Network Opportunity Map 2022

NOM2022

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The information contained in the NOM2022 is subject to annual review. Western Power is obligated to publish future editions by 1 October each year, in accordance with the *Electricity Network Access Code 2004* and changes made in September 2020.

Further Information

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Abbreviations

The following table provides a list of abbreviations and acronyms used throughout this document. Defined terms are identified in this document by capitals.

Term	Definition
AA	Access Arrangement
Access Code	Electricity Networks Access Code 2004 (& subsequent amendments)
Act	Electricity Industry Act 2004 (& subsequent amendments)
ADV	Annual Deferred Value
AEMO	Australian Energy Market Operator
AMF	Asset Management Framework
AMI	Advanced Meter Infrastructure
AMS	Asset Management System
AOS2021	Alternative Options Strategy 2021
BC	Business Case
BCH	Beechboro Zone Substation
BYF	Byford Zone Substation
CAG	Competing Applications Group
CBD	Central Business District
CKN	Clarkson Zone Substation
CPI	Consumer Price Index
CUSTED forecasts	Customers, Technology, Energy and Demand trends adjusted forecasts
DER	Distributed Energy Resources
DNSP	Distribution Network Service Providers
EDL1	Electricity Distribution Licence
EGF	Eastern Goldfields
EOI	Expressions of Interest
EPWA	Energy Policy Western Australia
ERA	Economic Regulation Authority
ERG	Emergency Response Generator
ETL2	Electricity Transmission Licence
ETS	Energy Transformation Strategy
ETT	Energy Transformation Taskforce
EV	Electric Vehicles
FRZ	Fire Risk Zone
FSP	Flexibility Services Pilot

FY	Financial Year
GIA	Generator Interim Access
GTEng	Grid Transformation Engine
HV	High Voltage
HVIU	HV Injection Unit
HBK	Henley Brook Zone Substation
IAR	Investment Approval Requests
KMG	Kalbarri Microgrid
LV	Low Voltage
MAOSC2021	Model Alternative Option Service Contract 2021
MH	Mandurah Zone Substation
MRL	Mean Replacement Life
MSS	Meadow Springs Zone Substation
MV	Medium Voltage
NBV	Net Benefit Valuation
NCMT	Network Capacity Mapping Tool
NCS	Network Control Service
NFIT	New Facilities Investment Test
NOM	Network Opportunity Map
NOM webpage	Network Opportunity Map webpage www.westernpower.com.au/network-opportunity-map
NOM2022	Network Opportunity Map 2022 (this document)
NQRS Code	Electricity Industry (Network Quality and Reliability of Supply) Code
NP	Network Plan
NSP	Network Service Provider
POE	Probability of Exceedance
PV	Photovoltaic Systems
RFP	Request for Proposal
RIS	Required in Service (date, usually part of a project definition)
RMU	Ring Main Units
ROI	Registration of Interest
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCED	Security Constrained Economic Dispatch
SNR	Southern River Zone Substation
SOTI	State of the Infrastructure Report

SPS	Stand-alone Power System
SSAM	Service Standard Adjustment Mechanism
SSB	Service Standard Benchmark
SST	Service Standard Target
SVC	Static Var Compensator
SWIN	South West Interconnected Network
SWIS	South West Interconnected System
TR	Technical Rules
TSP2022	Transmission System Plan 2022
VPP	Virtual Power Plant
WA	Western Australia
WAI	Waikiki Zone Substation
WEM	Wholesale Electricity Market
WOSP	Whole of System Plan
WOSS	Whole of System Study
YP	Yanchep Zone Substation

Executive Summary

Western Power's Network Opportunity Map 2022 (NOM2022) offers an insight into the South West Interconnected Network's (SWIN) challenges and intentions in the next 5 to 10 years, in an environment of rapidly evolving technology and unprecedented penetration of renewable energy sources. The report identifies existing and emerging network risks and constraints, offering the opportunity for third parties to provide solutions to overcome these constraints.

The NOM2022 is published on the Network Opportunity Map webpage (NOM webpage[1]) with the Alternative Options Strategy 2021 (AOS2021), Model Alternative Option Service Contract 2021 (MAOSC2021) and a suite of downloadable supporting data presented in a user-friendly format. The NOM webpage also houses a vendor NOM registration form and contact details as means for Western Power to engage with customers and the industry in developing alternative solutions to some of the emerging issues and constraints identified in the NOM2022.

The webpage and associated information, including NOM2022, aim to meet the intent and requirements set out in the September 2020 changes to the Electricity Networks Access Code 2004 (Access Code), specifically chapter 6A. To this end, NOM2022 contains details of identified emerging constraints and risks on Western Power's transmission and distribution networks in a format that can be used to anticipate future opportunities for alternative solutions. The document also gives a broad overview of the methodologies used to identify and quantify these constraints, as well as outlining the frameworks and regulations that govern how Western Power invests in solutions addressing emerging network issues.

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1 www.westernpower.com.au/network-opportunity-map

1. Introduction

Western Power has provided Western Australians with safe, reliable and efficient electricity for more than 70 years, growing with the State and changing with the times.

Our vast transmission and distribution network connects homes, businesses and essential community infrastructure to an increasingly renewable energy mix while meeting the changing energy needs of Western Australians. Demand for cleaner energy is transforming the traditional electricity value chain and understanding how the network needs to transform in response is the key to unlocking future opportunities for our customers, businesses and the State.

The NOM webpage enables this transformation by proactively seeking the input of business and industry communities when addressing the needs of the network and harnessing alternative solutions developed to benefit all Western Power customers.

The NOM has three distinct purposes:

- To provide a snapshot of the challenges, risks and constraints emerging for the network in the planning period (5 years) and in the foreseeable long term (10 years).
- To give all customers, industry and market participants an opportunity to anticipate network needs and proactively provide alternative solutions to those traditionally available to Network Service Providers (NSPs).
- To outline how Western Power will seek out, evaluate and engage with interested parties in developing alternative solutions to network constraints.

NOM2022 offers insight into emerging opportunities for development and deployment of alternative solutions. For some loads and/or generators, opportunities might be in the form of network areas with under or over-utilisation, both on transmission and distribution networks. For alternative solutions, opportunities could also include demand management, energy storage, reliability improvements and many other solutions, with focus on areas of the network where emerging constraints and issues have been identified.

The referenced data sheets listed on the NOM webpage include information that was previously published by Western Power through other channels such as our Annual Planning Report; there is now potential to phase out redundant publications.

Western Power intends to build on this NOM publication and the NOM webpage to provide additional insights and information that improve the visibility of new and emerging opportunities.

1.1 About Western Power

1.1.1 Our network

We build, operate and maintain the transmission and distribution network. Our service area of 255,064km^2:

- is bigger than the United Kingdom
- contains 103,733 km of circuit wire – two and a half times the Earth's circumference (40,075km)
- is geographically vast – an average of 4.6 customers per square kilometre

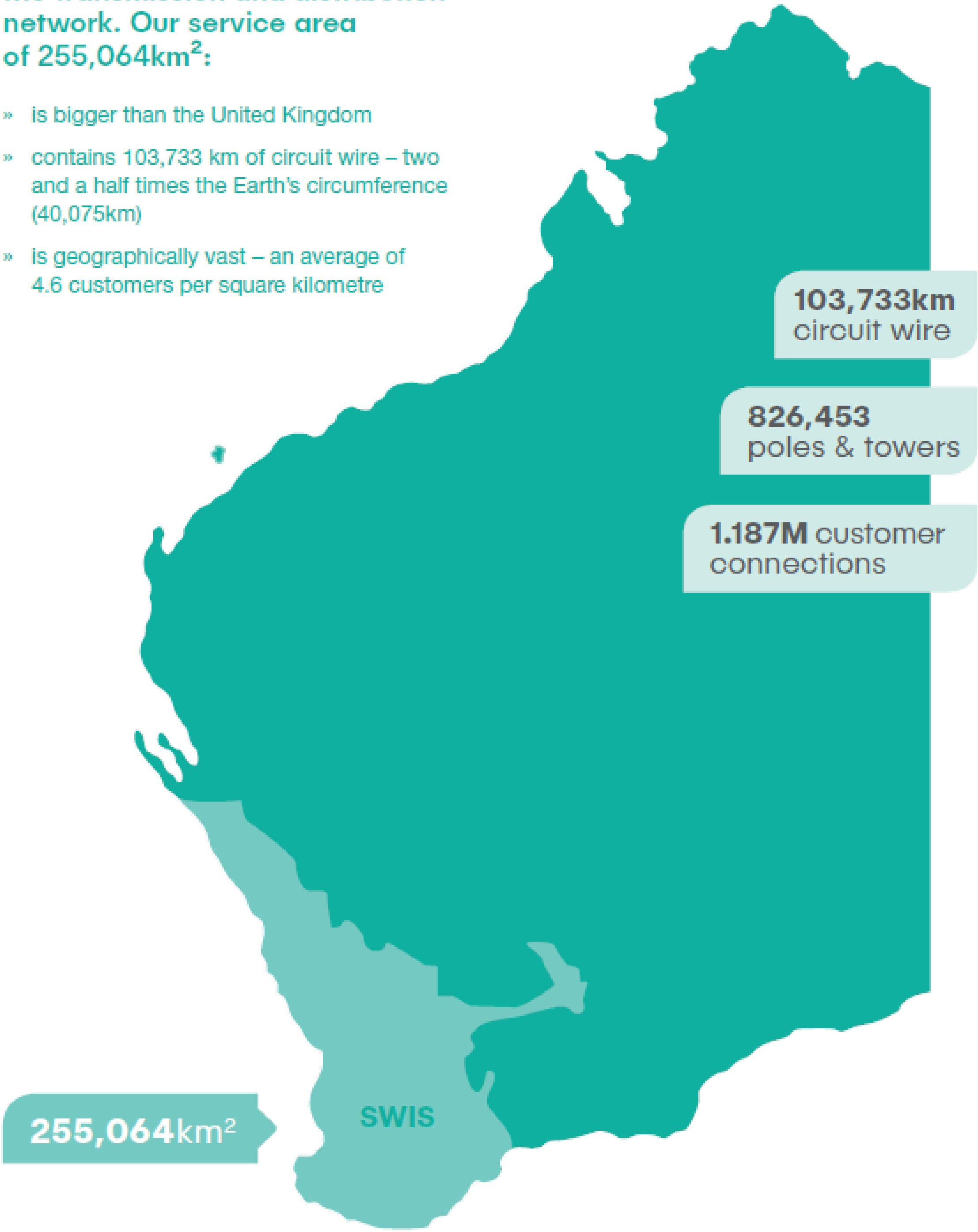

Figure 1.1: Overview of the Western Power Network

The Western Power network is unique due to its geographical size and overall low density of connections, and its isolation and lack of interconnections to any other large systems. These attributes make the network uniquely challenging in both operation and maintenance.

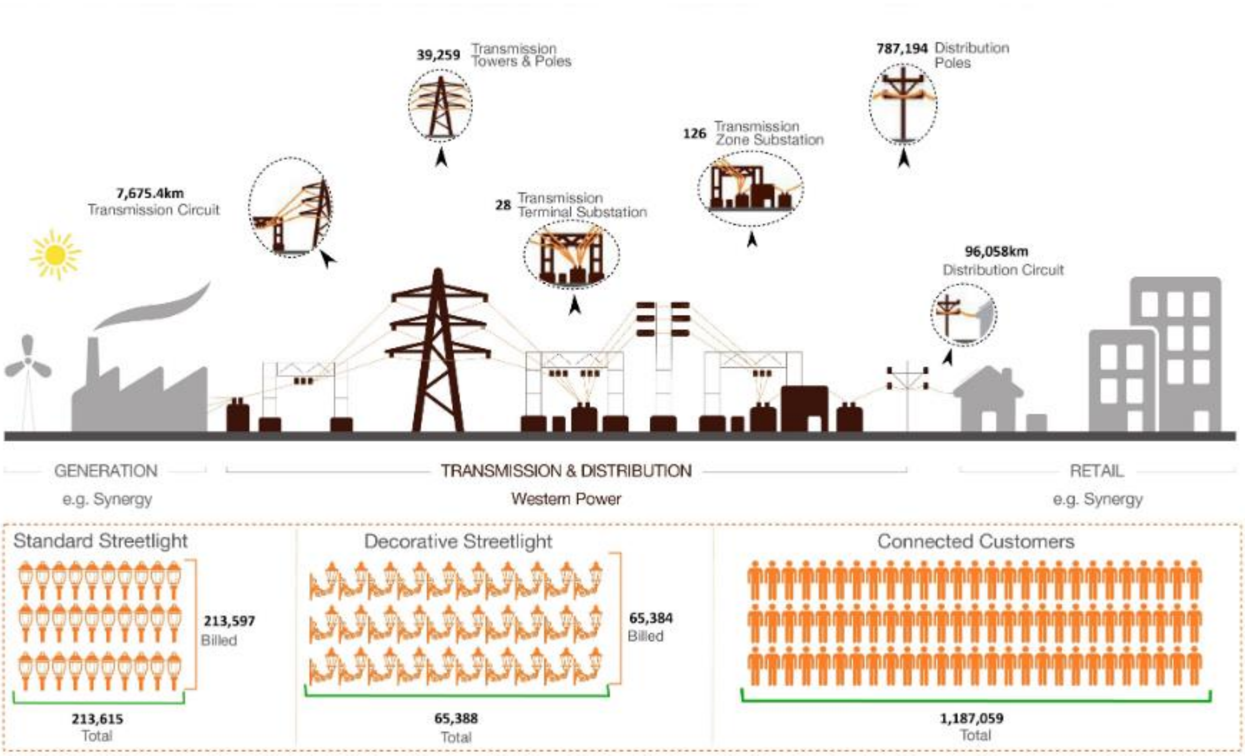

Figure 1.2: Western Power network metrics 2021 to 2022

The network incorporates:

- 13 community power banks
- More than 5,900 approved battery systems
- More than 1.76 GW of rooftop solar (about 30 per cent of homes)

Western Power's network is inherently dynamic and complex, with changing customer needs and expectations. We aim to be agile and responsive to these factors while maintaining a safe, reliable and efficient electricity supply, ultimately delivering an affordable and quality product for all Western Australians.

1.1.2 Our Corporate Strategy, Vision and Values

Western Power's Corporate Strategy 2021-2031[2] centres on 'powering the lives of our community'. It recognises that our community of 2.3 million Western Australians want Western Power to safely provide reliable, increasingly renewable electricity while keeping costs low and supporting jobs and growth.

Our strategy sets out our plan to meet these needs by transitioning to a modular grid and supporting the decarbonisation of the local economy.

We put the community at the centre of everything we do. As a GTE we're owned by the people of Western Australia which means we have a rigorous approach to financial sustainability while delivering on the energy needs of the community.

[2] Western Power Corporate Strategy | 2021-2031

With our renewed corporate strategy, we have aligned our corporate vision with the strategy with our corporate values remaining consistent and strong to support realising our strategy.

Our Vision

Powering the lives of our community by delivering the modular grid.

Our Values

1.1.3 Our Operating Environment

Western Power is a Western Australian State Government owned corporation responsible for building, maintaining and operating an electricity network. We are licenced under the *Electricity Industry Act 2004* (the Act) and regulated by the Economic Regulation Authority (ERA), which grants us our Electricity Transmission Licence (ETL2) and Electricity Distribution Licence (EDL1) and determines Western Power's revenue, services, policies and incentives via the access arrangement (AA).

The network facilitates the Wholesale Electricity Market (WEM) which is operated by the Australian Energy Market Operator (AEMO).

These laws and regulations govern all aspects of our operations, from how funding for works is obtained to our standards of supply and tariff structure. For more information, visit the Energy Policy WA (EPWA) website[3].

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3 https://www.wa.gov.au/organisation/energy-policy-wa/regulatory-framework

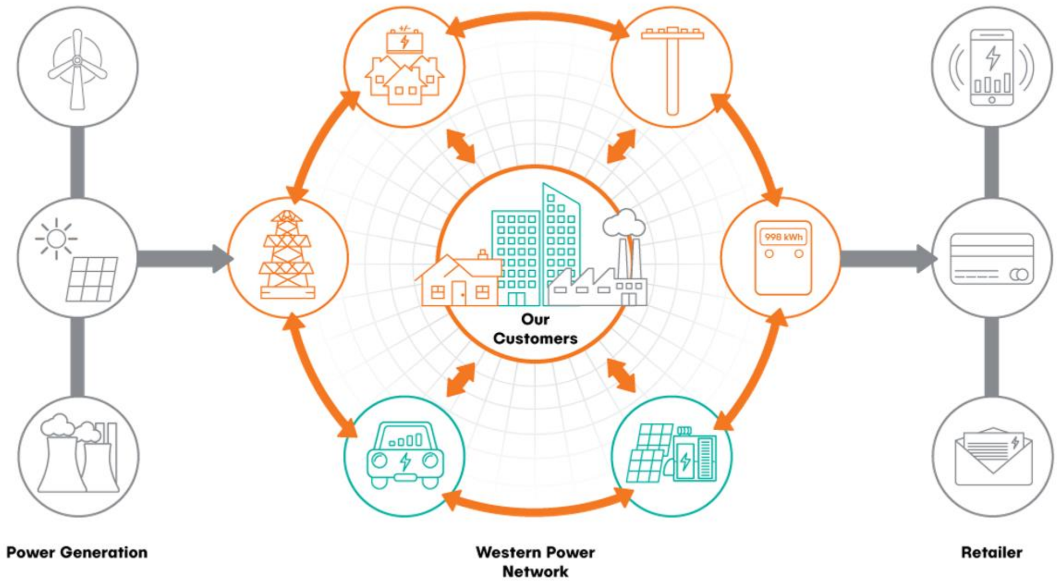

Figure 1.3: Western Power's role within Western Australia's electricity market

1.2 Role of the Network Opportunity Map

1.2.1 What is the Network Opportunity Map?

The Network Opportunity Map (NOM) is a regulatory requirement for Western Power outlined in chapter 6A of the Access Code[4]. The detailed requirements for the content and timing of the NOM can be found in Appendix A, along with references to sections of this document that address each requirement.

The Access Code changes are intended to work hand in hand with several other initiatives (Section 1.3) aimed at transforming our electricity industry into a flexible, future-focused model that leverages cleaner and more efficient new technologies in a more sustainable way.

A dedicated NOM webpage has been established within the Western Power website: www.westernpower.com.au/network-opportunity-map

The NOM webpage was published on 1 October 2021 and houses all NOM related documentation, data, forms, links and contact details including:

- The current edition of the head document, NOM2022 (this document)
- The first and current edition of the AOS2021
- The first and current edition of the MAOSC2021
- Data sheets supporting the NOM2022
- A vendor NOM registration form (three-year rolling register)
- Email contact details for feedback and suggestions (NOM.TSP@westernpower.com.au).

1.2.2 How are constraints identified?

The network we operate is always changing: the topology changes daily due to switching for planned and un-planned reasons, while the profile of demand and supply at various points can change minute by minute. Because of this, several assumptions must be made when identifying emerging risks and constraints. These are based on the best data available at the time, including but not limited to anticipated demand and supply patterns, the condition and capability of specific assets, changes in policy and regulatory requirements, and emerging technology. More details about the methodologies that influence network condition evaluations can be found in Appendix B.

The risks and constraints identified in any NOM version offer a snapshot of what we know about our network at that point in time. The amount of detail associated with each constraint can vary significantly, from well-defined and eventuating within a few years, to broad and with a timeframe extending to 10 years or beyond. The speed with which a constraint progresses to maturity depends on many factors, including the magnitude of the issue and applicable voltage as well as unforeseen events that may affect it.

While the NOM is published once a year, the solution development process for the network is continuous, with new information gathered about each issue year-round. A constraint is said to mature as the level of its certainty, detail and definition increases.

Figure 1.4 below shows a typical constraint maturation lifecycle with some notional timing.

Conceptual Constraint Lifecycle

4 https://www.wa.gov.au/sites/default/files/2019-08/ElecNetworksAccessCode.pdf

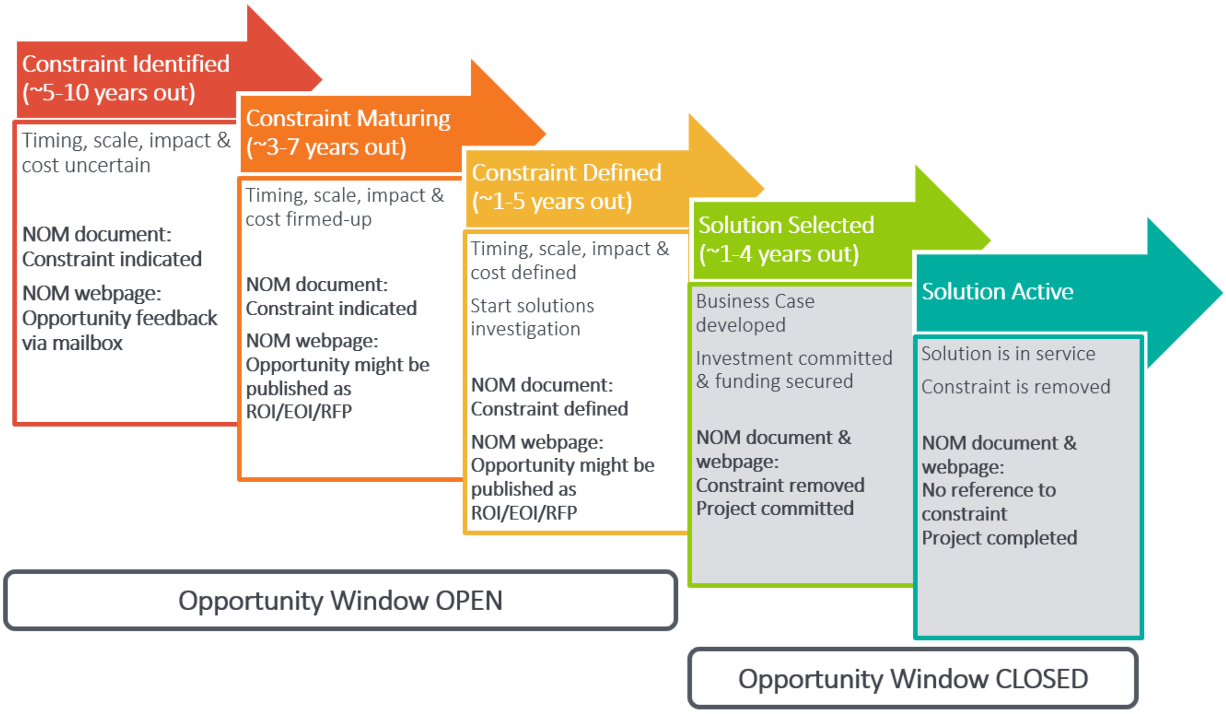

Figure 1.4: Example of a constraint maturation lifecycle

1.2.3 When is an opportunity ready for an alternative solution?

The emerging risks and constraints indicated within this document can be used to anticipate where, when and what kind of solutions might be required on the network in the coming years, presenting opportunities for participation. Some risks or constraints may suit alternative solutions, while others will be better served by traditional network solutions. In either case all customers, industry and market participants can use the information to gain an indication of the type of works Western Power may undertake in the short to medium term, and to proactively offer solutions to overcome risks and constraints.

