Network Opportunity Map 2023

NOM 2023

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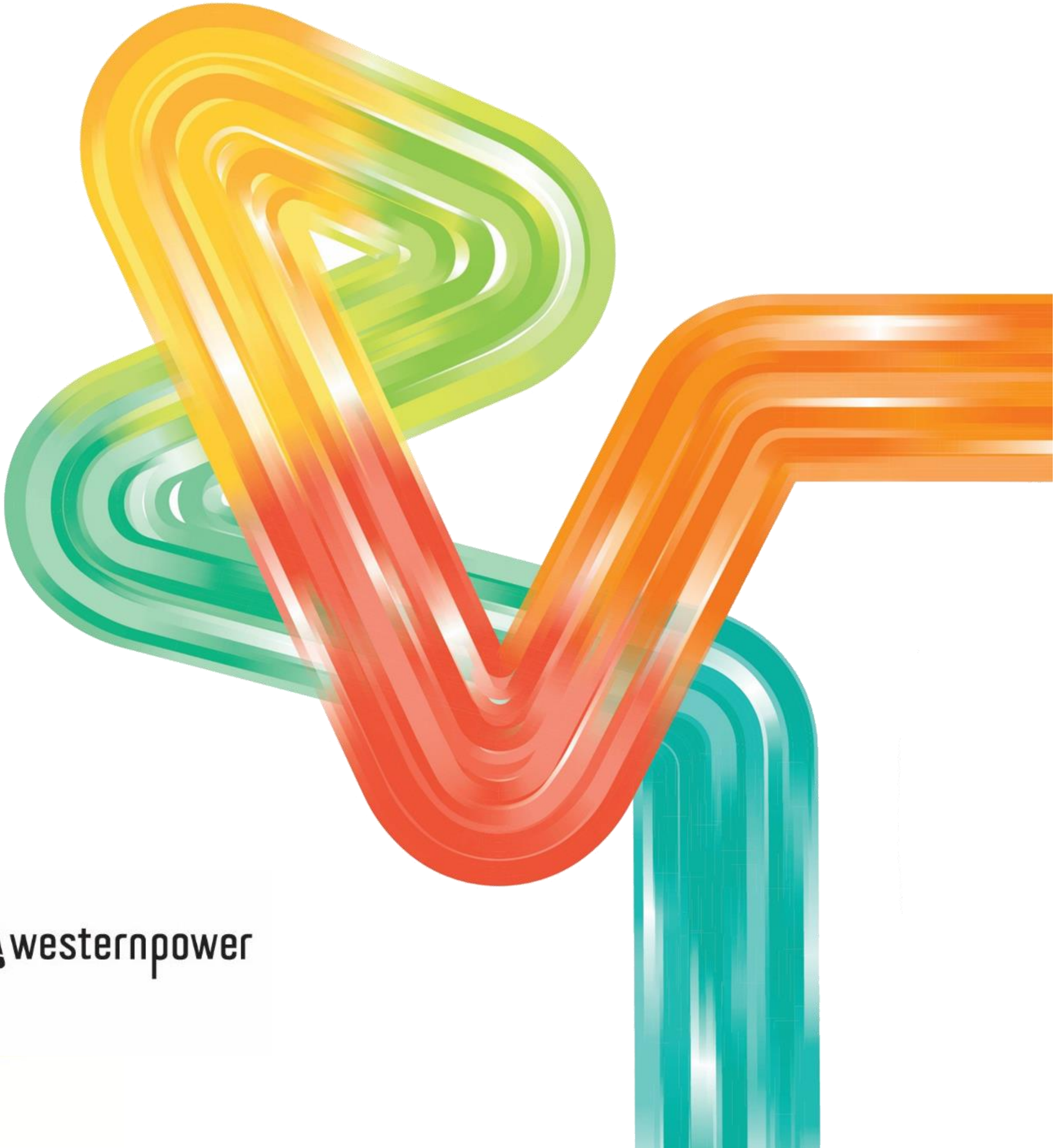

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The information contained in the NOM 2023 is subject to annual review. Western Power is obligated to publish future editions by 1 October each year, in accordance with the *Electricity Network Access Code 2004*.

