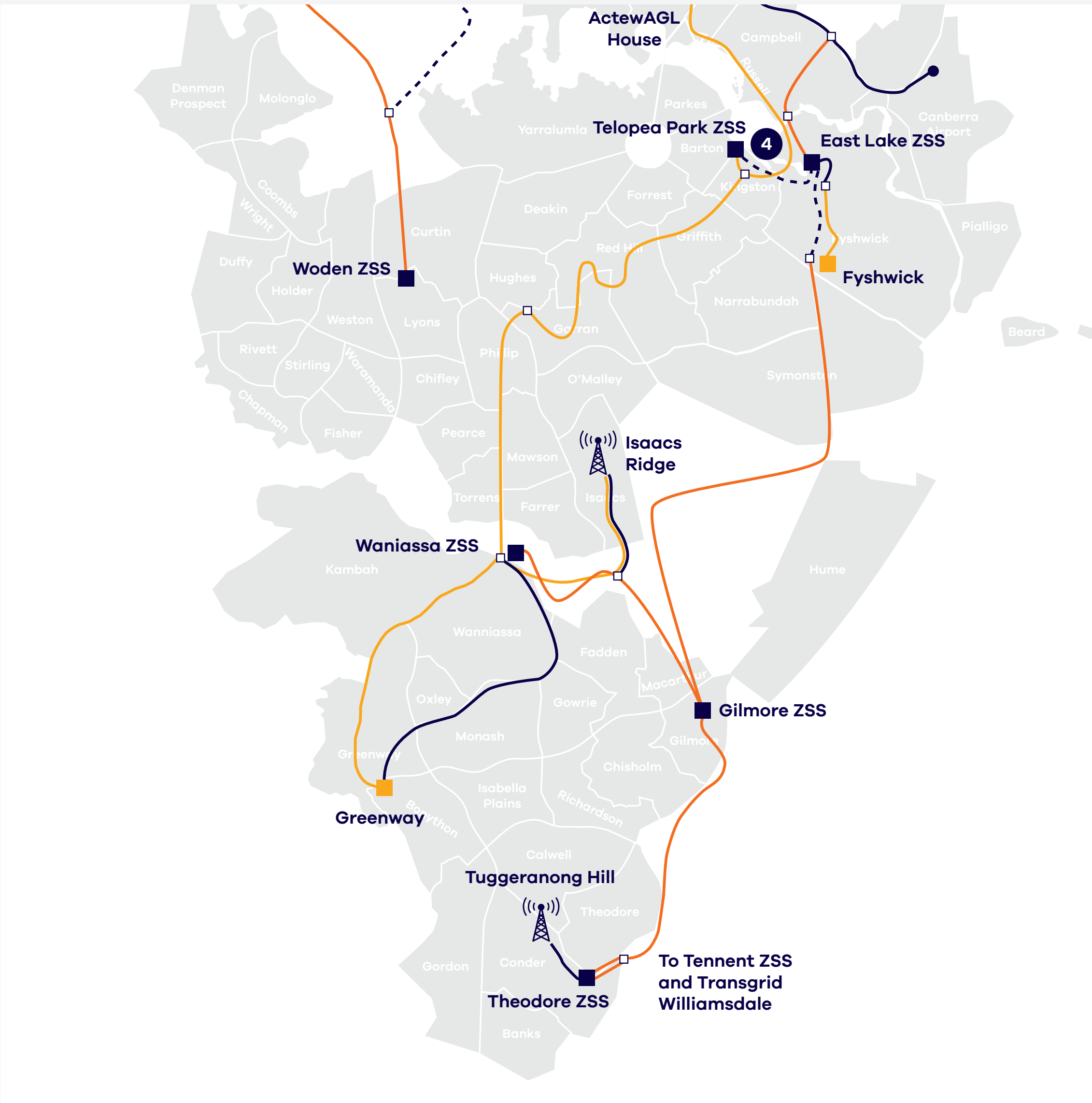
Proposed UG Optical Fibre Projects

2 Proposed Molonglo ZSS (2022_ Underground 132kv line and OF

3 Proposed Mitchell ZSS (2025) Underground 132kv line and OF

4 East Lake Stage 2 Underground 132kv line and OF

Figure 32. Fibre optic network – south ACT



6.2.5 Distribution substation monitoring

A project to install distribution substation monitoring will help Evoenergy monitor and identify power quality issues, which are arising from high penetration of embedded generation in parts of the Evoenergy distribution network. It will support the provision of reliable power quality supplied to our customers and help support Evoenergy customers' future energy ambitions. The distribution substation monitoring solution will provide real-time quality of supply monitoring from areas of the network most affected by disruptive technologies and enable load flow and voltage profiling functionality within the Advanced Distribution Management System (ADMS). With this visibility in ADMS, network performance at the low voltage level can be managed proactively and more economically, with voltage compliance assured across the network for all Evoenergy customers.

The program will address emerging network constraints and voltage issues arising from customers' energy generation, storage, and emerging technology use. The program will provide opportunities, through improved visibility, to remediate problems at the lowest cost, avoid unnecessary augmentation and asset replacements in brownfield areas, and deliver better network planning and investment outcomes in new developments.

In the last calendar year 2020, Evoenergy has installed 147 advanced distribution substation monitors as a pilot project of the overall strategy. More details on this project can be found in Section 4.2.

6.2.6 What we have achieved in the last year

During last year Evoenergy completed or progressed and number of secondary system projects including:

- Implemented SCADA and Automation interfaces to monitor and provide control over five embedded generation sites within the ACT
- Installed SCADA monitoring and control for ten new distribution substations improving visibility and remote switching capability in the 11 kV network
- Installed on-load tap changers for nine new distribution transformers, improving voltage stability in areas with high penetration of rooftop solar
- Completed proof of concept for a next generation digital zone substation approach utilising IEC 61850
- Replaced 132 kV transmission line protection relays at Latham Zone Substation and integrated with the new IEC 61850 system
- Installed Under Frequency Load Shedding System at City East Zone Substation
- Replacement of 11 kV feeder protection relays at Gold Creek ZSS
- Replacement of SCADA remote terminal units at Gold Creek ZSS
- Installation of Optical Fibre between Gold Creek ZSS and S9109 Civic
- Providing inter control centre SCADA communications and communications to the TransGrid and AEMO control centres, required as per our role as a Transmission Network Service Provider (TNSP) in the national grid.

6.2.7 Secondary system - planning outcomes

Evoenergy assesses secondary assets needs and risks considering asset conditions, performance, compliance, criticality, and safety. The structured analysis of the needs is conducted in accordance with the Evoenergy Asset Management System Requirements and documented in the Asset Specific Plans (ASPs) and Project Justification Reports. Chapter 3 provides more details on the Evoenergy Asset Management approach. Appendix H – includes additional description of the network technical parameters and systems.

Table 11 provides a summary of the secondary system projects systems planned for the five-year period. The program is being continually review and updated in accordance with the most recent data and information.

Table 11. Secondary system projects

Constraint/Need	System	Timeframe	Driver	Total Cost ($ million)
Upgrade of Zone Substation HMIs	SCADA	2020-24	Safety Reliability	$0.375m
Distribution Substation Monitoring	SCADA, Communications	2020-25	Quality Reliability	$3.5m
Voltage Regulation System Upgrades	SCADA, Protection	2020-25	Quality Reliability	$2.7m
Secondary Systems Cyber Security Program	SCADA, Communications	2021-24	Safety Reliability	$1m
City East ZSS Protection Replacement	Protection	2024-25	NER compliance Safety Reliability	$1.92m
Wanniassa ZSS Protection Replacement	Protection	2024-25	NER compliance Safety Reliability	$2.08m
Woden ZSS Protection Replacement	Protection	2020-21	NER compliance Safety Reliability	$2.08m
Telopea Park ZSS Protection Replacement	Protection	2021-23	NER compliance Safety Reliability	$2.08m
Latham ZSS Protection Replacement	Protection	2020-22	NER compliance Safety Reliability	$1.6m
Gilmore ZSS Protection Replacement	Protection	2021-22	NER compliance Safety Reliability	$0.8m
Theodore ZSS Protection Replacement	Protection	2024-25	NER compliance Safety Reliability	$0.84m
Belconnen ZSS Protection Replacement	Protection	2023-24	NER compliance Safety Reliability	$2.4m
Power Transformer Dissolved Gas Analysis Unit	Condition Monitoring	2020-21	Safety Reliability	$0.3m
Distribution Network Pilot Cable Replacement **(optical fibre)**	Communications	2021-25	NER compliance Safety Reliability	$0.9m
SCADA Network Radio and 4G Replacements	Communications	2021-25	Safety Reliability	$0.69m
Zone Substation WAN Router Replacements and Upgrades	Communications	2021-25	NER compliance Safety Reliability	$0.72m
Microwave Radio Replacements and Upgrades	Communications	2021-25	NER compliance Safety Reliability	$0.72m
Chamber Substations RTU Replacements and Upgrades	SCADA	2021-25	Safety Reliability	$1.5m

The above list is based on the ASPs for the secondary systems. In addition to the above projects, Evoenergy runs group programs groups for smaller assets such as consumer metering managed in accordance with metering asset management plan required by the NER (section 6.2.8).

6.2.8 Consumer metering

The primary purpose of meters is to record energy consumption for billing purposes.

In December 2017, the Power of Choice government regulatory reforms introduced changes to the metering arrangements. Firstly, all new and replacement meters installed from 2017 have to be advanced meters classified as Type 4 meters under the NER. Secondly, installation of the meters is done by the authorised service providers who provide service on competitive basis. Evoenergy no longer installs the new meters nor replacement meters.

Evoenergy continues to manage fleet of meters installed at around 158 000 connection points identified by National Market Identifiers. These locations include a fleet of around 180 000 of Evoenergy revenue meters. These meters are managed in accordance with NER requirements and in accordance with Evoenergy's Metering Asset Management Plan. Under the plan Evoenergy's role is to maintain and test existing meter fleet, but not to install new meters or replace existing meters.

The numbers of Evoenergy meters reduce every year when meters marked for replacement are progressively being installed by independent metering service providers with meters owned by other parties.

6.3 Information technology

Information Technology (IT) and Operational Technology (OT) systems are crucial to the operation and management of network assets. This suite of technology systems supports a wide-ranging set of business functions including works planning, billing, works management, asset management, design, planning, and network operations.

A continuous improvement philosophy is applied to the management of these IT and OT systems to achieve ongoing efficiency, business capability and customer service improvements.

Evoenergy utilises a set of core IT systems alongside a small number of special purpose technology systems to manage the electricity network. Our focus for these customer and asset information systems is consistently one where we leverage individual and collective capabilities to support the business with ongoing benefits realisation and innovation services. This focus continues through current and future programs to deliver changes and updates that apply across end-to-end business processes and to customer service delivery. To this end, a range of key projects have either been completed, are underway or are at a development and planning stage.

6.3.1 Information technology – planning outcomes

Whilst there is an ongoing process of review for major customer and asset systems changes, with particular attention given to Customer, Market, and Regulatory Compliance related activities the key strategic investments are expected to be focused on the following major Program of Works (PoW).

Table 12. Summary of information technology and operation technology program

Program	Project Title	Timeframe	Planned Outcomes
1	PowerPlan Updates	Q1 through Q3 FY2021	Deliver enhanced Program of Work planning and development capability, including Monetised Risk and Estimating capabilities.
2	Integration Architecture Platform	Q2 through Q4 FY2021	Replace customised integrations with a standards-based Integration Platform and Architecture.
3	Cityworks Portfolio Updates	Several programs running across Q1 to Q4 FY2021	Enhanced mobility and customised field force services, reporting, data management improvements, analytics capabilities, and productivity enhancements.

Program	Project Title	Timeframe	Planned Outcomes
4.1	ArcFM GIS Platform Upgrade	Q4 FY2020 through Q2 FY2021	Support and maintenance program, introducing enhanced visualisation tools and techniques, and field force functional enhancements.
4.2	ArcFM GIS GDA2020 Datum Research and Upgrade Definition	Q2 FY2021 through Q3 FY2021	Preparation for major platform upgrade to align with industry data exchange compliance program, and to provide greatly increased accuracy and consistency in mapping and visualisation services.
4.3	ArcFM GIS Maintenance	Ongoing programs from Q2 2021 through to Q2 2024	Ongoing maintenance and support updates alongside functional and visualisation improvements.
5	Five Minute Global Settlements	Q4 FY2020 through Q2 FY2022	Regulatory Compliance program.
6	Cloud Migration	Q4 FY2020 through Q4 FY2022	Transformation program to move core systems to a Cloud based infrastructure architecture.
7	Velocity Billing and Metering Updates	Q4 FY2020 through Q4FY2021	Compliance and Tariff related changes allied with functional improvements plus Life Support, Customer Switching and other Regulatory change programs.
8	Digital Platform	Q1 FY2020 through Q4 FY2024	Enhanced Customer Portal services.
9	Data Warehouse and Data Lake	Q3 FY2020 through Q4 FY2024	Enhanced Data services for Customers, Staff and industry partners alongside data analytics and insight services.
10	Drawing Management Systems	Q1 FY2020 through Q4 FY2024	Enhanced Mobility access systems.

6.3.2 Automating data flow between systems

Activities that improve or address opportunities in data management (related to Programs 2, 8, and 9) practice include:

- Increasing integration of our core customer and asset information systems including Velocity, Cityworks, Drawing Management System, ArcFM GIS, ADMS, Oracle, PowerPlan, and Aurion systems
- Simplification of data collection and management processes with a single set of master data that is shared and utilised across multiple business practices
- Providing improvements in quality, integrity, and reliability of data that serves multiple purposes across customer service and product management processes
- Enabling automatic synchronising of meter installations and improving the timeliness by which our network information is updated while decreasing manual effort
- Automated scheduling and actioning of service energising and de-energising
- Improvements in the timeliness and accuracy of customer notifications of planned outages with customers directly mapped to network supply points
- Visualisation of customer related incidents, asset location and connectivity, and planned service interruptions and maintenance or augmentation works
- Improved financial management and reporting services, human resource planning, and time management and enhanced analysis and forecasting services
- Forecasting and scheduling the operational PoW to support efficient and effective use of resources and thereby optimising effort, asset utilisation and minimising service interruptions.

6.3.3 Field mobility

Field Mobility programs enable work crews to execute key works management activities in the field including creation, actioning, and closure of work orders. This in turn leads to improvements in timeliness of works scheduling, planning and completion, availability, and accuracy of data. Further benefits to be gained from improvements to mobility services include improved response times to address priority field activities, increased field force productivity, as well as minimising the use of paper and manual process; ultimately delivering improvements in customer service.

Delivered in works related to Programs 3, 4.1, 8, and 10.

6.3.4 Customer portal

The Evoenergy Customer Portal provides customers with the capability to register and log in to a secured portal. This portal provides facilities for the customer to view consumption data, schedule service activations or disconnections, register private assets that are network connected, provide feedback, and view detailed information regarding planned and unplanned (emergency) service interruptions or network outages.

Delivered in works related to Programs 3, 4.1, 7, and 8.

6.3.5 Data warehouse and data lake

Data analytics and reporting oriented projects are supporting improvements in overall service delivery through use of data from a variety of sources consolidated to a single source.

Enhanced analytic techniques are also being applied to the operational data set to deliver product and service delivery enhancements. Consolidated views of network, customer, asset and works planning data are also being utilised to provide multidimensional insights that, for example reduce the number and length of planned service interruptions by intelligent scheduling of related or adjacent activities such as maintenance of existing assets or installation of new or replacement assets.

Enhanced reporting and analytic services to support provision of accurate forecasting services, self-service customer reporting and support services and collection, and storage and management of more extensive and granular customer and core networks data.

Delivered in works related to Program 2, 3, and 9.

6.3.6 Regulatory, governance and compliance

Core and special purpose technology systems are regularly reviewed and assessed for their general and specific alignment with regulatory, governance, and compliance requirements. Opportunities for improvement are identified and programs put in place to maximise the value proposition associated with the collection, management, retention, and use of data.

New data structures and information previously not recorded or retained for normal business operations are being included into functional scopes for technology systems with respect to existing and new asset types and classes. For example, data relating to assets such as Solar Panels, Battery Storage, Smart Meters, and other such technologies are being sourced, included, and maintained in operational and planning data sets to meet evolving customer and regulatory requirements, and to refine and improve business operations.

New collection, management, reporting, and storage facilities are being progressed to support improved timeliness, reduced complexity, and to reduce the cost of compliance and regulatory reporting practices.

Delivered in works related to Programs 4.2, 5, 7, and 8.

6.3.7 Program of work management

Upgrades and augmentation of existing asset information and asset planning systems will provide a more sophisticated toolkit for accurate forecasting and planning services that involve changing network assets.

Integration works to more closely align and connect core IT systems data is also benefiting the timely and efficient development of the Network PoW.

Predicting which assets need to be maintained using risk weighted data driven methodologies and processes will more appropriately drive programs for asset maintenance, replacement, or augmentation. It will also support improvements to scheduling and works planning which will further support changes to operate the minimum practical number of service interruptions for customers and supply partners.

Delivered in works related to Programs 1 and 2.

6.3 8 Cyber security

Cybersecurity programs are delivering improvements to the overall integrity and security of assets and data. Integrated into basic operational process and management practice; capabilities such as privilege management, multi-factor authentication, remote access, secure single-sign-on processes, and exception reporting are embedding a single simplified cybersecurity framework across the Evoenergy organisation.

Delivered in works related to all Programs.

6.3.9 Information technology - future areas

The future state of the customer and asset information systems environment is one that embodies a single, integrated, geospatial solution, built on enterprise integration that improves data visibility and has a clear customer focus.

The functionality of customer and asset information systems will continue to be developed to meet key business requirements including enabling, managing and coping with disruption, operational effectiveness, and efficiency and improving customer services and experiences.

These outcomes will be achieved through continuous improvement programs that include usability and functionality releases, major and minor system upgrades and augmentations, or system replacements. All programs will work in parallel with, and be underpinned by, the implementation of enterprise integration and data architectures, advanced data management and analytics techniques, and ongoing improvements to the systems and services that empower the consumer and Evoenergy staff.

Customer engagement

Providing our consumer with comprehensive 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 digitising customer interactions and opening new communication channels to make it easier for our consumers to work with us and so they can obtain the information they need to improve their experiences with Evoenergy. The expected benefits include:

- Timely, accurate, and complete data sets that enable customers to better manage their energy use and to visualise and plan their energy futures
- Ensuring our industry consumers see interactions with us as adding value to their businesses.
- Greater capability for consumers to view and act on managing their services
- Improving and extending the scope of direct communications to include providing information through our consumer's preferred channels.

Data visibility and availability

The value in our data is not in its collection or analysis, rather in the use of the data to change processes and improve outcomes. Evoenergy is implementing an enterprise data architecture and associated management techniques, platforms, protocols, and assets that enable data to be more readily accessed, easily viewed, analysed, reported, and displayed across the business and to our customers. The expected benefits of delivering such programs are:

- Reduced time, cost, and effort in developing new or in updating or changing existing reporting systems and services
- Increased use of visualisation techniques that bring together multiple data sources and types to create intelligence and actionable insight which was previously unavailable
- Increased capacity and capability for trend analysis that can be leveraged to improve end-to-end business processes and to improve our customer experiences
- Increased ability to make more meaningful information available to customers to improve our interactions and enable our customers to have greater management, control, and insight to their energy usage and to empower their decision-making processes for energy use.

Field digitisation

With the continuous enhancement of works management mobility systems, there is an opportunity to build on the mobility platform to further digitize workforce activities. This includes the provision of offline, regularly updated network maps, job risk assessments, forms management, workflow tools, and safety work method statements. These additional initiatives will be delivered in a continuous improvement pathway to increase functional availability and provide a richer user experience by way of improvements in visualisation and connected master data. The roll-out program will be based on activities that ensure priority for initiatives that have clear business and customer-oriented benefits.

The benefits anticipated from continued field mobility changes include:

- Faster data capture at the time and location of an activity to provide greater accuracy and validation of data at the collection point
- Richer data collection with enhanced metadata and new data forms including imagery to enable visualisation of data analytics and support further improvement in the end to end process for planned outage notifications to customers
- Data collection from multiple previously inaccessible sources to increase functionality and insight to field workers in their interactions with industry partners and customers
- Continuing to improve the safety of our workforce and the public through increased availability of accurate up-to-date information.

Enterprise integration

All core Evoenergy technology systems are tightly integrated though point to point bespoke services that are highly complex and require ongoing care and maintenance. 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 consistent integration architecture to simplify the overall systems environment and ensure customer and asset information systems can be managed in a more efficient and prudent manner. The following benefits are expected:

- The new integration architecture will enable the removal of bespoke and point to point system integrations, enabling applications to be built, maintained, and released independently of other system maintenance programs
- Reduced implementation risk associated with large scale projects by cutting scope to focus on individual systems and thereby reducing complexity, project costs, delivery times, and outage impacts of customers and industry partners
- More effective integrations will ensure that information is not lost between systems, is visible and manageable as it moves between systems, is translated and transferred consistently between platforms, and supports development of reliable and transparent business process flows.

6.3.10 What we have achieved - information technology change and Improvement

Since the previous reporting period there have been fundamental changes in the way services are provided and work is supported from technology teams through to the field staff.

Generational change has taken place across all core systems that are used within the Evoenergy business including Works Management, Asset Planning and Management, Geospatial Information Systems, and Billing and Customer Management systems.

Significant changes have also taken place to reduce reliance on office based or fixed location technology with physical upgrades to field and office use technologies.

There has been increased deployment of wireless network access and office support technologies for field staff to use in remote work locations allied with updates to latest generation mobility devices.

Customised commercial product use and deployment for the mobile workforce has also enhanced safety programs, certification management, inspection test capabilities, operational flexibility, and productivity.

Significant reductions in cost of service provision and increases in capacity acquisition from the Technology Division has transformed core infrastructure platforms based on a shift from physical on premise infrastructures in corporate data centres to latest cloud based systems and services in global service provider and commercial data centres.

The Cloud Program has brought forward a step-change in capacity, financial elasticity, and responsiveness that is not available with fixed investment hardware. This shift is forecast to continue through strategic Technology change programs.

Chapter 7: System planning

This chapter summarises network limitations identified as the result of the system planning review undertaken by Evoenergy. It describes those limitations that are proposed to be addressed over the planning period. The identified limitations will be subject to further investigations including demand side management, non-network, or embedded generation support required to defer the emerging need for network investment.

System planning is the process of investigating present and future system capability, optimising assets utilisation, identifying, evaluating, and initiating system solutions where required and where economically justified to do so. System planning is necessary to ensure that security of the power system is maintained, capacity is available to meet the future needs of our customers, and the operation is within specified technical parameters.

The planning methodology draws on various data sources including demand forecasts, customer connections, demographic, and economic data. 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 include supply security, power quality, safety, and reliability.

Evoenergy applies a structured system planning methodology within the Asset Management Framework certified to ISO55001. Evoenergy employs risk based probabilistic methods to assess the prudency of investment.

Other parts of this report provide additional information which is highly relevant to the system planning including:

Network limitations tables in accordance with the AER requirements for each identified network limitation are published on the Evoenergy website.

Chapter 3 and Appendix D – on the certification of the Evoenergy's Asset Management System to ISO55001.

Chapter 4 and Appendix F – and Appendix G – provide information on network performance with respect to reliability and power quality.

Chapter 5 and Appendix E –provide additional discussion of the demand forecast for the system and zone substations.

7.1 Network planning - what are the main challenges

Evoenergy plans its energy network to cater for existing and future demand. At the system level the projected summer and winter maximum demand is forecast to be relatively flat. The summer demand is forecast to grow slightly (around 1% over the next decade). The winter demand is also forecast to increase slightly during the same period (around 3% over the next decade). The network minimum demand is forecasted to reduce significantly over a decade with increasing possibility of ACT exporting power to NSW within the next 20 years. Chapter 5 and Appendix E – provide more information on the system and zone substations demand forecast. There are no significant system level constraints identified during the planning review. The network constraints identified in the planning process are localised and relate to distribution system and zone substation capacity limitations. They correspond to the areas of higher residential and commercial growth.