The magnitude and nature of an issue, as well as certainty of the timing for the risk or constraint, plays a role in determining when Western Power needs to commit to a solution that will address or defer the issue. Western Power may also evaluate the suitability of each risk or constraint as an opportunity for an alternative solution and establish a benefits baseline through comparison with a traditional network solution.

When a particular risk or constraint (or a group) identified as suitable for an alternative solution reaches critical maturity, a sourcing event will be raised through the NOM webpage.

From 1 February 2022 new WEM Rules came into effect as part of the State Government's Energy Transformation Strategy (ETS), placing obligations on Western Power to follow the procurement process outlined in section 3.11B when procuring an alternative or non-network service.[5] Western Power is developing business processes to transition to the new procurement process.

[5] Non-network services are referred as Non-Cooptimised Essential System Services in the new WEM Rules. For a network, these services can be procured to relieve network constraints, defer network augmentation, provide local network stability services, or address locational reliability needs.

Alternative Option Solution Sourcing

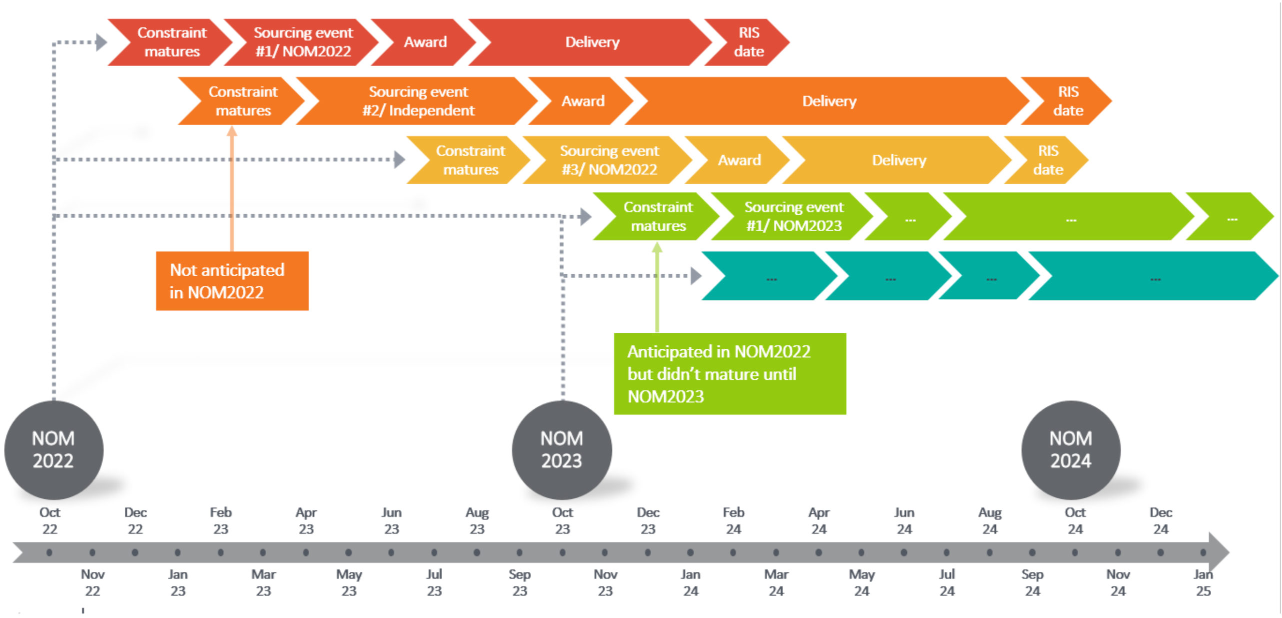

Figure 1.5: Alternative option solution sourcing

1.2.4 Participating for future procurement events

The most direct way to participate in the NOM is by filling out the vendor NOM registration form on the NOM webpage. Registrations are valid for three years and used by Western Power to notify all parties when a new edition of NOM is available or when a new sourcing event is published. At the end of the three-year period, vendors are invited to re-register. Whether registered or not, vendors can still respond to sourcing events of interest in line with the relevant specifications.

Figure 1.5 outlines the process from planning to when an alternative option procurement event is triggered seeking solutions from potential vendors.

The NOM provides insights into technologies being developed that may be used as alternative solutions, or to offer assistance with constraints that have not yet reached maturity.

Western Power welcomes ideas for improving the usefulness of the information contained within this document and associated NOM processes. Feedback can be provided via email – NOM.TSP@westernpower.com.au).

1.3 Network of the Future

The traditional energy service business model – a network of assets that delivers electricity in a one-way flow – is no longer the norm. Networks must facilitate bi-directional flow of energy, in addition to incorporation of islanded systems, microgrids and stand-alone power systems (SPS).

Western Power is embracing this changing environment and transforming how we plan, build and operate our network. New technologies and customers who are more conscious of their energy source are also driving demand for renewable energy and non-traditional solutions.

The diagram below depicts the transition from the existing integrated network to a modular network. It is reliant on community behaviour, technology advancement rates, regulation and policy.

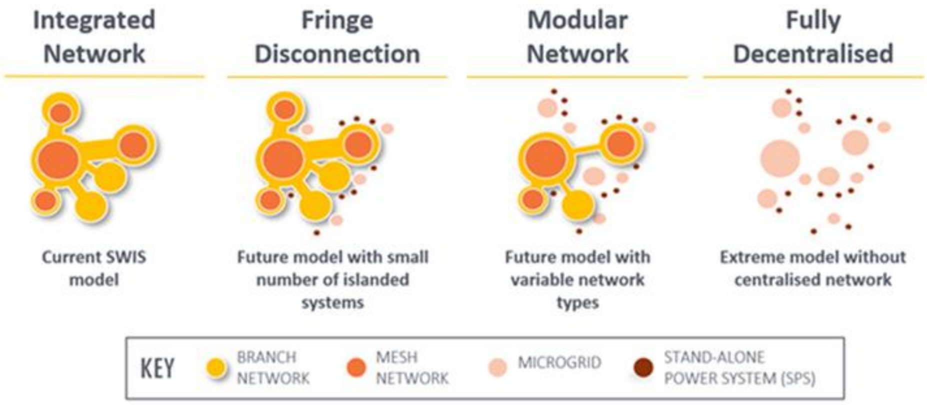

Figure 1.6: Network evolution model

Western Power is innovating with new technologies that have the potential to make the most of our network and better meet customer needs. The network is being transformed through adoption of the new technologies where they provide better cost and reliability performance compared to traditional solutions.

Figure 1.7: Modular grid and main elements of transformation

Some of the initiatives currently being developed or underway are explored in greater detail in the following sections. Many of these represent alternative options which are already deployed on the network and form a template for types of solutions being sought for the emerging network constraints under the NOM.

1.3.1 Energy Transformation Strategy

The ETS [6] concluded and has moved into stage 2 – a State Government work program aimed at delivering secure, reliable, sustainable and affordable electricity for years to come. Western Power has a significant role to play in assisting delivery the three key initiatives outlined in stage 2 of the ETS:

1. Implementing taskforce decisions
2. Integrating new technology
3. Keeping the lights on
4. Regulating for the future

1.3.2 Grid Transformation Engine

Network infrastructure typically has a long lifespan (beyond 50 years in many instances) which requires forward-looking investment planning. The rapidly changing nature of energy consumption and the use of electricity networks requires an update to traditional network planning approaches. The Grid Transformation Engine (GTEng) is a software system which considers different economic, demographic and technology scenarios across a 30-year period to inform network strategy, planning and investment. Enhanced planning systems such as GTEng are an essential part of the capabilities needed to realise the full benefits of new technology and regulatory changes.

1.3.3 Stand-alone Power Systems

One way of improving reliability in regional areas is by adopting newer technology, such as SPS. SPS is an alternative energy supply that uses renewable energy on site, so it does not rely on traditional long feeders to supply regional and remote customers. It is a grid-independent energy-generating system that consists of solar photovoltaic (PV) panels, battery storage, an inverter and a backup generator located in a restricted area on a customer's property. Modelling shows that by installing thousands of SPS over the coming decades a significant amount of the traditional overhead network which is more susceptible to reliability impacts can be removed.

In 2016 Western Power undertook a trial of six SPS to better understand what community, customer, commercial and environmental benefits could be realised. The trial exceeded expectations by significantly improving power reliability for customers and led to the roll-out of an additional 52 units in 2020 across regional Western Australia (SPS round 1) – the largest deployment of SPS in Australia. Western Power now has more than 100 SPS units commissioned across the network.

SPS has significantly improved customer experience, realising tangible commercial, environmental and social benefits. The potential deployment of around 6,000 units in coming decades will enable the decommissioning of more than 23,000km of overhead assets delivering significant cost savings. The associated customer and community benefits are overwhelmingly positive, and removing poles and wires will also improve safety and reduce bushfire risks for landowners.

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6 https://www.wa.gov.au/organisation/energy-policy-wa/energy-transformation-strategy

1.3.4 Community Batteries

Western Power has installed 13 community batteries at several locations[7] across our network. For the majority of these batteries, we partnered with Synergy, using PowerBank products that allow customers to store excess electricity generated by their solar panels in a network-scale battery and draw on this during peak times. We have also partnered with the Shire of Margaret River to install a community battery on the customer side of meters – a unique trial to investigate the local network benefits of network-scale batteries installed behind the meter.

1.3.5 Microgrids

The primary purpose of installing a microgrid on a section of Western Power's network is to provide power when normal supply is interrupted from the grid due to a fault and during restoration periods, improving reliability for impacted sections of the Western Power network. As mentioned in section 1.3, Western Power embraces evolution in the network with increasing distributed energy generation by customers causing bi-directional power flows as opposed to traditional network where customers are only power consumers. To ensure the most efficient use of these distributed energy resources, microgrids are being developed in areas where reliability performance is poor with distributed energy resources available in the daytime to minimise reverse power flows and supply power if required during peak demand periods. Microgrids can also provide voltage support and frequency support to Western Power's network if required.

Western Power's first reliability improvement in 2018 entailed the installation of a 1MW, 1MWh Battery Energy Storage System (BESS) on the outskirts the rural town of Perenjori, north of Perth. Once the system was commissioned it addressed both momentary and longer outages and has substantially improved reliability for customers in the town. The system also has the capability to control excess generation from solar PV systems when it is islanded from the grid.

The most recent microgrid deployment was the Kalbarri Microgrid (KMG), which comprises the portion of the distribution network that supplies the Kalbarri township and some customers south of the main town. The KMG can operate independently as an islanded network or connected to the grid (SWIN) and consists of a 6MW, 4.5MWh utility scale battery and inverter system which supplies the area if normal network supply via the SWIN is interrupted. Since being commissioned in October 2021, the KMG BESS has supplied Kalbarri during interruptions from the SWIN and provided voltage and frequency support services while connected to the SWIN. It has the capability to manage other energy resources such as a 1.6MW Synergy Windfarm and residential rooftop PV generation in 'island mode' to extend battery run time and recharge the battery when surplus power is available from these resources.

Another upcoming joint project between Western Power and WA-based engineering company Power Research and Development will be the State's first pumped-hydroelectric microgrid, to be built in Walpole in 2023. This project marks another step toward a cleaner and greener energy future by incorporating renewable generation and decarbonising communities, along with improving reliability for customers in the area at no additional cost. More details about the project can be found on the Western Power website's news page.

Western Power is also investigating opportunities for small disconnected microgrids for rural towns, similar to the concept of SPS in remote regional locations. Local renewable generation can be utilised to provide a

[7] The full list of community battery sites at the time of writing is: Meadow Springs, Falcon, Ellenbrook (No. 1), Ashby, Two Rocks, Canning Vale, Busselton, Kalgoorlie, Ellenbrook (No. 2 - Westgrove), Port Kennedy, Yokine, Parmelia, Margaret River (behind-the-meter).

self-sustaining islanded network for towns without reliance on traditional long rural pole and wire assets. It is envisaged that the deployment of many future disconnected microgrids along with standalone power systems would realise the potential of the modular grid in regional areas, providing customer experience benefits in both reliability and power quality.

1.3.6 Decarbonisation

Climate change commitments of net zero by 2050 (globally) and national emission reductions of 43 per cent by 2030[8] are driving action by industry in Western Australia and across the globe. Decarbonisation activities include:

- Electrification of major industry such as transportation and current gas-supplied processes.
- New loads from alternative energy sources such as hydrogen and ammonia.
- Commercial and residential vehicle electrification.
- Government policy commitments (e.g., Synergy coal-fired generation retirement).

These activities are likely to require a substantial step change in demand, renewable generation and energy storage. Western Power is working with EPWA and other government stakeholders to develop a grid vision for the network that can accommodate future decarbonisation requirements, along with conducting studies internally to identify opportunities to support decarbonisation.

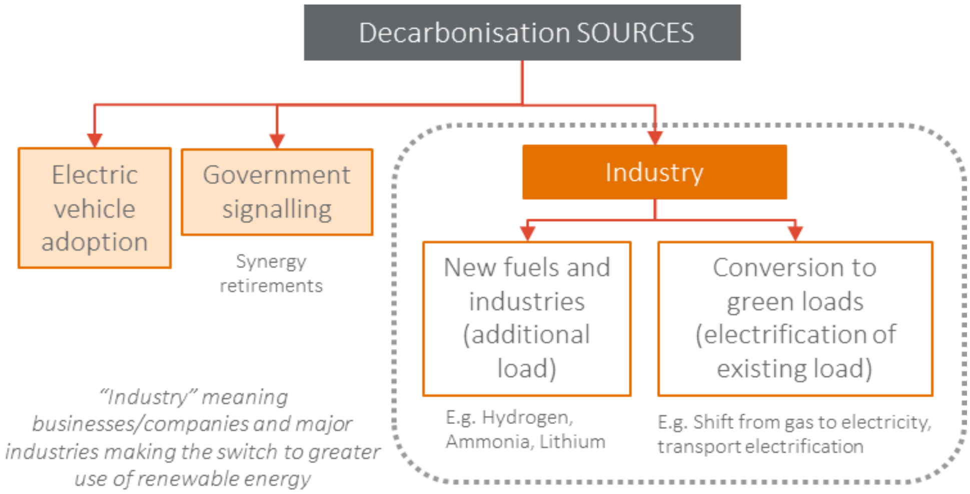

Figure 1.9: Decarbonisation sources

1.3.7 Project Symphony

The Project Symphony Virtual Power Plant (VPP) pilot is a collaboration between Western Power, Synergy and AEMO to help better understand the future design of Western Australia's electricity system. This innovative project aims to 'orchestrate' about 900 DER assets across 500 homes and businesses in Harrisdale and Piara Waters, in the Southern River region. More information about Project Symphony is available on the Western Power website's Energy Evolution page.

8 https://www.industry.gov.au/news/australia-submits-new-emissions-target-to-unfccc

2. Transmission Network

2.1 Transmission Regions

The Western Power network covers the area from Kalbarri in the north to Albany in the south and from Kalgoorlie in the east to the metropolitan coast.

The network has been segmented into six geographic regions for the purposes of network planning. Dividing networks into regions is designed for ease of network planning as these regions can share similar load characteristics and experience shared network issues.

Figure 2.1 provides an illustration of the geographic boundaries between regions, with three regions covering the metro area and three regions covering the remaining country parts of the SWIS.

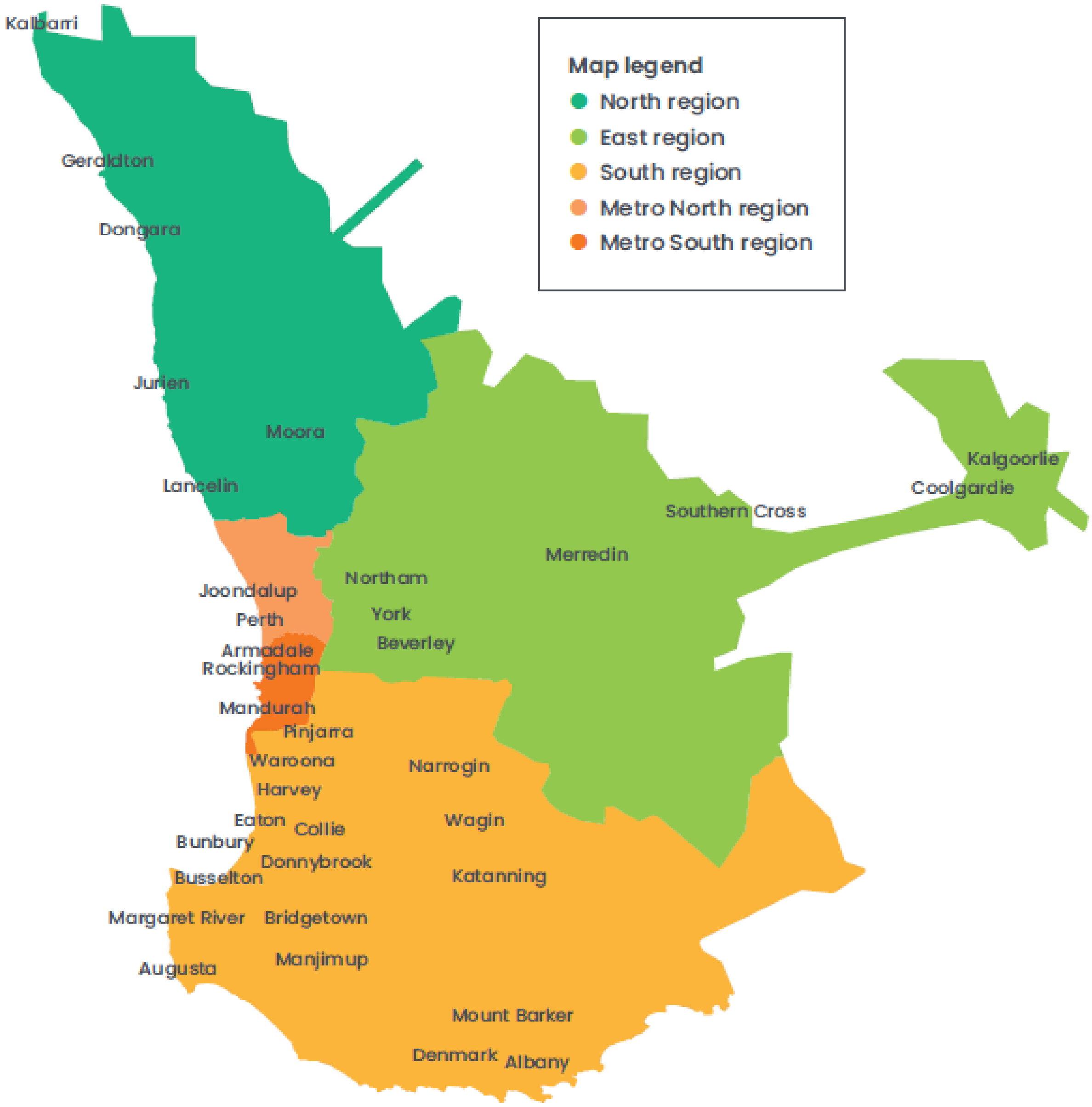

Figure 2.1: Western Power's transmission network regions

2.2 Transmission System Plan

The Transmission System Plan (TSP) is a new obligation for Western Power under section 4.5B of the WEM rules and is required to be published annually by 1 October. A draft version of the inaugural TSP is to be published by 1 October, with the final version to be published by 1 February 2023.

The purpose of the TSP is to present a 10-year forward plan for investment in the transmission network to deliver low-cost, safe, secure and reliable energy to consumers while operating within an increasingly complex and dynamic energy landscape. The TSP sets out potential investment opportunities, including alternatives to network augmentation, to alleviate identified network constraints to maintain power system security and reliability on the South West Interconnected System (SWIS) transmission network over a 10-year time horizon, while maximising the long-term interests of consumers.

The inaugural TSP covers the 2020/21 to 2029/30 planning horizon to enable alignment with Western Power's latest demand forecast[9] outlook and maintain continuity with existing network planning activities. As Western Power transitions to a forward-planning model, it is anticipated that future TSPs will cover the 10-year forward period.

2.3 Interaction between the TSP and NOM

The primary purpose of the NOM is to present network opportunities to providers of potential alternative options on both the distribution and transmission system within the 5-year time horizon, with opportunities on the transmission system limited to network constraints at the zone substation level.