Contents

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
AOS2023	Alternative Options Strategy 2023
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
MAOSC2023	Model Alternative Option Service Contract 2023
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
NOM2023	Network Opportunity Map 2023 (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
TSP	Transmission System Plan
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 2023 (NOM2023) 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 NOM2023 is published on the Network Opportunity Map webpage (NOM webpage[1]) with the Alternative Options Strategy 2023 (AOS2023), Model Alternative Option Service Contract 2023 (MAOSC2023) 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 NOM2023.

The webpage and associated information, including NOM2023, 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, NOM2023 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.

1 Transmission System Plan & Network Opportunity Map | Renewable Energy | Western Power (westernpower-website-content.azurewebsites.net)

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.

NOM2023 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.

1.1 About Western Power

1.1.1 Our network

Western Power builds, operates and maintains the SWIS transmission and distribution network. The network services an area of 255,064km[2]; it incorporates more than 1.9 GW of rooftop solar (installed at more than 34 per cent of homes and businesses within the SWIS) and supplies approximately 1.2 million connected customers.

[2] As per 7 July 2023

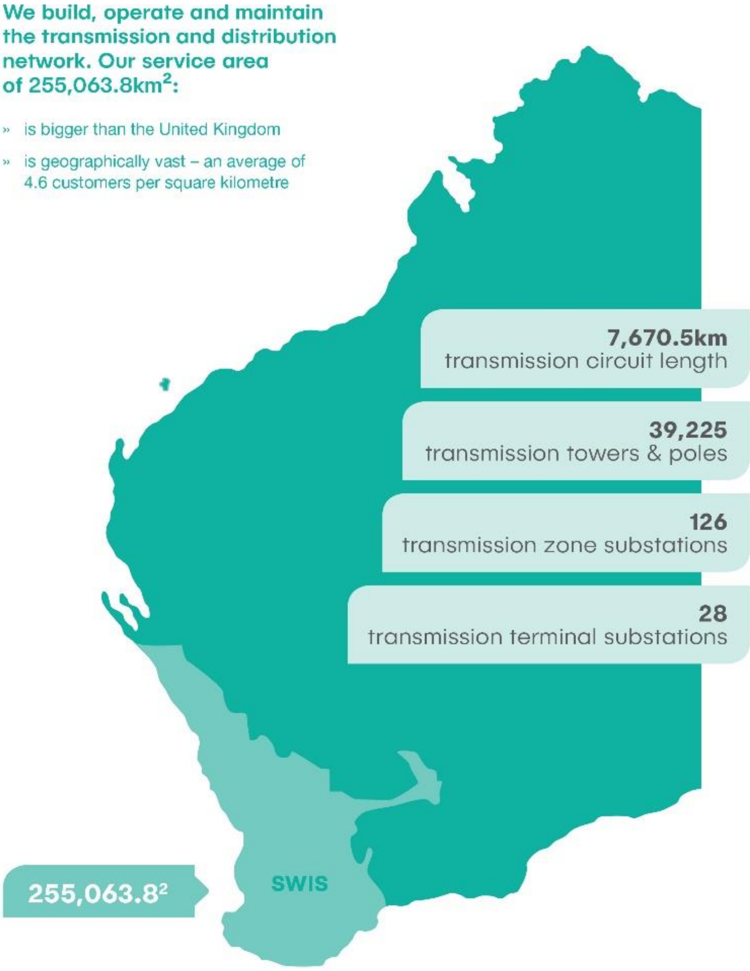

Figure 1.1: Overview of the Western Power Network[2]

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.