Evoenergy's current network development drivers and challenges are:

- Urban infill medium density residential, high density residential and commercial developments pushing the capacity limits within the distribution system in several established areas
- Increasing proportion of medium and high density residential developments in the greenfield areas which increases electrical load density within serviced areas in line with the ACT Planning Strategy 2018 which states that 70% of new housing will be built within the existing urban footprint
- Continuation of greenfield developments and expansion into the areas poorly serviced by the existing network including the Molonglo Valley and potential growth in the Western Edge Investigation Area, particularly all-electric developments
- Distributed energy resources impacting voltage regulation on LV distribution network and therefore creating network constraints (usually within low voltage network)
- The medium to long term impacts of the ACT Government energy policies which includes 2045 zero emission target and perpetual neutral carbon target for electricity.
- The impacts of potential decarbonisation of the existing gas network and transport with the implications of this for the peak demand of the electricity network.
- Need for optimising network investment, demand management, non-network solutions and network support including use of new technologies (e.g. network batteries, embedded generation, and distributed energy resources).

Evoenergy is also part of the ACT Government Utilities Working Group, an initiative led by the Chief Engineer, which aims to aid in holistic master planning, particularly in the Canberra CBD area.

7.2 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.

Previous joint planning meetings discussed and initiated improvement of security of supply to ACT to comply with the ACT regulations introduced by ACT Government. In response TransGrid's Stockdill Drive 330/132 kV bulk supply point substation (the second bulk supply to the ACT) and interconnecting transmission lines constructed respectively by TransGrid and Evoenergy (refer to section 7.6.1) are in the final stages of commissioning. Regular project 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.

Other items covered in the joint planning meetings include the lowering of 132 kV bus voltage float levels at Canberra Substation (to alleviate high voltages at Gold Creek Zone Substation), within Evoenergy's and Transgrid's annual planning reports, and the provision of updated data agreements.

Due to COVID-19 restrictions, this year's joint planning meeting was held via video conference in April 2020. Evoenergy and TransGrid also have regular discussions in addition to the formal joint planning meetings, to discuss and resolve technical issues. Most years Evoenergy participates in a joint training exercise with Transgrid to simulate the actions required to be taken by both parties in the event of a major system contingency that requires a total system restart (black start). This training was cancelled in 2020 due to COVID-19 restrictions but is expected to be completed in subsequent years.

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. For details refer to TransGrid's Transmission Annual Planning Report 2020[19].

19 https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2020%20Transmission%20Annual%20Planning%20Report.pdf

7.3 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 updated Integrated System Plan[20] (ISP) in July 2020 and is currently working on the 2022 ISP. The ISP identifies investment choices and recommends essential actions to optimise consumer benefits as Australia experiences what is acknowledged to be the world's fastest energy transition. That is, it aims to minimise costs and reduce the risk of events that can adversely impact future power costs and consumer prices, while also maintaining the reliability and security of the power system.

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, solar and wind powered generation in particular, and has identified key renewable energy zones (REZ). 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. Low cost of new rooftop solar PV systems continue 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.

It is noted that part of the Evoenergy 132 kV network meets the definition of the dual function asset, because it operates "... in parallel with or in support of the TransGrid's transmission network". However, none of the proposed projects described in this chapter are expected to have a material inter-regional impact, i.e. they will not impose power transfer constraints or adversely influence the quality of supply to adjoining transmission or distribution networks. Evoenergy considers that the key planning outcomes are not directly impacted by the ISP, NSCAS, and Inertia Report, System Strength Report, or power frequency risk review outcomes. These requirements will be subject to future reviews and planning consultation with TransGrid.

7.4 Urgent and unforeseen need

NER clause, schedule 5.8(g) requires Evoenergy to identify any projects above $2 million committed which are the result of urgent and unforeseen needs. For avoidance of the doubt, Evoenergy confirms that the forward program provided in this report, does not include projects which belong to this category.

7.5 Planning outcomes - network constraints and limitations

Table 13 lists identified locations where the network is constrained or limited or where the network limitations are likely to emerge. The identified network limitations will be subject to further investigations and engagement with interested parties in relation to demand management/non-network solutions. Chapter 1 provides more information on the stakeholder consultation process. Chapter 7.8 discusses current asset management and network initiatives.

Generally, Evoenergy does not prepare distribution feeder load forecasts. However, Evoenergy assesses different locations and parts of the network in terms of the available capacity, existing load and projected future loads including upcoming developments.

20 https://aemo.com.au/-/media/files/major-publications/isp/2020/final-2020-integrated-system-plan.pdf?la=en&hash=6BCC72F9535B8E5715216F8ECDB4451C

7.5.1 Upcoming developments

7.5.1.1 Residential developments

Planned residential developments cause some of the anticipated network limitations summarised in Table 13. The following is the list of the major residential developments planned within the five-year planning horizon which have identified during the planning review from the ACT Government Indicative Land Release Program or customer enquiries:

1. Ginninderry Estate, West Belconnen – Projected growth of approximately 300 dwellings per year throughout planning period
2. University of Canberra residential blocks, Bruce – two major high-rise developments with 3300 dwellings by 2024
3. Jacka Estate, Gungahlin –Stages 2 and 3 in currently undergoing Development Approval for a total of approximately 700 dwellings.
4. Throsby Estate, Gungahlin – In the final stages of development with approximately 164 dwellings to be released over the next two years.
5. Denman Prospect Estate, Molonglo Valley – Future stages totalling approximately 4,000 dwellings in various stages of development. Expected release of approximately 200-300 dwellings per year.
6. Whitlam Estate, Molonglo Valley – residential development. Stages 1 & 2 for approximately 900 dwellings currently in design with more future stages to come up to 2000 dwellings. Expected release of approximately 500-600 dwellings per year.
7. Kenny Estate, Gungahlin – 1000 dwellings expected between 2021 and 2023.

7.5.1.2 Commercial and mixed developments

Planned commercial and mixed developments cause some of the anticipated network limitations summarised in Table 13. The following is the list of commercial and mixed developments identified during the planning review:

1. Canberra Central Business District – multiple high-rise residential developments with 5,900 dwellings and commercial developments of approximately 308,000m^2 space within next 10 years.
2. Canberra North – several residential developments with 4,800 dwellings and commercial developments of approximately 155,000m^2 space in the next 5 years.
3. Gungahlin Town Centre East – multiple high-rise residential developments with 2,244 dwellings and commercial development with approximately 127,000m^2 space in next 5 years.
4. Belconnen Town Centre – multiple high-rise residential and commercial developments, approximately 32,000m^2 commercial space and 1,000 residential dwellings.
5. Woden – multiple residential development with 1,300 dwellings and commercial developments of approximately 9,500m^2 space. Stages 1, 2 &3 of CIT campus relocation and bus interchange upgrade
6. Mitchell, Hume - data centre(s)
7. Canberra Airport precinct - various commercial developments of 141,000m^2 space and data centre in next 5 years period.
8. Kingston - Kingston Arts Precinct & Kingston Foreshore – multiple high-rise residential developments with 4,600 dwellings and commercial developments of approximately 62,000m^2 space
9. Tuggeranong Town Centre – Aspen Development, 2,000m^2 commercial space and 622 residential units

7.5.1.3 Large scale embedded generation projects

A number of customers have submitted Embedded Generation Special Connection Request (SCR) forms to Evoenergy, and are in various stages of the connection process. Evoenergy considers all embedded generation over 1.5 MW to be connected to the network to be large scale. Some of these came out of upcoming forecasted network constraints which were identified in the Annual Planning Report 2019. The following projects are currently under consideration:

1. A proposed 2.5 MW Battery Energy Storage System (BESS) at Holt.
2. 5 MW Diesel Generators planned in Inner South Canberra configured as backup generators.
3. 4.5 MW Generators in Lower Molonglo currently configured as backup generators
4. 6.75 MW Diesel Generators at Russell configured as backup generators
5. 1.5 MW Solar Generation around the Russell Precinct
6. A potential 20 MW Solar Farm around Jerrabomberra with a possible additional 10 MW BESS which may be connected to the EvoenergyEvoenergy's network
7. 1.6 MW Diesel Generators in Bruce configured as backup generators.

In addition to these projects, ACT government has held a recent renewable electricity auction delivering up to 200 MW of wind equivalent capacity generation (equivalent to 250 MW of solar photovoltaic generation however other renewable energy generation types can be proposed) as well as 20 MW, 40 MWh of battery storage[21]. Connection sites and timelines are yet to be confirmed, however Evoenergy understands some connections may be to the transmission, not distribution, network.

Evoenergy also commenced the process of a Regulatory Investment Test for Distribution (RIT-D) in the Molonglo region for which another grid scale BESS is expected, more information on which can be found in Section 7.6.2.

Appendix B – provides more information on existing embedded generation connected to the Evoenergy and on installed capacity of small-scale PV generation.

Table 13. Network limitations

				MVA Required (cumulative)**					Dates					
Location	Network Element	Limitation	RIT-D	2021	2022	2023	2024	2025	Consult	Decision	Required	Estimated Cost***	Project Driver(s)	Project Reference
Gungahlin Town Centre	Feeder	Capacity	No	1.3	3.6	3.6	5.9	5.9	Dec-19^	Mar-20	Mar-21	$2.9m	See sections 7.5.1.1.7, 7.5.1.2.3	See section 7.8.1
Dickson – Dooring St	Feeder	Capacity	No	-	0.4	1.5	2.8	4.1	Dec-19^	Jun-20	Dec-21	$3.8m	See section 7.5.1.2.2	See section 7.6.3
Braddon – Donaldson St	Feeder	Capacity	No	-	-	-	-	1.7	Jun-22	Dec-22	Jun-24	$2.5m	See section 7.5.1.2.2	See section 7.8.4
Molonglo Valley	Zone Substation & Feeders	Capacity	Yes	0.7	3.9	5.8	7.6	9.1	Mar-20	Jun-20	Dec-21	$13.7m	See sections 7.5.1.1.5, 7.5.1.2.6	See section 7.6.2
Strathnairn	Feeder	Capacity	No	2.0	2.9	3.9	4.9	5.9	Jun-20^	Dec-20	Jun-22	$2.4m	See section 7.5.1.1.1	See section 7.8.2
Pialligo	Feeder	Capacity	No	3.4	4.9	6.8	7.3	8.0	Dec-20^	Mar-21	Jun-23	$4.8m	See section 7.5.1.2.7	See section 7.8.5
Belconnen Town Centre	Feeder	Capacity	No	-	2.4	4.7	7.1	7.1	Dec-20^	Jun-21	Dec-22	$1.3m	See sections 7.5.1.1.2, 7.5.1.2.4	See section 7.8.3
Fyshwick	Feeder	Capacity	No	-	-	38	39	40	Jun-21	Dec-21	Dec-23	$5.5m	See sections 7.8.6	See sections 7.8.6
Mitchell / Gold Creek	Zone Substation	Capacity	Yes	-	2	6	9	12	Dec-21	Jun-22	Jun-24	$6.2m	See section 5.2.1	See section 7.9.1
North Canberra	Transmission	Voltage	No	-	-	-	-	-	Jun-21	Dec-21	Jun-24	TBC	See section 4.2	See section 7.9.3
Strathnairn	Zone Substation	Capacity	Yes					2024-29 period					See section 7.5.1.1.1	See section 7.8.2
Gilmore	Zone Substation	Capacity	Yes					2024-29 period					See section 5.2.2	See section 7.9.2

*Network is operated beyond firm rating prior to the construction of new feeder.

**Cumulative MVA required represents a shortage of capacity required to supply forecasted load for a zone substation or group of distribution feeders. Based on the load forecast.

***Direct capital cost of credible solution identified by preliminary NPV analysis

^Where options analysis has determined that there is no viable non-network option, no public consultation was initiated for projects below the RIT threshold

21 https://www.environment.act.gov.au/energy/cleaner-energy/new-renewable-electricity-auction

Table 14. Locations where constraints are no longer applicable

Location	Reason for Revision
Canberra CBD Central	Feeder project completed
Canberra CBD East	Feeder project close to completion

7.6 Projects currently in-progress

7.6.1 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 8).

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

a) *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:*

b) *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;*

c) *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;*

d) *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*

e) *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 kV 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.

No non-network alternative to this project has been identified. Estimated cost of the Stockdill Substation to Canberra–Woden 132 kV transmission line plus installation of OPGW on the Canberra–Stockdill–Woden line is $9.4 million and proposed project completion is by December 2020.

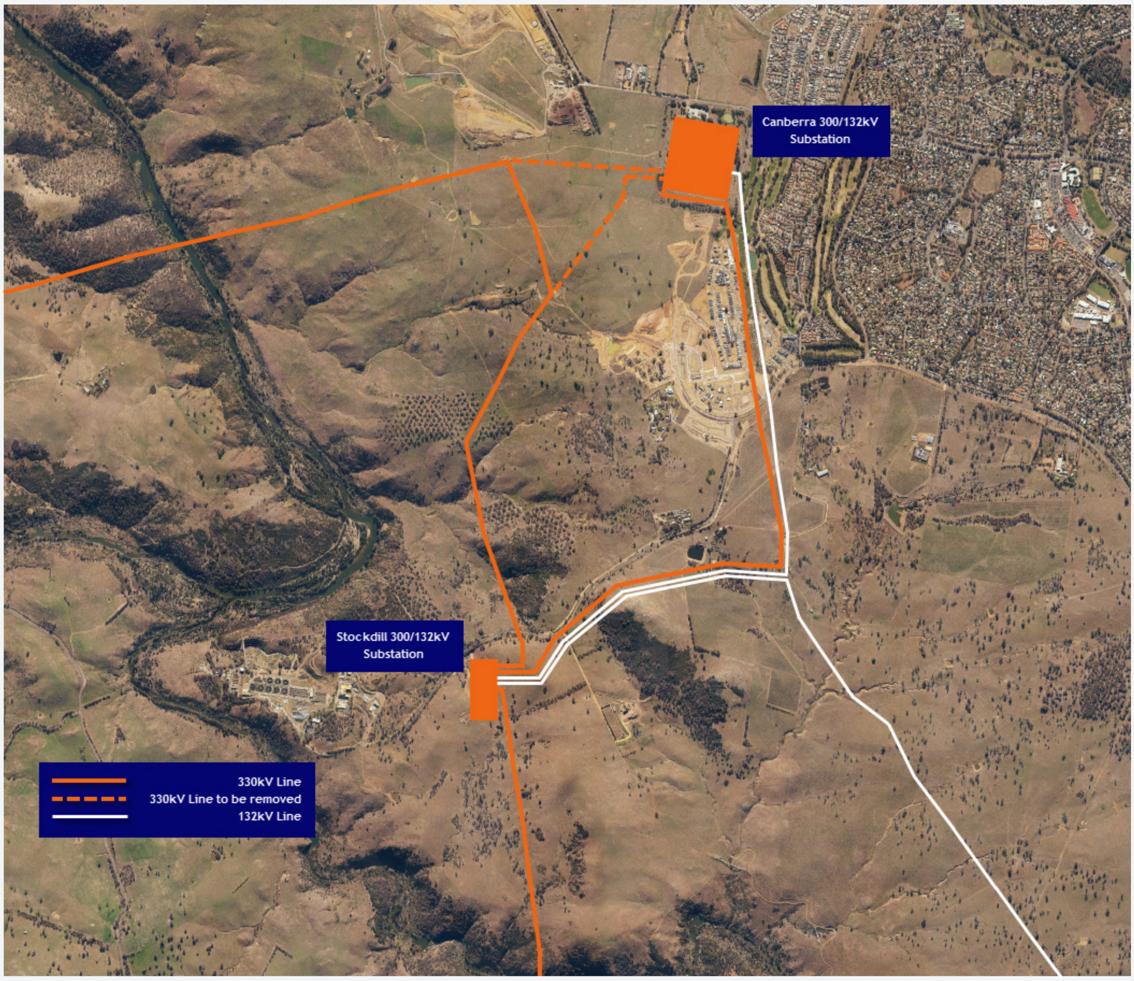
In the interim period until completion of this project, in the event of a loss of Canberra Bulk Supply Substation, a contingency plan has been made by TransGrid which has constructed assets at its Yass and Canberra substations to deal with this eventuality.

With Stockdill substation in place the originally proposed Theodore–Gilmore 132 kV line upgrade will not be required.

Figure 33 illustrates the scope of this project.

The joint planning with TransGrid and pending construction of the Stockdill bulk supply point promoted re-assessment of voltage levels in the system under contingency condition. 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 conducted initial investigations and intends to conduct detailed studies on the installation of reactive support equipment, to consider the installation of 11 kV capacitor banks at selected Evoenergy's northern zone substations or alternative voltage support arrangements such as grid scale batteries.

Figure 33. Stockdill Substation and 132 kV line connection



7.6.2 Molonglo Zone Substation

The Regulatory Investment Test for Distribution (RIT-D) is currently underway for the Molonglo Zone Substation project. This section summarises the status and outcomes of the process so far.

The Molonglo Valley District is a greenfield development area situated in Canberra's west, approximately 10 kilometres from the Canberra central business district (CBD). Over the next 30 years, the area, as one of the major urban growth corridors in Canberra, will be developed into the new suburbs of North Weston, Coombs, Wright, Denman Prospect, Whitlam, and Molonglo[22].

Land releases and development have already commenced in parts of the Molonglo Valley, with several new suburbs established. Land releases between 2020 and 2024 will support an estimated 4,357 residential dwellings in addition to a shopping centre, schools, commercial areas, and community facilities.

Initial 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 Whitlam commenced construction in 2019. Initial supply to Whitlam will be provided by the Black Mountain feeder from Civic Zone Substation.

In the short term there is a rapidly approaching constraint in the 11 kV distribution network. Peak demand is forecast to exceed the combined thermal capacity of the existing 11 kV feeders supplying the area by the summer of 2021/22. Over the longer term, the load in the Molonglo Valley will be sufficient to fully utilise a large zone substation with multiple transformers.

Evoenergy's assessment of permanent options covers both the feeder constraint and constraints on the zone substations that either currently or potentially in the future may supply the Molonglo Valley.

The tables below present forecast maximum demand for the central forecast scenario for winter and summer. Red values indicate demand is greater than the winter (23.4 MVA) or summer (20.9 MVA) thermal capacities of the existing 11 kV feeders.

Table 15. Maximum Demand Forecast – Winter (MVA)

Scenario	POE	2020	2021	2022	2023	2024	2025
Base	50	18.0	20.0	25.3	28.9	31.0	32.5

Table 16. Maximum Demand Forecast – Summer (MVA)

Scenario	POE	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
Base	50	14.8	16.7	21.6	24.8	26.7	28.0

The first stage of the preferred network option is to relocate Evoenergy's mobile substation (MOSS), which is a skid-mounted 132/11 kV setup with 15 MVA transformer capacity, and to install two new feeders from the MOSS to the Molonglo Valley load centre. The first stage also includes civil works to establish the zone substation site, including space for the future permanent transformers and switchgear that will be installed in stages 2 and 3. Stage 1 is proposed to be completed by June 2021.

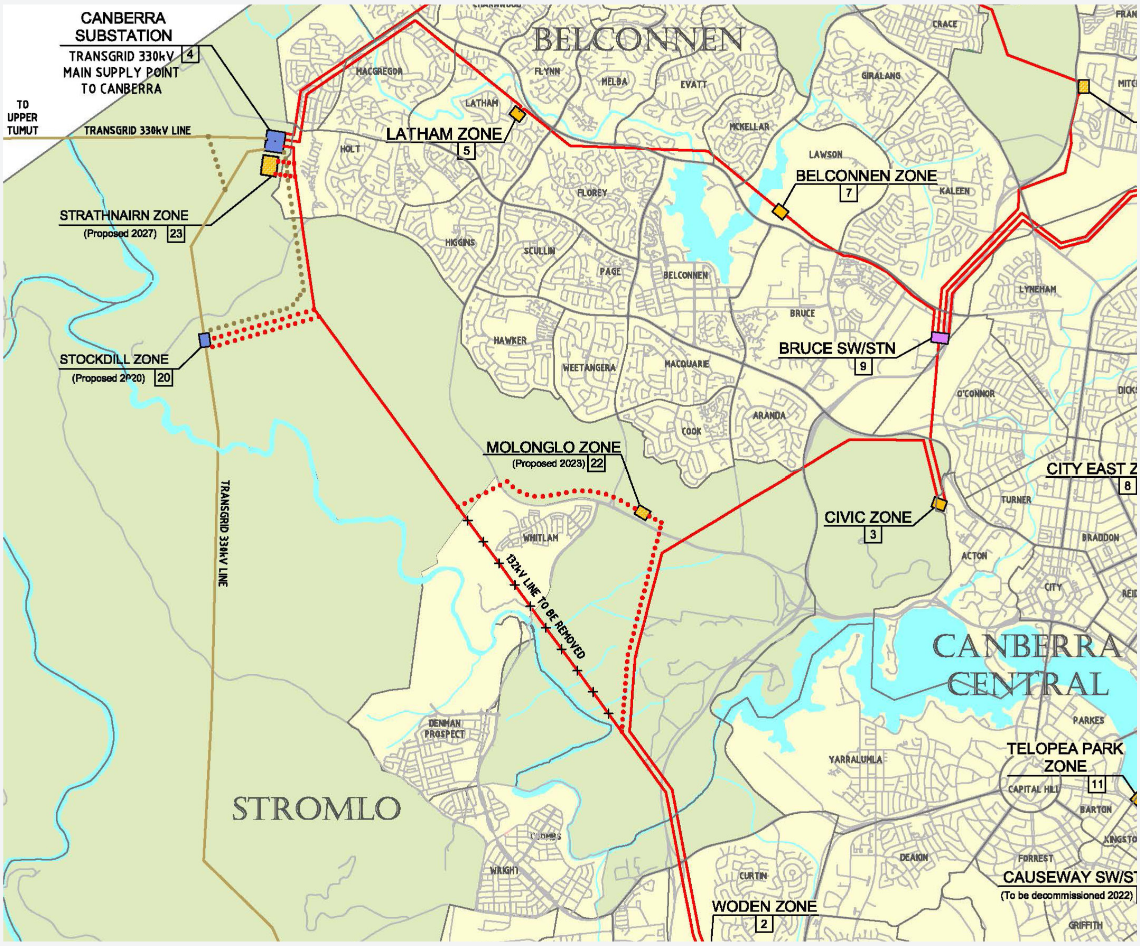
To enable the delivery of electricity from the substation to loads in the Molonglo Valley, Evoenergy will install new underground 11 kV cable feeders (including the undergrounding and reconfiguration of a section of the Black Mountain feeder) from the Molonglo zone substation during 2021-24.

Stages 2 and 3 are expected to occur after 2025 and are to address long-term zone substation transformer constraints in the Molonglo Valley. Additional feeders will be installed during stage 2 as this stage will add additional 11 kV switches to enable more feeders to be connected to the zone substation. The timing of all three stages will be continually reviewed based on updated actual and forecast load.

22 Coombs, Wright, Denman Prospect and North Weston are partially constructed. Construction is either in the early stages or not commenced at the other suburbs listed.

The total cost of this option is $31.2 million or $27.8 million in present value terms.

Figure 34. Evoenergy's 132 kV transmission lines and proposed Molonglo Zone Substation Site



Evoenergy's initial assessment of non-network solutions for the Molonglo Valley area found two credible non-network options. These were both based on the use of batteries to temporarily defer investment in a network augmentation. Option 1 involves two or more batteries located within the Molonglo Valley District near the load centre. This could include residential batteries aggregated by a Virtual Power Plant (VPP) scheme and controllable loads or larger more centralised batteries. Option 2 involves a single large battery located at or near the future Molonglo zone substation site. Option 2 requires Evoenergy to complete initial civil works at the future zone substation site and a feeder extension to connect the site, so the deferral value of this option is lower than for Option 1.

The potential credible options assumed that a battery or batteries will be installed with a primary purpose that is not to support Evoenergy's network. Examples of additional investment drivers include as part of a larger energy investment project, due to a government program obligation, for wholesale electricity price arbitrage, participation in the FCAS market or as part of a back-up system for an electricity user. The majority of the battery's value will likely come from these additional purposes, with network support payments from Evoenergy providing an additional revenue stream. Evoenergy undertook a preliminary evaluation of a wide range of non-network options for Molonglo such as demand management and embedded generation. These services were assessed as less likely to deliver a credible non-network solution for the Molonglo constraint.