Western Power's inaugural TSP presents a broader array of network opportunities on the transmission system beyond zone substation constraints, to promote transparency and to signal potential network opportunities as early as possible to assist planning within the 10-year TSP timescales[10]. This year's network opportunities will focus on alleviating thermal and voltage capacity constraints. Future versions will include a broader scope of opportunities as Western Power increases its knowledge and understanding in this area.

2.4 Zone Substation Loading - Historical and Forecast Performance

Table 2.2 shows existing and forecast peak load utilisation across the period 2020/21 to 2029/30 for all zone substations operated by Western Power, based on the substation utilisation classifications shown in Table 2.1. Western Power is in the process of finalising the 2021/2022 demand forecasts. As a result, the zone substation utilisation data presented in Table 2.2 remains similar to NOM 2021 but also includes PoE10% and PoE50% forecasts over the period 2020/21 to 2029/30.

Table 2.1: Utilisation legend (for Table 2.2)

LEGEND		
	Under utilised	below 40%
	Medium utilisation	>40% & <75%
	Highly Utilised	>75% & <95%
	Over Utilised	above 95%

9 Current demand forecasts were produced in 2020, looking forward from the period 2020/21 to 2029/30

10 Where Western Power decides to procure a service in response to a network opportunity, the Non Co-optimised Essential System Services framework as outlined in sections 3.11A and 3.11B will apply.

Table 2.2: Zone substation utilisation heat map

		Sub Capacity	Actual Utilization (%)	Forecast Utilization (%)																				Comments
Region	Substation	Current MVA	2020	2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		
				POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	POE10	POE50	
North	Clarkson[11]	56	129	117	101	117	101	117	101	116	101	116	100	115	100	115	99	114	99	114	98	113	98	Additional transformer (Scoping, RIS 2024)
North	Chapman	31	43	44	41	43	41	43	40	43	40	42	40	42	40	42	40	42	40	42	39	42	39	
North	Eneabba	31	31	30	23	29	23	29	22	29	22	29	22	30	23	30	23	30	23	30	24	30	24	
North	Geraldton	65	45	54	46	54	46	54	46	53	45	52	44	52	43	51	43	50	42	50	41	49	41	
North	Joondalup[11]	53	102	105	86	107	88	109	89	111	90	112	92	114	93	116	94	117	95	119	96	121	98	Additional transformer (Scoping, RIS 2025)
North	Landsdale	88	89	89	80	89	80	89	80	89	79	89	79	88	79	88	79	88	79	88	79	88	79	
North	Moora	16	89	95	88	96	87	96	87	97	87	97	88	98	88	99	88	99	88	100	88	100	88	

11 Western Power is developing contingency plans to manage the substation capacity shortfall risks prior to the installation of an additional transformer

North	Muchea	51	52	52	50	52	50	53	50	53	50	53	51	54	51	54	51	54	51	54	52	55	52	
North	Mullaloo	66	78	76	70	76	69	75	69	74	68	74	68	74	68	73	67	73	67	72	67	72	67	
North	Padbury	82	80	71	65	72	65	72	65	73	65	73	65	74	65	75	65	75	65	76	65	76	65	
North	Rangeway	69	51	44	37	46	38	47	38	48	39	49	40	50	40	51	41	53	41	54	42	55	43	
North	Regans -22 kV	19	55	54	52	53	50	52	50	53	51	55	52	56	54	58	55	59	56	61	58	62	59	
North	Regans - 33 kV	19	73	52	45	52	45	53	45	53	46	53	46	54	47	54	47	54	47	55	48	55	48	
North	Three Springs	16	54	58	51	59	52	60	53	61	54	62	55	63	56	63	56	64	57	65	58	66	59	
North	Wangara	28	73	81	76	83	79	86	82	89	85	92	87	95	90	97	93	100	96	103	99	105	101	Managed by distribution transfers
North	Wanneroo	84	60	70	61	70	61	70	61	69	61	69	60	69	60	69	60	69	60	69	60	69	60	
North	Yanchep	61	69	68	62	69	63	71	64	73	64	76	65	79	66	81	67	84	67	87	68	90	69	
South	Albany	60	91	90	84	90	84	89	83	88	83	88	82	87	82	87	81	86	81	86	81	85	80	

South	Beenup	14	48	49	42	50	41	50	41	50	40	50	40	50	39	50	39	50	38	50	38	49	37	
South	Boddington	10	55	55	41	55	41	55	41	56	40	56	40	56	40	56	40	56	40	56	40	56	39	
South	Busselton	71	71	72	67	73	67	74	68	75	69	76	70	77	71	78	72	79	73	80	74	81	75	
South	Bridgetown	29	99	104	90	104	90	104	90	105	91	105	91	105	91	106	92	106	92	107	92	107	93	Managed by distribution transfers
South	Bunbury Harbour	62	107	106	97	106	96	106	95	106	94	106	93	107	92	107	92	108	91	108	90	109	89	Managed by distribution transfers
South	Capel	43	46	58	48	58	48	65	54	65	54	65	54	65	54	65	54	65	54	65	54	65	54	Transformer Replacement (Scoping, RIS year 2027)
South	Coolup	12	65	65	36	65	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Coolup load transferred to Wagerup (2022) to facilitate substation decommissioning.
South	Collie	30	53	53	48	53	48	52	47	52	46	52	46	51	45	51	45	51	44	51	44	51	43	
South	Katanning	20	75	76	73	76	73	76	73	76	73	76	73	76	74	76	74	76	74	76	74	76	74	
South	Kojonup	10	27	27	25	27	25	27	25	27	25	27	25	27	25	28	25	28	25	28	25	28	25	
South	Mount Barker	44	18	17	16	17	15	16	15	16	14	15	14	15	13	14	12	14	12	13	11	13	11	

South	Manjimup	29	50	49	46	48	45	47	44	46	43	45	42	44	41	43	41	42	40	42	39	41	38	
South	Margaret River	37	47	47	45	47	45	47	45	47	45	47	46	48	46	48	46	48	47	49	47	49	47	
South	Marriot Road	67	61	112	103	112	104	113	104	113	104	113	104	113	104	113	104	114	105	114	105	114	105	A portion of non-reference customers have curtailable load such that the substation does not exceed capacity.
South	Narrogin	40	39	39	38	40	38	40	38	41	37	41	37	42	36	43	36	43	35	44	35	45	34	
South	Picton	74	64	65	58	66	58	67	59	68	59	69	60	70	60	71	61	72	61	73	61	74	62	
South	Wagin	6	90	89	84	88	83	87	83	86	82	86	82	85	81	85	81	84	81	84	80	83	80	
South	Wagerup	30	49	49	36	49	36	66	54	66	54	66	54	65	54	65	54	65	54	65	54	64	54	Load transfer from CLP (Execution, RIS year 2022)
East	Black Flag	31	118	142	105	140	127	139	127	139	127	139	127	139	127	139	128	139	128	139	129	139	129	A portion of non-reference customers have curtailable load such that the substation does not exceed capacity.
East	Boulder	62	47	45	40	44	38	44	38	45	38	46	39	46	39	47	40	48	40	50	41	50	41	
East	Bounty	10	102	114	100	114	100	114	100	114	100	113	100	113	100	113	100	113	100	113	100	113	100	10 MVA loading TR compliance limit

East	Carrabin	6	20	17	15	17	15	17	15	17	15	18	15	18	15	18	15	18	16	18	16	18	16	
East	Cunderdin	14	64	64	59	64	59	64	59	65	59	65	59	66	60	66	60	67	61	68	61	68	61	
East	Kellerberrin	6	54	53	50	53	51	53	52	52	53	52	54	52	55	52	56	52	57	52	59	52	60	
East	Kondinin	29	33	35	32	35	32	35	32	35	31	35	31	35	31	35	31	34	30	34	30	34	30	
East	Merredin	13	85	88	79	89	80	91	80	92	81	93	81	95	82	96	83	97	83	98	84	100	85	
East	Northam	41	66	67	65	66	65	66	64	66	64	66	64	66	64	65	63	65	63	65	63	66	64	
East	Piccadilly	64	61	58	51	58	51	59	51	60	51	60	51	61	51	62	51	63	51	64	51	64	51	
East	Sawyers Valley	56	45	45	37	46	37	47	37	48	37	69	56	70	56	71	56	72	57	73	57	75	57	
East	Southern Cross	13	20	20	16	19	16	19	16	19	16	19	16	19	16	19	16	19	16	19	16	19	16	
East	West Kalgoorlie 11 kV	31	43	43	36	44	37	45	37	46	37	47	37	49	38	50	38	51	38	52	39	53	39	

East	West Kalgoorlie 33 kV	30	46	74	58	120	104	120	104	119	104	119	103	119	103	119	103	119	103	119	103	119	103	New distribution block load in 2022. A portion of non-reference customers have curtailable load such that the substation does not exceed capacity.
East	Wundowie	16	67	68	64	68	64	68	64	67	64	67	63	0	0	0	0	0	0	0	0	0	0	
East	Yerbillon	5	54	67	58	75	67	82	73	88	79	93	85	99	91	105	97	111	103	117	109	123	114	
East	Yilgarn	29	43	56	44	56	44	56	44	56	44	56	44	55	44	55	43	55	43	54	43	54	43	
Metro North	Arkana	72	71	72	63	72	62	70	61	69	60	69	59	68	59	68	59	68	59	68	59	68	59	
Metro North	Balcatta	53	30	30	27	30	26	31	26	31	26	32	27	34	28	36	29	37	31	39	32	41	33	
Metro North	Beechboro	86	79	84	73	86	74	87	74	88	75	90	76	91	76	93	77	94	78	95	79	97	80	
Metro North	Cottesloe	54	86	87	73	87	74	87	74	87	74	87	74	87	74	88	75	88	75	88	75	88	75	
Metro North	Darlington	48	44	47	40	47	39	47	40	48	40	48	40	48	40	49	40	49	40	49	40	49	40	

Metro North	Forrestfield	80	33	49	35	49	35	50	35	50	36	51	36	51	36	52	36	52	36	53	37	54	37	
Metro North	Hadfield	77	66	66	59	65	58	64	57	64	57	63	56	62	56	62	55	61	55	61	54	60	54	
Metro North	Hazelmere	27	88	93	85	93	85	93	85	93	85	93	85	93	85	93	85	92	85	92	85	92	85	
Metro North	Henley Brook[12]	53	107	110	103	113	105	117	109	121	112	125	115	129	118	133	121	137	124	141	128	145	131	Additional transformer (Scoping, RIS year 2024)
Metro North	Kalamunda	77	40	44	39	43	38	42	38	42	37	42	37	42	37	41	36	41	36	41	36	41	35	
Metro North	Malaga	81	54	44	41	45	42	46	42	46	43	47	43	48	44	49	44	50	45	50	45	51	46	
Metro North	Manning Street	43	78	78	64	78	63	76	62	74	61	72	60	70	59	69	58	68	57	68	57	67	56	
Metro North	Medical Centre	83	59	60	57	61	58	62	59	63	60	64	61	65	62	66	63	67	64	68	65	68	65	

[12] Western Power is developing contingency plans to manage the substation capacity shortfall risks prior to the installation of an additional transformer

Metro North	Midland Junction	94	64	64	58	64	57	64	57	64	57	64	57	64	57	63	56	63	56	63	56	63	56	
Metro North	Morley	79	68	68	64	68	63	68	63	67	63	67	63	67	62	66	62	66	62	66	62	66	62	
Metro North	Munday	54	42	46	44	46	44	46	44	46	44	46	44	46	44	46	44	46	44	46	44	46	44	
Metro North	North Beach	75	77	77	69	76	68	75	66	74	65	73	64	72	63	71	62	69	61	68	60	67	59	
Metro North	Osborne Park	63	78	83	79	80	76	79	75	78	75	78	74	77	73	76	73	76	72	75	71	75	71	
Metro North	Shenton Park	71	72	72	65	75	69	76	69	76	69	76	69	76	69	76	69	76	69	75	69	75	68	
Metro North	Wembley Downs	43	84	91	76	90	78	92	80	93	81	94	83	96	85	97	87	99	89	101	91	103	94	Managed by distribution transfers
Metro North	Yokine	70	86	86	73	87	72	87	71	87	70	88	70	89	70	90	71	92	72	93	73	94	74	
Metro South	Amherst	85	83	80	67	80	66	81	66	81	65	82	65	83	65	83	65	84	65	85	65	86	65	

Metro South	Australian Paper Mills	46	65	64	58	65	58	65	58	66	57	67	57	68	57	69	57	70	57	71	57	72	56	
Metro South	Belmont	72	59	58	52	56	51	54	50	54	49	53	49	53%	49	53	49	53	49	53	49	53	49	
Metro South	Bentley	56	36	39	37	76	71	76	71	75	70	74	69	73	69	73	68	72	67	71	67	71	66	Load transfer from TT (Execution, RIS year 2023)
Metro South	Bibra Lake	56	96	98	84	99	85	100	86	101	87	102	87	103	88	104	89	105	89	106	90	107	91	Additional transformer (Initiation, RIS year 2028)
Metro South	Byford	77	96	105	97	107	99	109	101	111	103	113	105	115	107	117	109	118	111	120	113	122	115	Additional transformer (Scoping, RIS year 2025)
Metro South	Cockburn Cement	77	56	60	57	60	57	58	55	56	53	54	51	52	49	50	47	48	45	46	43	44	41	
Metro South	Clarence St	43	69	69	60	68	58	67	57	66	55	65	53	64	52	63	50	63	49	62	47	61	46	
Metro South	Collier	69	60	53	51	53	51	53	52	54	52	54	52	54	53	54	53	55	53	55	53	55	54	
Metro South	Canningvale	93	59	56	54	55	53	55	52	54	50	53	49	52	49	52	48	51	47	51	46	50	45	

Metro South	Edmund St	43	62	61	54	60	53	59	52	59	52	59	52	60	52	61	53	61	54	62	54	63	55	
Metro South	Gosnells	77	76	74	69	71	66	67	63	64	60	61	57	58	54	55	52	52	49	50	47	47	44	
Metro South	Kewdale	56	59	58	51	65	58	64	57	63	56	62	55	61	53	60	52	60	51	59	49	58	48	Load transfer from TT (Execution, RIS year 2023)
Metro South	Maddington	26	86	89	76	92	79	96	82	99	85	102	88	105	91	109	94	112	97	115	100	117	102	Managed by distribution transfers
Metro South	Medina	81	68	65	55	65	55	66	56	66	57	67	58	67	59	67	60	68	61%	68	62	68	62	
Metro South	Mandurah	76	97	100	89	99	87	98	86	98	85	98	84	98	83	98	83	98	82	98	82	98	82	Load transfer from BYF (Scoping, RIS year 2025)
Metro South	Mason Rd	74	64	60	63	62	65	64	66	65	68	67	68	68	69	69	70	71	71	72	72	74	73	
Metro South	Meadow Springs	86	81	83	73	84	74	84	75	84	75	85	75	85	76	85	76	86	76	86	77	86	77	
Metro South	Murdoch	54	70	71	66	71	66	71	66	71	66	71	66	71	66	72	66	72	66	72	66	72	66	

Metro South	Myaree	65	56	55	57	55	56	56	54	57	52	57	51	58	49	59	47	59	46	60	44	60	42	
Metro South	O'Connor	70	69	73	65	72	64	72	63	74	65	77	67	80	70	84	73	87	76	91	79	95	82	
Metro South	Pinjarra	57	36	42	37	44	39	45	40	46	41	47	41	48	42	49	43	49	44	50	44	51	45	
Metro South	Rockingham	75	73	71	64	71	64	72	64	72	64	72	64	72	64	72	64	72%	64	72	65	72	65	
Metro South	Riverton	81	92	86	70	86	72	85	73	85	74	84	75	83	77	83	78	82	79	82	80	81	81	
Metro South	Rivervale	83	57	57	53	71	65	71	65	71	65	70	65	70	64	70	64	69	64	69	63	69	63	Load transfer from TT (Execution, RIS year 2023)
Metro South	Southern River	85	92	93	83	95	85	97	87	99	89	102	91	104	93	106	94	108	96	110	98	112	100	Load transfer from BYF (Scoping, RIS year 2025)
Metro South	Tate St	72	56	59	54	59	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Substation retirement (Execution, RIS year 2023).
Metro South	Waikiki	80	93	95	86	97	87	98	88	99	89	100	90	102	91	103	92	104	94	105	95	107	96	Managed by distribution transfers

Metro South	Welshpool	90	69	70	66	75	69	74	68	74	66	73	64	73	63	73	62	73	60	73	59	73	57	Load transfer from TT (Execution, RIS year 2023)
Metro South	Willetton	26	86	85	76	82	72	78	69	75	66	72	63	70	60	67	58	65	55	62	53	60	50	
East Perth & CBD	Cook St	81	73	83	73	81	71	80	69	78	68	77	67	76	66	75	65	74	64	73	63	72	62	Additional transformer (Scoping, RIS year 2024),
East Perth & CBD	Forrest Ave	39	67	72	68	70	65	67	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Forrest St substation retirement and load transfers to Hay St and Joel Terrace substations (Execution, RIS year 2023),
East Perth & CBD	Hay St	143	52	47	42	47	41	55	46	54	45	54	44	53	42	53	41	53	39	53	38	53	36	Load transfers from Forrest St and (Execution, RIS year 2023) Wellington St substations (Scoping, RIS year 2024)
East Perth & CBD	Joel Terrace	76	41	41	37	40	35	79	71	77	68	75	66	72	63	70	60	68	57	65	55	63	52	Load transfers from Forrest St (Execution, RIS year 2023) and Wellington St substations (Scoping, RIS year 2024)
East Perth & CBD	Milligan St	134	51	54	52	51	49	53	51	51	48	49	46	46	43	44	41	41	39	39	36	37	34	
East Perth & CBD	North Perth	77	71	71	64	71	64	74	66	73	66	73	65	72	65	72	65	71	65	71	64	71	64	

East Perth & CBD	Wellington St	29	109	92	79	90	78	89	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Load transfers to Hay, Milligan and Wellington St substations (Scoping, RIS year 2024)

2.5 Transmission Network Opportunities

This section provides a summary of transmission network opportunities, as shown in the TSP. Refer to Western Power's TSP for more detail.

Table 2.3: List of transmission network opportunities identified in the TSP

Region	Project	Scope/Issue	Market Opportunity	By when	Lifecycle Status	Estimated Network Solution Cost ($M)
North	Clarkson Substation: Additional transformer	Installation of a third 132/22 kV 33 MVA transformers at Clarkson Substation.	To reduce demand in the area to eliminate, reduce of defer the need for additional transformer capacity.	2023/24	Scoping	9-12
North	Joondalup Substation: Additional transformer	Installation of a third 132/22 kV 33 MVA transformers at Clarkson Substation.	To reduce demand in the area to eliminate, reduce of defer the need for additional transformer capacity.	2024/25	Scoping	9-12
North	North Region: NCS contract	A NCS contract to call upon standby generation in the North Region upon the loss of both supplies north of Three Springs.	In the short-term, an opportunity exists to provide standby generation under an NCS contract arrangement to improve the level of reliability of supply to these areas. These NCS contracts are up for renewing at the end of 2022/23. Over the longer-term, reduce demand in the area to eliminate, reduce of defer the need for rebuilding the existing legacy transmission lines in the region that to remove the need for an NCS.	2023/24	Execution (existing NCS contract) / Initiation (Renewal of NCS/network augmentation)	~100[13]
North	MW-NB and NB-MN available import capacity	Spare available import capacity exists over a number of import boundaries within the North Region.	An opportunity exists to utilise spare available capacity within MW-NB and NB-MN import boundaries by increasing demand of existing loads or via the connection of new loads	Across the study period	n/a	n/a
North	TS-MW and MW-NB available export capacity	Spare available export capacity exists over a number of export boundaries within the North Region.	An opportunity exists to utilise spare available capacity within the TS-MW and MW-NB export boundaries by connecting new generation.	Across the study period	n/a	n/a

[13] Estimated cost of rebuilding the three circuits from Three Springs to Mungarra with an overhead earth wire.

Region	Project	Scope/Issue	Market Opportunity	By when	Lifecycle Status	Estimated Network Solution Cost ($M)
South	Busselton Substation – Install reactive support	Installation of new 5 MVAr 22 kV reactors at Busselton	Increase demand in the Busselton and Margaret River area during daytime minimum demand conditions to minimises the risk of post-contingent over-voltages.	2025/26	Planning	~0.8
South	Picton South Transmission Reinforcement – Stage 1 & 2	A staged 132 kV voltage conversion of the existing 66 kV supplies between Picton-Capel-Busselton.	Reduce the demand supplied in the Picton South area during peak demand conditions to potentially reduce or defer network augmentation to increase the power transfer capacity to the area.	2026/27	Initiation	45-50[14]
South	SW IMP 02 and SC IMP 01 available import capacity	Spare available import capacity exists over a number of import boundaries within the South Region.	An opportunity exists to utilise spare available capacity within SW IMP 02 and SC IMP 01 import boundaries by increasing demand of existing loads or via the connection of new loads	Across the study period	n/a	n/a
South	SW EXP 01 and SE EXP 01 available import capacity	Spare available export capacity exists over a number of export boundaries within the South Region.	An opportunity exists to utilise spare available capacity within the SW EXP 01 and SE EXP 01 export boundaries by connecting new generation.	Across the study period	n/a	n/a
East	Eastern Goldfields Load Permissive Scheme	The ELPS scheme is currently operational and provides a non-reference supply connection for a number of new loads into the Goldfields.	The ELPS can connect additional customers in the Goldfields under a non-reference arrangement.	Across the study period	n/a	n/a
East	Black Flag Substation: New Transformer	Install a new 66 MVA 132/33 kV transformer at Black Flag Substation	Additional transformer capacity will facilitate the connection of new load. Existing customers with a non-reference service may have the opportunity to convert a reference service.	Across the study period	n/a	n/a
East	Wundowie Substation: Decommissioning	Decommissioning of the 66 kV substation assets, including distribution load transfers to Sawyers Valley Substation.	To reduce demand in the area to reduce the scope of distribution load transfer works.	2023/24	Scoping	1.7

[14] This represents the estimated cost for the line upgrade works between Picton and Busselton.