Network Metrics 2022/2023

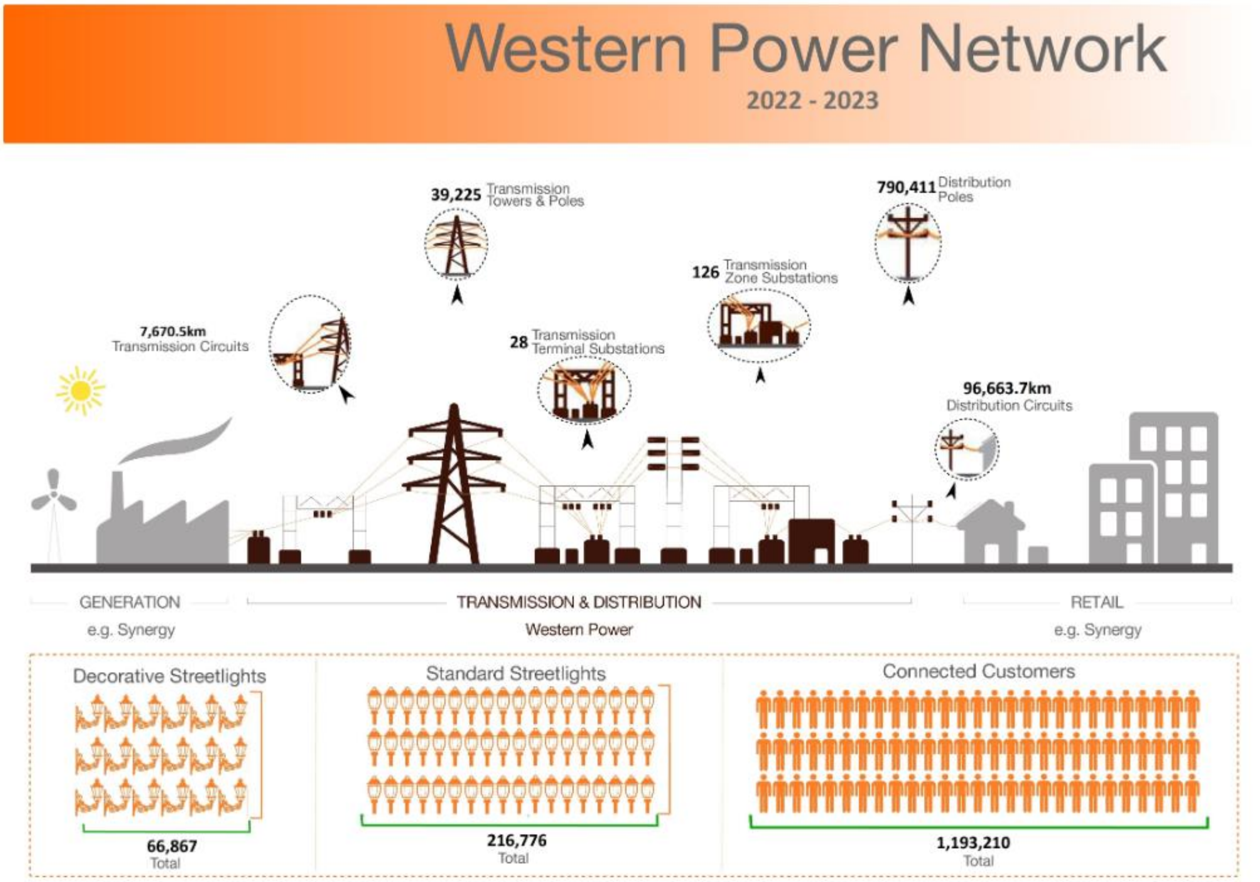

Figure 1.2: Western Power network metrics 2022 to 2023

The network incorporates:

- 13 community power batteries
- More than 11,785 approved battery systems
- More than 1.9 GW of rooftop solar (about 34 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.

The way we produce electricity and use it in our homes and businesses is evolving. We're tapping into more renewables that will help decarbonise our electricity supply, and new power generation and distribution technology is making it easier and more efficient to transport energy over long distances.