Evoenergy received three submissions from non-network providers in response to the NNOR. Of these submissions one, proposing a Battery Energy Storage System (BESS) at the future Molonglo Zone Substation site was considered compliant and is considered the recommended option.

The recommended option includes the provision of demand management services from a yet to be constructed 4 MW/8 MWh (or larger) BESS solution connected at 11 kV and established before the forecast constraint in summer of 2021/22. The BESS solution defers the network investment in relocating and establishing a MOSS to the Molonglo Valley area by two years to FY 23/24. Following this, depending on updated load forecasts, the permanent zone substation timeline will be reassessed as required.

The implementation of the BESS is proposed to be undertaken in two stages. Stage 1 involves a 4.95 MW connection capacity in operation by November 2021 that is subject to a connection application under Chapter 5.3A of the NER, while stage 2 involves the full capacity in operation by November 2022 that is subject to a connection application under Chapter 5 of the NER. The second phase of the BESS is not required for the identified need but is proposed by the non-network provider to derive revenue from the wholesale and FCAS markets.

The BESS is to be located adjacent to the future Molonglo zone substation site and specifically adjacent to the Black Mountain feeder. Connections to the Evoenergy network will be via underground cables. This solution aligns with non-network option 2 from the NNOR and meets the identified need to defer network investment of the Molonglo zone substation to at least 2023 under a base POE50 scenario.

Enablement of this solution is underpinned by Evoenergy undertaking construction of an 11 kV switching station and extension of the Streeton feeder to the BESS.

Detailed information on the RIT-D including the full Non-Network Options Report and Draft Project Assessment Report can be found on Evoenergy's Website.

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-2022
- Stage 2: Civic–Woden line section approximately 2030.

7.6.3 Supply to Dickson

The Canberra City North area, including Lyneham and Dickson suburbs, is experiencing significant load growth, driven by the ACT Government's Urban Renewal program. This involves the demolition of a large number of old single level flats and office buildings (e.g. the Motor Vehicle Registry and MacArthur House) and their replacement with multi-storey apartment and commercial buildings.

It is forecast that additional load requirements of these developments will approach 14 MVA by 2024. Some capacity can be provided by existing feeders but the proposed new feeder, Civic zone substation to Dooring Street is required to make up the shortfall.

Evoenergy has considered two options to supply the additional load as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct a new 11 kV cable feeder from Civic Zone Substation to Dooring St, Dickson	$3.8m	Preferred
2	Non -network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves constructing a new 11 kV feeder from Civic Zone Substation to SOHO stage 1 development at B3 S12, Dickson, establish a 4-way switching station with SCADA and remote-control function at Dooring Street verge. With the proposed network augmentation solution of construct new 11 kV cable feeder from Civic Zone Substation to Dooring Street will fully mitigate the network capacity and unserved energy risks.

Option 2 considers non-network initiatives including:

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

To defer the Dooring feeder to the next regulatory control period (beyond 2024), it is estimated that non-network solutions would need to provide a maximum demand of approximately 3.8 MVA within the next two years.

Latent demand management within the existing customer base was investigated, with a maximum estimated capacity of 0.24 MVA. This does not meet the minimum capacity to enable the new feeder to be deferred.

This feeder project interacts with the Haig feeder extension (completed) and the Donaldson feeder project outlined in section 7.8.4 which together form part of a master plan for the area.

7.6.4 Other projects currently in progress

This section provides a brief description of other projects which are in progress:

- 132 kV Transmission line relocations in the 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. Development Approval (DA) for this project is currently in progress. Coupled with this proposed project, the site for the future Molonglo Zone Substation has been relocated. This project is forecasted to be completed in Feb-April 2022. This project is entirely customer funded
- Hume – commercial development to supply a data centre requiring the construction of two 11 kV Bulk Supply Points and associated 11 kV feeders from Gilmore Zone Substation to supply 19 MVA of requested load. Completion is forecasted for February 2021
- Proposed Harman 132/11 kV Zone Substation and 2.2 km of 132 kV overhead transmission line to supply increased load in the surrounding area. This project is currently in development/design stage. This is a customer-initiated project entirely funded by the external parties
- Whitlam 1 1A & 1B; Strathnairn 1 2B, 2A1, 2A2 & 2A3; Taylor 3 2A, 2B & 3 and Redhill Precinct - Reticulation (HV & LV) for residential development are in progress with energisation expected June 2021
- Whitlam 2 2B & 2C and Strathnairn 1 2B2 - Reticulation (HV & LV) for residential development are in progress with energisation expected February 2021.

7.7 Projects completed

Significant project completed during the year include:

- 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. These projects were completed in July 2020
- Supply to Canberra CBD West (Edinburgh feeder)
- The project to install 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 was completed in November 2019
- Installation of 11 kV Feeder from Civic Zone to Canberra CBD West (Edinburgh feeder) was completed in November 2019
- Australian National University – construction of permanent replacement 11 kV bulk supply point switching station (BSP 1) was completed in July 2020
- The construction of an additional 11 kV Feeder from Civic Zone to major residential and commercial developments around City Hill (London Feeder) expected to be completed in December 2020
- Taylor 3 1B – Reticulation (HV & LV) for residential development was completed for energisation in June 2020
- Taylor 3 1A - Reticulation (HV & LV) for residential development was completed for energisation in June 2020
- Taylor 2 4A & 4B - Reticulation (HV & LV) for residential development was completed for energisation in June 2020
- Taylor 2 1A1 & B1C - Reticulation (HV & LV) for residential development was completed for energisation in June 2020

- Taylor 2 2A & 2B - Reticulation (HV & LV) for residential development was completed for energisation in June 2020
- Taylor 2 3A & 3B - Reticulation (HV & LV) for residential development was completed for energisation in June 2020
- Denman 2C - Reticulation (HV & LV) for residential development was completed for energisation in June 2020.

7.8 Proposed network developments

7.8.1 Supply to Gungahlin Town Centre

The maximum demand in the Gungahlin Town Centre East area is forecast to increase 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, 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 by approximately 7.6 MVA required to service the area.

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	$5.10m	Not Preferred
2	Network	Construct new 11 kV cable feeder from Gold Creek Zone Substation	$3.85m	Preferred
3	Non-Network	Demand side management and embedded generation	N/A	Not preferred as does not meet need
4	Non-Network	Grid Battery to defer or avoid Option 1	$6.31 - $10.61m	Not considered a commercially viable option and therefore not credible

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.

Option 3 considers non-network initiatives including:

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

To defer the Valley feeder to the next regulatory control period (beyond 2024), it is estimated that non-network solutions would need to cater for a maximum demand of at least 7.6 MVA.

Latent demand management within the existing customer base was investigated, with a maximum estimated capacity of 1.62 MVA, if all non-network options were implemented including customer-owned embedded generation, energy storage and voluntary load curtailment. This does not meet the required capacity to enable the new feeder to be deferred.

Option 3 therefore does not meet the need and not preferred.

Option 4 considers grid batteries to either defer or avoid the costs associated with the augmentation in Option 2. While this option has potential future advantages in battery redeployment, this option is not preferred due to it having significantly higher costs than the network options.

Option 2 has the lowest cost and highest NPV and is preferred. Estimated cost is $3.85 million and proposed project completion is by June 2021.

7.8.2 Supply to Strathnairn

This section describes the proposed solution to address the constraint in the Strathnairn district which comprises the extension of existing O'Loghlen feeder in the first instance (to defer the Strathnairn zone substation to the next regulatory period) and the construction of the zone substation and corresponding feeders subsequently as the population and load grow.

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, with minimal available spare capacity.

To meet demand until the Strathnairn Zone Substation is constructed, 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.

With expected 100% penetration of rooftop generation, the network also faces hosting capacity constraints. 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 may include controlling the output and use of rooftop solar PV generation and battery storage systems via in-home demand management systems. These systems may be used to manage the combined load on the feeders. Evoenergy is progressing the pilot project to confirm feasibility of the "behind the meter" battery solution. In addition, Evoenergy intends to explore the installation of the network batteries in collaboration with the ACT Government reversed auction participants. The results may impact the timing of the project. If required, the annual planning report will be updated accordingly.

Estimated cost for extending the O'Loghlen feeder to the Strathnairn development is $3.0 million with proposed completion by June 2022. The project timing has changes assuming the demand management options can be utilised to reduce maximum demand and peak lopping of existing two feeders, Latham, and Macrossan. For further detail on demand management initiatives in the area please see section 9.5.

Future feeders will be installed from the proposed Strathnairn Zone Substation in stages as development and load increases. See section 7.9.4 for additional detail.

7.8.3 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, and proposed development at the University of Canberra are driving residential growth, whereas proposed development of the Belconnen Trades Centre is driving commercial and light industrial growth.

Load is forecast to increase by 2.7 MVA by 2024 and 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 a new 11 kV cable feeders from Belconnen Zone Substation to new load centres	$1.3m	Preferred
2	Non-network	Demand side management	N/A	Not preferred as does not meet need
3	Non-network	Delayed preferred network option using grid battery	$5.5m	Not selected as deferral not economical

Option 1 involves the installation of a new 11 kV cable feeders from Belconnen Zone Substation to the new load centres. The length of the feeder would be approximately 1.5 km.

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

Estimated cost is $1.3 million and proposed project completion is by December 2022.

7.8.4 Supply to Braddon

New 11 kV feeder from City East Zone Substation to Donaldson St by December 2020 to supply new developments in the Canberra City North area. The project timing has changed as the expected development at section 96 Canberra City deferred to 2023. Estimated cost is $2.5 million.

The Canberra City North area, including Braddon and Reid suburbs, is experiencing significant load growth, driven by the ACT Government's Urban Renewal program. This involves the demolition of many old residential buildings and their replacement with multi-storey apartment and commercial buildings. Further redevelopment of existing open carparks to high-rise commercial and residential buildings with basement carparks (e.g. Canberra Centre extension)

Evoenergy has considered 2 options to supply the additional load as follows:

Option	Option type	Description	Cost	Evaluation
1	Network	Construct a new 11 kV cable feeder from City East Zone Substation to Canberra Centre at the corner of Cooyong St and Donaldson St, Canberra City North.	$2.5m	Preferred
2	Non -network	Demand side management and embedded generation	N/A	Not preferred as does not meet need

Option 1 involves constructing a new 11 kV feeder from City East Zone Substation to Canberra Centre at the corner of Cooyong Street and Donaldson Street, Canberra City North. With the proposed network augmentation solution of construct new 11 kV cable feeder from City East Substation to Canberra Centre will fully mitigate the network capacity and unserved energy risks.

Option 2 Considers non-network initiatives including:

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

To defer the Donaldson feeder to the next regulatory control period (beyond 2024), it is estimated that non-network solutions would need to provide a maximum demand of approximately 1.7 MVA per annum.

Latent demand management within the existing customer base was investigated, with a maximum estimated capacity of 0.8 MVA. This does not meet the minimum capacity to enable the new feeder to be deferred

7.8.5 Supply to Pialligo

The maximum demand in the Pialligo area near Canberra Airport is forecast to increase due to commercial development in the area including the Brindabella Business Park, Macquarie Telecom Data Centre, Australian Defence Force expansion, and light industrial development in the Beard Industrial Estate. The maximum demand of the area is forecast to increase by 8 MVA over the next 5 years.

The Pialligo area is currently supplied by the Aero Park feeder from City East Zone Substation, the Airport and Pialligo 11 kV feeders from Fyshwick Zone Substation, and the Dairy North 11 kV feeder from East Lake Zone Substation.

This project proposes two new 11 kV cable feeders to be installed from East Lake Zone Substation. One feeder from East Lake is proposed to the Brindabella Business Park to meet the growing customer demand. The length of the feeder is approximately 3.2 km. The second feeder from East Lake will enable the heavily loaded 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 between Dairy North and Abattoir feeders. Spare conduits will be installed along all new feeder routes to provide for future developments and load growth.

The proposed feeders will inter-tie with existing feeders emanating from Fyshwick and City East zone substations, and thus improve the security of this meshed part of the network.

Other options considered include the installation of additional feeders from Fyshwick Zone Substation, demand management, and a grid battery either to defer or remove the augmentation requirement. The feeders from Fyshwick were excluded due to a high net present cost (compared to the preferred option). Demand management was not considered feasible due to the insufficient existing capacity such that there is a requirement for 60% of new demand to be offset. The grid battery was excluded due to a higher net present cost and the relative certainty of the demand increase (noting grid batteries and other modular solutions deliver a higher options value in the context of uncertain demand).

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	$4.85m	Preferred
2	Network	Construct one new 11 kV feeder from Fyshwick Zone Substation, one new 11 kV feeder from East Lake Zone Substation and link Dairy North and Abattoir feeder.	$4.95m	Not preferred due to higher NPC
3	Non-network	Demand side management	N/A	Not preferred as does not meet need
4	Non-network	Delayed preferred network option using grid battery	$5.0m	Not selected as deferral not economical
5	Non-network	Grid battery only	$16.15m	Not considered to be commercially viable and therefore not a credible option.

7.8.6 Feeders from East Lake Zone Substation to Fyshwick Zone Substation

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/400 mm^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 150 mm diameter PVC conduits exist from East Lake Zone Substation approximately 1.8 km towards Fyshwick. Thus, only 0.9 km would be required to be directional drilled and have conduits installed to Fyshwick Zone Substation.

Estimated cost is $5.51 million. Proposed project completion is by December 2023.

7.8.7 Decommissioning of Causeway 132 kV Switching Station

Please note that this project is initiated and fully funded by the customer and hence timelines are dependent on the customer.

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 the Suburban Land Agency (SLA) has indicated their desire 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/630 mm^2 Cu XLPE) from East Lake Zone Substation through the Jerrabomberra wetlands to Causeway Switching Station to through-joints 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 approximately 1.4 km underground cable connected to approximately 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 approximately 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 35 shows the existing Causeway 132 kV Switching Station.

Figure 35. Causeway Switching Station

The overhead to underground conversion works including decommissioning of Causeway Switching Station will be funded by the project proponent (developer). Approval for the amendment to the original Development Approval (DA) is currently being sought. The original proposed project completion date was December 2020 however, it is likely to change as the timing is driven by SLA development program that is yet to be forecasted in this area.

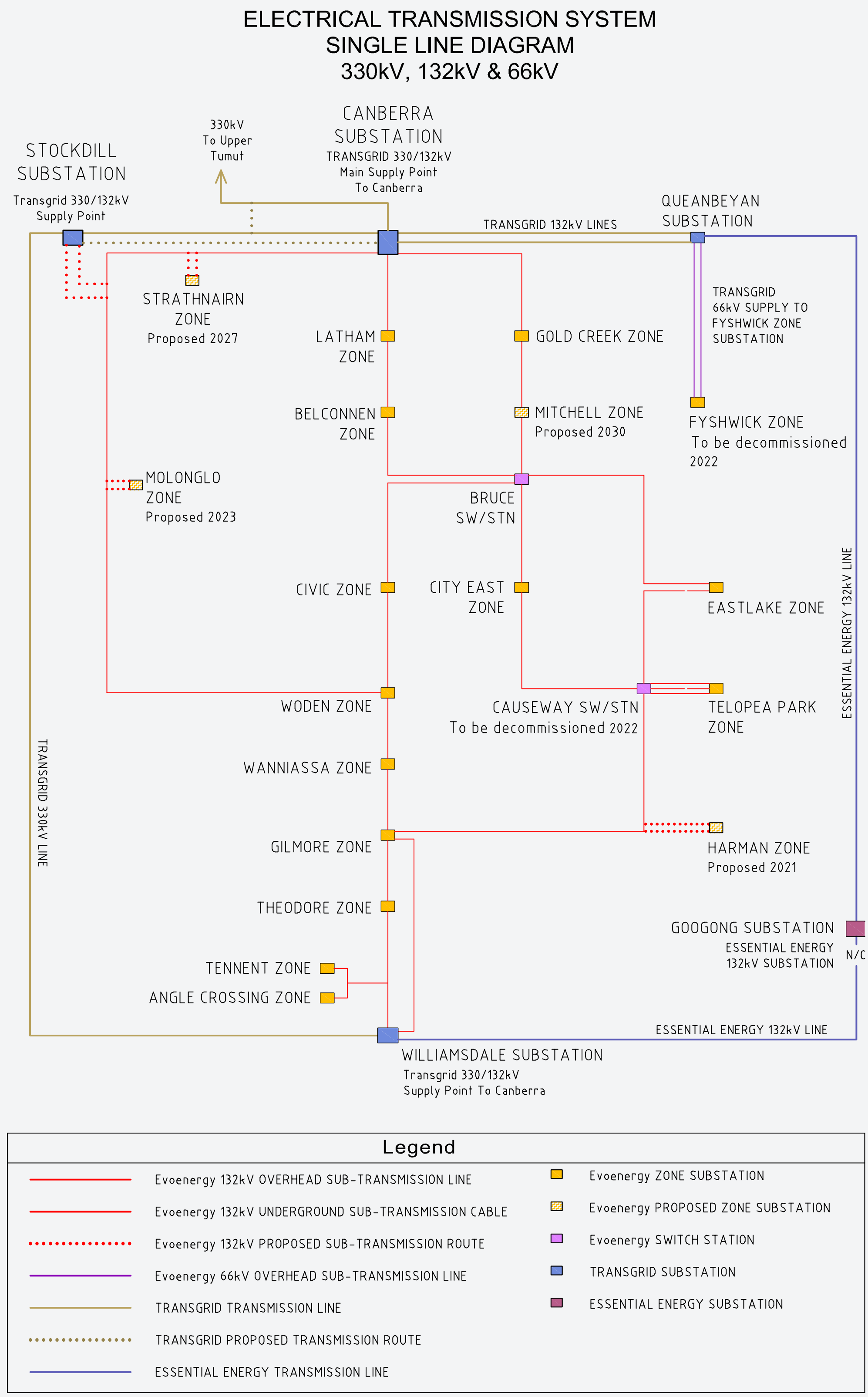
Figure 36 illustrates this proposed development.

Figure 36. Causeway Switching Station – Proposed 132 kV Cabling

7.8.8 Future Transmission Network

Figure 37 shows future development of the transmission network over the next ten years.

Figure 37. Future (10 years) Transmission Network



7.9 Constraints requiring detailed technical studies

7.9.1 Mitchell Zone Substation / Gold Creek 3rd Transformer

The maximum demand in the Gungahlin District is forecast to increase over the next ten 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, medical centre, and other community facilities.

Mitchell is a light industrial and commercial suburb in the Gungahlin District to the east of the Gungahlin Town Centre. Peak demand at Mitchell is also growing rapidly.

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 and insufficient spare capacity in the two nearest zone substations at Gold Creek and Belconnen.

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

Option	Option type	Description
1	Network	Install the 3rd transformer at Gold Creek Zone Substation
2	Network	Construct a new zone substation at Mitchell

Option 1 involves the installation of the 3rd transformer at Gold Creek zone substation to meet the growing demand.

Option 2 involves the construction of a new zone substation at Mitchell, which is closer to the locations of the new industrial loads at Mitchell and new residential areas at Kenny, Throsby, and North Watson.

Option 1 is likely to be the lowest (initial) cost option but will incur high cost in the future due to longer 11 kV feeder runs from Gold Creek and higher electrical losses, which are estimated in the form of Distribution Loss Factor (DLF).

Option 2 is going to cost more initially but subsequent feeder runs will be shorter which results in lower costs and lower electrical losses while also resulting in a network with higher resilience due to more diversified interconnection.

The above table lists two primary network options for augmentation of capacity in the Gold Creek and Mitchell areas. In addition, non-network options will be investigated as part pf the RIT-D process. The rating of the Gold Creek Zone Substation is based on the 2-hour emergency rating of the 132 kV/11 kV transformers. In case, of emergency (network contingency) at the time of maximum demand on the substation part of the load would have to be transferred away from Gold Creek. The current estimated maximum transfer capacity is no more than 18.5 MVA.

7.9.2 Gilmore Zone Substation 3rd Transformer

Evoenergy has identified increased future supply requirements within the Hume district of the ACT. This area contains a mix of commercial and industrial customers, including some medium scale embedded generators. These are currently supplied by Evoenergy's Gilmore Zone Substation.

Gilmore Zone Substation was commissioned in 1987 and contains two 132/11 kV transformers that provide a firm capacity of 45 MVA. The substation has two 11 kV switchboards that supply a mix of industrial and residential loads.

The majority of the industrial and commercial load supplied by Gilmore Zone Substation is located in Hume. Hume is an industrial suburb in the south east of Canberra bordering with New South Wales. According to the ACT Government Territory Plan, industrial land usage within the Hume Industrial estate has been allocated to Precinct 'a' uses, implying provision of land for manufacturing, warehousing and transport related land uses, along with a small local commercial centre. A significant rise in data centre load has driven both a historical and forecast increase in peak demand both in summer and winter.

The existing transformers at Gilmore Zone Substation are in the later part of their projected life. The projected load growth along with the condition of these assets indicates that further consideration must be given to the potential solution. The zone transformer asset condition is considered further in section 6.1.4 – Provisional 132 kV Power Transformer.

The construction of Harman Zone Substation is expected to provide Evoenergy with some opportunity to mitigate anticipated load issues, however this does not resolve concerns with asset condition.

Evoenergy proposes that a detailed study of the load and asset condition is completed in 2021 feeding into a full analysis of options with the proposed project to be published in the 2021 Annual Planning Report.

7.9.3 Contingency voltage support

At the time of writing this report Stockdill was energised on the 330 kV side of the substation and due to be energised in the 132 kV side of the substation in early December 2020.

During joint planning with TransGrid and the design stage of Stockdill bulk supply point the voltage levels in the system under contingency condition were reassessed. Analysis showed that in the event of a total Canberra Substation outage, voltage levels in the northern part of Evoenergy's network could 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.

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.

The scope and sequence of 11 kV 10 MVAr capacitor banks installation is as follows:

- Stage 1 – Latham, Gold Creek and Belconnen
- Stage 2 – Molonglo
- Stage 3 – Strathnairn.

Other options investigated regarding reactive power support devices included a 132 kV 50 MVAr static synchronous compensator (STATCOM). This option is more expensive than 11 kV capacitor banks, however the STATCOM device can also provide voltage support during the daytime (not during contingency) when excess rooftop PV generation in the residential area is causing over-voltage in some parts of the network.

This study must be reviewed due to the increased penetration of distributed energy resources including the large batteries proposed under the ACT Government renewables reverse auction process and other programs.

7.9.4 Strathnairn Zone Substation

When complete, Ginninderry is expected to have approximately 11,500 dwellings. 6,500 of these are proposed to be in the ACT and 5,000 in NSW. Latham Zone Substation is the closest for supply, however distances from Latham Zone to the later stages are expected to result in voltage regulation challenges. Currently there is provision for a new zone substation in the development, known as Strathnairn Zone Substation. Further studies need to be conducted to understand the full range of options available to supply later stages of the development.

7.10 Regulatory Investment Test

Under NER projects above $6 million funded by Evoenergy are subject to regulatory investment test. During the last year Evoenergy underwent one regulatory investment test for the Molonglo Zone Substation as outlined in section 7.6.2. Subject to the outcome of detailed technical studies, currently the network limitations identified during the planning review include two additional limitations which are likely to require regulatory investment test: Gold Creek/Mitchell and Strathairn.

Chapter 8: Demand Management

8.1 Overview

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

Historically, DM has been focused on addressing network constraints resulting from a growth in demand using 'non-network' options. These options are increasingly capable of being leveraged to address additional constraints, such as thermal or quality of supply issues, resulting from increased DER penetration. The drivers of network constraints, including DER, are outlined in Chapter 4 and Chapter 5.

Effective application of DM can defer the need to augment parts of the network to address constraints. This reduces the capital costs of assets and leads to lower costs to customers. Evoenergy intends 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.

We encourage all customers interested in participating in demand management to engage with Evoenergy through the pathways outlined in Chapter 1.