Region	Project	Scope/Issue	Market Opportunity	By when	Lifecycle Status	Estimated Network Solution Cost ($M)
East	Eastern Goldfields NCS contract	A NCS contract to call upon standby generation in the East Region upon the loss of the single 220 kV circuit.	To provide standby generation under an NCS contract arrangement to improve the level of reliability of supply to these areas. These NCS contracts are up for renewing at the end of 2022/23. Over the longer-term, reduce demand in the area to eliminate, reduce of defer the need for a new 330 kV circuit from Muja to West Kalgoorlie Terminal, which will remove the need for an NCS.	2023/24	Execution (existing NCS contract) / Initiation (Renewal of NCS/network augmentation)	~1,000[15]
East	EC IMP 01 available import capacity	Spare available import capacity exists over a number of import boundaries within the East Region.	An opportunity exists to utilise spare available capacity within EC IMP 01 import boundaries by increasing demand of existing loads or via the connection of new loads	Across the study period	n/a	n/a
Metro North	Henley Brook: New Transformer	Installation of a third 132/22 kV 33 MVA transformer at Henley Brook Substation	Reduce the demand supplied By Henley Brook Substation during peak demand conditions to potentially reduce or defer network augmentation to increase the power transfer capacity to the area.	2023/24	Scoping	7-9
Metro North	WT IMP 01, NT IMP 01 and GLT IMP 01 available import capacity	Spare available import capacity exists over a number of import boundaries within the Metro North Region.	An opportunity exists to utilise spare available capacity within WT IMP 01, NT IMP 01 and GLT IMP 01 import boundaries by increasing demand of existing loads or via the connection of new loads	Across the study period	n/a	n/a
Metro South	Bibra Lake Substation: Additional transformer & load transfers	Installation of a third 132/22 kV 33 MVA transformer and distribution load transfers to facilitate the decommissioning of Australian Paper Mills Substation	To reduce demand in the area to eliminate, reduce of defer the need for additional transformer capacity.	2027/28	Initiation	9-12

15 High level cost estimate to construct a new 330 kV circuit from Muja Terminal to West Kalgoorlie Terminal.

Region	Project	Scope/Issue	Market Opportunity	By when	Lifecycle Status	Estimated Network Solution Cost ($M)
Metro South	Willetton Substation: Additional transformer & load transfers	Installation of a second 132/22 kV 33 MVA transformer and distribution load transfers to offload the Southern River Substation	Address existing substation capacity shortfall and accommodating increase demand in the area	2027/28	Initiation	9-12
Metro South	Waikiki Substation: Additional transformer & load transfers	Installation of a fourth 132/22 kV 33 MVA transformer and distribution load transfers to offload the Mandurah Substation	To reduce demand in the area to eliminate, reduce of defer the need for additional transformer capacity.	2027/28	Initiation	9-12
Metro South	Byford Substation: Additional transformer & load transfers	Installation of a second 132/22 kV 33 MVA transformer and distribution load transfers to offload the Southern River Substation	To reduce demand in the area to eliminate, reduce of defer the need for additional transformer capacity.	2024/25	Scoping	9-12
Metro South	KW330 IMP 01, SF IMP 01 and CT IMP 01 available import capacity	Spare available import capacity exists over a number of import boundaries within the Metro South Region	An opportunity exists to utilise spare available capacity within the KW330 IMP 01, SF IMP 01, CT IMP 01 import boundaries by increasing demand of existing loads or via the connection of new loads	Across the study period	n/a	n/a
Metro South	KW330 EXP 01 available import capacity	Spare available export capacity exists within the KW330 EXP 01 boundary within Metro South Region	An opportunity exists to utilise spare available capacity within the KW330 EXP 01 export boundaries by connecting new generation.	Across the study period	n/a	n/a
East Perth & CBD	Wellington St Substation: Decommissioning	The 66 kV power transformers and supply lines into Wellington St Substation are to be decommissioned. In addition, the installation of a new 66 MVA Cook St transformer, along with four distribution feeders to the Wellington 11 kV switchboards	To defer or completely offset the need to install a third Cook St 66 MVA transformer by reducing the demand supplied by the Hay St and Milligan St Substation, particularly during peak demand conditions.	2022/23	Scoping	~36.2

Region	Project	Scope/Issue	Market Opportunity	By when	Lifecycle Status	Estimated Network Solution Cost ($M)
East Perth & CBD	CBD IMP 01 available import capacity	Spare available import capacity exists over a number of import boundaries within the East Perth and CBD Region.	An opportunity exists to utilise spare available capacity within the CBD IMP 01 import boundary by increasing demand of existing loads or via the connection of new loads	Across the study period	n/a	n/a

3. Distribution Network

Western Power's distribution network complements its transmission network and associated zone substations, providing the capillary system that delivers energy to most of our customers. The network operates at voltages below 66 kV, with voltages above 1 kV often referred to as medium voltage[16] (MV) and those below 1 kV as low voltage (LV). The MV and LV networks have different risk and constraint profiles and can look very different geographically depending on the density of connections and distances between neighbouring feeders and zone substations.

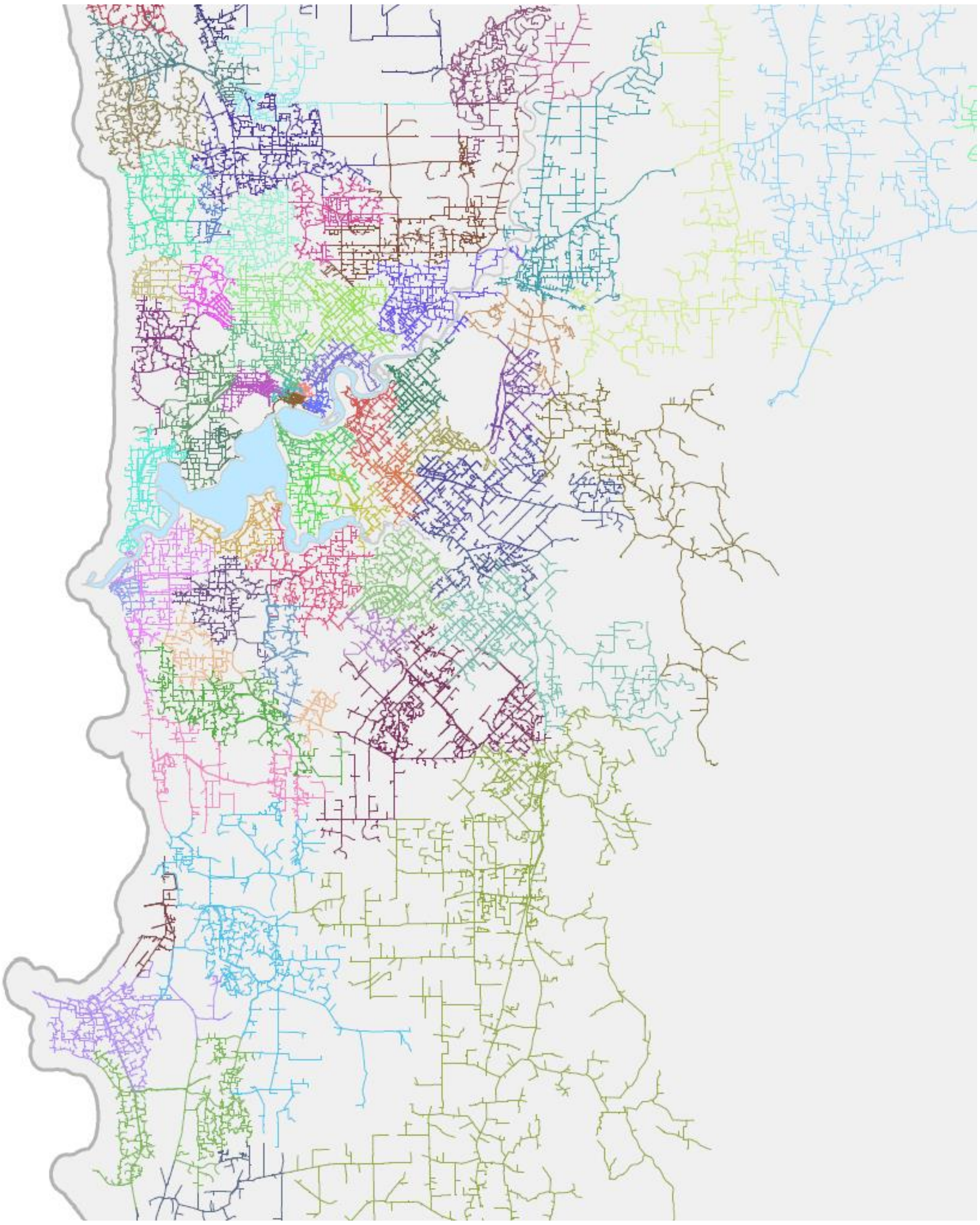

Figure 3.1: A section of Western Power's MV distribution network in the Perth metro area

[16] May also be referred to as HV distribution voltage

3.1 Challenges

During the summer of 2021/22, an unexpected heatwave in Perth resulted in four consecutive days of temperatures of 40° C or more over the Christmas period. The heatwave put pressure on LV and MV networks with high peak demands causing a strain on localised networks and feeders. While Western Power has been working on expedited action plans ahead of the 2022/23 summer, projected overloading on some feeders has been indicated as a future opportunity in Section 3.4 for providing other solutions, as it is expected that the impact of climate change and unexpected events will continue to require mitigation into the future.

The advance of new technologies continues to disrupt traditional network models, primarily in the distribution network space. Under certain conditions, the distribution network becomes the largest generator on the grid, with embedded PV outperforming other individual generators.

The WA Government's ETS and Energy Transformation Taskforce have provided clear priority to network transformation to accommodate and support these technological advances. The Distributed Energy Resources (DER) Roadmap sets out goals and targets to manage future increased penetration of DER such as residential PVs, batteries and electric vehicles on Western Power's network.

Western Power's intent to move toward a modular network not only helps to address the above DER challenges, but also assists with replacing the aging distribution network and improving reliability performance. More about these initiatives can be found in Section 1.3 and via associated links.

Further information about asset management challenges can be found in Appendix B.2.

3.2 Distribution Network Performance Strategies

Distribution performance strategies are developed to guide Western Power's network investments to accommodate future customer requirements. While distribution strategies are under review, the five described here have very strong relationships between each other and have been the strategic cornerstone for some time. Some of the strategies are undergoing a significant evolution. For example, the Feeder Voltage Strategy once fell under the Power Quality Strategy, but has become its own entity due to the urgency and enormity of challenges that increased DER growth on the network has presented.

3.2.1 Feeder Loading

Western Power has an obligation to deliver energy safely and reliably to our customers under all credible scenarios, while ensuring efficient and cost-effective use of any assets. This is achieved by ensuring the assets are fit for purpose at the time of design and installation, and that they are maintained and operated in accordance with their specifications throughout their useful life. Exceeding ratings can significantly increase maintenance costs for an asset, and at times precipitate early failure and impact reliability.

3.2.2 Feeder Voltage

Western Power is required to operate and maintain its network within prescribed voltage limits outlined in the TR[17]. A range of voltages are used across the network to distribute electricity, selected to maximise efficiency and minimise cost in scenarios such as long distances or anticipated levels of demand and generation. As network use changes, it may be necessary to adapt the network topology and operating voltages to ensure continuing reliability, efficiency and cost effectiveness.

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17 Approved Technical Rules - Economic Regulation Authority Western Australia (erawa.com.au)

3.2.3 Power Quality

Power Quality addresses the voltage, frequency and waveform characteristics of the electricity supply from the network to our customers. Examples of common power quality problems are harmonic distortion, voltage instability and voltage imbalance. A strategy in place to manage voltage within limits is outlined in Section 3.2.2. Frequency management is the responsibility of AEMO and is not addressed in this strategy.

3.2.4 Reliability

Distribution networks are designed and built to provide a level of service which meets defined performance requirements across the system. Reliability qualifies that level of service and quantifies it in terms of availability of the electricity supply to customers, expressed mainly as supply interruption duration, frequency, and number of impacted customers. For more on the definition of reliability criteria, refer to the NQRS Code, Service Standard Benchmark (SSB) and TR, as well as Section 3.3.2 in this document**.**

3.2.5 Protection

Faults in the network have the potential to injure people and damage the environment, property, equipment or community assets. Protection systems detect faults through continuous monitoring of network conditions and clear them by de-energising faulted equipment. The downside of this is an interruption of supply to customers. As a result, protection systems are optimised to operate only when required and allow for the fastest possible restoration of safe supply.

3.3 Performance Measures

Several of the distribution network performance measures related to the strategies above are being developed to accommodate changes driven by ETS and to provide more meaningful indicators to third parties. Only the two mature performance measures, feeder loading and reliability, will be described in further detail below.

3.3.1 Feeder Loading

Target feeder loading levels are dependent on the type of load being supplied, and the number of interconnections with contiguous feeders. Higher feeder loading can mean better utilisation of an asset but can also reduce reliability due to difficulties in finding alternative supply in case of an outage. Because of this, feeder loading can have a significant impact on both feeder utilisation and reliability.

Feeder load fluctuates throughout the day, becoming more apparent during cloudy days as installed PV systems' output fluctuates. Western Power must plan the grid to support the load when there is no PV output, while considering the correlation between demand and weather, and maximising the day-to-day utilisation of any assets.

Peak feeder loading generally occurs on the Western Power network in summer when there is large demand for air conditioning in the evening with no offset from solar PV. Feeder peaks are chiefly driven by residential cooling loads that only occur for a number of hours per year – between about 3 per cent and 5 per cent of the year in total.

A feeder's loading performance measure is shown as utilisation percentage, representing the ratio of the expected peak feeder load divided by the feeder's capability. The feeder's utilisation target depends on the number of network interconnections. In urban areas where the majority of residentially driven summer peak loads are experienced, an assumption is made that each urban feeder has at least four interconnections with other urban feeders, enabling multiple alternative paths to supply restoration in the event of an outage. This results in an optimum feeder utilisation target of 80 per cent for feeders supplying urban communities.

More data on urban feeder loading performance is available in the Network Data link on the NOM webpage, under Distribution Feeder Utilisation.

Feeder Loading Investment Triggers

When considering investments to address high feeder loading, a balance is sought to ensure Western Power doesn't over invest in the grid based on projections of maximum feeder loadings, as it is unlikely that a fault will occur at the precise peak load time for that feeder. Traditional network augmentation that increases feeder capacity results in lower feeder utilisation levels at other times (up to 97 per cent) of the year and presents a low return on investment value. In addition, the projected load is an estimate only and may not eventuate, posing further risk in the form of underutilised stranded assets.

To mitigate these network investment risks and ensure prudent network investments are made to manage high feeder utilisation, a deterministic approach is not always used. Instead, an approach that involves assessing the trend in network risk from the projected utilisation is applied. If the network risk is reducing over time, Western Power investigates alternatives that can defer the need for investment. An example of such a measure is 'network switching' to an adjacent underutilised network to balance overall feeder utilisation in an area.

When a switching option is not available and projected network risk is expected to increase, a feeder loading investment is triggered. This typically occurs when the contiguous feeders are supplying similar customer types with no diversification in load response to weather events – for example, all the contiguous feeders have a very high percentage of residential load that has identical response to hot weather patterns.

Western Power is currently experiencing high feeder loading issues on feeders that supply urban residential communities at large multi-staged land developments. These high load events occur in the evening, as these areas usually also have significant PV penetration supplementing their cooling consumption during daylight hours. Table 3.1 summarises triggers for feeder loading investments, the impact of not addressing risks, and an example of how Western Power would traditionally proceed to manage risk.

Table 3.1: Feeder loading investment summary

Investment Trigger	What is the issue?	When does it occur?	Potential impact if not addressed	Traditional network solution?
Feeder Loading **(MV Network Thermal Overload)**	MV network capacity rating exceeded due to load growth (from new or increased demand).	Typically, during peak load (5-8pm). Seasonal variation depending on location (Winter / Summer peak).	• Equipment failure • Accelerated asset aging and increased maintenance costs • Increased safety risk due to clearance issues (excessive overhead conductor sag etc).	• Installation of new MV feeders or feeder interconnections • Transfer of load to contiguous networks • Conversion of existing overhead conductor to higher thermal capacity underground cable.

3.3.2 Reliability

Reliability is a measure of service Western Power provides to customers connected to our grid. The minimum reliability standards and method of calculation are determined by the ERA. The level of reliability service is quantified in terms of availability of electricity supply to customers and is expressed as supply interruption duration and frequency.

The two primary measures used for reliability performance on the distribution network are:

- System Average Interruption Duration Index (SAIDI), which includes all network outages (minutes per year) for the distribution network; and
- System Average Interruption Frequency Index (SAIFI), which includes all network outages (number of interruptions per year) for the distribution network.

SAIDI and SAIFI are directly linked to regulatory compliance by the requirement for performance to remain better than SSB, and either financial rewards or penalties for Western Power for reliability performance better or worse than Service Standard Targets (SST), applied from the Service Standard Adjustment Mechanism (SSAM). For more information, refer to the latest version of the AA[18].

As feeders supply differing customer types, the distribution network is divided into four feeder categories used for monitoring reliability performance. These end up being broadly geographically based and are consistent with the measures used by other Distribution Network Service Providers (DNSP) in Australia. The following table summarises the four distribution feeder categories Western Power uses.

Table 3.2: Distribution feeder categories for reliability

Feeder category	Definition
Perth CBD	A feeder supplying predominantly commercial, high-rise buildings, supplied by a predominantly underground distribution network containing significant interconnection and redundancy when compared to urban areas.
Urban	A feeder which is not a CBD feeder, with actual maximum demand across the reporting period per total feeder route length greater than 0.3 MVA/km.
Rural Short	A feeder which is not a CBD or Urban feeder, with a total route length less than 200 km.
Rural Long	A feeder which is not a CBD or Urban feeder, with a total route length greater than 200 km.

This results in SAIDI and SAIFI minimum reliability measures SSB against each of the four feeder categories set out by the regulator at the beginning of each AA. Western Power is currently in its fifth AA (AA5)[19] which ends in the 2026-27 financial year. For the first year of AA5 (2022-23 financial year) the reliability performance benchmarks remain the same as the AA4 arrangement; from the 2023-24 financial year on, new performance benchmarks shall be finalised when AA5 is approved by the ERA.

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18 https://www.erawa.com.au/AA5

19 https://www.erawa.com.au/cproot/22418/2/Access-Arrangement-Information-for-the-AA5-Period-1-February-2022-.pdf

Table 3.3: Minimum reliability performance

Measure	Feeder category	Current SSB FY2022-23
SAIDI	CBD	33.7
	Urban	130.6
	Rural Short	215.4
	Rural Long	848.3
SAIFI	CBD	0.21
	Urban	1.27
	Rural Short	2.34
	Rural Long	5.70

Due to the average nature of the SSB, some individual feeders may perform below the average while others perform above. This balances the overall performance of the network and while the SSB for a particular feeder category might be met, some customers may consistently experience below average reliability.

Feeder Reliability Investment Triggers

Western Power seeks to invest in the grid where economically viable, in a way that maintains performance above minimum SSB requirements while targeting specific locations where reliability experience has been consistently below average.

If customer density is high or close to a zone substation, additional feeders and feeder interconnections may be an economical way to deliver improved reliability. However, where poor reliability performance is a recurring problem due to long radial overhead networks providing supply through environmentally challenging areas prone to high winds or bushfire risk, traditional network solutions are becoming increasingly uneconomic. A step change in network topology is required to enable generation to be closer to the load, bypassing the long radial overhead network which is prone to both transient and longer duration outages.

The following table summarises common triggers for feeder reliability investments, the impacts when not addressed, and examples of how they are addressed through traditional network solutions.

Table 3.4: Reliability investment summary

Investment Trigger	What is the issue?	When does it occur?	Potential impact if not addressed	Traditional network solution?
MV & LV Network Reliability	A fault event 'upstream' causing an outage and loss of supply to a customer or a group of customers.	Events can be random but most commonly occur seasonally, during periods of extreme weather, or at locations susceptible to unfavourable environmental conditions (i.e., saline or dust pollution, heavy vegetation or smoke).	Customers without supply until issue is cleared and power restored Reliability impact, which can pose financial penalties and/or reputational damage.	MV and/or LV network re-configuration Installation of MV or LV feeder interconnections Replacement of bare overhead conductor with covered conductor or underground cable Additional distribution automation Improved condition monitoring and diagnostics for proactive identification of network issues MV or LV emergency response generators.

3.4 Identified Opportunities

3.4.1 Feeder Loading

Western Power assesses zone substation feeder utilisation across our network annually. In the NOM2021, the two priority locations identified to have projected feeder over-utilisation and increasing network risks were the Beechboro (BCH) and Yanchep (YP) zone substations. As mentioned in section 3.1, this year's peak demand was significantly higher during summer which affected the projections for feeder utilisation. After assessing latest available feeder utilisations, including re-assessment of the BCH and YP zone substations, listed below are the top five zone substations with projected over-utilised feeders:

1. Southern River (SNR)
2. Clarkson (CKN)
3. Meadow Springs (MSS)
4. Yanchep (YP)
5. Byford (BYF)

These projected over-utilised feeders will trigger a network investigation to identify the best way to manage the issue, concluding with the recommendation of a specific solution. The investigation of options will include alternative solutions such as a dedicated non-network solution or a hybrid between non-network and traditional network solutions. All the solutions are comprehensively assessed, evaluating their technical, economical and deliverability characteristics before the best option is selected.