1.1.2 Our Corporate Strategy, Vision and Values

Western Power's Corporate Strategy 2023-2031[3] centres on 'working together to power a cleaner energy future'. It recognises WA's accelerated pathway towards decarbonisation and the role the network plays in enabling industry and the community to achieve their decarbonisation goals and our ongoing drive to provide safe, reliable and affordable electricity.

Our strategy encapsulates our commitment to the community. It sets out our priorities that provide the backbone of how we will achieve this.

Western Power remains firmly focused on maintaining and transitioning our existing network to a modular grid to continue delivering reliable power in the face of increasing climate change impacts. This includes continued investment in undergrounding of urban areas, stand-alone power systems (SPS) in some regional areas and creating autonomous networks where it makes sense.

Our strategy recognises the growth in demand for renewables and the need for electrification on a large scale. It will involve a once-in-generation unparalleled growth in our transmission network, and the use of new technologies and processes required to meet the renewable generation powering our community and industrial energy users over the next decade and beyond.

The community remains at the centre of everything we do. As a Government Trading Enterprise, we're owned by the people of Western Australia which means we have a rigorous approach to financial sustainability while delivering the energy needs of the community.

Our strategy lays out our plan to future-proof the network and decarbonisation energy future for the benefit of all Western Australians.

Our Vision

Working together to power a cleaner energy future.

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3 Western Power Corporate Strategy | 2023-2031

Our Values

Our values

Safe and caring

We always work safely because we care
We all take responsibility for protecting our people, our community, and the environment
We assess and manage risk – if it's not safe we don't do it

Results focused

We focus on the end goal
We spend our time and money wisely
We set challenging goals, work hard and hold ourselves accountable to deliver for our customers

Acting with integrity

We exercise good judgment
We do the right thing
We build trusted relationships by being open and honest

Working together

We're one team with a shared purpose
We collaborate with our colleagues, our customers and the community to get the job done
We consider the impact of our work on others

Always improving

We're always looking for ways to be better, no matter how big or small
We innovate to solve problems and seize opportunities
We are resilient and embrace change

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[4].

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

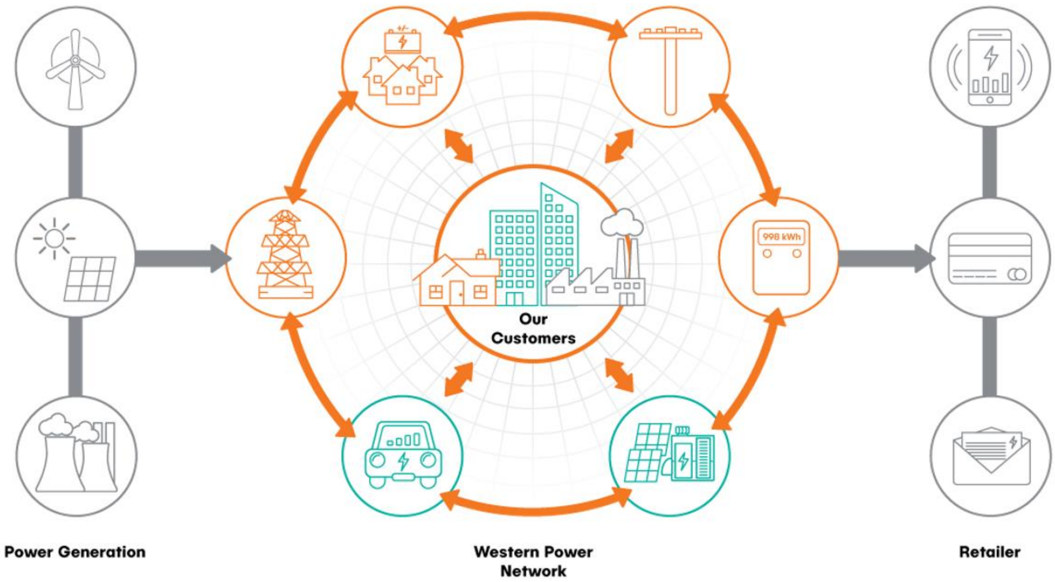

Figure 1.3: Western Power’s role within Western Australia’s electricity market

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[5]. 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 houses all NOM related documentation, data, forms, links and contact details including:

- The current edition of the head document, NOM2023 (this document)
- The current edition of the Transmission System Plan
- The current edition of the AOS2023
- The current edition of the MAOSC2023
- Data sheets supporting the NOM2023
- 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.