8.2 Demand management challenges

There are a number of challenges for both Evoenergy and proponents of demand management that affect the proliferation of DM within the network. Some of the key challenges for Evoenergy include:

- **Identification of need** – the ability to identify the demand management opportunities driven by factors impacting future network development (as outlined in Chapter 2) with sufficient time to establish a non-network solution. This is especially evident on small-to-medium scale constraints where the timeframe from need identification to implementation is reduced
- **Communication of need** – communicating the constraint and relevant information to proponents in a way that is targeted, timely and effective to enable proponents to engage with DM opportunities
- **Availability of options** – there are a limited number of established DM options that can be deployed in targeted network locations where a localised constraint is identified
- **Commercial considerations** – the implementation of technology-based DM requires robust commercial arrangements where the proponent is satisfied and Evoenergy ensures that risks related to the safe, reliable, and secure management of the network are appropriately managed
- **Regulations** – the regulatory framework restricts Evoenergy's ability to effectively deploy some DM solutions to address network constraints. The review of the framework and associated market rules currently being performed by governing bodies may address these challenges or pose additional regulatory challenges.

Some of the current challenges for proponents of DM solutions include:

- **Cost** – the cost of technology-based DM solutions and establishment remains prohibitive for a number of scenarios, such as community batteries
- **Assurance of Investment** – proponents of DM solutions want to minimise the risk to returns on invested capital. This is difficult with potential changes to market structures occurring in over the medium term[23]
- **Technology** – although technology is evolving rapidly, a number of DM-capable solutions are yet to mature or adhere to common standards required for application. This is expected to change in the near term.

Evoenergy is working to address these challenges and maintaining an awareness of the challenges facing proponents to ensure that the full scale of DM options is addressed against network needs.

8.3 Demand management initiatives

Evoenergy have several existing mechanisms to promote demand management and address key challenges as outlined below:

Need identification

- Planning processes for the distribution network consider non-network options within business cases and project justification reports. This provides assurance that the optimal solution is identified and overall cost benefit impact for both network and non-network options are evaluated
- Proactive engagement with customers in large greenfield estates, such as Ginninderry, have resulted in DM solutions being implemented.

Communication

- Evoenergy has developed a Demand Side Engagement Strategy (DSES) that is published on our website[24]. This strategy outlines the approach to building and promoting constructive working relationship between Evoenergy and non-network solution providers
- Forecast network constraints are published in the Annual Planning Report (Chapter 7)
- Evoenergy maintains a Demand Side Engagement Register[25] where network service providers can register as an interested party
- We maintain direct engagement with major customers to identify and implement DM solutions where required.

Availability of options

- Through arrangements with aggregators the use of virtual power plants to address network constraints is developing wider coverage across the network
- Evoenergy engages in a number of DM innovation projects, as outlined below, to support the development and application of non-network options.

Commercial considerations

- Evoenergy have established contracts with aggregators and is increasingly engaging more proponents in the DER Aggregation program
- Large customers have been engaged under DM contracts to reduce peak demand.

Regulations

- Evoenergy maintains active participation in industry bodies to support advocacy in pursuit of the national electricity objective
- Our network management processes include maintaining visibility of, and responding to, rule change proposals and consultations from electricity governing bodies such as the AEMC, AER and AEMO that address regulatory barriers associated with DM implementation.

These mechanisms are supported by a number of projects demonstrating application of different demand management solutions on the network:

- **Ginninderry Residential Battery Trial –** exploring the DM capabilities of smart residential battery systems in managing local network constraints in this fully electric, 100% solar uptake greenfield developments
- **Molonglo RIT-D –** a greenfield development where load is rapidly approaching network capacity and a battery energy storage system has been assessed as a credible option as a result of the RIT-D process
- **DER Integration and Automation Program –** investigating and testing options to

23 Energy Security Board post 2025 market review http://www.coagenergycouncil.gov.au/energy-security-board/post-2025

24 https://www.evoenergy.com.au/emerging-technology/demand-management/demand-side-engagement

25 https://www.evoenergy.com.au/emerging-technology/demand-management

effectively integrate DER into the energy system and enabling customer utilisation of DER to their full potential
- **Residential maximum demand tariffs –** Maximum demand tariffs were introduced as the default option for new customers in 2017. Uptake has been monitored and will be analysed for resulting DM effects.

Chapter 7 and Chapter 9contain additional details regarding these projects.

8.4 Demand management future

Evoenergy is committed to continue actively seeking to implement non-network solutions to replace or complement the need for network investment where this delivers a lower cost outcome that benefits all customers.

In addition to the existing mechanisms Evoenergy is currently employing to develop our interaction with customers and DM proponents, we are aiming to:

- Enhance our publication of network constraint reporting by developing our ability to identify network constraints, including those originating from DER, and publish these to proponents
- Grow our DER aggregation program both by supporting customer uptake of DER and by engaging DER aggregators to provide DM and data services. Under the Next Generation Energy Storage program (Next Gen)[26], the ACT Government is supporting up to 5,000 battery storage systems in ACT homes and businesses. To be eligible for the program, battery systems are required to have the capability to send real-time data to the ACT Government. This is usually achieved through capabilities provided by a DER aggregator. Evoenergy is actively engaging with Next Gen providers with the intention of growing the Aggregation program by procuring data and DM services, especially in areas where a network need is identified
- Invest in, prepare for, and leverage future technologies. Through strategic initiatives and innovation projects, Evoenergy is ensuring that the DM opportunities presented by these technologies are effectively leveraged to manage network constraints. Additional detail regarding current innovation projects is included in Chapter 9
- Further advocacy and engagement with stakeholders. Evoenergy is proactively engaging with local government to identify upcoming DM opportunities such as land releases, urban infill incentive schemes and changes to government policies.

Evoenergy aims to utilise the outcomes from these activities to develop a DM toolkit that supports existing planning and operational processes to facilitate the application of DM on the network.

26 https://www.actsmart.act.gov.au/what-can-i-do/homes/discounted-battery-storage

Chapter 9: Future ways of working

9.1 Overview

The generation, transmission and distribution of electrical energy are changing rapidly with new advances in technology. These advances are impacting all parts of the supply chain and are offering opportunities for us to change the way we design, construct, and manage the Evoenergy network. This chapter provides additional detail for the key activities we have undertaken to leverage technology and provide benefit our customers in support of Evoenergy's business strategy and strategic initiatives.

9.2 Substation Automation Systems – IEC 61850

As outlined in Chapter 2, Evoenergy is currently working on upgrading the substation automation systems for numerous Zone Substations across the ACT. These systems will utilise the latest industry developments in protection and SCADA technology and will be based on the IEC 61850 international standard. The IEC 61850 standard provides tools which assist in the implementation of substation automation systems including communications protocols that allow Intelligent Electronic Devices (IED) such as protection relays to exchange high speed messages and standard data structures that allow IEDs from different vendors to be easily integrated.

The IEC 61850 approach provides many benefits over a conventional approach including:

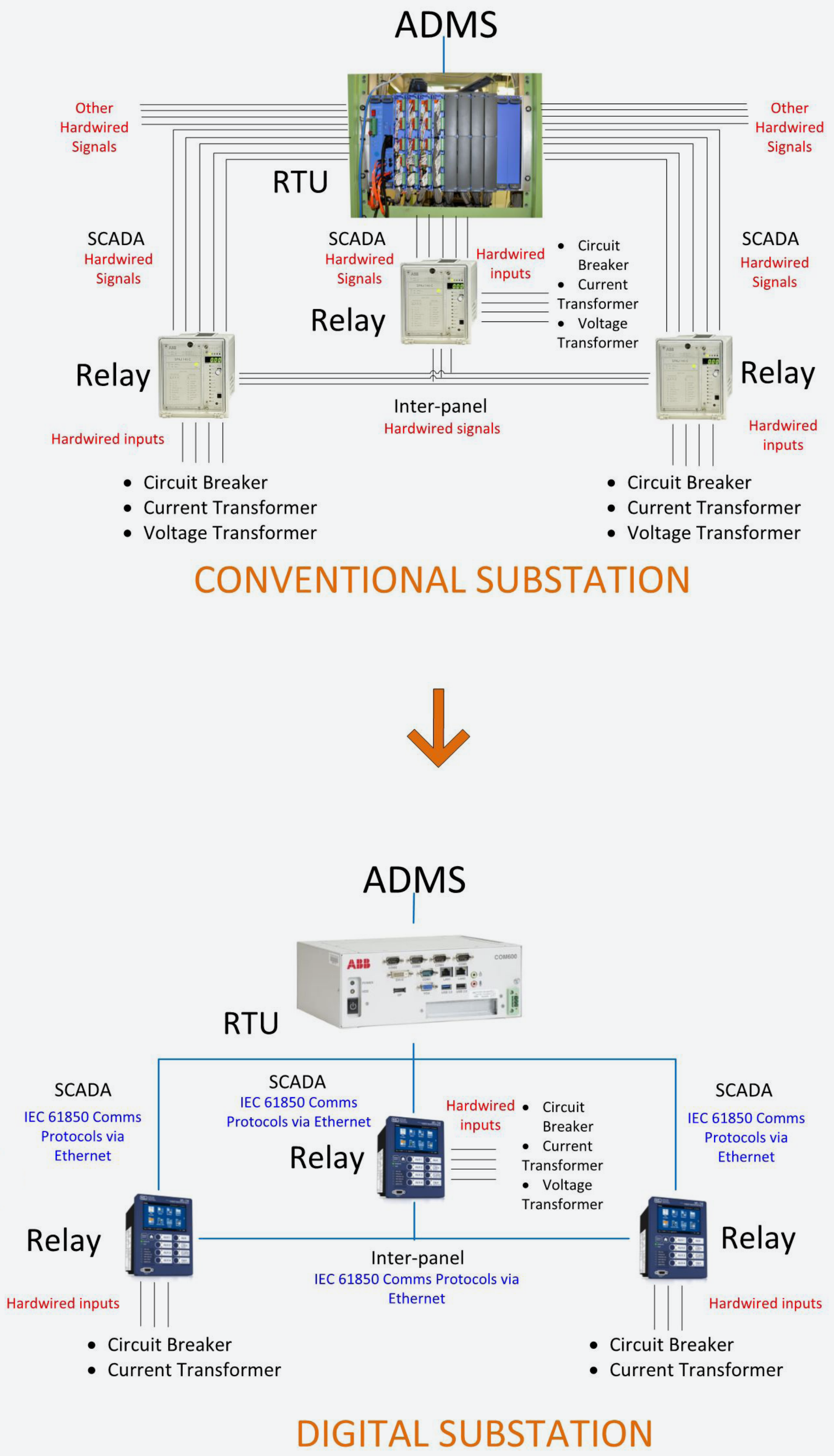
Safety benefits

- Reduced requirement for DC wiring in protection panels. Communication between IEDs (Intelligent Electronic Devices) within the substation utilise fibre optic ethernet networks rather than hardwiring
- Increased visibility and reporting on communications and overall system health
- Additional controls to avoid errors during testing and maintenance activities.

Financial benefits

- Reduced material costs due to less hardwiring
- Reduced design time due to simplified drawings and schematics
- Reduced engineering time due to standard file types and templates (defined by the IEC 61850 standard)
- Greater flexibility and reduced cost in upgrading existing schemes – existing IEDs within the substation can be updated/reconfigured with software rather than having to run additional physical wiring or introduce new devices
- Greater support and system longevity as vendors and other DNSP/TNSPs are also moving towards modern digital substation approaches utilising IEC 61850.

The following diagram provides a simplified overview of the differences between Evoenergy's conventional approach compared to our new digital approach utilising IEC 61850.


ADMS
RTU
Other Hardwired Signals
Other Hardwired Signals
SCADA Hardwired Signals
SCADA Hardwired Signals
SCADA Hardwired Signals
Hardwired inputs
• Circuit Breaker
• Current Transformer
• Voltage Transformer
Relay
Relay
Relay
Hardwired inputs
Inter-panel Hardwired signals
Hardwired inputs
• Circuit Breaker
• Current Transformer
• Voltage Transformer
• Circuit Breaker
• Current Transformer
• Voltage Transformer
CONVENTIONAL SUBSTATION
ADMS
RTU
SCADA IEC 61850 Comms Protocols via Ethernet
SCADA IEC 61850 Comms Protocols via Ethernet
SCADA IEC 61850 Comms Protocols via Ethernet
Hardwired inputs
• Circuit Breaker
• Current Transformer
• Voltage Transformer
Relay
Relay
Relay
Hardwired inputs
Inter-panel IEC 61850 Comms Protocols via Ethernet
Hardwired inputs
• Circuit Breaker
• Current Transformer
• Circuit Breaker
• Current Transformer
DIGITAL SUBSTATION

9.3 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' bushfire prone areas.

Evoenergy identified two sites on the end of long rural feeders to install Remote Area Power Supplies (RAPS). The first is the Gudgenby Homestead and Cottage at the end of the Matthews feeder, and the second is at Corin Dam, which is at the end of the Reid feeder. Installing RAPS systems at the end of these feeders enabled Evoenergy to decommission 16.5 km of bushfire zone overhead 11 kV lines.

The RAPS systems consist of solar PV system, battery energy storage, a back-up generator and energy efficiency improvements.

Gudgenby Homestead and cottage

The property sits within the Namadgi National Park and is owned and operated by the ACT Department of Parks, Conservation and Lands (ACT Parks). Supply to this site was via a 7 km overhead 11 kV line that ran through a bushfire prone area and required significant maintenance. Evoenergy has decommissioned this section of the line and is now sourcing the power from an 18 kVA RAPS system.

There is still 0.3 km of overhead line allowing a single RAPS system at the homestead to delivery power to the cottage.

Photo: Gudgenby Homestead before and during RAPS installation

Corin Dam

Corin Dam is at the end of a 9.5 km section of three phase overhead 11 kV line (Reid feeder) which runs through bushfire prone areas in the Namadgi National Park. The site contains pumping facilities owned by Icon Water and a rangers' house owned by ACT Parks. A remote area power supply was installed at this location in 2019.

Photo: Corin Dam

Summer bushfires 2020

During the summer of 2020, the Orroral Valley bushfire devastated the Namadgi National Park. During these fire pole and lines leading to both these RAPS systems were damaged by the fires however because the RAPS were installed no remedial action was required to replace or repair these assets and some assets were able to be decommissioned as a result. The retirement of these lines is referenced in 6.1.3.

There are no further RAPS planned as part of the immediate program of work, however Evoenergy has established the methodology to assess the application of RAPS for other sites that meet the economic or risk criteria.

9.4 Advanced fault detection and auto-reclosing schemes

Electricity distribution networks inherently involve bushfire risk to the environment and the community. Evoenergy is trialling a new type of switchgear primarily to reduce the risk of bushfires. Our bushfire management plan includes trailing this new type of switchgear to reduce bushfire risk on overhead distribution lines traversing high bushfire risk areas.

This trail includes installation of pulse closing S&C 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 grassfire or bushfire. This is a risk to the community especially during extremely dry summer months.

This technology 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 and the switchgear supplier have jointly developed a Voltage supervised Sensitive Earth Fault (V-SEF) protection "bushfire algorithm" that will detect very low energy earth faults to isolate and clear such faults. Such faults are typically caused by vegetation contacting overhead conductors and can cause localised heating that could lead to a bushfire.

In addition, a series of reliability improvement projects are being undertaken which would involve installing the new NOJAs reclosers on feeders subjected to high frequency of fault occurrences.

9.5 Virtual Power Plants (VPPs)

A Virtual Power Plant (VPP) 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 into a Distribution System Operator (DSO) it will need to either develop new tools internally or integrate with external experts.

Evoenergy have undertaken a number of VPP trials under an agreement with an external aggregator. The trials attempted to control the capabilities of solar PV generation and battery storage to dispatch when energy demand requirements on the Evoenergy network are at their maximum, typically on extremely hot or cold days. The VPPs were also used to investigate innovative techniques to value add to the functionality of the DER in the network to manage power quality issues that end users, the customers, were reporting.

In the past year, the fleet of DER available for VPP operations has increased by 30% as additional customers in the ACT opted for solar and battery solutions at their residences. This meant Evoenergy has a wide array of devices and combinations of inverters and batteries to test the functionality of network support from customer residences and observe the typical usage pattern of the customers based on the data reported back from the devices. The fleet is expected to continue increasing in the future.

Evoenergy is using the lessons gained from aggregator operations to form the basis of targeted network trials to leverage DER/VPPs to tackle the upcoming challenges for the local network. Evoenergy's approach is to transition the trial to business-as-usual based on the amount of DER installed in areas network where they can help alleviate network constraints. VPP trials are expected to continue to run in parallel with as the DER and VPP space is evolves, both from regulatory and market design perspectives.

9.6 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 obtained *a Territory Plan Waiver from the ACT Government's Environment, Planning and Sustainable Development Directorate (EPSDD)* 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 solar PV systems.

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 solar 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. This can be done through Demand Management (DM) aggregators who can install Home Energy Management Systems (HEMS) at the residences who can integrate with Evoenergy for network services. Evoenergy intends to partner with ACT Government to utilise the *Next Gen Battery Scheme* to maximise the uptake of battery powered systems to trial for the energy pilot in conjunction with the HEMS devices. In line with this objective, in September 2020, Evoenergy received a grant from the ACT Government under the Renewable Energy Innovation Fund (REIF) for the Ginninderry Residential Battery Trial. This grant is being used to provide further subsidies for residential batteries in Stage 1A of the development, in addition to the Next Gen Battery rebates. The Trial is aimed at exploring how HEMS enabled residential battery systems can be leveraged to manage the local network in this fully electric, 100% PV penetration scenario.

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. Stage 1 of Ginninderry has been developed by installing automatic On-Load Tap Changer (OLTC) substations and other combinations of technologies are to be trailed 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, the 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. Evoenergy considers optimum network and non-network solutions for Ginninderry development and from the network capacity limitations perspective it is also discussed in Chapter 7.

9.7 DER Integration and Automation Project

The DER Integration and Automation project is investigating and testing options for how DER can effectively integrate into the energy system and how they can be used by customers to their full potential. The project demonstrates how collaboration between a Distributed Energy Resources Management System - DERMS (Schneider Electric's DERMS) and a DER marketplace (GreenSync Decentralised Energy Exchange - deX) platform can unlock existing network hosting capacity to enable consumers gain more value from their energy assets such as solar, batteries and electric vehicles. The project is co-funded by the Australian Renewable Energy Agency (ARENA) with Evoenergy as the lead party on the project along with partners including Schneider Electric, GreenSync, and Withywindle (knowledge sharing partner).

The goal of the project is to utilise DER for avoiding upstream capacity constraints and hence defer the need for grid augmentation investment and at the same time optimise grid capacity to host more DER. This is done by validating proposed schedule of aggregated DER, a virtual power plant (VPP), and to resolve predicted issues resulting from their operations.

9.8 Innovation projects

In addition to the targeted activities outlined above, Evoenergy is currently engaged in several additional innovative projects that will help shape the future working and operation of our business. These projects are in conjunction with universities, private enterprises, retailers, and other network providers who are investigating options to maximise the consumer benefit of the existing infrastructure while unlocking the value generated by our customers. These projects enhance the capabilities of Evoenergy to transition into a Distribution System Operator (DSO) in line with our strategy.

Table 17 outlines some of the key projects we are currently involved in and their proposed timing.

Table 17. Innovation Projects

Innovation Projects	Timing	Details	Website
Realising Electric Vehicle to Grid Services (REVS)	2020- 22	Demonstrate the economic, technical, and social case for leveraging V2G (Vehicle to Grid) services within the electricity grid, and reduce the complexity and confusion for consumers, business, and policy decision-makers. The deployment of the systems and capabilities outlined by the project, as well as the research and analysis from all parties will provide the roadmap for accelerated V2G adoption both in ACT and nationally	Link
DER Lab Project	2019- 22	Establish a test facility at the Australian National University to allow for safe testing of new DER-based technologies, market participation software and other innovative new products under development.	Link
Community Energy Models	2019- 21	Investigate community energy models, where distributed generation, storage and load are not co-located behind a single metered, connection point. Through this work, the project aims to provide the basis for greater adoption and deployment of community energy models both in Australia and around the world.	Link

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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
DDRN	Digital data radio network
DER	Distributed Energy Resource
DM	Demand Management
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
ECRC	Energy Consumers Reference Council
ENA	Energy Networks Australia
EOI	Expression of Interest
FCAS	Frequency Control Ancillary Services
FLISR	Fault Location, Isolation and Supply Restoration
HMI	Human Machine Interface
HV	High voltage
ICRC	Independent Competition and Regulatory Commission
MVA	Mega Volt Amperes

Term	Definition
MW	Mega Watts
NPC	Net Present Cost
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
NPV	Net Present Value
NSCAS	Network Support and Control Ancillary Services
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
PoE	Probability of Exceedance
PoW	Program of Works
PV	Photovoltaic
QOS	Quality of Supply
RAPS	Remote Area Power Supply
RDSE	Register of Demand Side Engagement
REZ	Renewable Energy Zones
RIT-D	Regulatory Investment Test for Distribution
RIT-T	Regulatory Investment Test for Transmission
RTU	Remote Terminal Unit
VPP	Virtual Power Plant
ZSS	Zone Substation

Appendix B: Network physical characteristics

In addition to the overview provided in Chapter 2, this Appendix provides more details describing Evoenergy's transmission and distribution network including capacity , security and ratings of the zone substations, transmission lines, and the number of key assets.

Configuration of Evoenergy's network

The Evoenergy network is supplied from TransGrid NSW network through three bulk supply points. A fourth bulk point, Stockdill substation is currently under construction by Transgrid.

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 four bulk supply points supplying the Evoenergy network, all owned and operated by TransGrid Limited as follows:

- Canberra 330/132 kV bulk supply substation
- Stockdill 330/132kV 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, 22/0.400 kV and 11/0.400 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.

With the planned decommission of Fyshwick Zone Substations, the Queanbeyan Bulk Supply point no longer supply ACT and Evoenergy's 66 kV lines will become obsolete.

A second power transformer was commissioned at East Lake zone substation in November 2019. Tennent zone substation has one permanent power transformer supported by the temporary mobile substation deployed at the adjacent Angle Crossing zone substation. All other zone substations have two or three power transformers, providing some redundancy based on 2-hour emergency rating. In a case of network N-1 contingency such as a transformer outage, Evoenergy would allow remaining transformer(s) to be loaded up to their 2-hour emergency rating for a limited time.

There are currently 260 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. 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) software. 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.

Approximately 58% of Evoenergy's distribution network and 2% of the transmission network is underground.

The network supplies around 204 000 electricity customers. There are 34 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). 11kV / 400 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.

Electrical energy consumed in the ACT is generated mainly outside the ACT and enters via TransGrid's transmission network. However, increasing proportion of demand is being satisfied form internal sources.

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

Chapter 2 includes transmission schematics and geographic representation of the Evoenergy transmission network.

System supply security

Supply is secure when the system capacity is sufficient to cater for the existing and forecasted demand.

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.

There is one 66 kV bulk supply point and three 132 kV bulk supply points interconnecting Evoenergy network to NSW network.

The three 132 kV bulk supply points are Canberra Substation, Stockdill Substation, and Williamsdale Substation. The 66 kV bulk supply point is located at TransGrid's Queanbeyan Substation.

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.

Any imbalance between generation and load in the electricity transmission grid will result in abnormal variations in system frequency. As the majority of generation and bulk transmission is located externally to the ACT, system frequency is not controllable 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. To meet this requirement, Evoenergy has implemented automated under frequency load shedding (UFLS) systems at zone substations.

A summary of Evoenergy's major network assets is shown Table 18.