The feeders identified in Table 3.5 are typical of highly utilised Western Power feeders, usually supplying large multi-staged residential subdivisions that also have high levels of PV penetration (and expectation for further increase in solar PV). The large proportion of residential customers results in an evening peak in summer, mainly driven by undiversified air-conditioning load. Opportunities exist here for solutions that would reduce the overall peak, preferably shifting the demand into a high PV output portion of the day. Western Power has recently trialled battery storage as a means of achieving such an outcome without investment in traditional network assets.

Table 3.5 indicates the projected feeder's utilisation, the present customer segment breakdown and an estimated amount of solar PV installed. Additional urban feeder loading can be found in the linked network data sheet on the NOM webpage, per Section 3.3. Customer segment and solar PV capacity information for some of the feeders have been marked 'TBD' because these feeders are under planning for switching to be ready for the Summer of 2022-23.

LEGEND		
(red)	High Utilisation	above 80%
(green)	Target Utilisation	>40% & <80%
(cyan)	Low Utilisation	below 40%

Table 3.5: Anticipated distribution feeder utilisation

Feeder	**Summer 2026-27** Projected Utilisation Performance	Customer Segment				Estimated embedded PV (kVA)
		Residential (%)	Small Commercial (%)	Large Commercial (%)	Large Distribution Generator (Y/N)	
SNR 504	(red)	95%	3%	1%	N	4554
SNR 505	(red)	95%	4%	1%	N	6891
SNR 507	(red)	96%	4%	1%	N	6244
SNR 508	(red)	98%	2%	0%	N	4831
SNR 516	(red)	92%	7%	1%	N	7179

Feeder	**Summer 2026-27** Projected Utilisation Performance	Customer Segment				Estimated embedded PV (kVA)
		Residential (%)	Small Commercial (%)	Large Commercial (%)	Large Distribution Generator (Y/N)	
SNR 517		95%	3%	1%	Y	3576
SNR 526		91%	8%	1%	N	3793
SNR 537		95%	4%	1%	N	7520
SNR 539		7%	80%	13%	N	673
SNR 540		99%	1%	0%	N	6498
CKN 504		95%	4%	2%	N	5353
CKN 505		66%	28%	6%	N	7921
CKN 507		89%	8%	2%	Y	6442
CKN 508		95%	3%	1%	N	5826
CKN 536		98%	1%	1%	N	1391
CKN 539		98%	2%	1%	N	2836
CKN 540		96%	2%	1%	N	6501
MSS 504		95%	4%	1%	N	4380
MSS 505		97%	2%	1%	N	4627
MSS 508		96%	3%	1%	N	8911
MSS 529		93%	6%	1%	N	8693
MSS 530		88%	10%	2%	N	8950
MSS 536		97%	2%	1%	N	7084
MSS 540		82%	15%	3%	N	3987
YP 502		96%	4%	1%	N	6044
YP 505		97%	3%	0%	N	10697
YP 507		75%	13%	12%	N	643
YP 514		96%	3%	1%	N	5159
YP 517		85%	9%	6%	N	2244
YP 530		94%	4%	2%	N	2796
BYF 503F		TBD	TBD	TBD	TBD	TBD
BYF 503R		TBD	TBD	TBD	TBD	TBD
BYF 504		89%	10%	2%	N	3822
BYF 505		89%	9%	2%	N	3517
BYF 508		89%	8%	3%	Y	3225
BYF 510		94%	5%	1%	N	3423
BYF 515F		TBD	TBD	TBD	TBD	TBD
BYF 515R		91%	7%	2%	N	2069
BYF 523		87%	11%	2%	N	6493
BYF 524		98%	2%	0%	N	8051
BYF 527		93%	6%	1%	N	10122

The following maps from Figure 3.2 to Figure 3.6 show the location of high utilisation feeders for the five substations listed above.

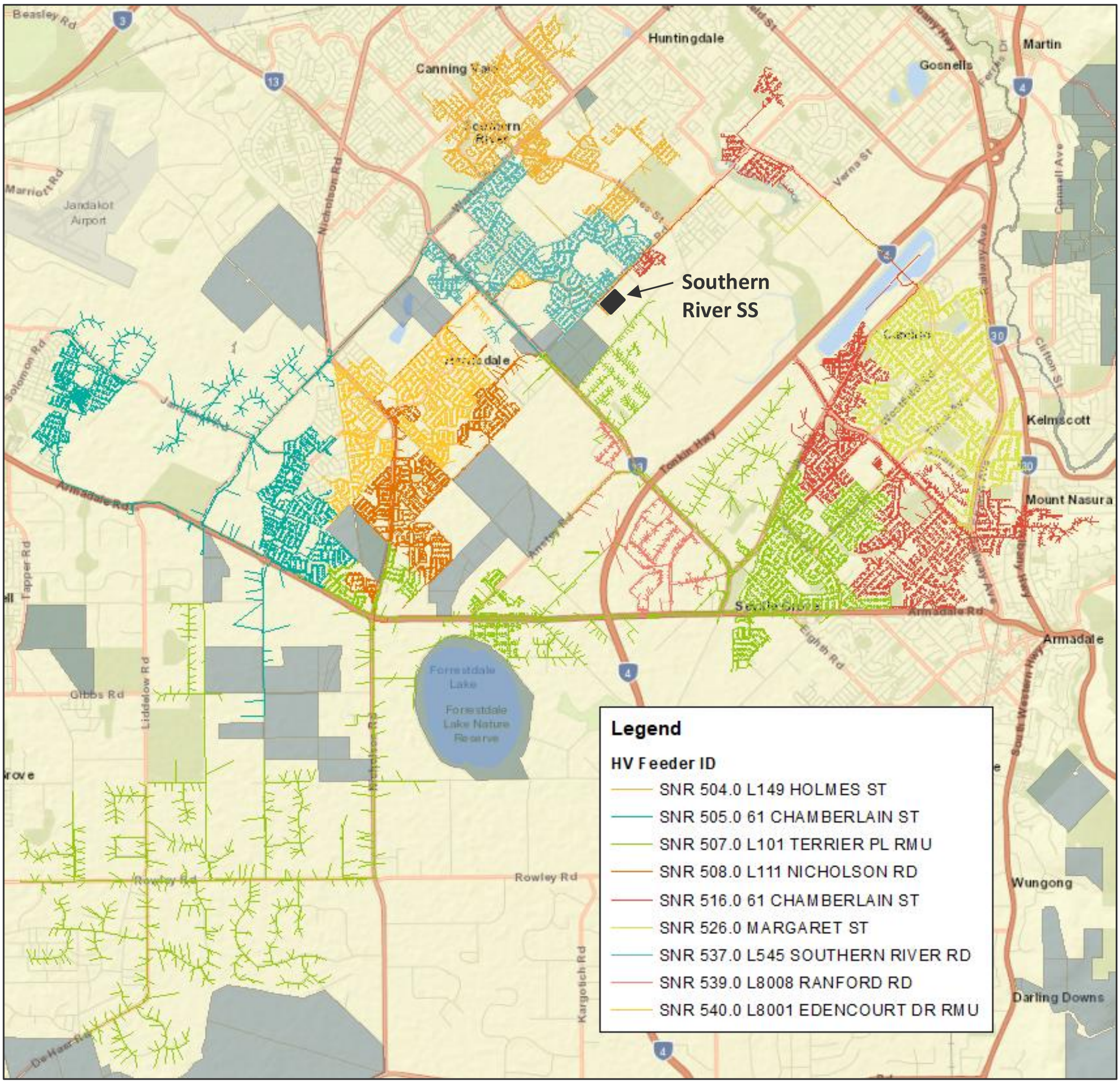

Figure 3.2: Geographical distribution of Southern River high utilisation feeders

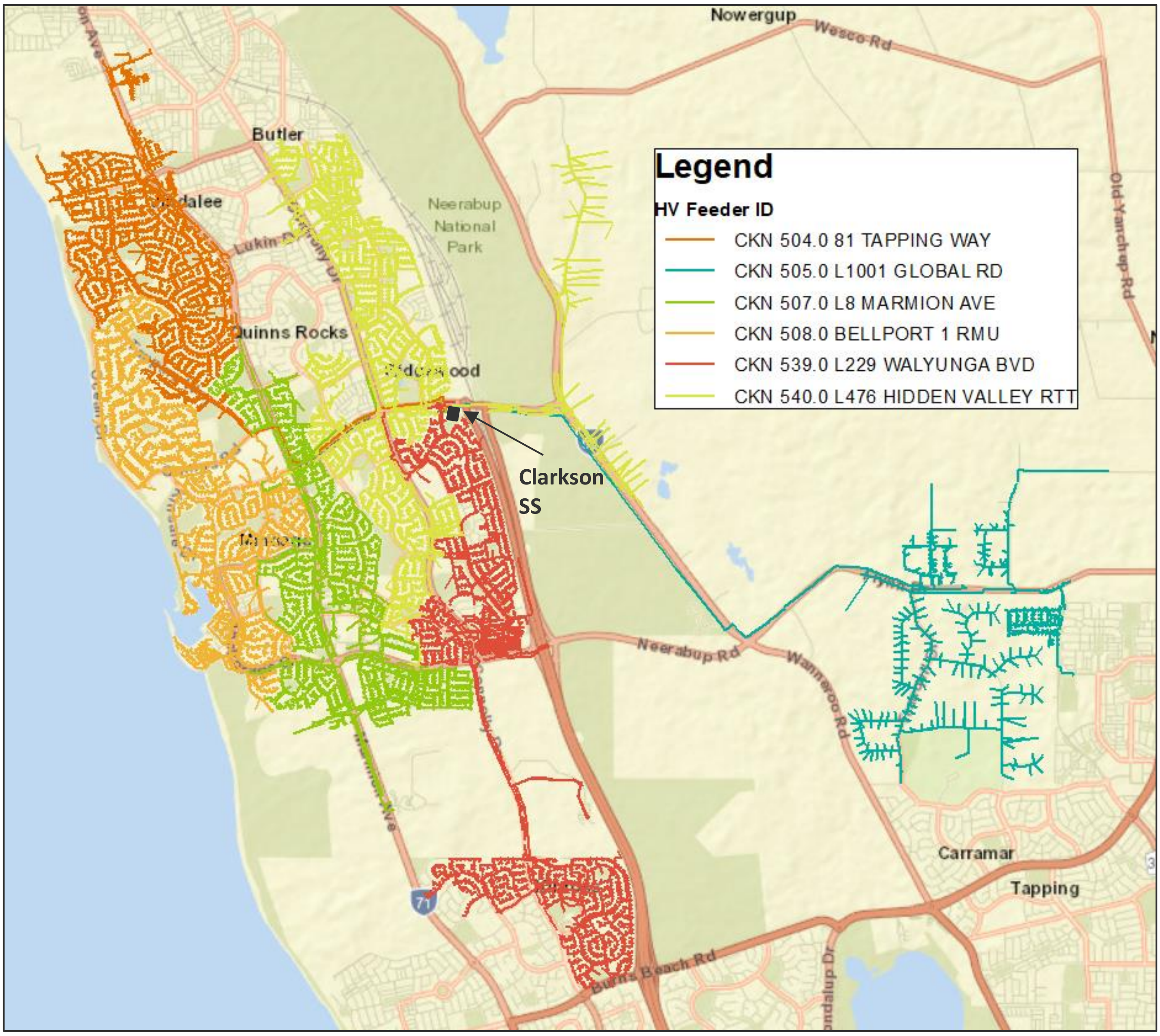

Figure 3.3: Geographical distribution of Clarkson high utilisation feeders

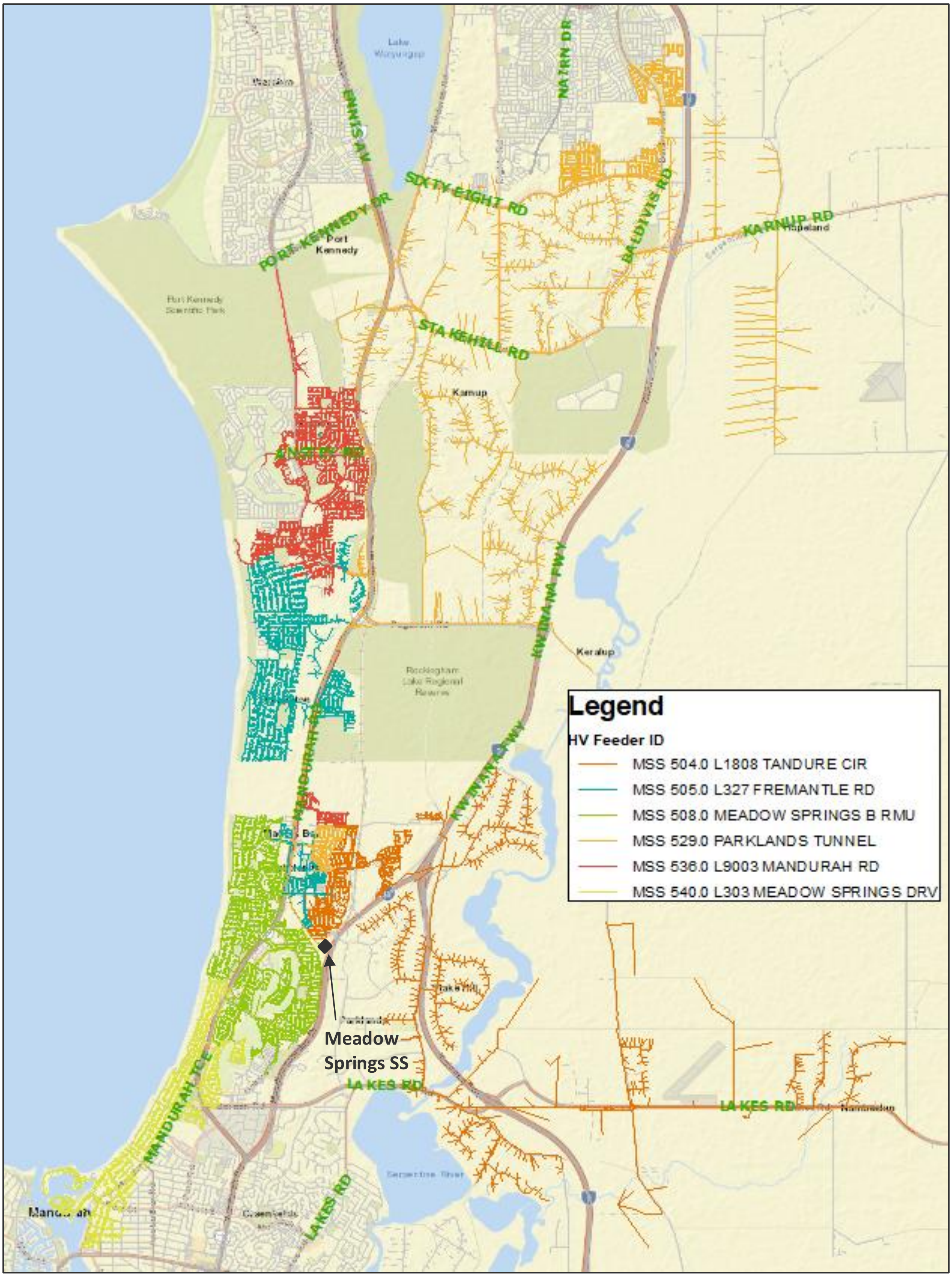

Figure 3.4: Geographical distribution of Meadow Springs high utilisation feeders

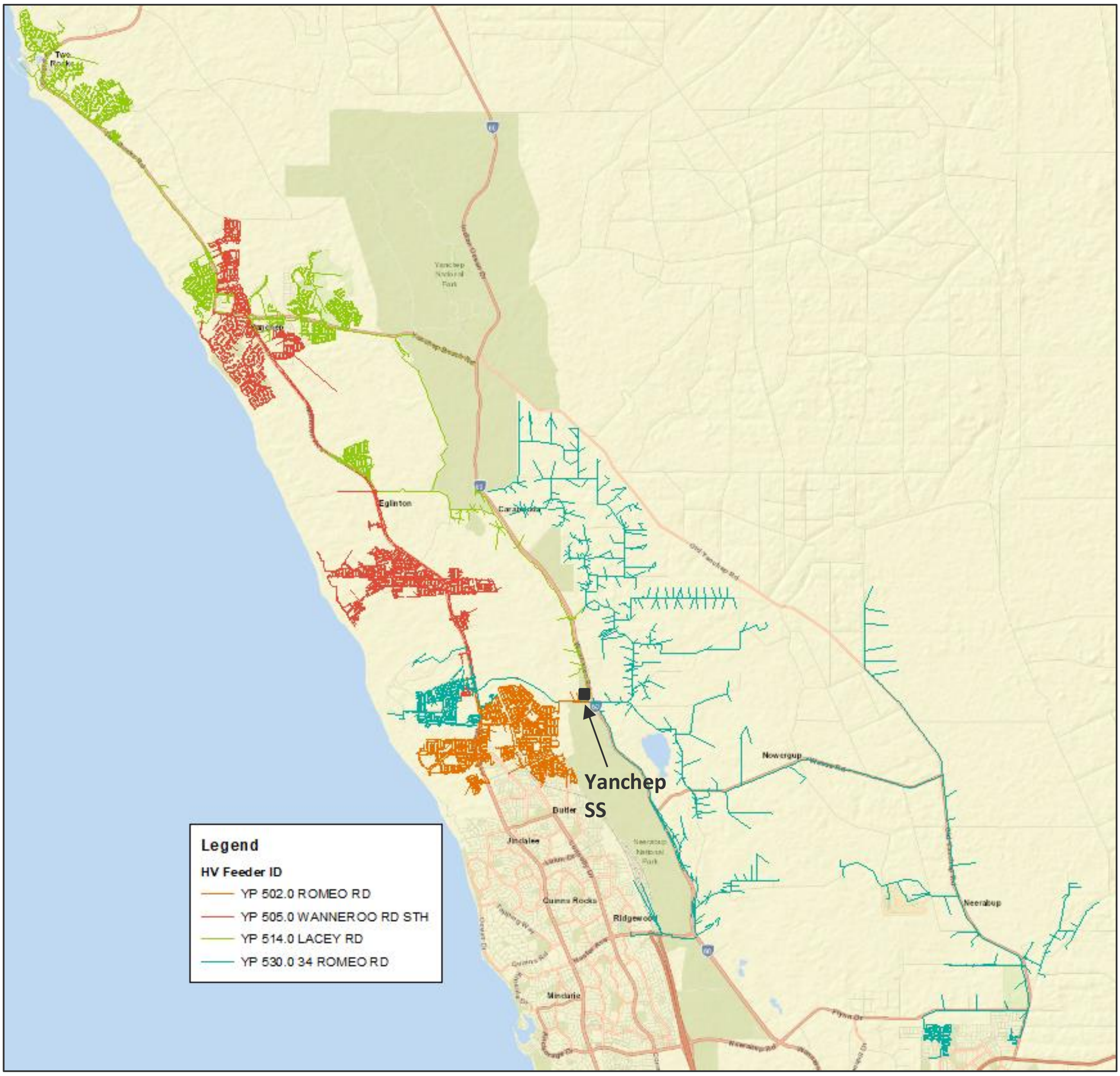

Figure 3.5: Geographical distribution of Yanchep high utilisation feeders

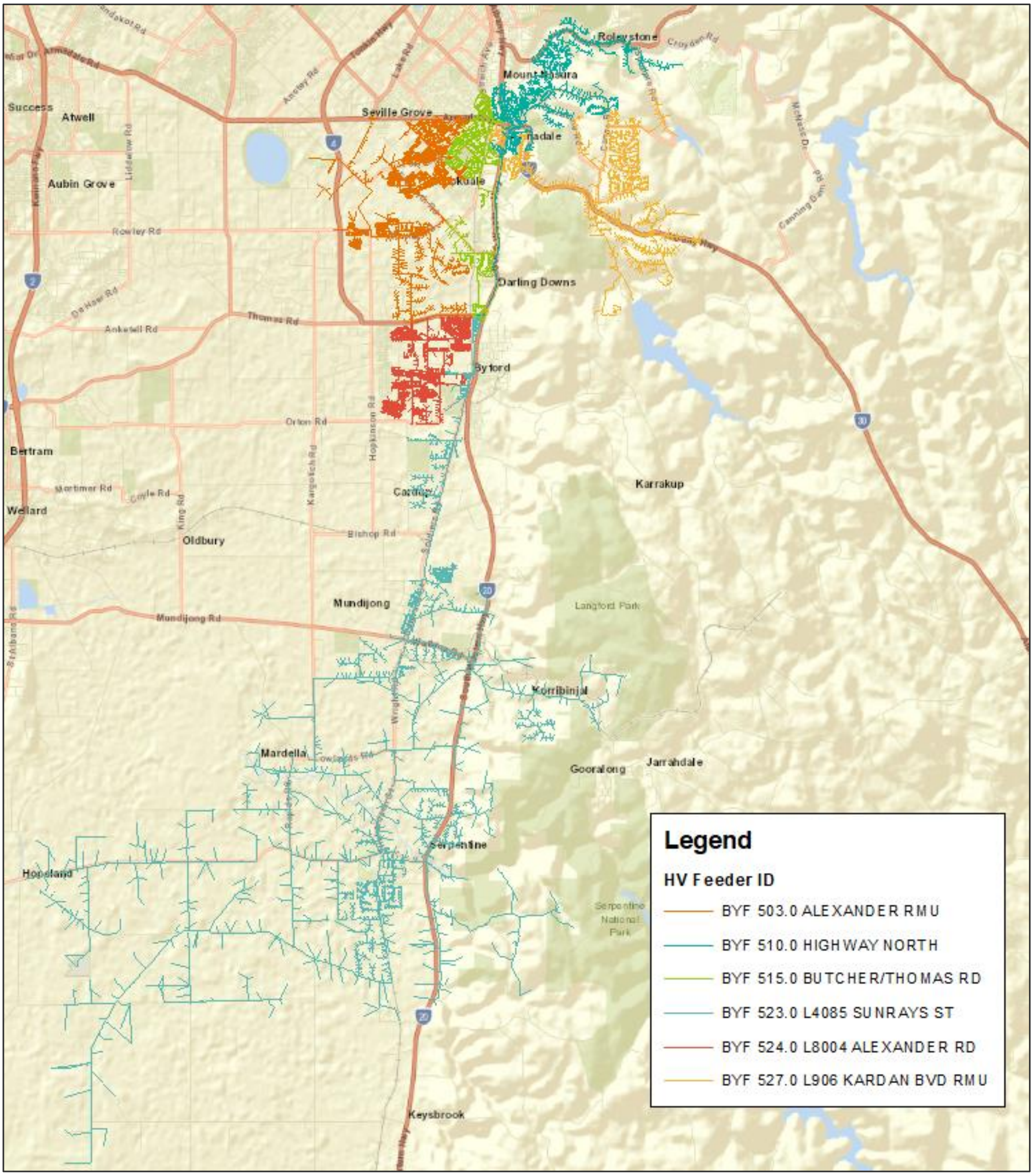

Figure 3.6: Geographical distribution of Byford high utilisation feeders

Network investigations will be triggered based on the escalating risk profile that feeder over-utilisation poses. For a geographical representation of where feeders are located, use Western Power Network Capacity Mapping Tool (NCMT)[20].