[5] Electricity Networks Access Code - Unofficial Consolidated Version (www.wa.gov.au)

Conceptual Constraint Lifecycle

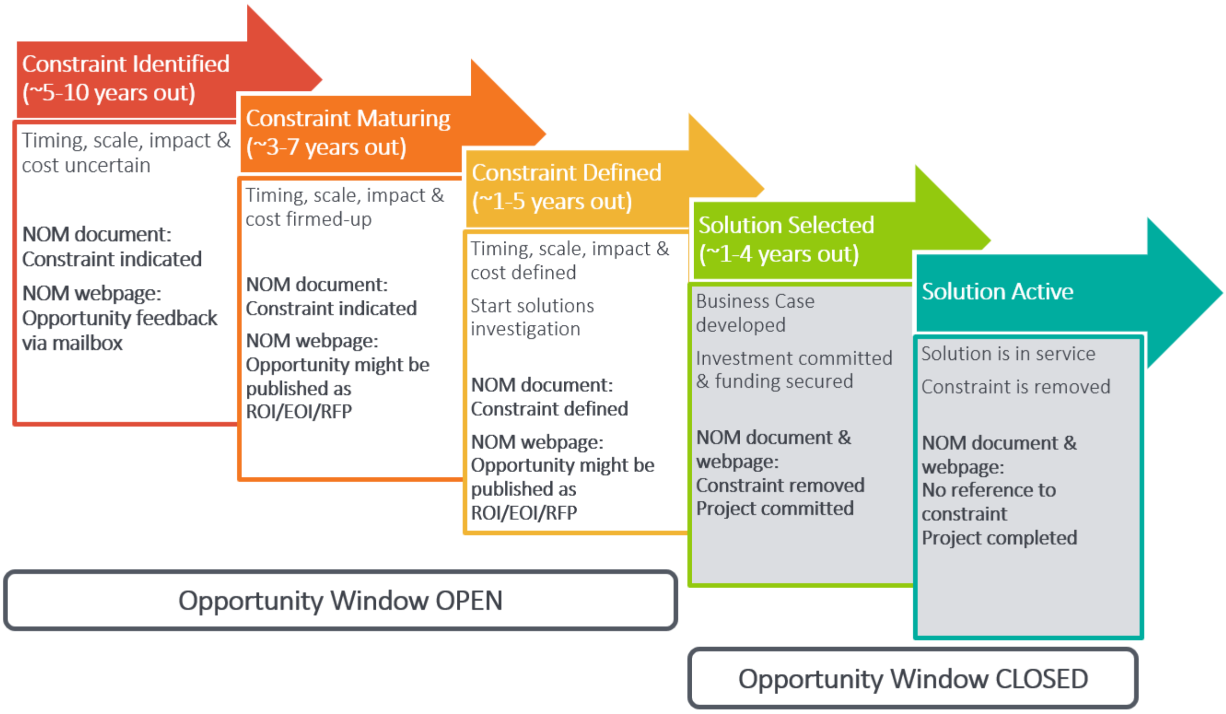

Figure 1.4: Example of a constraint maturation lifecycle

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 may be raised.

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.[6] Western Power is developing business processes to transition to the new procurement process.