Table 18. Evoenergy Network Assets

Asset Type	Nominal Voltage	Quantity
Bulk Supply Points[27]	330/132 kV	2
	132/66 kV	1
Transmission Lines	132 kV	190 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	13 (+ 1 mobile substation)
	66/11 kV	1
Power transformers	132/11 kV	30
	66/11 kV	3
Feeders	22 kV	2
	11 kV	260
Distribution Substations	22 kV/400 V	10
Distribution Substations	11 kV/400 V	4,668
Distribution Switching Stations	11 kV	342
Number of transmission towers and pole structures	132 kV	1,426
	66 kV	52
Number of poles	22 kV, 11 kV and 400 V	48,896
Circuit km of distribution overhead lines	22 kV, 11 kV and 400 V	2,162 km
Circuit km of distribution underground cables	11 kV and 400 V	3,118 km
Number of customer connections	22 kV	2
	11 kV	34
	400 V / 230 V	202,513
Coverage area		2,358 km^2
System maximum demand		635 MW

27 At the time of writing this report Stockdill was yet to be energised on the 132 kV side so has not been added to this quantity.

Ratings of zone substations and transmission lines

Zone substation ratings

Evoenergy operates the thirteen 132/11 kV zone substations and one 66/11 kV substation.

Table 19 summarises the total capacity and firm capacity for each substation including the year of commissioning. The firm capacity refers to the capacity of the substations available after a single credible network contingency event (e.g. usually an outage of one of the power transformers)

Table 19. 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	169 MVA	112 MVA	3
Civic	1967	132/11 kV	165 MVA	110 MVA	3
East Lake	2013	132/11 kV	110 MVA	55 MVA	2
Fyshwick	1982	66/11 kV	70 MVA	45 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

Additional notes on zone substation ratings:

In addition to the ratings listed in Table 19, for network planning and operations, Evoenergy is using 2 hour emergency rating of the transformers. 2-hour emergency rating refers to the estimated level of electrical load which transformer could supply for up to two hours.

Transmission line ratings

Evoenergy currently operates a number 132 kV lines and two 66 kV lines. Table 20 list continues rating and emergency rating of Evoenergy lines.

Table 20. Evoenergy Transmission Line Ratings

LINE			CURRENT RATING (AMPS)			
			Summer Day (35°C ambient temperature)		Winter Day (15°C 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
Wanniassa	Woden	A-40	1990	3002	2586	3374
Angle Crossing Tee	Theodore	97H/2	968	1458	1257	1638
Angle Crossing Tee	Williamsdale	97H/1	1934	2916	2514	3277
Angle Crossing Tee	Tennent Tee	97H/3	968	1458	1257	1638
Angle Crossing	Tennent Tee	97H/4	968	1458	1257	1638
Tennent	Tennent Tee	97H/5	968	1458	1257	1638
66 kV						
Fyshwick 1	Queanbeyan 1	0844	583	865	750	970
Fyshwick 2	Queanbeyan 2	0845	583	865	750	970

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
- Gas, including bio-gas (from land fill sites)
- Micro hydro.

Capacities of these EGs vary from domestic solar PV systems of typically 5-10 kW to a 20 MW solar PV farm. The total installed capacity of embedded generation is approximately 201.85 MW as of 30 June 2020. Of this 145.2 MWs are Micro and Low Voltage (small-scale and medium scale) rooftop solar PV, and the remainder is a mixture of High Voltage (large scale) solar, hydro and gas.

There are some small embedded generation facilities in the ACT, the largest being the Royalla Solar Farm at Royalla which has a maximum output of 20 MW. Mugga Lane Solar Park at Mugga Lane in 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 116.2 MW of installed residential rooftop photo-voltaic (PV) generation capacity consisting of around 28766 installations as of 30 June 2020. This represents approximately 25% of residential dwellings. 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. Several residential developments mandated use of PV generation, resulting in 100% penetration.

The table below summarises data for connection enquiries and connection applications.

PV installations – number of enquiries, number of applications and time to process applications; FY 2019 – 2020

Installation Size	Number of Enquiries	Number of Applications	Average timeframe to process connection application (days)
< 5kW Basic Micro	N/A*	2517	<5
< 30kW Complex Micro	N/A*	2272	8.04
> 30kW Low Voltage and High Voltage	68	82	78.01

*N/A – not applicable

To date there are approximately 1500 domestic battery systems connected beyond-the-meter and no battery storage systems connected directly to the Evoenergy distribution network. However, large systems are actively being considered.

PV generation is unpredictable due to intermittent cloud cover. It is difficult to forecast availability and output accurately which makes it difficult to account for in network planning. However, research is currently being undertaken to correlate weather forecast information more closely with solar generation to provide a degree of forecasting capability in real time.

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 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.

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

Appendix G –provides further information on power quality issues associated with embedded generation.

Figure 38. Distribution of domestic rooftop solar PV installations throughout the ACT.

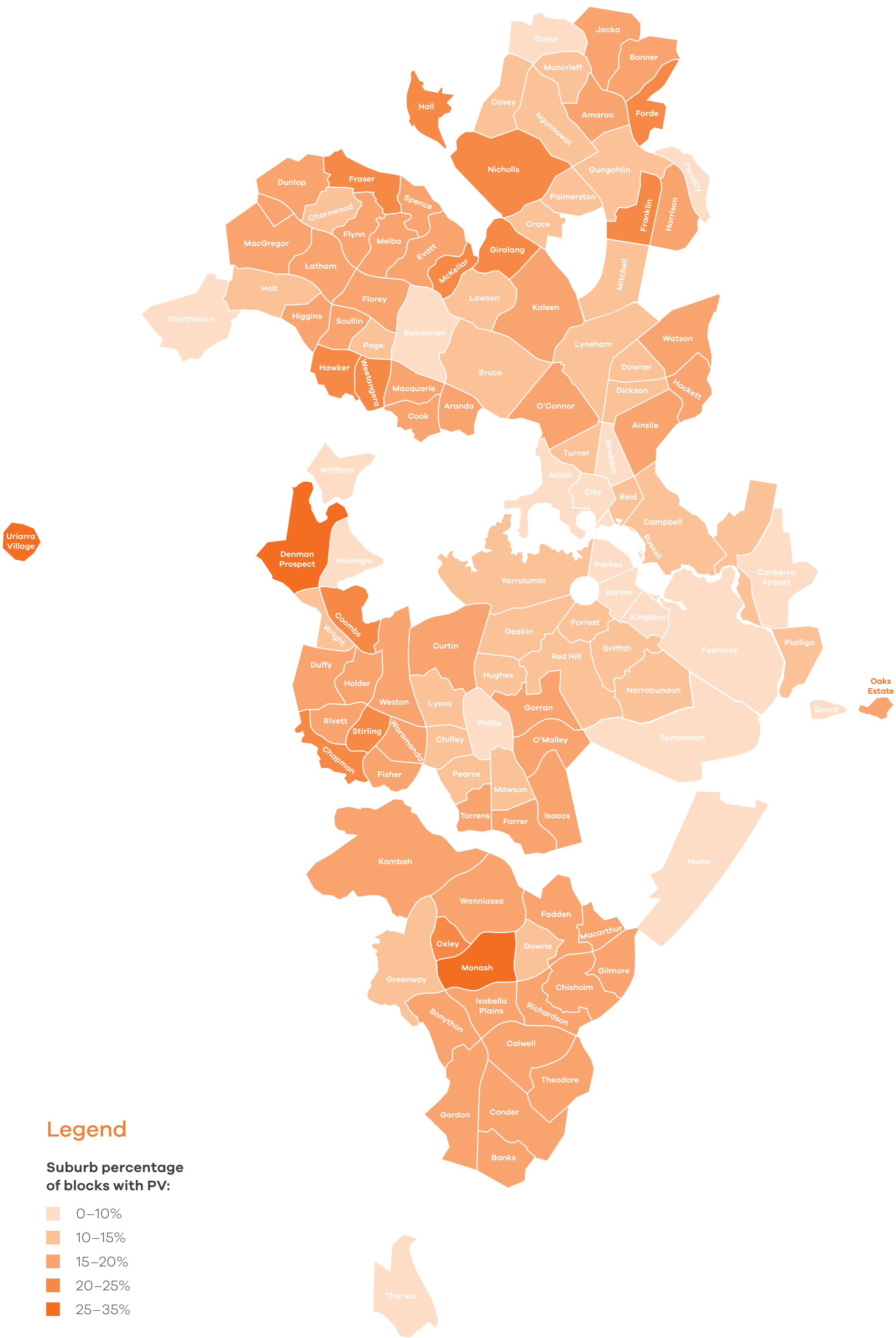

Table 21. Rooftop solar PV generation (Micro and LV) installations by feeder as of 30 June 2020

Zone Substation / Feeder	No. of Sites	Installed Capacity (kW)
BELCONNEN	**2,447**	**10,368**
Baldwin-Joy Cummins	354	1,437
Battye	1	5
Benjamin-Laurie	299	1,117
Cameron South	28	88
Chuculba	218	919
Eardley	69	264
Haydon	133	587
Maribyrnong	45	333
Mcguiness-Bellbird	195	863
Meacham-Bean	424	1,832
Shannon	261	1,021
Swinden-Lampard	86	425
William Slim	334	1,478
CITY EAST	**1,922**	**10,464**
Braddon	2	95
Chisholm	118	556
Constitution	9	111
Cowper	104	410
Duffy	180	780
Ebden	305	1,139
Electricity House	3	45
Fairbairn	5	25
Ferdinand	179	767
Haig	27	252
Ijong	16	85
Mackenzie	423	3,326
Masson	9	103
Northbourne	9	99
Quick	21	118
Stott	275	1,056
Wakefield	127	1,026
Wolseley	110	472
CIVIC	**1,273**	**5,674**
Belconnen Way North	180	752
Belconnen Way South	279	1,076

Zone Substation / Feeder	No. of Sites	Installed Capacity (kW)
Black Mtn	180	732
Dryandra	267	1,153
Hobart Long	2	55
Hobart Short	4	150
McCaughey	47	294
Miller	274	1,210
Nicholson	40	251
EAST LAKE	79	1656.839
Dairy North	16	301
Dairy South	20	506
Isa	26	553
Lyell	17	298
FYSHWICK	132	2425.15
Abattoir	25	484
Airport	8	540
Barrier	29	389
Domayne	11	199
Gladstone	7	148
Tennant	37	310
Whyalla-Pialligo	15	356
GILMORE	1,473	7,495
Alderson	32	758
Beggs	114	478
Edmond	206	837
Falkiner	117	759
Findlayson	192	835
Jackie Howe	203	820
May Maxwell	187	723
Monaro	2	20
Penton-Willoughby	223	1,034
Rossman	176	779
Tralee	21	453
GOLD CREEK	4,654	22,779
Anthony Rolfe	148	1,163
Barrington	515	2,266
Birrigai	333	1,610
Ferguson	451	1,650
Gribble	105	1,431

Zone Substation / Feeder	No. of Sites	Installed Capacity (kW)
Gungahlin	35	574
Hamer	411	1,792
Lander	333	1,342
Lexcen	284	1,222
Ling-Hughes	287	1,106
Magenta-Boulevard North	152	1,182
Nona	310	1,251
Riley	145	954
Saunders	395	1,873
Wanganeen-Bunburung	200	917
Wellington-Gurrang	201	910
West	349	1,536
LATHAM	4,818	20,431
Bowley	325	1,485
Conley	155	639
Copland	192	688
Elkington	217	904
Fielder	62	503
Florey	418	1,561
Homann	245	1,137
Latham	281	1,185
Lhotsky	568	2,145
Low Molonglo East	48	160
Low Molonglo West	90	729
Macrossan	245	949
Markell	291	1,286
Melba	204	866
O-Loghlen	263	1,062
Paterick	143	792
Powers	156	596
Seal	236	946
Tillyard	234	984
Verbrugghen	169	712
Weir	276	1,101
TELOPEA PARK	1,276	7,387
Blackall	4	80
Cunningham	306	1,226
Empire	181	898

Zone Substation / Feeder	No. of Sites	Installed Capacity (kW)
Forster	83	503
Giles	22	94
Jardine	6	29
KF1	32	262
King Edward + Belmore	46	476
Kurrajong	2	33
Monash	15	85
NSW Cres	27	439
Ovens	25	162
Power House	102	651
Queen Victoria Terrace	4	80
Riverside	1	25
Strzelecki	105	451
Sturt	123	675
Telopea Park East	7	118
Throsby	185	1,100
THEODORE	**2,458**	**10,254**
Banyule	265	984
Callister	440	1,787
Chippindall	293	1,283
Eaglemont	385	1,619
Fairley	262	1,107
Lawrence Wackett	255	1,053
Lethbridge	202	1,052
Morison	230	874
Templestowe	126	495
WANNIASSA	**4,668**	**19,353**
Ashley	197	797
Athllon	236	880
Bissenberger-Hawkesbury	501	2,031
Brookman	195	966
Conolly	179	708
Fincham	7	42
Gaunson	143	614
Gouger	132	553
Grimshaw	386	1,261
Hawker-Pridham	268	1,083
Hemmings	167	706

Zone Substation / Feeder	No. of Sites	Installed Capacity (kW)
Lambrigg	115	536
Langdon	237	975
Longmore	280	1,143
Mannheim	177	750
Marconi	228	1,073
Matthews	374	1,094
Muresk	309	1,358
Pitman-Rowland	8	75
Reid	277	1,208
Sainsbury	113	498
Sternberg	1	276
Symers	138	728
WODEN	**4,463**	**20,820**
Bunbury	356	1,554
Carruthers	233	1,168
Cooleman	162	671
Corinna	3	30
Cotter 11 kV	342	1,779
Curtin North	234	1,395
Daplyn	198	749
Deakin No 1	112	451
Deakin No 2	82	476
Devonport	54	339
Easty	4	100
Follingsby	279	1,428
Hilder	334	1,568
King	21	350
Launceston	3	83
Lyons West	373	1,253
McInnes	190	800
Phillip North	8	115
Phillip South	1	3
Streeton	700	2,980
Theodore	188	973
Tidbinbilla 22 kV	4	45
Weston East	222	871
Wilson	268	1,146
Yarralumla	92	493

Hydro-electric and gas

There is an existing micro-hydro generator connected to the Evoenergy network, the Stromlo micro-hydro which has a peak output capacity of 630 kW. This is connected to Woden Zone Substation via a shared 11 kV feeder.

There is currently one operating bio-gas, and one gas fuelled generator site connected to the Evoenergy network

The bio-gas generator is located at Mugga Lane Waste Transfer Station. This 5 MVA generator is connected to Gilmore Zone Substation via a shared 11 kV feeder. There are two gas generators at Canberra Airport with a total generation capacity of 2.9 MVA. These are connected to Fyshwick Zone Substation via a shared 11 kV feeder.

Appendix C: The regulatory framework and operating environment

Section 2.3 provides an overview of Evoenergy regulatory environment. This appendix includes additional commentary on Evoenergy as a regulated entity.

The National Energy Market (NEM) physical infrastructure comprises both government owned and private assets managed by participants. The NEM includes operation of physical infrastructure including national grid and the operation of energy market. The market uses sophisticated algorithms to dispatch generation according to demand, network capacity, network availability, energy price, and available generation capacity.

Evoenergy is a Registered Participant in the NEM. Evoenergy is registered as the Distribution Network Service Provider (DNSP) and Transmission Network Services Provider (TNSP). The networks are regulated entities. The regulated entities within NEM are ring-fenced from the competitive market to ensure that the competition is not distorted either through cost transfer or some competitors gaining unfair advantage. Day to day operation of NEM is managed by the Australian Energy Market Operator (AEMO) with the oversight of wholesale generation, dispatch, and transmission of electricity in Queensland, New South Wales, South Australia, Victoria, the ACT and Tasmania. AEMO manages NEM in line with the *National Electricity Law* (NEL) and the *National Electricity Rules* (NER).

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

The economic regulation within NEM is managed by the Australian Energy Regulator (AER) in accordance with the NER, and procedures and guidelines developed under NER. Every five years, after detailed review, the AER which determines the revenue allowance which Evoenergy is allowed to earn in the following five years.

The Australian Energy Market Commission (AEMC) is the rule making body which administers National Electricity Rules, consults on proposed changes with the NEM participants and publishes the changes. Some obligations relating to consumers are covered in the National Energy Retail Rules and National Energy Retail regulations under the umbrella of National Energy Customer Framework (NECF).

Evoenergy is a holder of the distribution licence in the Australian Capital Territory which was granted by the Independent Competition and Regulatory Commission (ICRC). The ICRC also monitors compliance with the licence conditions. The licence is granted under *Utilities Act (2000) ACT*. More detailed requirements under the act are covered in the industry codes, such as the Consumer Protection Code which includes Guaranteed Service Levels and the corresponding penalties which are applicable if Evoenergy performance falls below the stated levels. The Code is administered by the ICRC.

The ACT Technical Regulator's 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's Technical Regulator. *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.

The paragraphs below provide a brief description of key regulatory artefacts relevant to network planning and asset management.

National Electricity Rules

The NER covers a broad range of economic, technical, and legal obligations which NEM participants must comply with. From the network planning perspective, *NER Chapter 5* and *Chapter 5A* describe the main requirements 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.

Electricity Distribution Supply Standards Code

The *Electricity Distribution Supply Standards Code* sets out technical 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.

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.

Regulatory Investment Test

Clause 5.16 of the NER describes the Regulatory Investment Test for Transmission (RIT-T) and *clause 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 $6 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 including non-network alternatives without bias.

Incentive schemes

Service Target Performance Incentive Scheme

Evoenergy is subject to the AER's *Service Target Performance Incentive Scheme (STPIS)*.

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 response to consumer outages. STPIS achieves this by rewarding network businesses that outperform their targets or by penalising network businesses that do not.

The AER applied the STPIS to Evoenergy for the 2019-24 regulatory control period. The AER set the targets based on the Evoenergy's reliability performance for the previous 5 years. The value of annual incentive is capped at 5% or revenue. The estimated monetary value of reliability is a based on economic value of reliability to customers as approved by the AER.

For full details of the STPIS refer to the *AER Electricity Distribution Network Service Providers - Service Target Performance Incentive Scheme Guideline v2.0 - 13 December 2018 (STPIS Guidelines)* and AER determination for Evoenergy for the 2019-24 period available from the AER website.

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.

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. 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.

For further detailed discussion on performance metrics relating to reliability refer to Chapter 4. In addition to reliability performance, the scheme also includes the customer service performance measure based on the customer call centre telephone answering times.

Capital Expenditure Sharing Scheme

Evoenergy is subject to the AER's *Capital Expenditure Sharing Scheme (CESS)* administered by the Australian Energy Regulator.

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.

Consumers generally benefit from improved capital efficiency through lower regulated prices. Under the CESS, a service provider retains 30% of any underspend or overspend while consumers retain 70% of underspend or overspend. This means that for a one dollar saving in capex, the service provider retains 30 cents of the benefit while consumers keep 70 cents of the benefit. The management of capital expenditure by Evoenergy must be carefully managed because it is subject to factors which are outside our control. For example, the residential or commercial land development programs or customer-initiated works may fluctuate significantly according to market conditions. Higher level activity in those areas may translate to capital expenditure above the allocated regulatory allowance. For the overall capital expenditure to stay within the regulatory envelope, a reduction in other capital programs must offset higher customer-initiated capital programs.

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

Efficiency Benefit Sharing Scheme (EBSS)

The EBSS is designed to ensure electricity distributors are provided with a continuous incentive throughout the regulatory control period to achieve the lowest efficient levels of operating expenditure through the sharing of efficiency gains and losses with customers. The EBSS gives a consistent incentive to deliver efficiency improvements throughout the regulatory period by allowing the distributor to retain a share of the efficiency gains over time. For the five-year regulatory period, efficiency gains or losses are shared approximately 30% to the distributor and the remaining 70% to customers.

The EBSS scheme is relevant to the network investment decisions for several reasons. Different solutions to network limitations may be associated with different levels of operating expenditure. More importantly, many non-networks and demand side management solutions, especially involving other parties replace the capital investment in the network with operating investment. For example, if Evoenergy provides an incentive for another party to install a network battery, the incentive amount would count as operating expenditure. Similarly, if Evoenergy contracts customers to reduce electrical demand in exchange for the monetary compensation, any incentive paid out would count towards our operating expenditure.

The additional details on EBSS are contained in the *AER's Efficiency Sharing Scheme Guidelines, November 2013 (EBSS guideline) available from the AER website.*

Demand Management Incentive Allowance Mechanism

Currently, Evoenergy is subject to the two schemes which provide incentives in relation to the application of demand side management and non-network solution. Evoenergy participates in both demand management schemes.

During the current 2019-24 regulatory period Evoenergy participates in the Demand Management Incentive Allowance Mechanism (DMIAM). The DMIAM has been introduced by AER under *National Electricity Rules*. AER provides and oversight of the allowance mechanism. The DMIAM provides funding to distributors to undertake demand management research and development projects that have the potential to reduce long-term network costs. The DMIAM provides Evoenergy with an allowance which is available for eligible projects. The allowance for the regulatory period is capped at a fixed percentage of the distributor's revenue allowance. For Evoenergy for the five-year regulatory period the allowance is estimated at around $1.5 million dollars. Evoenergy is supporting DMIAM and considers eligible projects as part of its network planning process. Further information on DMIAM is provided in the *AER's Demand Management Incentive Mechanism Guideline, December 2017 available form AER's website.*

Demand Management Incentive Scheme

During the current 2019-24 regulatory period Evoenergy participates also in the Demand Management Incentive Scheme (DMIS). This participation is consistent with AER's revenue determination for Evoenergy published for the current regulatory period in April 2019.

The DMIS provides Evoenergy with an incentive to undertake efficient expenditure on non-network options relating to demand management. Specifically, the DMIS provides networks with a cost-uplift of up to 50% for eligible efficient demand management projects, subject to net-benefit constraints stipulated in the AER guidelines for the scheme. The overall uplift which can be allowed to Evoenergy under the scheme is subject to an overall annual limit. The scheme recognises that some existing regulatory settings provide disincentives to non-network and demand side management solutions. DMIS is designed to provide a greater incentive for the distributors to implement demand management solutions. Evoenergy supports in principle application of DMIS to non-network projects. As part of its network planning process, Evoenergy considers projects eligible for the scheme.

A comprehensive description of the DMIS is provided in the *AER's Demand Management incentive Allowance Guideline, December 2017* which is available from the AER website.

Appendix D: Asset Management System Certification

Certification of Asset Management System to ISO 55001:

ISO 55001 states the requirements 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.

Evoenergy holds a current certification under the standard.

Annual audits are undertaken on our Asset Management System in order to retain our certification to *ISO 55001*. An audit was conducted in 2019 and at the time of preparation of this Annual Planning Report the 2020 re-certification audit was in progress.

BUREAU VERITAS
Certification

Certification

Awarded to

ACTEWAGL DISTRIBUTION
T/a EVOENERGY

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

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Appendix E: Demand forecasts – supplementary information

This appendix provides supplementary information in relation to the demand forecasts discussed in Chapter 5.

The information provided includes:

- The key relevant definitions, formulas, assumptions, and a high-level explanation of the forecasting methodology
- Demand forecast tables for connection points of Evoenergy network to TransGrid network (bulk supply points)
- Zone substation demand forecast tables and charts.

Overview

Maximum demand forecasts provide long-term summer and winter maximum demand estimates conditional on observed annual historical data during those seasons. Similarly, minimum demand forecasts provide long-term daytime and night-time minimum demand estimates conditional on observed annual historical data during those time-of-day periods.

In alignment with previous years' reports and compliant with AEMO's revised connection point forecasting methodology, forecasts provide:

- seasonal maximum demand (as apparent power in MVA) for the zone substations Belconnen, City East, Civic, East Lake, Fyshwick, Gilmore, Gold Creek, Latham, Telopea Park, Theodore, Wanniassa, and Woden,
- seasonal maximum demand (as real power in MW) for the bulk supply points Canberra Bulk Supply Point, Queanbeyan Bulk Supply Point, Williamsdale Bulk Supply Point; and
- seasonal maximum and time-of-day minimum demand (as real power in MW) for the system.

The demand forecasting horizon is 10 years except for Fyshwick Zone Substation and Queanbeyan Bulk Supply Point for which the forecasting horizon is 4 years (due to the planned decommissioning of Fyshwick Zone Substation by 2024).

In addition, the forecast includes seasonal 10-year maximum demand forecasts for the new Stockdill Bulk Supply Point. The forecast is based on seasonal Canberra Bulk Supply Point forecast and load sharing between Canberra Substation and Stockdill Substation estimated through a load flow analysis. The forecasts are summarised in the "Bulk Supply Points Demand Forecasts" section below.