20 https://www.westernpower.com.au/industry/calculators-tools/network-capacity-mapping-tool/

3.4.2 Reliability

Reliability performance against SSB compliance for the distribution network is monitored monthly as a rolling 12-month average. As new reliability issues arise, they are appropriately remediated and assessed to discover if there are any systemic issues which may impact other parts of the network. Generally, less than a third of outages are directly controllable by Western Power. The remaining two thirds of supply interruptions are mainly due to windborne debris, extreme weather events or caused by a third party.

Due to the network characteristic where rural communities are supplied by long radial overhead feeders, and the susceptibility of these connections to environmental challenges, reliability is often below average for remote and rural locations.

Table 3.6 shows five of Western Power's reliability focus localities, typically characterised by supply via long overhead network feeders, that are susceptible to both frequent and longer duration supply interruptions. A step change in the network's topology supplying these locations is needed to remove their dependence on the long radial overhead network, where this action proves economic.

Table 3.6: Western Power's 5 reliability focus localities

Locality	Feeder Category	Customer Number
Port Denison	Rural Long	1,098
Dongara	Rural Long	1,258
Lancelin	Rural Long	1,068
Northampton	Rural Long	514
Denmark	Rural Long	1,579

Figure 3.7 to Figure 3.10 illustrate the geographical location of these localities, demonstrating their significant distances to zone substations. The NCMT can be used for a more detailed view of the topology of Western Power's network in the area.

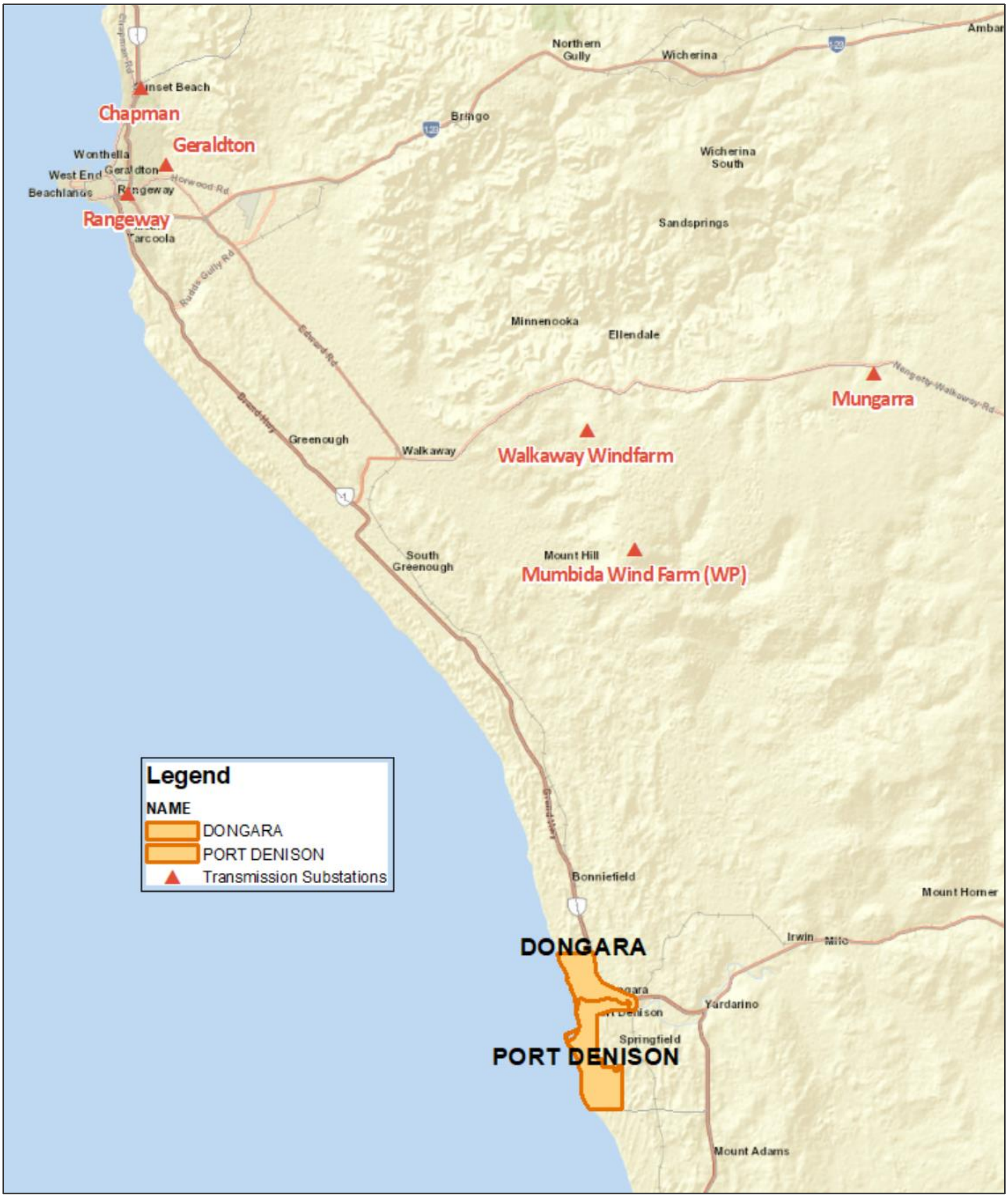

Figure 3.7: Geographical location of Dongara and Port Denison in relation to surrounding zone substations

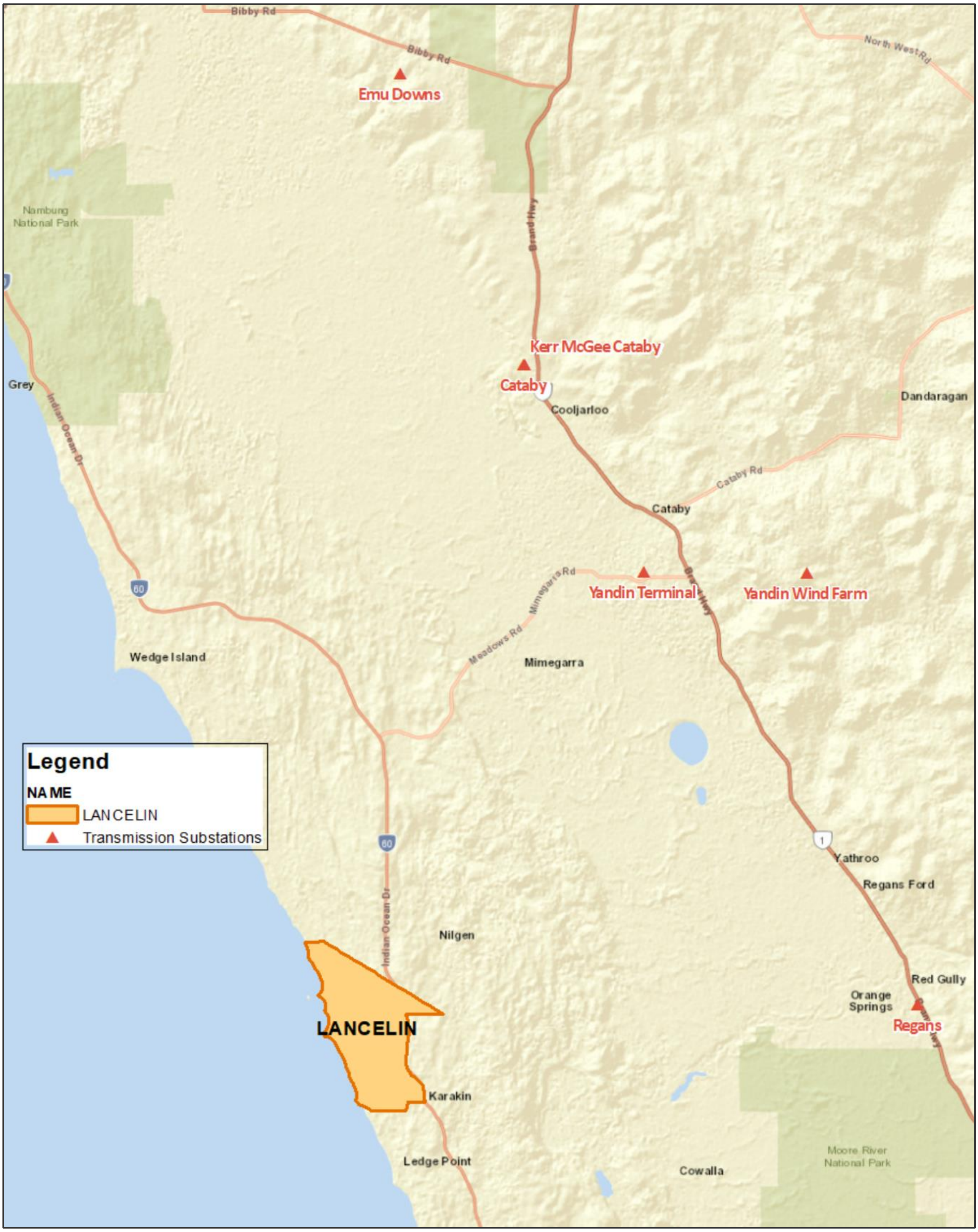

Figure 3.8: Geographical location of Lancelin in relation to surrounding zone substations

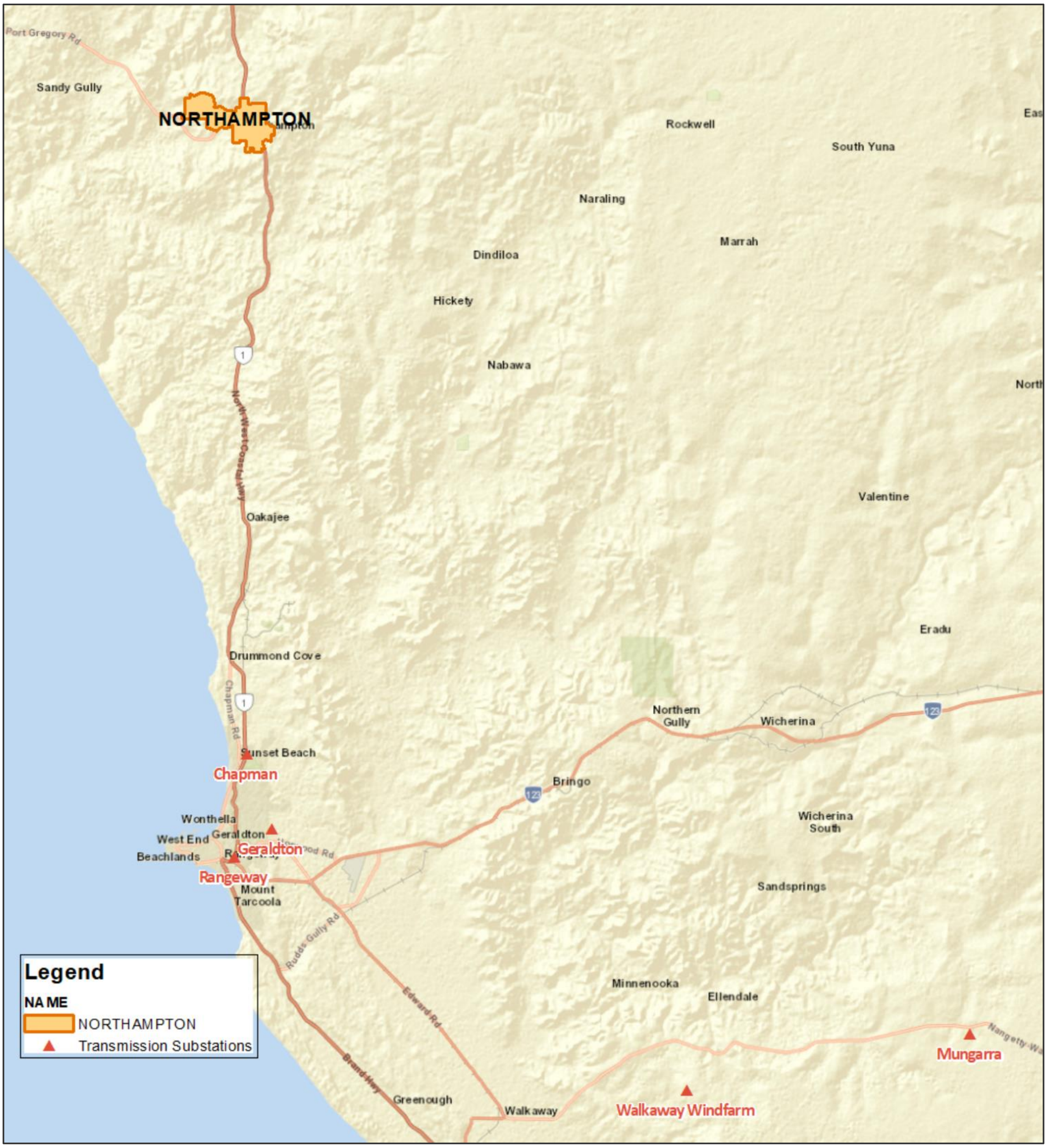

Figure 3.9: Geographical location of Northampton in relation to surrounding zone substations

Figure 3.10: Geographical location of Denmark in relation to surrounding zone substations

3.4.2.1 Alternative options for Reliability

As mentioned in section 1.3.5, the town of Kalbarri has been equipped with a BESS, temporary Emergency Response Generators (ERG) and a HV Injection Unit (HVIU) which has the capability to improve reliability performance for the town when fault durations are longer and BESS is depleted. Similarly, Walpole will be equipped with a pumped hydro microgrid in 2023 with the objective of providing cleaner and greener energy and improved reliability for customers in the area. In conjunction with the BESS and pumped hydro microgrid, other greener solutions are invited for a more futuristic approach to support existing reliability performance improvement measures at Kalbarri and Walpole.

3.4.3 Network Control Service

There is an existing 2 MVA power station in Ravensthorpe that provides network control service (NCS) to Western Power. Connected to a 33kV KAT 509.0 feeder of the Katanning Zone Substation, this power station caters to supply existing and forecast load within power quality limits via daily peak lopping and can form a microgrid to improve reliability performance. Western Power is looking for alternate options with similar capacity and capability to connect at 33kV with synchronising capabilities.

The information in this report should be used only as a guide and we recommend that you get in touch with us as early as possible when planning your project. We perform detailed system studies to confirm the technical feasibility of connections and having this information early can greatly assist in planning your project.

Appendix A

ACCESS CODE 2020 REQUIREMENTS

A.1 Access Code Requirements Indexed to Network Opportunity Map 2022

The following table is based on amendments to the Access Code 2004[21] that describe the Network Opportunity Map requirements and provides a guide to locations in this document where each requirement is addressed. Where defined terms are used, indicated by *italics*, the full definition should be sought in the complete Access Code document.

Access Code 2020	Description of the Obligation	Relevant section of this document
NETWORK OPPORTUNITY MAP		
6A.1	A *service provider* must *publish* and update a *network opportunity map* (NOM) by no later than 1 October each year.	This document, referenced data sheets and the NOM Webpage
6A.2	A *network opportunity map* must include:	
6A.2(a)	a description of the *service provider's network;*	Section 1.1 About Western Power
6A.2(b)	a description of its operating environment;	Section 1.1 About Western Power
6A.2(c)	the methodologies used in preparing the *network opportunity map*, including methodologies used to identify transmission and distribution system *constraints* and any assumptions applied;	Appendix B.1 Planning Methodology
6A.2(d)	analysis and explanation of any aspects of forecasts and information provided in the *network opportunity map* that have changed significantly from previous forecasts and information provided in the preceding year;	Appendix B.3 Forecasting Methodology
6A.2(e)	forecasts for the five-year forward planning period, including at least: (i) A description of the forecasting methodology used, sources of input information, and the assumptions applied; and (ii) Load forecasts for zone substations; (iii) To the extent practicable, primary distribution feeders, having regard to: (a) the number of customer connections; (b) energy consumption; and (c) estimated total output of known embedded generating units including, where applicable, for each item any capacity or voltage constraints on distribution feeders where applicable including estimated constraint periods; and	Appendix B.3 Forecasting Methodology Referenced Network Data

21 Electricity Networks Access Code - Unofficial Consolidated Version (www.wa.gov.au)

6A.2(f)	forecasts of future zone substations including: (i) location; (ii) future level of output, consumption or power flow (in MW) of a *generating plant* or *load*; and (iii) proposed commissioning time (estimate of month and year);	Not Applicable No new zone substations are proposed at this time.
6A.2(g)	a description of any factors that may have a material impact on the *service provider's network*, including factors affecting: (i) fault levels; (ii) voltage levels; (iii) power system security requirements; and (iv) the quality of supply to other *users* (if relevant);	Refer to TSP Transmission Network Section 3 Distribution Network
6A.2(h)	the annual deferred value for *augmentations* for the next 5 years;	Appendix C Referenced Network Data
6A.2(i)	for all *network asset* retirements and for all *network asset* de-ratings that, in each case, would result in transmission and distribution system *constraints*, that are planned over the forward planning period, the following information in sufficient detail relative to the size or significance of the *network asset*: (i) a description of the *network asset*, including location; (ii) the reasons, including methodologies and assumptions used by the *service provider*, for deciding that it is necessary or prudent for the network asset to be retired or de-rated, taking into account factors such as the condition of the *network asset*; (iii) the date from which the *service provider* proposes that the *network asset* will be retired or de-rated; and (iv) if the date to retire or de-rate the *network asset* has changed since the previous *network opportunity map*, an explanation of why this has occurred;	Appendix B.2
6A.2(j)	a high-level summary of each: (i) *major augmentation* for which the *regulatory test* has been completed in the preceding year or is in progress; and (ii) *priority project;*	Appendix C
6A.2(k)	a summary of all *committed* investments to be carried out within the forward planning period with an estimated capital cost of $2 million or more that are to address a *network* issue, including: (i) a brief description of the investment, including its purpose, its location, the estimated capital cost of the investment and an estimate of the date (month and year) the investment is expected to become operational; (ii) where there are reasonable *alternative options* to that investment, a brief description of the *alternative options* considered by the *service provider* in deciding on the preferred investment, including an explanation of the ranking of these options to the investment;	Appendix C Referenced Investment Data

6A.2(l)	information on the *service provider's* asset management approach, including: (i) a summary of any asset management strategy employed by the *service provider*; (ii) an explanation of how the *service provider* takes into account the cost of line losses when developing and implementing its asset management and investment strategy; (iii) a summary of any issues that may impact on the transmission and distribution *constraints* identified in the *network opportunity map* that has been identified through carrying out asset management; (iv) information about where further information on the asset management strategy and methodology adopted by the *service provider* may be obtained.	Appendix B.2

Appendix B

METHODOLOGIES

B.1 Planning Methodology

As an NSP it is Western Power's role to provide power transmission and distribution services to generators and load customers within the SWIN. In providing these services, Western Power not only operates the existing network, but also undertakes planning activities to ensure that new generator connections can be accommodated with new and growing loads supplied according to established standards.

Every year Western Power produces a Network Plan (NP) which forms a baseline for all network related expenditure across a 10-year outlook. NOM2022 is based on NP24, updated in April 2022 on the basis of system studies, analysis and forecasts completed during 2021.

B.1.1 Network Planning Process

The NP considers all relevant network strategies and follows a planning process to convert an unconstrained case (reference case) to a constrained case following prioritisation and further optimisation.

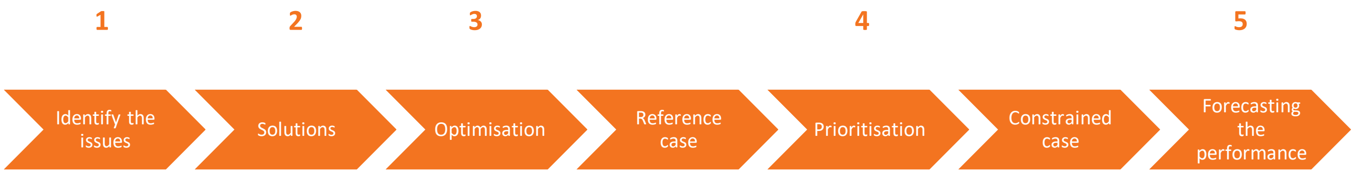

Figure B.1.1: High level end-to-end planning process

The end-to-end network planning process has five key steps as outlined in Figure B.1.1. It is broadly the same for all types of network expenditures (capacity expansion and replacement) with some differences in the method of prioritisation and optimisation based on the level of risk, and whether works relate to the transmission or distribution network. This includes the evaluation of non-network solutions and application of new or emerging technologies.