Key forecasting terms as applied by evoenergy in this report

Maximum demand

Zone substations

For zone substations, maximum demand is defined as the maximum apparent power (in MVA) recorded during a specific financial year and season.

$$\text{Maximum demand (in MVA)} = \max_t S_t \text{, and}$$
$$t^{\text{Maximum demand}} = \arg\max_t S_t.$$

Annual & seasonal zone substation maximum demands are non-coincident maximum demands, i.e. maximum demands correspond to the absolute maximum values recorded at every individual asset, and timestamps of the individual assets' maximum demands do not coincide with the timestamp of the overall system maximum demand.

Bulk supply points

For bulk supply points, maximum demand is defined as the maximum real power (in MW), recorded during a specific financial year and season.

$$\text{Maximum demand (in MW)} = \max_t P_t\text{, and}$$
$$t_{\text{Maximum demand}} = \arg\max_t P_t.$$

As with the zone substation maximum demands, annual & seasonal bulk supply point maximum demands are non-coincident maximum demands.

System maximum demand

The annual & seasonal system maximum demand is the overall maximum of the coincident sum of individual maximum demands (in MW) measured at every bulk supply point. The time covers all 15-minute intervals within a specific financial year and season.

Maximum demand (in MW) =

$$\max_t \sum_{i \in BSP} \text{Maximum demand (in MW)}_{i,t}$$

System minimum demand

The system minimum demand is defined as the minimum of the coincident sum of individual maximum demands (in MW) measured at every bulk supply point. The time covers all 15-minute intervals within a specific financial year and time of day.

Minimum demand (in MW) =

$$\min_t \sum_{i \in BSP} \text{Maximum demand (in MW)}_{i,t}$$

Financial year

A financial year (FY) is defined as the period from (and including) 1 July, 00:00 AEST until (and excluding) 30 June, 00:00 AEST (left-inclusive interval). Throughout this section, the terms "year" and "financial year" are used interchangeably, and always refer to a financial year as the unit of time.

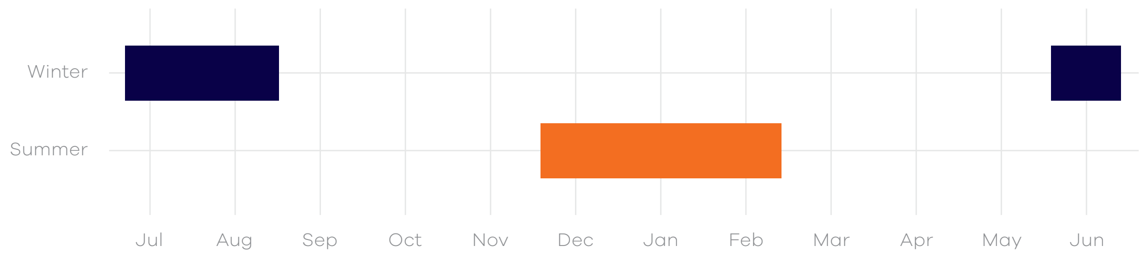
Seasons

The summer and winter seasons are defined by the months

- "Summer": December, January, February,
- "Winter": July, August, June.

Note that "Winter" is a non-contiguous period.

Seasons across one financial year



Time-of-day periods

The daytime and night-time periods are defined by hours

- "daytime": 8:00 AM – 8:00 PM
- "night-time": 8:00 AM – 8:00 PM

Which is a definition used commonly within the industry.

Probability of exceedance

Compliant with the National Electricity Rules (NER) on load forecasting, forecasts show estimates for "least-likely" and "most-likely" scenarios. Specifically, the forecasting model provides estimates for the maximum and minimum demand data (both historical and forecasts) at different probability of exceedance (PoE) levels; maximum and minimum demands at the 10%, 50% and 90% PoE level correspond to values that are expected to be exceeded in 1, 5, and 9 out of 10 years, respectively.

Source Data

Maximum demand data

Historical data of seasonal maximum demands during previous financial years excluding the current financial year (FY19/20) for the zone substations (in MVA), bulk supply points (in MW) and the system (in MW) are measured by the network metering installed in those locations.

Data for the current financial year (FY19/20) are extracted from measured energy values recorded by network metering installed at bulk supply points (operated by TransGrid) and zone substations (operated by Evoenergy).

Energies are then converted to powers as follows: Active (real) powers *P* and reactive powers *Q* are calculated from the corresponding real and reactive energy consumptions, by assuming uniform usage during the time interval

P [in MW] = 4×10^{-3} × active energy consumption [in kWh]

Q [in MVAR] =4×10^{-3} × reactive energy consumption [in kVARh].

The factor of 4 is due to the fact that there are four 15-minute intervals per hour, and consumptions are measured in kilo watt (volt ampere reactive) hours over a 15-minute interval.

For zone substation data, the apparent power *S* is then calculated from *P* and *Q* as

$$S \;= \sqrt{P^2 + Q^2}\,.$$

Minimum demand data

All historical system data are extracted from measured energy values recorded by network metering installed at the TransGrid connection points.

Real energy consumption values at the bulk supply points are converted to real power values, for the 15-minute interval and as detailed in the previous subsection.

Block loads

Forecasts account for known commercial and residential block loads. The block load information was collated on the connection enquires, applications and government land release programs, and are summarised in Table 29.

Forecasting Model

A fully Bayesian model for seasonal maximum and time-of-day minimum demand data was developed, motivated by the need for coherence, plausibility and parsimony of model assumptions and predictors affecting long term demand forecasts. The predictive performance of the model was assessed by comparing maximum demand forecasts with those from last year's annual planning report using the same historical data. 10-year forecasting results using the new parsimonious Bayesian model is consistent with the previously used Monash Electricity Forecasting Model (MEFM); and demonstrate the suitability of the Bayesian model framework for long term demand forecasting, both minimal and maximal.

The new long-term demand forecasting model implements a joint model for temperature *T* and maximum/minimum demand as a function of time (corresponding to a specific financial year and season/time-of-day) *t*. Specifically, the maximum/minimum demand of measurement *i* is

$$\begin{aligned} \mathrm{MD}_i &\sim N(\mu_{\mathrm{MD},i}, \sigma_{\mathrm{MD}})\,, \\ \mu_{\mathrm{MD},i} &= \mu_{\mathrm{baseline},i} + \mu_{\mathrm{temp},i} + \mu_{\mathrm{growth},i}\,, \end{aligned}$$

where

$$\begin{aligned} \mu_{\mathrm{baseline},i} &= \beta_{00,\mathrm{MD}} + \sum_{k=1}^{N_{\mathrm{ch}}} I(t_i, t_{\mathrm{ch},\,k})\beta_{0k,\mathrm{MD}}\,, \\ \mu_{\mathrm{temp},i} &= \beta_{1,\mathrm{MD}}(T_i - \min(T_i))\,, \\ \mu_{\mathrm{growth},i} &= \beta_{2,\mathrm{MD}} t_i\,, \end{aligned}$$

and the likelihood of is modelled using a Gumbel distribution:

$$\begin{aligned} T_i &\sim \mathrm{Gumbel}(\mu_{T,i}, \sigma_T)\,, \\ \mu_{T,i} &= \beta_{0,T} + \beta_{1,T} t_i\,. \end{aligned}$$

The following (weakly) informative priors are used:

$$\begin{aligned} \beta_{0,T} &\sim \mathrm{N}(\min(T), \sqrt{\mathrm{abs}(\min(T))})\,, \\ \beta_{1,T} &\sim \mathrm{N}(0.01, 0.001)\,, \\ \sigma_T &\sim \text{Half-Cauchy}(0,2.5)\,, \\ \beta_{00,\mathrm{MD}} &\sim \mathrm{N}(\mathrm{mean}(\mathrm{MD}), 10\sqrt{\mathrm{mean}(\mathrm{MD})})\,, \\ \beta_{0k,\mathrm{MD}} &\sim \mathrm{N}(0,10)\,, \\ \beta_{1,\mathrm{MD}} &\sim \begin{cases} \mathrm{N}(0,10) & \text{for maximum demand modelling}, \\ \mathrm{N}(0,0.1) & \text{for minimum demand modelling}, \end{cases} \\ \beta_{2,\mathrm{MD}} &\sim \mathrm{N}(0,3)\,, \\ \sigma_{\mathrm{MD}} &\sim \text{Half-Cauchy}(0,2.5)\,. \end{aligned}$$

Key features of the model can be summarised as follows:

- Maximum demand is decomposed into a baseline, temperature and (organic) growth component. All three components have either a direct (baseline, growth) or indirect time dependence (temperature).

- The baseline component allows for historic block loads by fitting a piecewise constant to the observed data using the indicator function

$$I(t_i, t_{\mathrm{ch},k}) = \begin{cases} 1 & \text{if } t_i \geq t_{\mathrm{ch},k}\,, \\ 0 & \text{else}\,, \end{cases}$$

where $t_{\mathrm{ch},k}$ is the time of the th change point (block load).

- For maximum demand modelling, the temperature component uses recorded annual extremal temperatures (maximum temperatures for the summer MD model, minimum temperatures for the winter MD model) for the years with recorded historical MD data. Simultaneously, the model estimates the parameters of the underlying Gumbel temperature distribution using *all* available temperature data. Annual extremal temperature data are available from 1996 onwards, and are averaged across two weather stations in the ACT (Canberra Airport and Isabella Plains (Tuggeranong)). Characterising both models jointly ensures that uncertainties in the parameter estimates from both the MD and T models are properly included in the long-term MD forecasts. For minimum demand modelling, a narrow and strongly informative prior centred around zero is chosen for $\beta_{1,\mathrm{MD}}$, whose regularisation properties characterise the lack of any strong temperature dependence in minimum demand data.
- In alignment with model parsimony, organic growth is modelled using a simple linear time dependence; it was confirmed that a higher-order polynomial fit to the historical MD data does not provide better forecasts. The organic growth component can be interpreted as the compound effect that captures economic growth as well as the MD offset due to increased PV generation.
- As with all Bayesian models, using sensible prior distributions on all parameters is critical to obtaining meaningful posterior densities. Specifically, a narrow and informative prior was chosen for $\beta_{1,T}$ to include a small and realistic time-dependent global warming effect. The mean time-dependent effect of 0.01 °C per year is in agreement with the observed changes in the global Australian climate system of about 1 °C since 1910 [Australian Government Department of Agriculture, Water and the Environment, Climate change]. All other weakly informative priors are chosen in agreement with common prior choice recommendations [Gelman, Prior Choice Recommendations].

Forecasts are then obtained following a three-step process:

- First, forecasts of temperature values T_{pred} for future years t_{pred} are obtained based on the fitted Gumbel model with posterior densities for the location μ_T and scale parameters σ_T.
- Posterior predictive densities of T_{pred} as well as posterior densities of all MD model parameters are then used to obtain MD predictions as posterior predictive densities $\mathrm{MD}_{\mathrm{pred}}$ for all future years.
- Posterior predictive densities of maximum demand estimates are then adjusted for future block loads using afore-mentioned indicator function $I(t_i, t_{\mathrm{ch}})$ which shifts the posterior predictive density by the future block load BL_q at time t_q. A table summarising future block loads is given in Table 29. Final MD estimates at the 100α% level is then obtained from the 100(1 - α)% quantiles of the posterior predictive MD density at every year. Posterior predictive densities of minimum demand densities are not adjusted for future block loads, as the effect of block loads on minimum demand is difficult to assess; consequently, minimum demand estimates provide a lower bound on the forecast minimum demand trends.

All models are fitted to maximum and minimum demand data using the Bayesian inference framework and probabilistic programming language Stan [Stan Development Team, 2020, Stan Modeling Language Users Guide and Reference Manual] through the R interface rstan [Stan Development Team, 2020, RStan: the R interface to Stan, R package].

Feeder forecast

Evoenergy does not prepare routinely feeder forecasts and feeder forecast are not included in this report. The distribution system capacity limitations are usually identified by Evoenergy for a supply area and often include several interconnected feeders. The area forecasts are based on the inherent load trends specific to that area and known block loads. The project justification reports include forecast for respective areas and projected feeder loadings which are available for any network studies or consultation on non-network solutions.

Bulk Supply Points Demand Forecasts

Tables below show the results for the summer and winter demand forecast for bulk supply point at Canberra Substation, Stockdill Substation, Williamsdale Substation, and Queanbeyan Substation. These are connection points between the Evoenergy network and TransGrid network operated by TransGrid.

Please note that the minimum demand forecast included in the APR this year is based on the updated methodology which differs to the one which was employed last year. The methodology is subject of further consultation between NEM participants and AEMO.

Canberra Bulk Supply Point Demand Forecast

The demand forecast at Canberra Zone Substation has been scaled down due to the imminent energisation of Stockdill Substation which will take some load from Canberra. Load sharing between the substations was determined using preliminary load flow studies. The following steps were taken:

- Forecasting on Canberra Zone Substation was completed based on historic data with no consideration of Stockdill Zone Substation,
- An indicative load flow study at the sub-transmission level was completed to determine the approximate proportional division of load between Canberra and Stockdill after Stockdill is fully energised.
- These proportions were applied to the values determined in step 1 to provide an updated forecast for both Canberra and Stockdill.

It must be noted that Williamsdale forecasts were not changed.

Post-Stockdill energisation it is assumed that Canberra would take approximately 73% of the previously forecast load in summer and 72% of the previously forecast load in winter.

Table 22. Summer (Su) and Winter (Wi) maximum demand forecast table (MW)

Year	POE90 (Su)	POE50 (Su)	POE10 (Su)	POE90 (Wi)	POE50 (Wi)	POE10 (Wi)
2021	261	291	321	302	354	401
2022	260	291	322	303	355	402
2023	259	291	322	301	355	402
2024	257	290	322	303	355	404
2025	275	310	343	322	375	425
2026	274	310	344	322	376	427
2027	272	309	345	320	376	428
2028	270	309	346	320	376	429
2029	269	308	347	320	377	430
2030	267	308	348	319	377	431

Stockdill Bulk Supply Point Demand Forecast

Stockdill substation is due to be energised in December 2020. Because of this there is no historical data at the site which can be used for forecasting. Please see the Canberra Bulk Supply Point Demand Forecast section above for further details on methodology.

On the basis of the load flow studies, it has been assumed that Stockdill would take approximately 27% of the Canberra Substation load in summer and 28% of the load in winter.

Table 23. Summer (Su) and Winter (Wi) maximum demand forecast table (MW)

Year	POE90 (Su)	POE50 (Su)	POE10 (Su)	POE90 (Wi)	POE50 (Wi)	POE10 (Wi)
2021	97	108	119	118	138	156
2022	96	108	119	118	138	156
2023	96	108	119	117	138	156
2024	95	107	119	118	138	157
2025	96	109	121	119	140	160
2026	96	109	122	119	140	160
2027	95	109	122	119	140	161
2028	94	109	123	119	141	161
2029	94	109	123	119	141	162
2030	93	108	123	118	141	162

Queanbeyan Bulk Supply Point Demand Forecast

Please note once Fyshwick Zone Substation is decommissioned Evoenergy will contribute no load to Queanbeyan BSP hence there is no forecast for these years.

Table 24. Summer (Su) and Winter (Wi) maximum demand forecast table (MW)

Year	POE90 (Su)	POE50 (Su)	POE10 (Su)	POE90 (Wi)	POE50 (Wi)	POE10 (Wi)
2021	13	23	33	23	27	30
2022	12	22	33	24	28	31
2023	11	22	33	24	29	32
2024	9	21	32	25	30	34
2025	-	-	-	-	-	-

Williamsdale Bulk Supply Point Demand Forecast

Table 25. Summer (Su) and Winter (Wi) maximum demand forecast table (MW)

Year	POE90 (Su)	POE50 (Su)	POE10 (Su)	POE90 (Wi)	POE50 (Wi)	POE10 (Wi)
2021	138	191	242	167	200	231
2022	138	192	244	168	202	233
2023	139	194	247	169	204	235
2024	139	195	249	170	206	238
2025	146	204	259	178	215	248
2026	145	206	261	179	217	251
2027	145	206	264	180	218	253
2028	146	208	267	179	219	257
2029	146	210	270	179	221	260
2030	144	211	274	180	223	263

Zone Substations Limitation Tables

The table below show the summer and winter demand (MVA) forecast for the zone substation and comparison with the two hour and continuous emergency rating of the substations. POE10, POE50 and POE90 are included in the tables. The identified limitations over the 10-year period are highlighted in **the orange font**.

Table 26. Zone substation - summer forecast demand (MVA) summary

ZSS	Continuous Rating	Emergency 2-hr Rating	POE	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Belconnen	55	74	90	47	48	50	50	51	50	49	48	48	47
			50	56	57	59	60	61	60	60	59	58	58
			10	65	67	69	69	70	70	70	69	69	69
City East	95	95	90	60	68	71	72	74	75	75	76	76	76
			50	70	78	81	83	84	86	87	87	87	88
			10	81	89	93	94	**96**	**98**	**99**	**100**	**100**	**101**
Civic	110	114	90	50	55	60	68	71	70	69	68	67	66
			50	57	62	68	75	78	78	77	76	75	74
			10	65	70	76	83	87	86	86	85	84	84
East Lake	50	60	90	11	16	20	23	32	34	36	37	38	38
			50	16	21	25	28	38	41	43	44	45	46
			10	20	26	31	34	44	47	50	52	53	55
Fyshwick	28	28	90	27	30	31	32	-	-	-	-	-	-
			50	32	36	38	39	-	-	-	-	-	-
			10	34	39	41	42	-	-	-	-	-	-
Gilmore	45	62	90	31	32	33	35	36	37	38	39	40	41
			50	36	37	38	39	40	42	43	44	45	46
			10	40	41	43	44	45	46	48	49	50	52
Gold Creek	57	74	90	63	66	69	72	**75**	**78**	**81**	**84**	**87**	**90**
			50	73	**76**	**80**	**83**	**86**	**89**	**92**	**95**	**99**	**102**
			10	**84**	**87**	**90**	**94**	**97**	**101**	**104**	**107**	**110**	**114**
Latham	95	95	90	46	47	47	48	52	52	53	54	54	55
			50	54	55	55	56	60	61	62	62	63	64
			10	63	64	64	65	70	70	71	72	73	74
Telopea Park	100	114	90	71	73	74	78	81	82	82	83	85	86
			50	83	86	88	92	96	98	99	101	102	104
			10	95	98	101	106	111	114	**115**	**118**	**120**	**123**
Theodore	45	62	90	20	20	20	20	20	20	19	19	19	19
			50	25	25	25	25	24	24	24	24	24	24
			10	29	29	29	29	29	29	29	29	29	29

ZSS	Continuous Rating	Emergency 2-hr Rating	POE	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Wanniassa	95	95	90	50	49	48	48	47	46	44	43	42	41
			61	60	60	60	59	58	57	56	55	54	61
			10	73	72	72	72	72	71	70	69	69	68
Woden	95	95	90	61	65	69	72	71	71	72	71	71	71
			50	72	77	81	84	84	84	84	84	85	85
			10	86	90	**95**	**98**	**98**	**98**	**98**	**99**	**99**	**100**

Note: Tennant Zone Substation has not been included in this table as no forecast is required.

Table 27. Zone substations - winter demand forecast (MVA) summary and capacity constraints

ZSS	Continuous Rating	Emergency 2-hr Rating	POE	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Belconnen	55	76	90	54	57	59	60	62	62	62	62	61	61
			50	58	60	62	64	66	66	66	66	66	66
			10	61	64	66	68	69	70	70	70	70	70
City East	110	114	90	70	76	80	82	84	86	85	85	84	84
			50	72	79	82	85	86	88	88	87	87	87
			10	74	81	85	87	89	91	90	90	90	90
Civic	110	143	90	51	56	60	67	71	72	72	71	71	70
			50	53	58	62	69	73	75	74	74	73	73
			10	55	60	64	71	75	77	76	76	76	75
East Lake	55	60	90	12	17	20	23	32	36	39	41	42	42
			50	15	19	23	26	36	40	43	45	46	47
			10	18	22	26	29	39	43	47	49	50	52
Fyshwick	28	28	90	23	26	26	27	-	-	-	-	-	-
			50	28	31	33	34	-	-	-	-	-	-
			10	31	35	36	38	-	-	-	-	-	-
Gilmore	45	69	90	35	36	37	38	39	40	41	42	43	44
			50	37	38	39	40	41	42	43	44	45	46
			10	38	40	40	42	43	44	45	46	47	48
Gold Creek	57	84	90	77	81	**84**	**87**	**91**	**94**	**97**	**101**	**104**	**107**
			50	81	**85**	**88**	**91**	**95**	**98**	**102**	**105**	**109**	**112**
			10	**85**	**88**	**92**	**95**	**99**	**102**	**106**	**109**	**113**	**116**
Latham	100	114	90	64	65	65	65	70	70	71	71	72	72
			50	68	69	69	70	74	75	75	76	77	78
			10	72	73	73	74	78	79	80	81	82	83

ZSS	Continuous Rating	Emergency 2-hr Rating	POE	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Telopea Park	100	114	90	79	81	83	88	91	93	93	95	97	98
			50	81	84	86	90	94	96	96	98	100	102
			10	84	86	88	93	98	99	100	102	104	106
Theodore	45	69	90	26	26	26	25	25	25	24	24	24	24
			50	27	27	27	26	26	26	26	25	25	25
			10	28	28	28	28	27	27	27	27	27	26
Wanniassa	100	114	90	68	66	66	65	64	63	61	60	58	57
			50	70	69	68	68	67	65	64	63	61	60
			10	72	71	71	70	69	68	67	66	64	63
Woden	100	114	90	80	88	93	97	99	101	104	106	108	110
			50	84	92	97	102	104	106	109	111	**114**	**116**
			10	88	96	102	107	109	111	**114**	**116**	**119**	**122**

Notes:

Woden substation load includes the load of the future Molonglo Zone Substation

Tennant Zone Substation has not been included in this table as forecast is required due to the nature of the load (please refer to the table below)