B.1.1.1 Step 1 – Identify the Issues

Western Power assesses the current and projected performance of the network from both an asset and network constraint point of view following:

- Change in forecast load and demand
- Introduction of new loads or generation sources
- Change in asset condition
- Past reliability, safety or other network performance characteristics.

These are assessed against the asset management requirements and objectives, TR[22], NQRS Code[23], expected generation scenarios, condition of the existing assets and forecast of future performance.

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22 Approved Technical Rules - Economic Regulation Authority Western Australia (erawa.com.au)

23 https://www.wa.gov.au/organisation/energy-policy-wa/regulatory-framework

Western Power regularly publishes a Service Standard Performance Report[24], detailing performance of the network against reliability criteria including SAIDI and SAIFI, and a State of the Infrastructure Report (SOTI)[25] which details the safety and condition of the Western Power network.

This step generates a list of network or asset issues that need to be further examined and addressed.

B.1.1.2 Step 2 – Option Analysis

This step develops a series of options or solutions to address the emerging limitations in the network and asset class. This will include analysis of trade-offs between operational and capital expenditure, asset replacement and maintenance solutions. It also includes initial assessment of alternative options to traditional network solutions.

For the capacity expansion network augmentation category, studies will be performed using a one-in-ten-year peak demand forecast and substation peak demand forecasts. This ensures worst-case bulk transmission limitations and worst-case localised overloads are identified. An assessment of emerging limitations under off-peak conditions is expected for voltage studies. For distribution studies, feeder capacities are compared with future load forecasts. The strategic direction needs to be considered and must be based on long-term plans for the network and corporate performance measures such as reliability and safety, along with operational experience, to identify issues that are present on the network.

Several generation scenarios are modelled into the probabilistic assessment of generation and load development options across a 10-year period, comprising the five-year access arrangement period and several years post the regulatory period to assess the performance of the transmission and distribution networks.

Contingency analysis is then undertaken with the credible contingencies based on the TR and Planning Guidelines. All the credible contingencies are considered for any single contingency (N-1) and a single contingency and outage (N-1-1) analysis.

The outcome is high level options that will be developed based largely on network solutions. The option analysis will also provide commentary on the possibility of various alternative options and non-network solutions.

To estimate cost, Western Power uses a blend of historical average unit rates, estimations and capital project building blocks based on previous projects and/or benchmarking. Specific project estimates are developed where there are unique project components, or a benchmark does not exist.

The output of this process is an unconstrained case that includes all the projects with respect to the network and asset needs.

B.1.1.3 Step 3 – Optimisation

The optimisation process includes actions such as:

- Identification of network need and opportunities (reference scenario)
- Outputs from condition assessments
- Verification of the lowest cost option

[24] https://www.erawa.com.au/cproot/21552/2/2019-20-Service-Standard-Performance-Report.PDF
[25] https://www.westernpower.com.au/media/4763/state-of-the-infrastructure-report-2019-20-20210209.pdf

- Completion of risk reduction benefit assessments
- Incorporation of the corporate strategy and plans for the network, including where higher capacity assets are needed in the long term, taking into account the utilisation and decommissioning assets.

Where overlaps of drivers or dependencies with other projects exist on targeted assets, consideration is given as to how to optimise the solutions across projects.

Optimisation with asset condition drivers in transmission is typically restricted to large assets such as power transformers, indoor switchboards and transmission lines. These assets are characterised as bulky, expensive and with long lead times, presenting opportunities to optimise replacement plans with other network investment drivers. For works on the distribution network, optimisation occurs by using the outputs from scenario forecasting tools to optimise timing network maturity against the long-term vision of the network.

B.1.1.4 Step 4 – Prioritisation

The prioritisation process considers cross-portfolio assessment and applies a scoring methodology when assessing a variety of options in both the short and medium term.

The selection of capacity expansion, replacement and maintenance investments for each year is based on a series of criteria covered in Step 1 – Identify the Issues. These investments are prioritised through a multi-criteria assessment which provides an overall business value of the proposed investment in the network.

Assets within a particular group are prioritised and optimised in line with the relevant asset strategy, with the volume set by delivery constraints or the number of assets that can be addressed within the next 10 years. At an investment level these are prioritised by considering factors such as customers at risk, likelihood of failure, asset condition and criticality[26].

Some level of further optimisation is done at this stage with respect to the timing of works.

At the completion of this process, each portfolio is prioritised to satisfy any delivery or funding constraints (the constrained case).

B.1.1.5 Step 5 – Forecasting the Future Performance

Following the end-to-end process, Western Power forecasts the performance of the network based on the proposed projects against measures such as SSBs, anticipated safety performance, and movements in risk indices.

B.1.2 Annual Planning Cycle

The annual planning cycle includes all the activities required to produce or update a NP. It commences with the acquisition of latest telemetry and metering data and culminates in a (constrained) list of issues that require attention inclusive of remediation cost for the short to medium future, and publication of the Network Opportunity Map (previously Annual Planning Report). The process takes roughly 12 months to complete with ad-hoc updates for any significant departures from anticipated results.

[26] Criticality with respect to the network is considered only for transformers, switchboards and lines, which might take longer to be replaced or brought back to service, and supply a large number of customers.

The NP is usually finalised in the second quarter of a calendar year and contains all approved and nominated projects, as well as candidates to address various notional issues in the network. As a result, NOM2022 is primarily based on NP24 updated in April 2022.

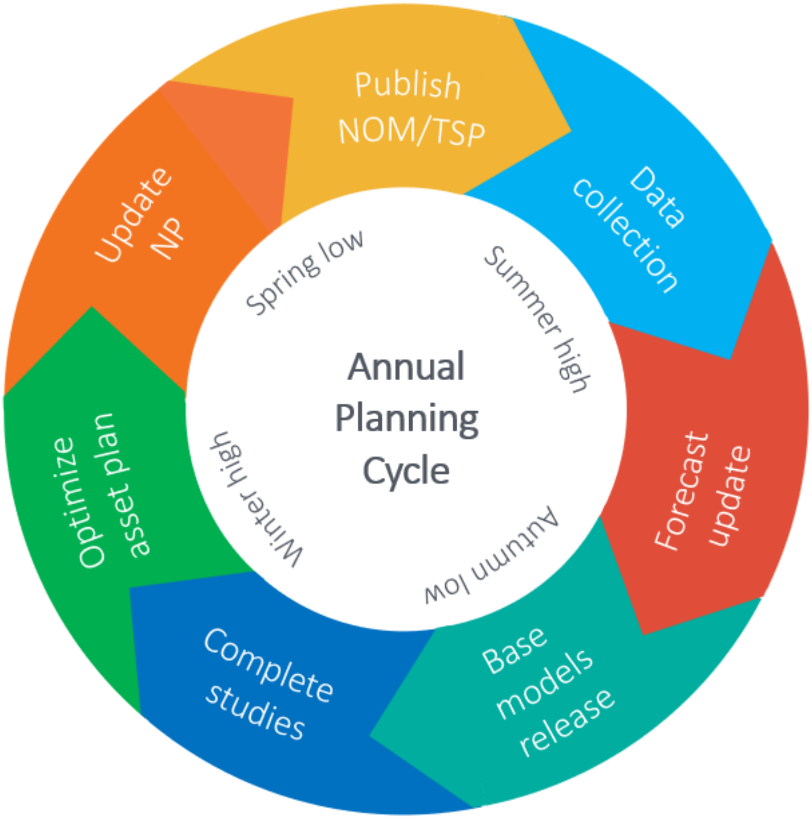

Figure B.1.2: Annual planning review and reporting cycle

It is important to note that the timing of the NOM publication (before 1 October) does not change the timing of individual opportunities, as those will be published on the NOM webpage as they reach maturity and become ready for option scoping. Opportunities published on the NOM webpage throughout the year may or may not be clearly indicated in the latest NOM, as they may arise in response to events or studies that eventuated after publication.

B.2 Asset Management Methodology

B.2.1 Asset Management Framework

Western Power's Asset Management System (AMS) has undergone a range of independent assessments for maturity, adequacy and application. An ISO 55001 audit[27] concluded in June 2019 awarded the certificate against the requirements of ISO 55001:2014 and found that, "Western Power has a number of industry leading practices".

Western Power's AMF is set within the context of the Australian and International Standard on Asset Management (ISO55001), ERA audit guidelines, Electricity (Network Safety) Regulations 2015 and Electricity Network Safety Management Systems standard (AS 5577).

This framework underpins Western Power's Asset Management Policy and defines the structure of Western Power's AMS. Western Power's AMS has been built on this framework and is a collection of strategies, standards, specifications, procedures, processes, tools and systems used for Asset Management. The AMS is a structured tool for fulfilling due diligence requirements and achieving continuous improvement in Asset Management performance. The AMS supports decision-making and sustainable management of network assets, as per the requirements of Western Power's operating licences (ETL2 and EDL1) and other compliance requirements. This encapsulates all asset management documentation, responsibilities and supporting systems.

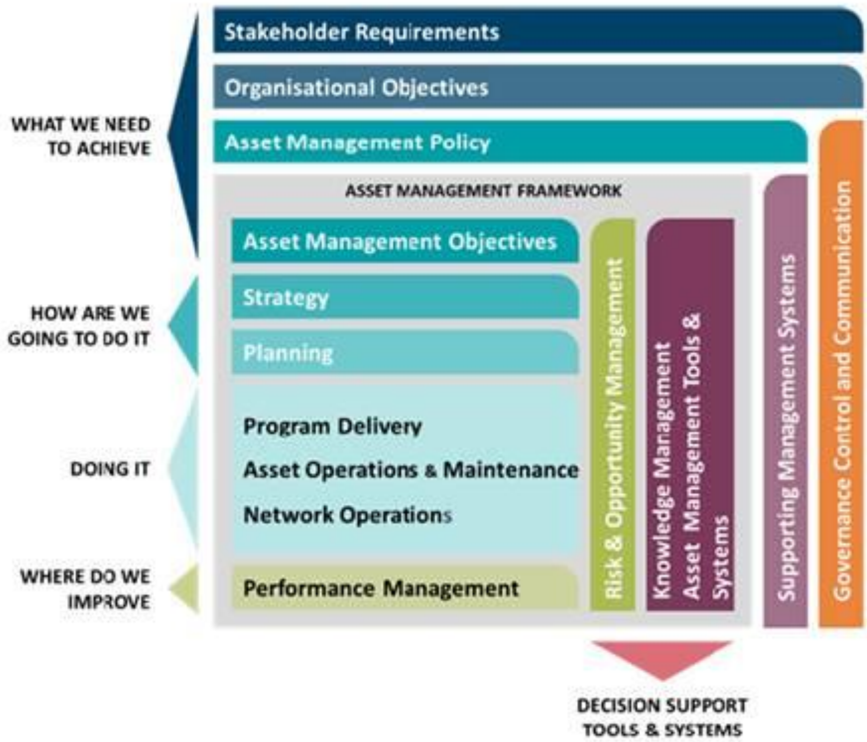

Figure B.2.1: Western Power's Asset Management Framework components

27 http://www.erawa.com.au/cproot/21688/2/Final-asset-management-system-review-report---2020-Review---EDL001-ETL002---Western-Power.PDF

B.2.2 Asset Management Objectives

Asset management objectives are reflective of the value that Western Power should realise from its assets. They are aligned to Western Power's corporate objectives and customer insights and are summarised in Table B.2.1.

Table B.2.1: Western Power asset management objectives

Asset Management Objectives	Description
Safe (Safety and Environment)	• Maintain overall safety of the network in line with jurisdictional obligations (eliminate/ reduce risk as low as is reasonably practicable), with actual performance not deteriorating below recent historical levels. • The safety performance is measured qualitatively through risk ratings and quantitively through failures and incidents. Incidents refer to fires, electric shocks and physical impacts due to Western Power's electricity Tx and Dx networks. • Manage environmental performance by maintaining current network environmental risk rating.
Reliable	• Maintain current service standard levels as defined by the relevant regulations; whilst ensuring ongoing sustainability of the network. • Optimise the transition to the modular grid.
Affordable	• Deliver safe and reliable supply at agreed levels of service at the lowest practical cost. Whole of life cycle costs and risk reduction are some of the key considerations.
Compliance	• Comply with applicable regulatory obligations, unless otherwise agreed with the relevant authorities. Maintain current network compliance risk rating.
Sustainable	• Enable the renewable future for the community by improving DER integration and coordination DSO functions with the help of advanced meter infrastructure (**AMI**), modernised connection standards for DER, and greater amounts of grid-connected storage to help balance periods of low demand and intermittent supply. This objective is primarily addressed through the Grid Strategy.

B.2.3 Asset Management Challenges and Strategies

Western Power's strategies aim to meet the asset management objectives outlined above for its transmission, distribution, and SCADA and Telecommunications network assets. The subsections below summarise the key challenges and strategies to manage the network assets as defined in Western Power's Network Management Plan and the statistical data presented reflects the operating context as of 30 June 2020.

B.2.3.1 Transmission Network

Western Power's transmission network comprises lines, terminals and zone substations, operating as a system with voltages from 66kV to 330kV to transmit energy from large-scale generators to terminal substations, then to zone substations for distribution to customers (up to 33kV). There are more than 100,000 transmission assets grouped into 15 asset classes (including plant, lines and network facilities).

In broad terms, the transmission network faces the following challenges:

- Challenging network access to perform maintenance due to higher network stability risks and more stringent AEMO requirements for planned outages approval.
- An ageing fleet, particularly on the 66kV network, compounded by the need to extend operating life and increase asset utilisation to support transformation (network rationalisation, de-meshing).

Table B.2.2: Transmission Asset Class Challenges and Strategies

Transmission Asset Class	Challenges	Strategies
Transmission Lines	• Increased load due to capacity expansion or network rationalisation through line uprating. • Aging of wood pole fleet (including crossarms), overhead conductors and steel structures. Jarrah wood poles being susceptible to carroty rot compound this issue. • Pole top fires due to electrical tracking across insulators and cross arms. • Increasing vegetation encroachment find rates (25 per cent in five years).	• Identify condition and reinforce, repair or replace based on condition, prioritised by risk. • Commence a program of detailed corrosion assessment on steel structures. • Align transmission line replacements with substation maintenance to optimise outage management and delivery efficiency.

Transmission Asset Class	Challenges	Strategies
Transmission Plant	• Increase in the number of conditions that require capex treatment: 27 per cent of power transformers and 19 per cent of primary plant • Obsolescence: 8 per cent of power transformers and two types of switchboards: Yorkshire (5) and GEC (2). • Diverse asset base: 25 manufacturers (19 models) of on-load tap changers and 20 manufacturers (75 models) of outdoor circuit breakers.	• Identify condition and repair, refurbish or replace based on condition, prioritised by risk. Implement condition monitoring, prioritized by criticality. • Early assessment of network access risks and contingencies. • Early assessment of alignment between capex treatments and future vision for the substation. • Adjust scope of refurbishment to address most critical failure modes (e.g., bushing, tap changers, bunding, arc-flash). • Expand strategic spare coverage through trade-offs with other capex treatments and component harvesting. • Apply In-Service Network Spare Management Standard to determine optimum spare levels.
Network Facilities (includes distribution and transmission buildings and grounds)	• Ageing of network facilities, compounded by historically low levels of investment. • Limited inventory and condition data available. • Statutory requirements related to workforce safety (fire protection, asbestos management). • Support to new functionalities required for assets installed in network facilities. • Cybersecurity and unauthorized access threats.	• Identify building elements, their conditions and repair or refurbish based on condition, prioritised by risk. • Improve network facilities inventory data. • Develop and implement a cybersecurity strategy. • Progressively replace mechanical key with electronic access. • Progressively upgrade fire suppression systems.

B.2.3.2 Distribution Network

The distribution network consists of a high voltage (**HV**) distribution system operating at voltages of 33kV, 22kV, 11kV and 6.6kV and a LV distribution system operating at voltages of 415V and 240V. The distribution network consists of more than 2,000,000 assets grouped into multiple asset classes. This includes structures, overhead conductors, underground cables, pole top and ground-mounted plant and facilities, SPS, microgrids, service connections and public lighting. These are either electrically interconnected and working together, or dependant on each other (e.g., poles physically supporting conductors) to distribute electricity for end-customers.

Table B.2.3: Distribution Asset Class Challenges and Strategies

<table>
<tr><th>Distribution Focus Area</th><th>Challenges</th><th>Strategies</th></tr>
<tr><td>Distribution Overhead (OH) Network</td><td>Ageing distribution overhead network with approximately 55 per cent of assets reaching end of life maturity in the next 10 years.
Wood poles and bare overhead conductors form the majority (~97 per cent) of the distribution overhead network, covering a vast and varied geographical area. While overhead network can provide an affordable option, it also presents an increased safety and reliability risk relative to other network construction options (e.g., underground or standalone power systems).
Optimum investment balance between short to medium term risk management and network transformation where opportunities to transform the network take time to be realised.
Reliability and economic impacts of external events (e.g., extreme weather events, bushfires destroying assets) present significant challenges for the distribution overhead network.
There is an increasing trend of pole top fires on the distribution overhead network, contributing to 37 per cent of all ground fires in the distribution network over the past five years, impacting both safety and reliability.</td><td>Monitor condition through routine inspections. Every structure in extreme and high fire risk zones or very high and high public safety zones will be inspected at least once every year as a part of the Holistic Inspection regime.
Distribution OH network rebuild strategy identifies mature sections of the network to be rebuilt prioritised by risk, enabling transformation of parts of the network as per the Grid Strategy. The network rebuild strategy also identifies high risk assets for treatment to manage short term risk and minimise regrettable investment in areas to be transformed.
Pole top fires are mitigated through applying silicone grease to insulators with a higher likelihood of leakage currents, prioritised by risk. Silicone insulators are specified for use in areas where polymeric insulators are not performing well.</td></tr>
</table>

Distribution Focus Area	Challenges	Strategies
Distribution Underground Network	• High volume (~2,400 km) of cable is operating beyond their mean replacement life (MRL). • Increasing trend of unassisted failure of distribution underground cables over the past five years, leading to reliability impacts especially in CBD and urban areas. • Past asset management strategies have been predominantly to treat on failure with little proactive management. • Asset data in systems (e.g., installation data and type) is limited in some cases.	• Carry out targeted testing on priority cables to assess condition. • Identify priority cables considering asset knowledge, past performance and criticality (per centage of loading, number of customers, type of customers, Distribution Transfer Capacity (DTC) and feeder supply arrangement). • Replace cables where condition indicates end of life. • Use insights gained from testing regime to enhance understanding of condition of the cable fleet.
Service Connections	• Service connections continue to be the highest (%) contributor to the electric shock count due to Western Power's network. There is an increasing trend in shocks due to underground service connections. • Visual inspection of OH service connections can identify obvious defects and many remaining 'twistie' type connections but are ineffective at identifying failure modes that contribute to most shocks (e.g., high resistance neutral connections). • Most failures on underground service connections are due to vehicles colliding with the pillars.	• Apply Service Connection Condition Monitoring (SCCM) on OH and UG customer service connections through AMI to detect electric shock hazards. • Assess condition of OH service connections though periodic visual field inspection and prioritise treatment of defects by risk. • Identify and replace remaining 'twistie' type of service connections. • Identify frequently hit pillars and relocate, protect (bollards) or replace with underground service pits.
Ring Main Units (RMU)	• There are ~2,000 RMUs, manufactured between 2011 and 2016, that are more prone to gas leaks due to a type defect. The failure rate of these RMUs has been increasing over the last few years.	• Apply operational restrictions on these RMUs to prevent remote operation on a low gas unit. • Replace these RMUs, prioritising by risk.

Distribution Focus Area	Challenges	Strategies
Public Lighting	• Growing asset base driven by increasing undergrounding activity. • Ratification of Minamata convention results in Western Power being unable to procure globes for maintenance of in-service mercury vapor luminaries (49 per cent of public lighting luminaries).	• Assess condition of Public Lighting, Dedicated Streetlight Metal Pole (DSLMPs) through periodic inspection and remediate defects (replace or reinforce) based upon condition. • Reactively remediate luminaire and streetlight cable faults reported by customers. • Use of LED globes to replace in-service mercury vapour globes.

B.2.3.3 SCADA and Telecommunications Network

The SCADA and telecommunications network is integral to the safe, reliable and efficient operation of Western Power's transmission and distribution networks, providing services such as protection, monitoring, control operational voice, meter reading, remote management and maintenance.

The SCADA and telecommunications network consists of more than 10,000 assets and over 5,000 km of communication cables/links.

Table B.2.4: SCADA and Telecommunications Asset Class Challenges and Strategies

SCADA and Telecommunications Asset Class	Challenges	Strategies
Grid Automation Assets	• 47% of transmission substation automation assets are beyond their MRL, however 75% are obsolete as they've reached the end of their manufacturing lifecycle and have no manufacturer support resulting in the depletion of electronic spares and performance issues (obsolete automation electronic assets cannot be expanded to accommodate protection relay upgrades, resulting in capacity issues). • There are mandatory requirements for Western Power to provide connectivity and visibility of the network to AEMO.	• Replace non-compliant, end-of-life and obsolescent assets on a risk priority basis, ensuring replacement assets: – Use open standards rather than proprietary standards. – Meet cybersecurity compliance requirements. – Use digital rather than analogue technology. – Use IP rather than serial communications. – Support dual (diverse) path connectivity. – Support IP connectivity to relays / IEDs. – Have sufficient capacity to meet forecast growth requirements.

SCADA and Telecommunications Asset Class	Challenges	Strategies
Telecommunications Network Access Assets	• Telecommunications network access assets are electronic equipment that generally exhibit a random pattern of failure that can be difficult to effectively predict. To compensate for the random failure, Western Power monitors the telecommunications network access assets in real time, designed network redundancy, maintains a strategic spare holding and perform periodic software and firmware updates. • The lifecycle of electronic assets is not significantly impacted by the reliability of the assets but rather the supportability driven by product obsolescence. The obsolescence risk is assessed and addressed by a planned program or work 60% of Tx substation automation assets are obsolete (end of life with no manufacturer support) resulting in the depletion of electronic spares and performance issues (obsolete automation electronic assets cannot be expanded to accommodate protection relay upgrades, resulting in capacity issues). • There are mandatory compliance requirements for Western Power telecommunication network to: – support associated Technical Rules (Sections 2.9, 3.4.10 and 3.5) compliance in relation to primary plant protection and to monitor and control primary plant with SCADA. – provide operational voice communications to generators as set out in Section 3.3.4.3 (d) of the Technical Rules. – manage our communications facilities within the Telecommunications Act (1997).	• Plan prioritised, proactive 'whole of family' replacement on service withdrawal, technology obsolescence, type defects, endemic degraded performance, or reduced capacity. • Periodic audit and review of internal cyber security frameworks and standards and plan corrective remediation, as required • Explore options to apply current design standards, retire or expand service given the telecommunications network strategy • Monitor concurrent Electrical network programs to optimise implementation plans • Meet all regulatory and contractual obligations and prepare supporting documentation. • Telecommunications network access assets risk are assessed within the guidelines on the Network Risk Management Standard (NRMS) which is a key component within Western Power's Asset Management System. – The likelihood of the loss of service is assessed on the defect history, age, cyber security, and availability of manufacturer support. – The ability of the asset to provide the required capability and capacity to meet the intended service. – The consequence of a loss of service is assessed on its impact to work force safety and protection of electrical assets.

SCADA and Telecommunications Asset Class	Challenges	Strategies
Radio System	• There are mandatory compliance requirements for Western Power telecommunication network to: – support associated Technical Rules (Sections 2.9, 3.4.10 and 3.5) compliance in relation to primary plant protection and to monitor and control primary plant with SCADA. – provide operational voice communications to generators as set out in Section 3.3.4.3 (d) of the Technical Rules. – manage our communications facilities within the Telecommunications Act (1997). • Several frequency spectrum embargoes are currently in place limiting the number of microwave radio licences available for use. Embargo 49 has the most impact which limits the use of most of the microwave frequency spectrum (2 to 52 GHz). This embargo was enacted to support the development of space communications facilities in the general area of Northern WA. Even if a conditional licence is issued, a licence holder needs to vacate a frequency within 90 days if Australian communication management authority (ACMA) deemed it necessary to allow for its intended purpose as per the corresponding embargo. • Increasing bandwidth requirements for current and upcoming services are putting a strain on the capacity limits of UHF/VHF radios. These radios are designed to carry low- to medium-capacity traffic and once this limit is breached, a move to higher frequency microwave radios will eliminate the need for these types of radios. In this instance it will be subjected to the same challenges as microwave radios, such as ACMA embargoes.	• Plan prioritised, proactive ‘whole of family’ replacement on service withdrawal, technology obsolescence, type defects, endemic degraded performance, or reduced capacity • Meet all regulatory and contractual obligations and prepare supporting documentation • Radio systems risk are assessed within the guidelines on the Network Risk Management Standard (NRMS) which is a key component within Western Power’s Asset Management System. – The likelihood of the loss of service is assessed on the defect history, age, cyber security, and availability of manufacturer support. – The ability of the asset to provide the required capability and capacity to meet the intended service. – The consequence of a loss of service is assessed on its impact to work force safety and protection of electrical assets.

B.2.4 Supporting Strategies

In addition to asset management-specific strategies, Western Power also has several underpinning strategies that guide day-to-day decision making, ensuring everything from compliance with regulations to the safety of our people.

B.2.4.1 Reliability Strategy

Reliability is a key measure of network performance that reflects the service that Western Power delivers to its customers. Western Power is required to ensure reliability of supply is maintained at acceptable levels. Reliability is measured in relation to the number of sustained interruptions of power supply experienced by customers.

We aim to maintain current service performance levels in accordance with SSBs, maintain current levels of compliance with the minimum service standard performance levels defined by the NQRS Code where reasonably practical, and improve service standard targets where it is valued by customers and economically prudent. Where there is non-compliance (or a trend towards non-compliance) a pathway to compliance will be established.

B.2.4.2 Power Quality Strategy

Power quality is the level of useability (or usefulness) of the electricity supply delivered to the customer. This is quantified in terms of the degree to which the electricity supply is of a voltage that is free from major distortions and fluctuations, and maintains a stable frequency. Power quality focuses on characteristics such as steady state voltage limits (high and low volts), voltage unbalance, voltage flicker, voltage transients (voltage step change, sags and swells), harmonics (waveform distortion) and system frequency.

We aim to meet the power quality objectives as specified in the TR, NQRS Code and applicable industry standards through appropriate maintenance, performance monitoring, investigations and appropriate design.

B.2.4.3 Safety and Environment Strategy

Electricity by its nature is hazardous. To serve its purpose, Western Power builds, operates and maintains potentially hazardous assets. The electricity network presents safety risks to members of the public, Western Power's workforce and fauna, due to:

- Electric shock from contact with electricity
- Fires due to failure of network assets or interference from external factors (e.g., third party, vegetation or fauna interference)
- Physical impact due to failure of network assets.

Environment hazards associated with the network include impact on flora and fauna. In addition, environmental hazards such as asbestos, noise, SF6, oil leaks, polychlorinated biphenyls and electromagnetic frequency pose health and safety consequences.

Western Power aims to maintain the overall safety of the system in line with all jurisdictional obligations, including eliminating safety risks so far as is reasonably practicable (SFAIRP), and if it is not reasonably practicable to eliminate a safety risk, reduce that risk to as low as reasonably practicable (i.e., ALARP). This implies that if a safety measure exists that can reduce the risk of an incident occurring, it must be implemented if the cost is not grossly disproportionate to the benefit gained. Western Power will continue to implement these principles at all levels of our business.

B.2.4.4 Customer, Compliance and Efficiency Strategy

Table B.2.5: Customer, Compliance and Efficiency Strategy Outline

Objective	Strategic Response
SUSTAINABILITY: Meeting the needs of current and future generations by considering social advancement, environmental protection, climate change and economic prosperity in business activities and decisions.	Enable a renewable future for the community by improving DER integration and coordination (Distribution System Operator (DSO) functions) with the help of advanced meter infrastructure (AMI), modernised connection standards for DER, and greater amounts of grid-connected storage to help balance periods of low demand and intermittent supply.
COMPLIANCE: Complying with all applicable legislation, statutory and regulatory requirements, and formal agreements with customers, consistent with asset capability.	Western Power is governed by many legislative, statutory and regulatory requirements and engages with a vast number of customers through formal agreements. Western Power measures its compliance through specific performance objectives in line with regulatory determinations and customer agreements. Industry standards reflect "good industry practice". Western Power aligns all its activities with applicable Australian and international standards, where they deliver value to its customers and shareholders.
AFFORDABLE: Undertaking a balanced evaluation of all relevant factors and alternatives, including demand-side management and other non-network solutions, optimising life cycle costs of asset management and maximising risk reduction for investments made.	Our objective is to maximise the utilisation of the existing assets to supply an efficient and affordable supply to the customers. Western Power is focused on improving the condition of the existing assets to address network risk, while keeping costs low. Whole-of -lifecycle cost assessments provide the optimal balance between short-term cost reductions and long-term sustainability. Asset investments are prioritised based on the level of risk they present.

B.2.5 Network Asset Retirements and De-ratings

B.2.5.1 66kV to 132kV Conversion Strategy

One of the key transmission network transformation strategies is the 66kV Rationalisation Strategy, which provides guidance on investment decisions related to the replacement of the 66kV network. This strategy highlights the opportunities that are available to reduce costs when replacing the 66kV networks with a smaller number of higher capacity 132kV assets. In the long term, it is anticipated that all the 66kV assets will be removed from the network, reducing the volume of assets requiring maintenance.

Most of the 66kV networks are at or near their mean replacement life and in some cases their design capacity levels. As a result, a portion of 66kV network assets will require replacement in the short- to medium-term. Further opportunity exists to improve medium- to long-term affordability by converting to the higher capacity 132kV network, which also reduces the number of assets to replace and maintain.

Western Power has nine 66kV loops scheduled for progressive conversion into 132kV in the next 60 years as assets reach their end of life, including:

- Bunbury: staged conversion from 2021 until 2078
- Muja: conversion of Muja 66kV assets by 2032 and Collie 66kV assets by 2078
- South Fremantle: conversion between 2035 and 2039
- Western Terminal: conversion in 2035
- East Perth: conversion in progress
- Kojonup: staged conversion from 2023 until 2055
- Cannington: staged conversion from 2023 until 2049
- Kwinana: to coincide with major works
- East Country: under development

The 66kV conversion strategy is expected to deliver:

- Maximised utilisation of the 66kV assets prior to conversion
- Ensure risk profile is maintained while assets await conversion
- Delivery of long-term cost reductions
- Provision of a set of strategic rules to support end-of-life asset management
- Improved alignment between network and asset strategies.

B.2.5.2 Asset De-ratings

Western Power's meticulous maintenance strategies, implemented through a range of preventative and corrective programs, ensure that in-service assets rarely need to be de-rated. On occasion, because of an unplanned event a temporary reduction in load bearing capacity may be applied to an asset or part of the network until such time as necessary repairs can be made. Each asset class has a defined spares strategy that ensures works are carried out quickly and efficiently.

B.3 Forecasting Methodology

B.3.1 Forecasting Principles

Electricity demand and its patterns are one of the critical factors determining the size, timing and location of investments and many other operational and strategic network decisions made by Western Power.

Western Power develops forecast models with a ‘middle-out’ approach segmented by customer type, tariff, and different network levels and scenarios. The models are also produced at different hierarchy levels, reconciled to ensure consistent results. It is important to note that not all forecasts are developed for all scenarios, at all levels, or even every year.

Western Power’s development of forecast models is guided by the guiding principles of accuracy, transparency, and evidence-based decision-making. The forecasting process checks the validity of forecasts by running statistical tests to ensure consistency at different levels of aggregation. Western Power continually improves the quality of its forecasts to ensure they do not contain any systematic bias, mainly by evaluating existing forecasts using observed data.

The accuracy of past forecasts is monitored, and any significant departures analysed for possible causes of inaccuracy. Adjustments are then made in the design of new forecast models, or the type and quality of the data used. All input data is assessed for credibility and relevance before being approved for inclusion in the forecasting processes. For electricity demand, Western Power measures and aggregates five-minute averages for the purposes of forecasting.

Trends in connected customer count, imported energy from technology (mainly solar PVs) and energy demand form the basis of most energy forecasts, commonly referred to as Customers, Technology, Energy and Demand (CUSTED) forecasts**.** Aside from reconciled and validated actual demand data, other inputs of note in the forecasting methodology are econometric forecasts obtained from reputable sources such as CSIRO and Bloomberg, which are analysed for impact and included where and if relevant.

B.3.2 Forecasting Methodology Changes

Since the previous NOM publication, there has been no change to the forecasting methodology and principles adopted by Western Power for the information published in NOM 2022. Western Power is reviewing the forecasting methodology to consider extreme weather scenarios in consideration of climate change. Changes to forecasting methodology will be discussed in future NOM publications when implemented.

B.3.3 New Technology Impact

Speculation about mass adoption of new technologies has intensified in recent years with rapid adoption of battery storage systems seen as a primary driver for a decrease in demand.

Figure B.3.1: Drivers, barriers and enablers for new technologies

Western Power has developed a model to assess customers incentives to adopt solar PV and battery storage systems for inclusion in its forecasts. The model indicates that the average customer did not have the incentive to install batteries and that the effects of residential battery installations on peak demand during the forecast five-year horizon would be small. The latest forecasts do not include any adjustment for the uptake of electric vehicles, with up-front cost parity with internal combustion vehicles expected in 2030. Before then, the effect of electric vehicles on energy consumption and demand is expected to be small.[28]

28 Based on CSIRO's forecasts, AEMO estimated that by 2024/25 electric vehicles will increase peak demand in the SWIS between 1.1 MW and 17.2 MW (and network energy consumption between 8.7 GWh and 122.0 GWh). Refer to AEMO,2019. 2019 Electricity Statement of Opportunities, A report for the Wholesale Electricity Market, p. 34.

B.3.4 Customer Connections, Solar PV and Energy Forecasts

The method used to produce energy export forecasts from the network is based on three trends: customer connection numbers, adoption of solar PVs, and energy imports from solar PVs. This allows the model to reliably incorporate the effect of socio-economic and technological forces that result in highly dynamic and evolving energy consumption patterns.

Customer Connections Forecast

This forecast includes gross regional product, gross regional demand and regional population to model estimated monthly connection numbers. The number of connections comprises counts of National Metering Identifier and connection counts for streetlights and unmetered supplies.

Solar PV Capacity Forecast

Producing reliable long-term forecasts for solar PV installations is important for developing accurate forecasts for electricity consumption and demand. Although the mass adoption of solar PV installations is a relatively recent phenomenon, the rate of adoption has had a material demand-reducing impact. Given its importance, Western Power has conducted several investigations into forecasting methods for solar PV capacity and counts.

Energy Forecasts

The energy forecast model produces separate forecasts for exported energy from the grid and imported energy from solar PV panels. The model produces monthly forecasts at different hierarchy levels comprising tariff type, customer segment, and substation levels. It also reconciles forecasts at different hierarchy levels.

SUMMARY JUNE 2022

PV installations

430,365 ↑ 1.9%

PV capacity

1,768MW ↑ 2.6%

PV uptake overall/ residential

32.9% ↑ 0.5%

35.9% ↑ 0.6%

Avg PV capacity per installation

5.4kW

Batteries

5,922 ↑ 25%

57MWh ↑ 24%

EVs and PHEV's

4,608 ↑ 6%

B.3.5 Demand Forecasts

Western Power has continually improved its demand forecasting methods. The latest method provides for internal consistency between forecasts for energy demand and those for the number of connections, energy exports to customers and solar PV capacity installed. The new method provides forecasts for both minimum and maximum demand, as well as reactive power.

The increased penetration of behind-the-meter solar PV systems has created challenges for the operation of the network when customers' demand is met, or even exceeded, by energy imported from solar PV during daytime, usually in mild sunny weather conditions. This has made daytime minimums one of the critical forecasts for planning purposes.

Reactive power represents the hidden component of network congestion that can greatly impact available capacity. Network development and operation plans must suitably consider changes in minimum, maximum and reactive power flows.

Due to variability, forecasts are expressed at three probability of exceedance levels, rather than as single point forecasts. For any given season or year, POE10, POE50 and POE90 are defined as:

- POE10 or 10 per cent POE demand value is expected to be exceeded, on average, one year in 10.
- POE50 or 50 per cent POE demand value is expected to be exceeded, on average, five years in 10.
- POE90 or 90 per cent POE demand value is expected to be exceeded, on average, nine years in 10.

The following forecast information is included in the linked data spreadsheet, for each zone substation for 2021 to 2030:

- Zone Substation Summer and Winter Maximums at System Peak
- Zone Substation Summer and Winter Maximums at Regional Peak
- Zone Substations Absolute Summer and Winter Maximums
- Zone Substation Absolute Daytime Minimum

Detailed data can be accessed in the Network Data link on the NOM webpage, under Zone Substation Capacity and Zone Substation Forecasts.

Appendix C

INVESTMENTS

westernpower

C.1 Investment Framework

C.1.1 Investment Management Lifecycle

The purpose of Investment management is to monitor and manage the progress of an individual investment through its lifecycle to ensure it meets its objectives. The investment management lifecycle is a gated process with six phases and six control gates, where each control gate sets the mandatory deliverables and approvals that must be in place before the investment can progress to the next phase.

The Scoping Phase is a key period in which a proposal might be sought via any channels available to Western Power (online, via registered suppliers) for a solution that does not involve traditional network assets.

Investment Management

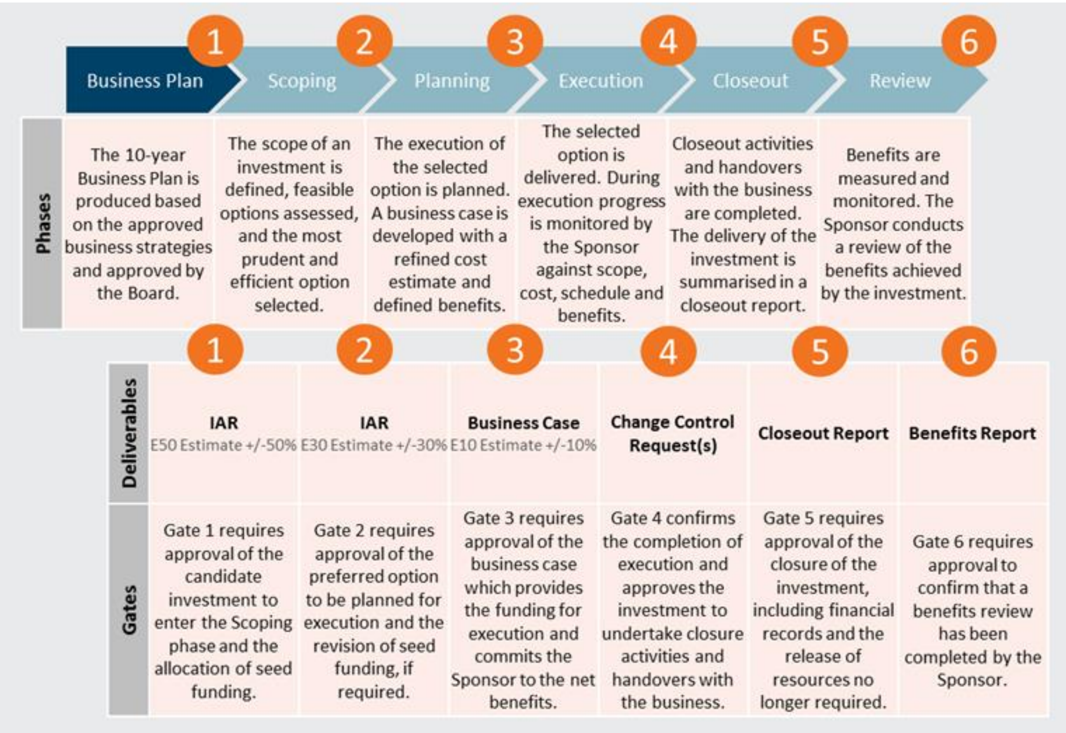

Figure C.1.1: Details of phases and gates in the investment lifecycle

C.2 Network Opportunity Valuation

C.2.1 Annual Deferred Value for Augmentation

During the scoping phase of an investment, various network and non-network solutions that address the constraint, risk or limitation identified by the proposed investment are investigated for feasibility, then scoped and estimated. A Class 5 estimate (C.1.1) is usually produced for all feasible solutions for the purposes of comparison and evaluation. Where alternative solutions are a viable option, Western Power might use available methods to consult industry participants and providers. One method also includes seeking RFPs, outlined in more detail in AOS.

One of the options routinely assessed in the scoping phase when considering network augmentation is investment deferral. It is based on the estimated value of the most likely, most efficient network option being considered as a potential solution. Network options are diverse in their nature and cost, they can range from asset replacements or upgrades to changing the network layout via a switching program.

If a non-network investment can effectively defer investment in upgrading a network asset, then there is a financial benefit to the network associated with that deferral. The maximum value of such a benefit is calculated using the formula

ADV(Y) = PNI x (WACC +DEPR)

where:

- Y is the year of calculated value
- ADV is the annual deferred value (ADV) in year Y in $/annum
- PNI is the potential network investment being deferred
- WACC is the Weighted Average Cost of Capital (nominal value)
- DEPR is the Depreciation Rate (straight line, average weighed lifespan of 30 years)

It is important to note that network augmentation investments can only be deferred if no substantial financial commitments have been made and solution options are still being examined.

C.2.2 Net Benefit Valuation Guidelines

The Net Benefit Valuation (NBV) Guidelines[29] were published by the ERA in December 2021. The NBV is expected to become a critical factor when assessing if an investment (either network or non-network) has met the Regulatory Test.

[29] New Facility Investment Test and Net Benefits Guideline - Economic Regulation Authority Western Australia (erawa.com.au)

C.3 Network Investments

C.3.1 Committed Investments and Initiatives

Investments are considered committed when in the execution phase. Other criteria for investments to be considered as committed are:

- Ministerial approval (if required)
- Board commitment (if required)
- Western Power funding approval in the form of a business case
- Regulatory Test met (if required)
- For augmentations required to connect a customer, that a customer has unconditionally signed a contract with Western Power (if required)

While investments deemed to be in the planning phase are not normally considered committed, they are assumed to be for the purposes of NOM2022. This is because while those investments do not have full funding approval, options analysis has been completed and a solution for the specific network issue has already been selected. A re-evaluation of additional options would impact the project progress, potentially jeopardising the required in-service date.

Committed transmission network investments above $2 million in capital cost, developed in response to existing or emerging constraints, can be found on the NOM webpage. The list contains a brief description of the investment, its location and network driver, estimated cost (A1 and A2 class) and a required in-service date. Where applicable and available, investment details also provide summary of alternative options that were considered.

Detailed data can be accessed via the Investment Data link on the NOM webpage.

C.3.2 Proposed Investments and Initiatives

For the purposes of NOM2022, a proposed investment is an investment that is either in or preceding the scoping phase at the early stage of inclusion in the investment governance framework. These investments might only have a notional description and value until such time as they are assessed in more detail and potential solutions can be considered.

For proposed network augmentations, investments are associated with an ADV which demonstrates anticipated deferral value should an alternative option be found to be cost-favourable to the anticipated network solution.

The details of network augmentations can be found via the Investment Data link on the NOM webpage.