Zone substation demand forecast charts

Figure 39. Belconnen Substation 10-year summer and winter demand forecast chart

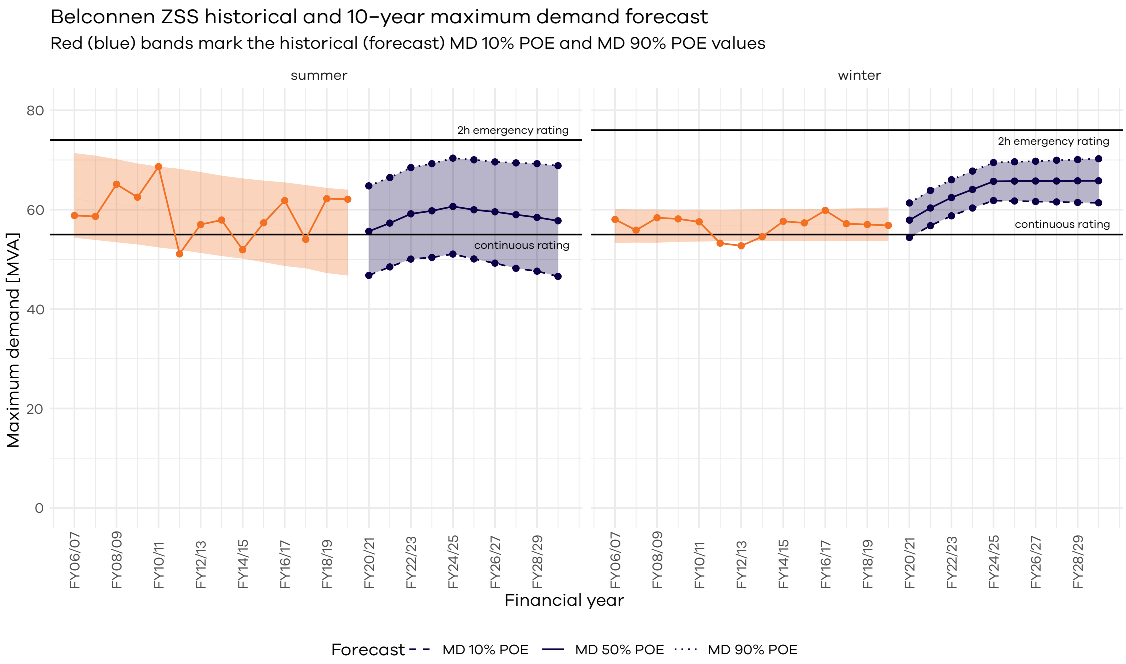


Figure 40. City East Substation 10-year summer and winter demand forecast chart

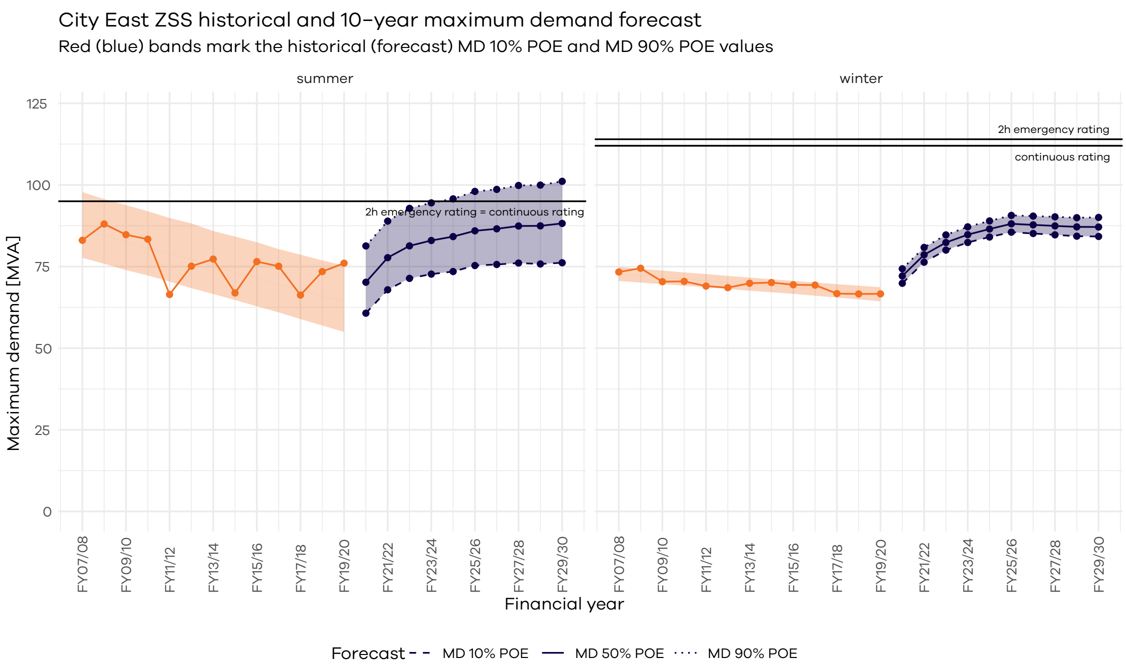


Figure 41. Civic Substation 10-year summer and winter demand forecast chart

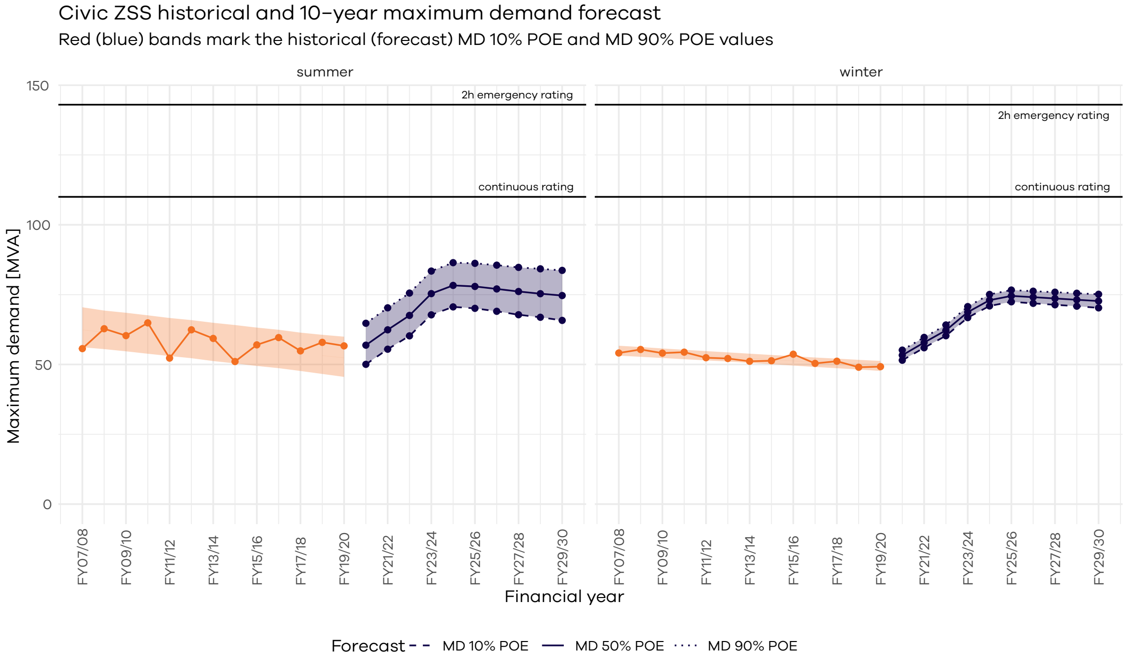


Figure 42. East Lake Substation 10-year summer and winter demand forecast chart

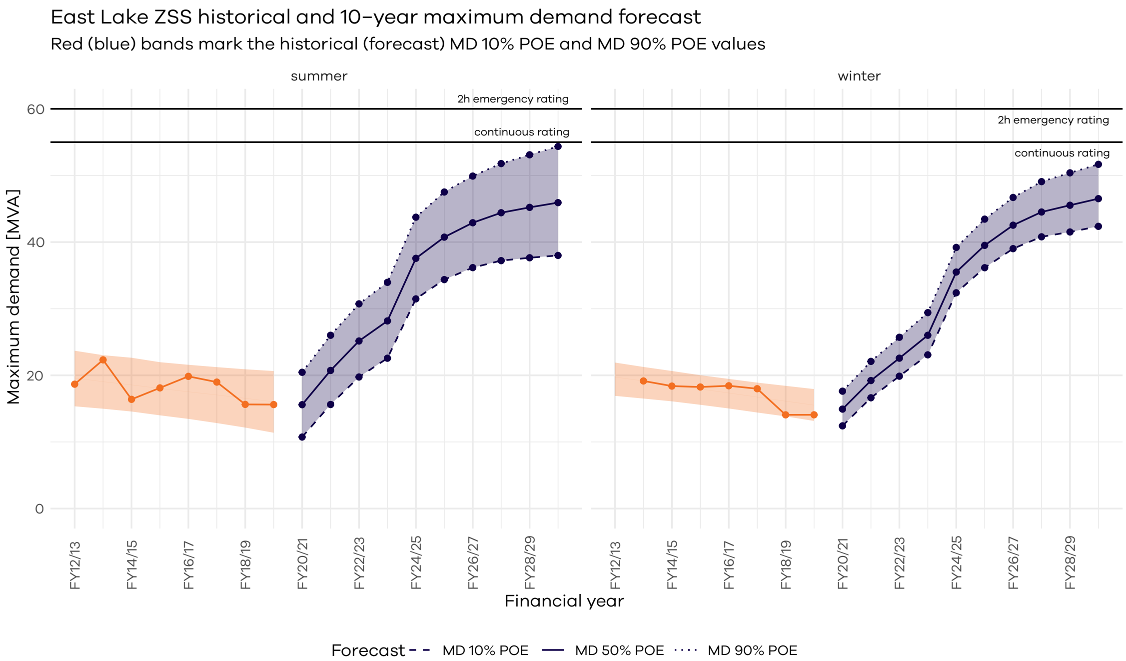


Figure 43. Fyshwick Substation 10-year summer and winter demand forecast chart

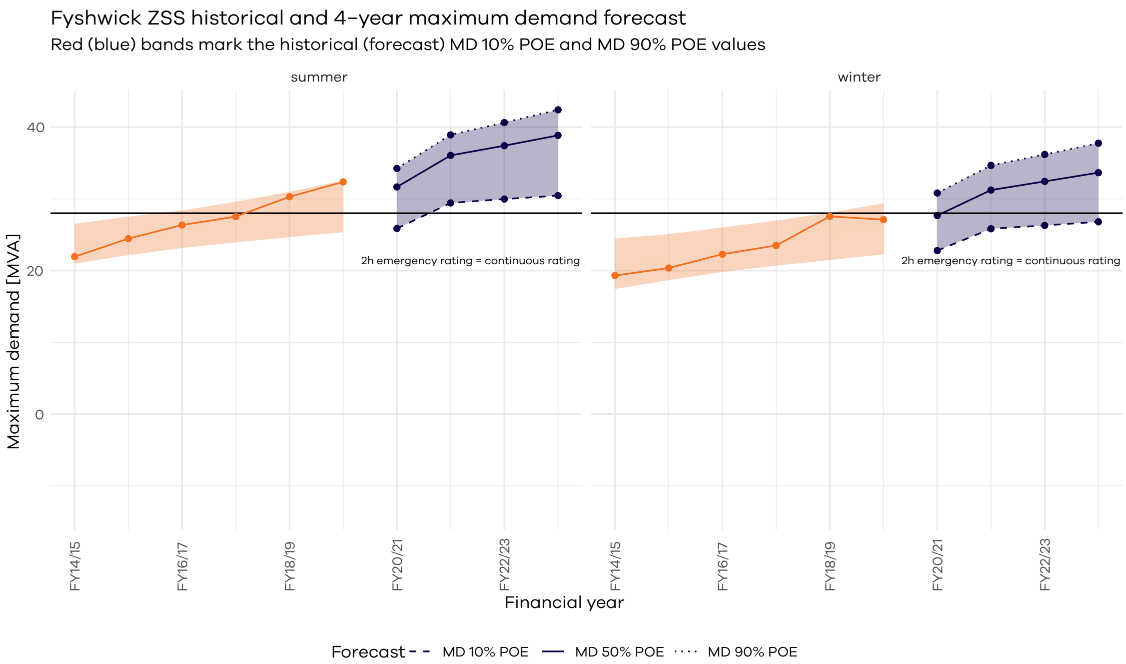


Figure 44. Gilmore Substation 10-year summer and winter demand forecast chart

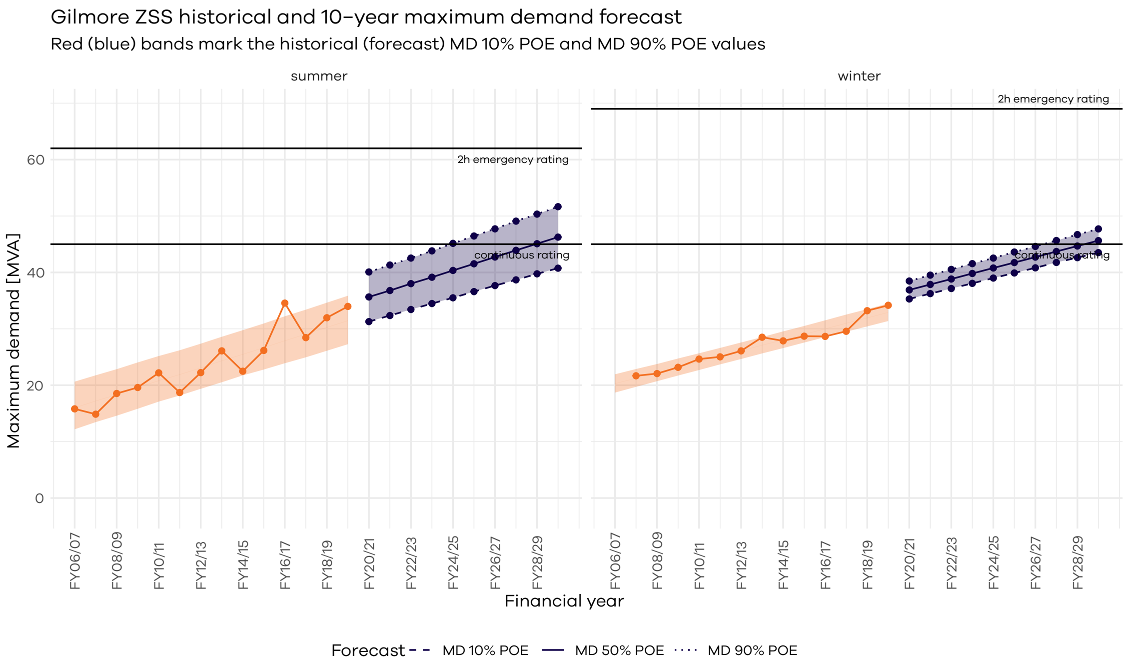


Figure 45. Gold Creek Substation 10-year summer and winter demand forecast chart

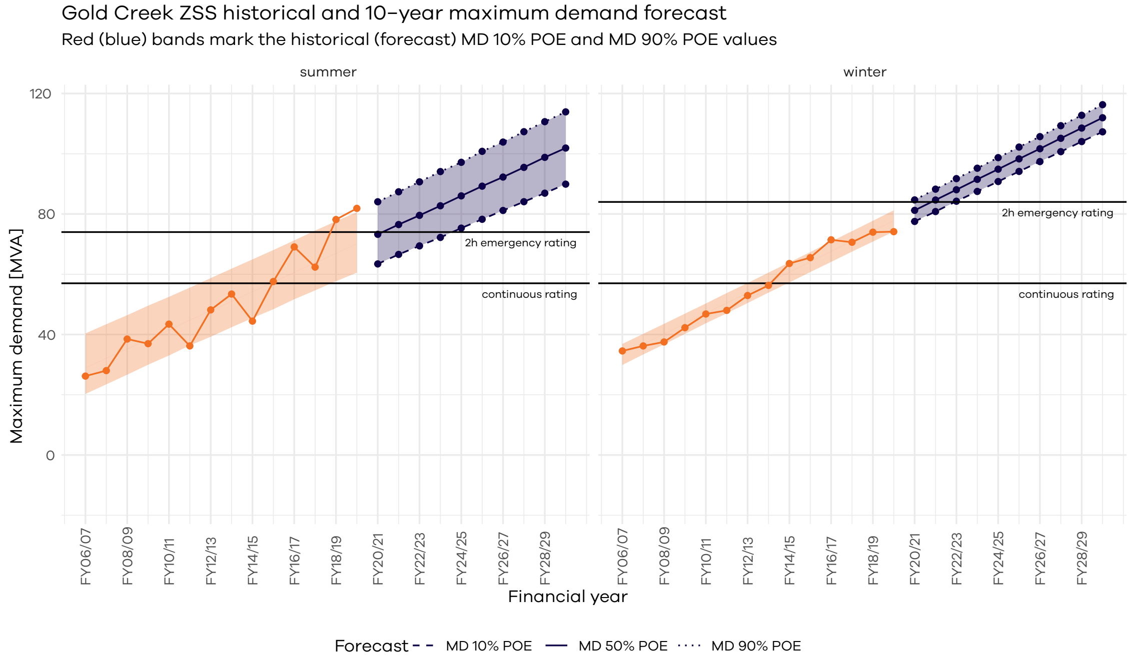


Figure 46. Latham Substation 10-year summer and winter demand forecast chart

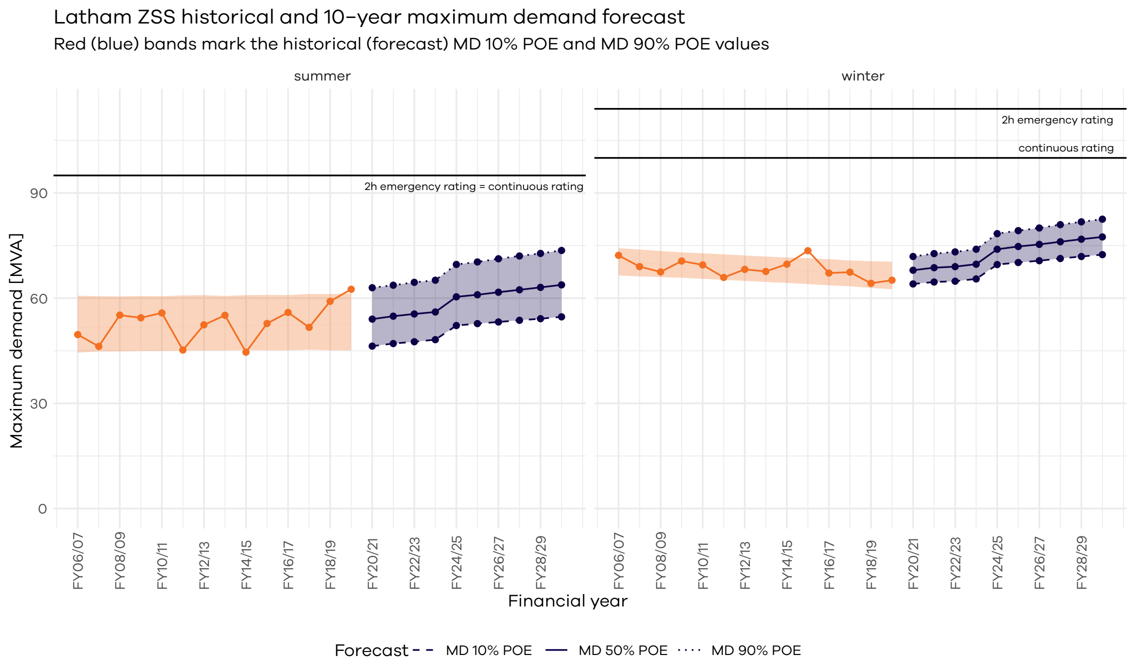


Figure 47. Telopea Park Substation 10-year summer and winter demand forecast chart

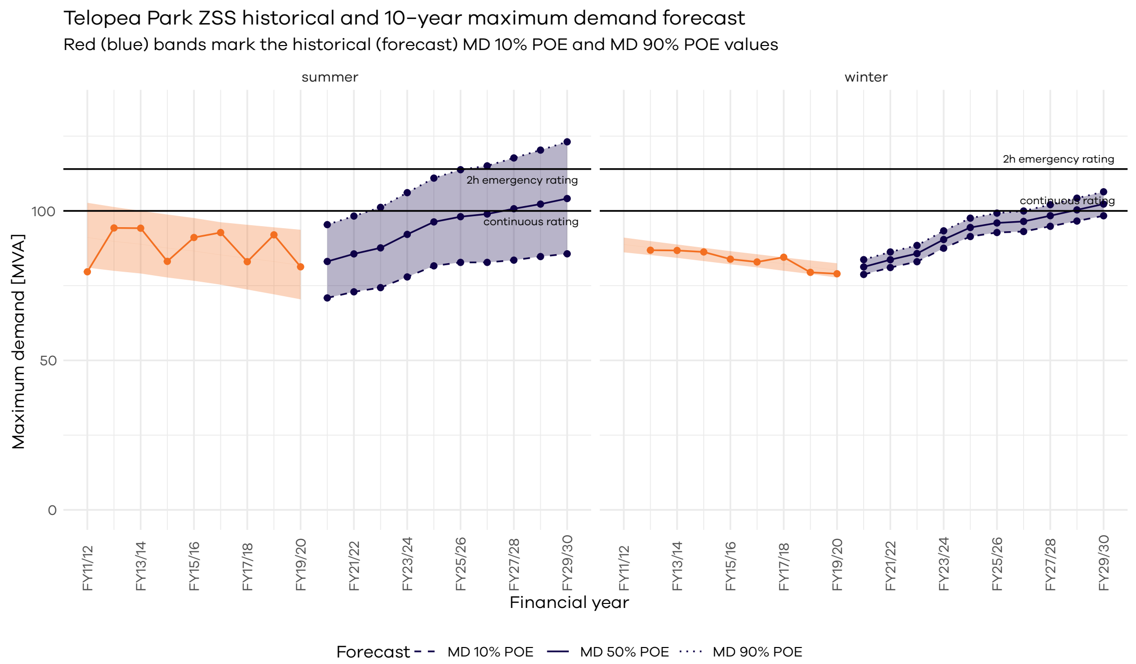


Table 28. Tennent Substation Historical Generation & Consumption Peaks

Year	Season	Generation Peak (MVA)	Consumption Peak (MVA)
2019	Summer	10.	2.5
2019	Winter	7.2	0.2
2020	Summer	9.9	0.1
2020	Winter	8.7	1.7

Tennant is a zone substation purpose built to connect to the large-scale Royalla solar farms. The generation peak is higher than the load peak. It is geographically removed from Canberra and there is no growth in either consumption or generation. For this reason, a forecast has been deemed unnecessary.

Figure 48. Theodore Substation 10-year summer and winter demand forecast chart

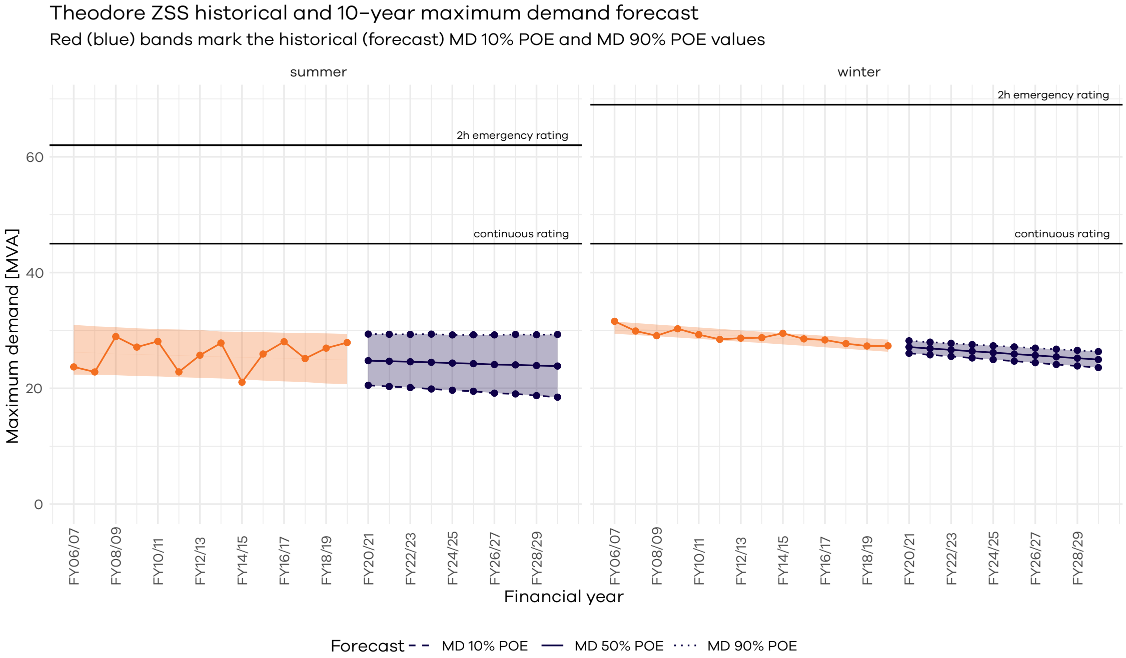


Figure 49. Wanniassa Substation 10-year summer and winter demand forecast chart

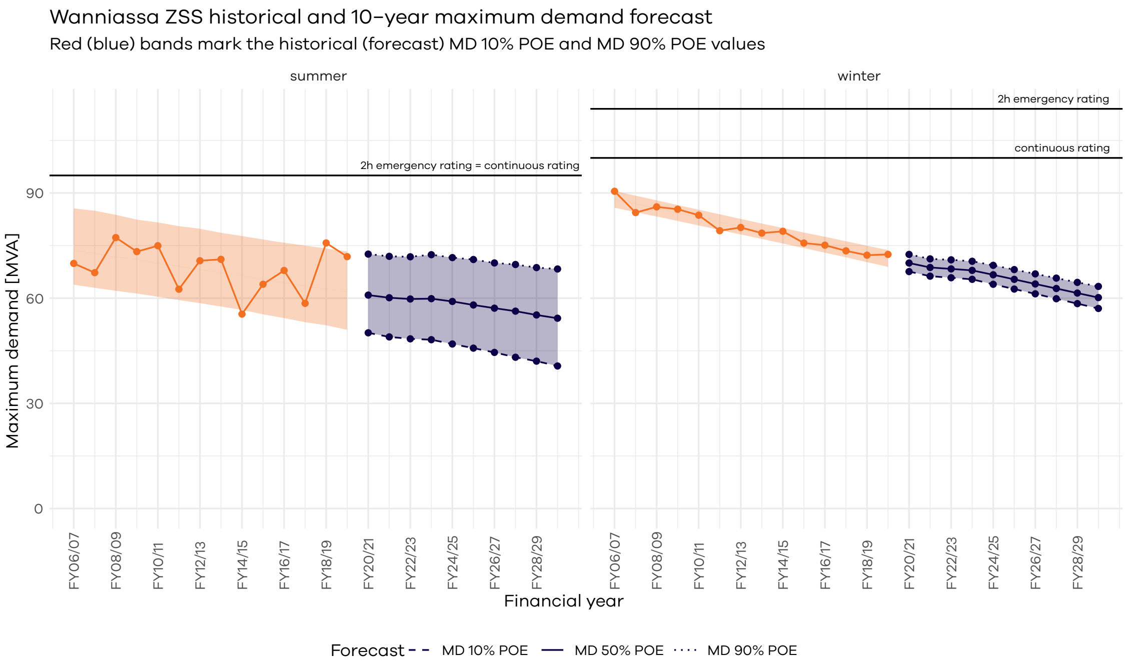
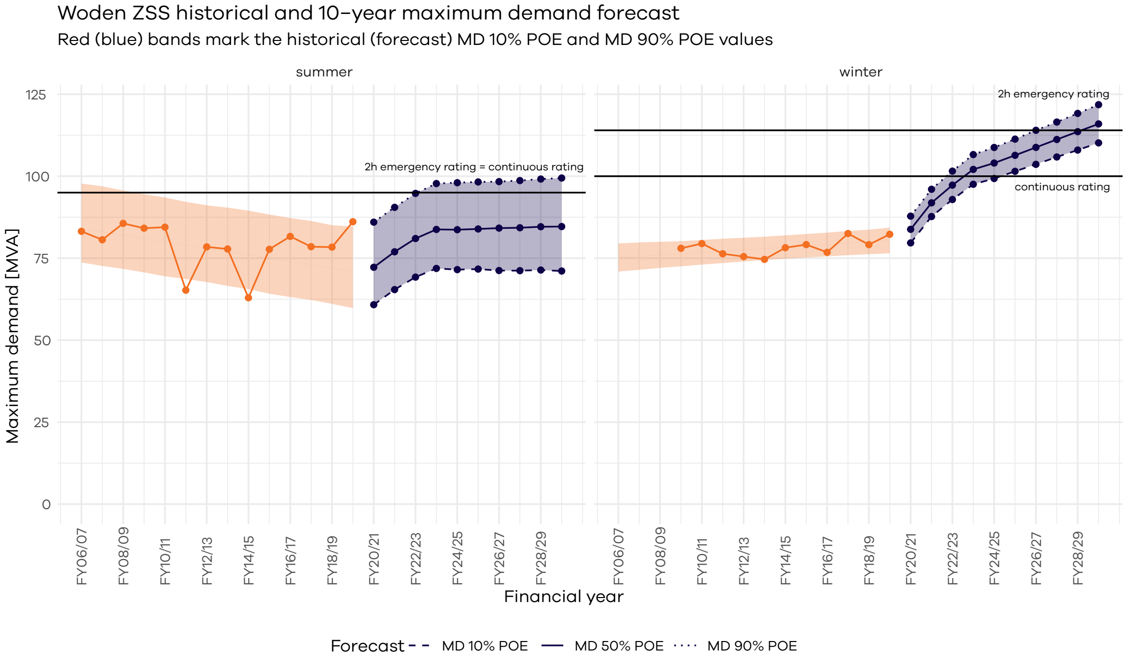


Figure 50. Woden Substation 10-year summer and winter demand forecast chart



Block Load Summary

This section provides a summary of block loads considered in forecasts by year and zone substation.

Table 29. Block Load Summary

Zone	2021 (MVA)		2022 (MVA)		2023 (MVA)		2024 (MVA)		2025 (MVA)		2026 (MVA)		2027 (MVA)		2028 (MVA)		2029 (MVA)		2030 (MVA)	
	Su	Wi	Su	Wi	Su	Wi	Su	Wi	Su	Wi	Su	Wi	Su	Wi	Su	Wi	Su	Wi	Su	Wi
Belconnen	1	0.8	2.3	2.4	2.3	2.1	1.3	1.6	1.3	1.6	0	0	0	0	0	0	0	0	0	0
City East	7.8	6.1	9.3	7.0	5.5	4.4	3.4	2.9	3	2.3	3.8	2.1	2.5	0.3	2.5	0.3	2	0.3	2.5	0.5
Civic	5.4	4.4	6.4	5.1	5.9	4.8	8.7	7.0	3.8	4.7	0.5	2	0	0	0	0	0	0	0	0
East Lake	0	0	5.7	4.9	4.9	4	3.5	4	9.9	10.1	3.7	4.6	2.7	3.6	2	2.6	1.3	1.6	1.3	1.6
Fyshwick	0	0	3	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gilmore	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Latham	1.4	1.8	0.6	1	0.6	0.6	0.6	1	4.2	4.6	0.6	1	0.6	1	0.6	1	0.6	1	0.6	1
SYSTEM	0	0	9	9	11.4	11.4	2.8	2.8	0.2	0.2	6.6	6.6	6.4	6.4	6.5	6.5	6.6	6.6	6.5	6.5
Telopea	2.4	2.3	3.7	3.5	3.3	3.1	5.6	5.8	5.4	5.1	3	2.6	2	1.6	3	3	3	3	3	3
Various	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wanniassa	0	0	0	0	0.9	0.9	0.9	0.9	0	0	0	0	0	0	0	0	0	0	0	0
Woden	2.2	3	5.7	7.7	5.2	5.0	3.8	4.4	0.9	1.5	1.2	2	1.2	2	1.2	2	1.2	2	1.2	2

Note: **Su** is Summer, and **Wi** is Winter

Appendix F: Network reliability standards and performance

Key definitions

- **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.

Network reliability standards (set by the Australian Energy Regulator and jurisdictional technical regulator), the performance and the key reliability measures are outlined in the following sections:

Australian Energy Regulator Reliability Targets

The purpose of the Service Target Performance Incentive Scheme (STPIS) is to provide an incentive to maintain existing supply reliability to customers, and to implement improvements to match customer's value of supply reliability. The scheme includes financial incentives or penalties based on improvement or deterioration in network performance compared to past benchmarks. The scheme currently applies to unplanned supply interruptions.

The determination by AER for Evoenergy in April 2019 applied the STPIS scheme to the 2019-24 regulatory control period. In each year, the incentives and penalties are capped at 5% of the annual Evoenergy allowance.

STPIS targets are set by the AER for the five-year regulatory control period. The targets set by AER for 2019-24 are in Table 30. The targets apply to unplanned supply interruptions only.

Table 30. STPIS Reliability Performance Targets for Unplanned Outages:

Year	2019-24
Unplanned SAIDI I[28]	
Urban	32.524
Short Rural	35.056
Whole Network (weighted average)	33.366
Unplanned SAIFI[29]	
Urban	0.565
Short Rural	0.591
Whole Network (weighted average)	0.574

Jurisdictional Regulator Reliability Targets

The ACT Utilities (Technical Regulation) Act requires Evoenergy to comply with the relevant technical codes. The reliability targets specified in the Electricity Distribution Supply Standards Code are shown in Table 31. The ACT targets apply to planned and unplanned supply interruptions. Table 31 below includes full set of actual reliability performance figures for planned and unplanned outages.

Table 31. Electricity Distribution Supply Standards Code Annual Reliability Targets

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

28 SAIDI-System Average Interruption Duration Index – refers to the combined length of supply interruptions (minutes) which average customer experiences during the year

29 SAIFI-System Average Interruption Duration Index – refers to the number of sustained (not momentary) supply interruptions which average customer experiences during the year.

Performance against the reliability targets

Table 32 provides the historical reliability performance statistics for Evoenergy's network. The table includes SAIDI and SAIFI figures for the rural network, urban network, and the whole of the network from the year 2015 onwards. The planned and unplanned outages are set out against jurisdictional and STPIS reliability targets.

Table 32. Performance vs targets – planned and unplanned interruptions

	2015-17			2017-19			2019-24	
Network Reliability Category	**Target**	2015-16	2016-17	**Target**	2017-18	2018-19	**Target**	**2019-20**
SAIDI								
Whole Network Overall	91 (ICRC)	74.01	83.74	91 (ICRC)	88.49	92.53	**91 (ICRC)**	81.70
Whole Network Planned	-	38.89	44.21	-	57.05	41.54	**-**	33.32
Whole Network Unplanned	-	35.12	39.53	-	31.44	34.94	**-**	34.81
Urban Unplanned	31.912 (AER)	35.73	42.74	30.32 (AER)	29.81	33.19	**32.524 (AER)**	29.32
Short Rural Unplanned	49.32 (AER)	30.25	39.11	46.86 (AER)	34.11	36.58	**35.056 (AER)**	46.63
SAIFI								
Whole Network Overall	1.2 (ICRC)	0.86	0.902	1.2 (ICRC)	0.7	0.95	**1.2 (ICRC)**	0.715
Whole Network Planned	-	0.185	0.212	-	0.2	0.19	**-**	0.167
Whole Network Unplanned	-	0.675	0.69	-	0.49	0.63	**-**	0.489
Urban Unplanned	0.616 (AER)	0.682	0.669	0.585 (AER)	0.45	0.60	**0.565 (AER)**	0.445
Short Rural Unplanned	0.942 (AER)	0.616	0.852	0.895 (AER)	0.56	0.60	**0.591 (AER)**	0.586
CAIDI								
Whole Network Overall	74.6 (ICRC)	86.06	92.84	74.6 (ICRC)	126.41	96.92	**74.6 (ICRC)**	114.33
Whole Network Planned	-	210.22	208.54	-	285.25	215.58	**-**	199.31
Whole Network Unplanned	-	52.03	57.29	-	64.16	55.09	**-**	71.19
Urban Unplanned	-	52.39	63.89	-	66.24	55.18	**-**	78.22
Short Rural Unplanned	-	49.11	45.90	-	60.91	60.92	**-**	79.57

Reliability Strategy and Plan

Evoenergy reliability strategy is published on Evoenergy website. The current strategy for Evoenergy is to maintain the existing reliability performance and target improvement in the selected areas for the worst performing feeders and worst served customers. Evoenergy's network reliability strategy and plan considers the following tactics to manage our network reliability for customers.

Prevention

Minimise asset failures

Asset failures often result in an unplanned outage for customers. Reducing the number of asset failures can reduce unplanned outages for customers and improve network reliability. An objective of Evoenergy's asset maintenance programs is to optimise asset life-cycle and reduce asset failures in the network through assets inspection, maintenance, refurbishment and replacement by applying risk-based methods.

Reduce outages caused by vegetation

Vegetation can cause unplanned outages on overhead networks. Outages can occur when trees come in contact with overhead wires or when trees fall on overhead networks, often during storms. Evoenergy vegetation management strategy aims to reduce the number of outages caused by vegetation through regular inspections and tree clearing around overhead power lines.

Reduce third party damage

Damage to Evoenergy's network by other parties may cause unplanned supply outages to customers. For example, damage to our network may be caused by hitting an underground cable while excavating, a crane coming in contact with overhead lines or a vehicle crashing into a network asset such as a substation. Evoenergy runs public awareness campaigns, offers electrical safety rules training and publishes its underground network assets on Dial Before You Dig (DBYD) platform to mitigate damage to our network caused by other parties.

Decommission legacy assets

Removing unreliable assets from the network, removes potential points of failure. Part of Evoenergy's asset management strategy seeks opportunities to decommission legacy assets from the network when they are in need of replacement. This not only results in reduced replacement expenditure (avoided REPEX) but reduces potential failure points which may cause customer outages.

Design reliable networks

Probabilistic planning is a risk-based methodology that effectively manages network reliability. Often the dominant risk considered is a risk of supply interruptions. The value of the risk is expressed as the value of energy at risk or unserved energy. The value is derived from the probability of supply interruptions and the value of energy to customers.

Dispatch Distributed Energy Resources (DER)

During peak demand, generation, transmission or distribution networks cannot always meet peak demand events particularly in case of asset outages. When these events occur, load shedding (disconnection of customers) may be required to maintain the stability and reliability of the grid. At the national level, load shedding events are directed by AEMO. Any events resulting in the ACT distribution network constraints are managed by Evoenergy.

Controlled dispatch of Distributed Energy Resources (DER) including batteries can reduce the likelihood of load shedding events by reducing demand during peak periods. This approach may reduce unplanned outages for customers and reduce the likelihood of AEMO or Evoenergy load shedding.

Maximise availability for PV generators

The number of low voltage (LV) photovoltaic (PV) generators is increasing, challenging LV network voltage regulation capability limits. These generators operate within a prescribed voltage standard and if the voltage drifts outside the range, the generator must disconnect from the network, until the voltage is within the tolerance limits. Although the network is available for customers to receive electricity, their generator may experience an outage. Evoenergy's power quality strategy aims to maintain LV voltage regulation and thus maximise network availability for PV generators.

Minimise the number of planned outages

Planned outages are required to provide safe access to maintain and install new capacity in the network. Evoenergy's asset management plans synergise maintenance tasks to reduce planned outages for customers. For example, primary and secondary asset maintenance strategies are aligned so that one planned outage is required to maintain as many assets in a single outage as practicable.

Minimisation

Auto-reclosers

Many overhead network faults are transient. Auto-reclosers are switchgear designed to isolate faults when they occur, then attempt to restore supply automatically if the fault is intermittent. Reclosers can reduce the number of customers impacted by faults and a number of sustained faults.

Diversify network outage risk

Diversifying network outage risk refers to network design which limits the number of customers affected by a single fault on the network. Evoenergy's asset management planning does this by analysing feeder outage rates, optimising the number of customers connected to feeders, design and installation of network protective devices and catering for credible network contingencies.

Restoration

Fault Location, Isolation & Service Restoration (FLISR)

Evoenergy's strategic plan towards a smart and self-healing network utilises automated Fault Location, Isolation and Service Restoration (FLISR) for the safe and fast restoration of supply to customers. Automated FLISR is a collection of tools including switchgear with remote control and indication, integrated with the centralised Advanced Distribution Management System (ADMS). Current fleet of switchgear with remote control and indication is currently being reviewed for compatibility with an automated FLISR system.

Remote network indication & control

Some overhead and underground switchgear is installed with remote indication and control capability. Remote control allows Evoenergy's 24-hour control centre to respond to faults by enabling faster identification and isolation of faulty sections of the network and quicker restoration of supply to customers who are connected to healthy sections. The restoration can take place, before crews are dispatched on-site.

Maintain asset availability to enable fast restoration

When assets fail and an outage occurs, supply is often restored to customers by isolating the failed section of network and restoring supply from an adjacent "healthy" part of the network. The defects must be repaired in a timely manner and the network restored to its normal configuration. If these defects are not repaired, and another fault occurs in the same area, the time to restore supply to customer is likely to increase significantly as the adjacent network is defective and not available to restore supply.

Evoenergy's asset management plans and network defects triage process seeks to identify network defects with high reliability risk to prioritise repairs in a timely manner.

Appendix G: Power quality standards and obligations

This appendix provides additional information in relation to power quality in addition to the information provided in Chapter 4.This appendix provides additional information in relation to power quality in addition to the information provided in Chapter 4.

The appendix includes the following commentary:

- An overview of the main standards, guidelines and other technical requirements relating to power quality
- Description of key power quality parameters and requirements
- Summary of power quality issues related to embedded generation

Power quality standard and references

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 NER requirements, relevant standards codes, and guidelines. These include:

- *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.

Power quality parameters

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.

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.

Steady state voltage at the customer's point of supply is measured to ensure the V1%, V99% and V50%, (phase-to-neutral and phase-to-phase).

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)

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% 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 online starting of induction motors.
- Electric welders.
- Arc furnaces.

Evoenergy responds to a customer report of flicker by installing a mobile power quality analyser. Evoenergy either 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.*

Voltage fluctuation

Compatibility levels for flicker in lv systems	
P_{st}	1.0
P_{lt}	0.8

Compatibility levels are not defined for MV, HV and EHV systems in the Australian Standards.

P_{st} refers to "short term severity level" and is determined for a 10-minute period.

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 consectutive10-minute periods.

Voltage flicker levels for different voltage levels

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

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, sectionalises and fault passage indication devices to reduce fault switching.

Voltage Dip Voltage Tolerances[30]

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 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.

30 ACT Electricity Distribution Supply Standards Code

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:

1. Inadequate earthing (high earth resistance or open circuit earth) at substations.
2. 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.

Act Electricity Distribution Technical Standards Code prescribes voltage difference between neutral and earth is < 10 V steady state (5-minute average) at the point of supply.

Voltage difference between neutral to earth limits[31]

Voltage Difference Between Neutral to Earth
< 10 Volts (5 minute average at the point of supply)

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

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*.

Compatibility levels for voltage levels in LV and MV systems

Maximum Negative Sequence Voltage (% of nominal voltage)
2%

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.

31 Electricity Distribution Supply Standards Code

Harmonics

Harmonics are usually customer-generated. Non-linear loads such as industrial equipment (e.g. arc welders), variable speed drives, uninterruptible power supplies, some types of lighting, 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.

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

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).

Power quality issues associated with embedded generation

Voltage stability and regulation

Synchronous generators provide dynamic voltage support to the power system, particularly during and immediately following system faults. 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. The replacement of synchronous generation with asynchronous generation reduces the fault current and can lead to a "weak" system. 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 may cause high voltage on the distribution network so output from DC/AC inverters will need to be strictly adhered to.

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.

Solar PV generation both on a large scale (e.g. solar farm) and small scale (e.g. residential rooftop system) can be intermittent and difficult to forecast. 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.

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, that is 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. To maintain low voltage levels within regulatory limits, Evoenergy is trialling 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.

Frequency stability

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.

The inertia of the rotating plant of such generators can support system frequency following a system disturbance such as loss of a transmission line or large generator. 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 flywheel or similar. When a network has little or no inertia, 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 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.

Appendix H: Network technical parameters and systems

This appendix provides and additional information on the network technical parameters and systems.

Key network systems

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.

Further benefits are expected in the next few years with Evoenergy's transition to IEC 61850 based SCADA and protection systems for Zone Substations.

Protection systems

Evoenergy uses protection systems thought the network including 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 under-performing protection relays that have reached the end of their economic life. Old electro-mechanical and static/electronic protection devices are being progressively replaced with modern numerical relays.

- 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.

Network voltage regulation

The Evoenergy network is supplied from TransGrid's bulk supply substations at Canberra, Williamsdale, and Queanbeyan. Voltage levels on the 132 kV bus at Canberra and Williamsdale 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.

The 11 kV bus voltage at each Evoenergy 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.).

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 to AEMO, 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 is considering the application of smart metering technology to further ensure compliance of steady state voltage levels.

Network fault level and protection

Fault level is defined in terms of fault 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.

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.

Earthing and earth potential rise

The role of the network earthing is to ensure that the voltage does not raise above the acceptable limits under defined network fault conditions. The earthing also provides a path to earth for fault currents directly impacting the fault current levels and an operation of the electrical protection system.

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:

1. Inadequate sizing of the earth conductor relative to the maximum fault current.
2. 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[32]. 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. Evoenergy is developing a set of guides and standards relating to earthing

32 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 design, construction, and testing.

Electrical earthing audit 2018

In 2018, the ACT Technical Regulator conducted and audit of electrical earthing practices within Evoenergy's network. The audit identified some non -conformances and recommended several improvements.

In response, Evoenergy initiated a set of initiatives to address the identified deficiencies. Using risk assessment, Evoenergy developed and prioritised a program which addresses earthing design, construction and testing, work practises, testing and records management.

The actions taken include updated Evoenergy earthing design manual and design software based on the relevant standards. In addition, Evoenergy developed a suite of seven earthing manuals for the construction and testing which are covering end to end information and methods from earthing fundamentals, construction, testing to training. While most manuals have been published, some training manuals are being completed. The objective of the newly introduced software and documentation is to align Evoenergy with the industry best practise and full compliance with the relevant standards.

The earthing test program for transmission assets, distribution assets, and zone substations was prioritised in accordance with the risk profiles including asset type, age, condition and a likelihood of persons being exposed to earth potential rise. Evoenergy's 2018-19 testing program and beyond is conducted in accordance with the risk based priorities. Evoenergy is developing a set of guides and standards relating to earthing design, construction, and testing.

Transmission service network 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).

Customer metering - competition in metering

Evoenergy manages a fleet of approximately 180,000 revenue meters installed at customer premises. The main purpose of conventional meters is to measure a consumption of electricity. The meters are being managed in accordance with Evoenergy's metering asset management plan. In 2017 a set of regulatory reforms under the Power of Choice banner expanded contestability to the installation of all customer metering. Under new rules the meter installation is subject to completion and can be provided by parties authorised by AEMO. The rules also require all new and replacement meters to be Type 1-4 meters (advanced meters). The functionality of advanced meters goes well beyond the metering of energy consumption. The latest generation of meters include functionality which can provide additional information to customers on their energy consumption, assist with network operation and provide additional data in relation to power quality.

Evoenergy is exploring opportunities to work with retailers and metering providers to utilise advanced meters functionality in relation to cost reflective tariffs, outage management, network planning, power quality monitoring and demand management.

Key network technical parameters

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)[33] 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.

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.

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).

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).

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.

System losses

As electrical energy flows through the transmission and distribution networks, a portion is lost due to the electrical resistance and heating of network elements such as conductors and transformers. Across the Evoenergy network these losses may be up to 3%–5% of the total energy transported. Energy losses on the

33 https://www.energynetworks.com.au/resources/fact-sheets/emf-management-handbook/

network must be factored in at all stages of electricity production and transport, to ensure adequate supply is available to meet prevailing demand and maintain the power system in balance. In practical terms, this means more electricity must be generated to allow for this loss during transportation.

Management of losses assists with achieving better business and environmental outcomes.

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.

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. Evoenergy's service and installation rules require that the power factor is not lower than 0.9. However, there a number of challenges with monitoring and enforcement of this requirement. Maximum demand and capacity tariffs, may be effective in reducing peak load on the network, will also result in reduced currents and therefore reduced network losses.

The asset life-cycle cost assessment ensures that the capital cost is one of the factors 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.

Evoenergy considers network losses in the major investment decisions. Whenever appropriate, distribution losses are included in system planning. If a significant network augmentation option being considered offers a benefit of substantially reduced losses – that benefit is taken into account in cost benefit analysis of this option vs other alternatives. However, value of losses is usually not sufficient to justify investments. Depending on the specific solutions, the level of losses may however influence a selection of preferred option.

Evoenergy standardises cables and conductors approved for the application in the network. The standard cables allow Evoenergy to gain efficiency in procurement, design, construction and maintenance. While different size cables result in different electrical losses, cables are usually sized according to capacity requirements. In most cases the differences in value of electrical losses is not sufficient to justify a selection cable.

Distribution loss factors

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. Loss factors are calculated and fixed annually to facilitate efficient scheduling and settlement processes in the NEM.

Under the NER *Clause 3.6.3*, Evoenergy is required to calculate and publish annually the distribution loss factors on its network. Publishing of the loss factors improves transparency of the network loss performance to retailers and customers. Evoenergy calculates 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 or 40 GWhs consumption) and average DLFs for non-site-specific consumers. High voltage distribution feeders and transmission lines are analysed using data from Evoenergy's Advanced Distribution Management System (ADMS).

The DLF calculation methodology can be found on Evoenergy's website[34], and Evoenergy's published DLFs can be found on AEMO's website[35].

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

35 https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/loss_factors_and_regional_boundaries/2020-21/dlf-2020-2021.pdf?la=en