Alternative Option Solution Sourcing

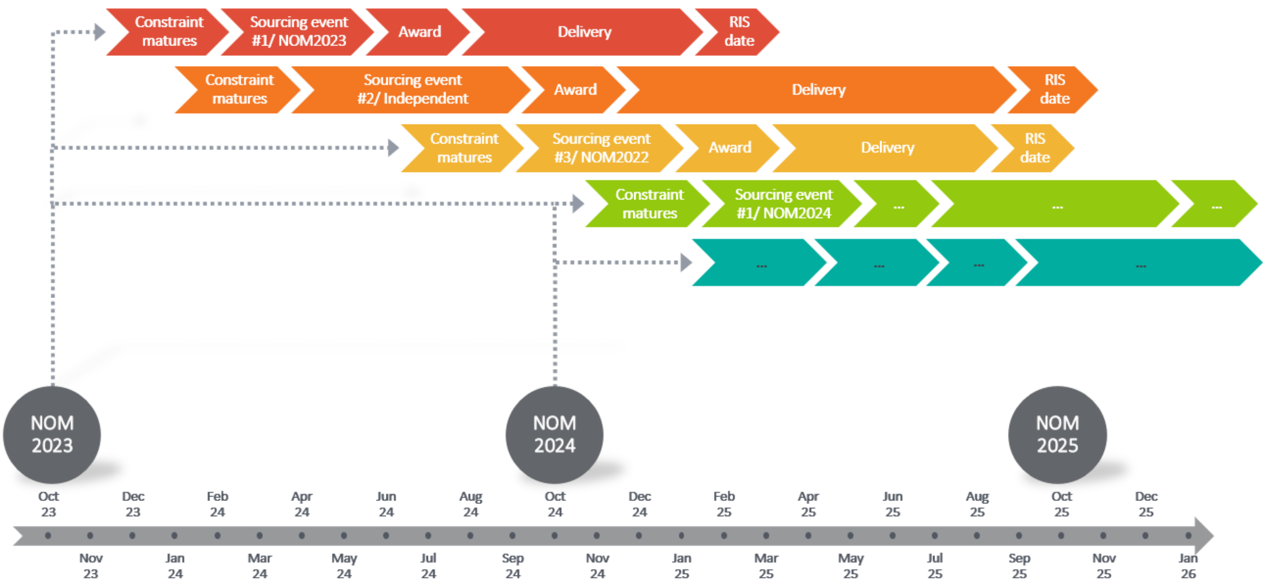

Figure 1.5: Alternative option solution sourcing

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 parties when a new edition of NOM is available or when a new sourcing event is published. At the end of the three-year

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[6] 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.

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).

1.2.5 Non-Network Solutions

At the time of publishing, Western Power has four areas where non-network solutions have been deployed, these being:

- Bremer Bay
- Ravensthorpe
- North Country
- Eastern Goldfields

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 SPS.

Western Power is embracing this changing environment and transforming how we plan, build and operate our network. Customers who are more conscious of their energy source and new technologies 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.

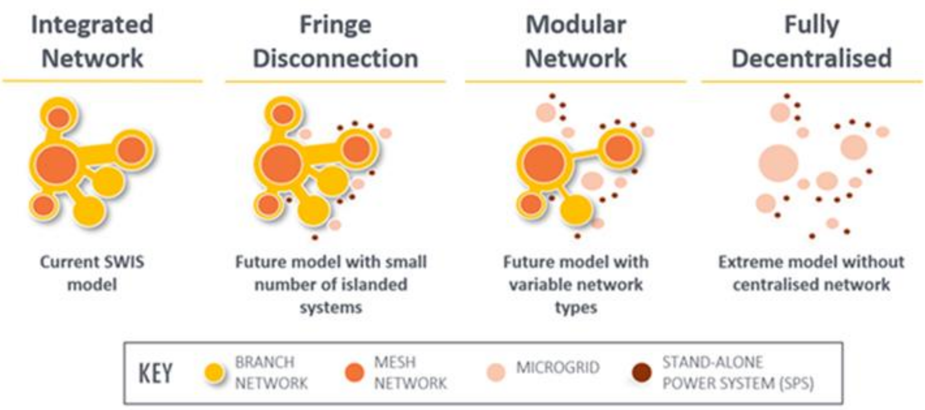


Figure 1.6: Network evolution model

Western Power is innovating with new solutions 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.

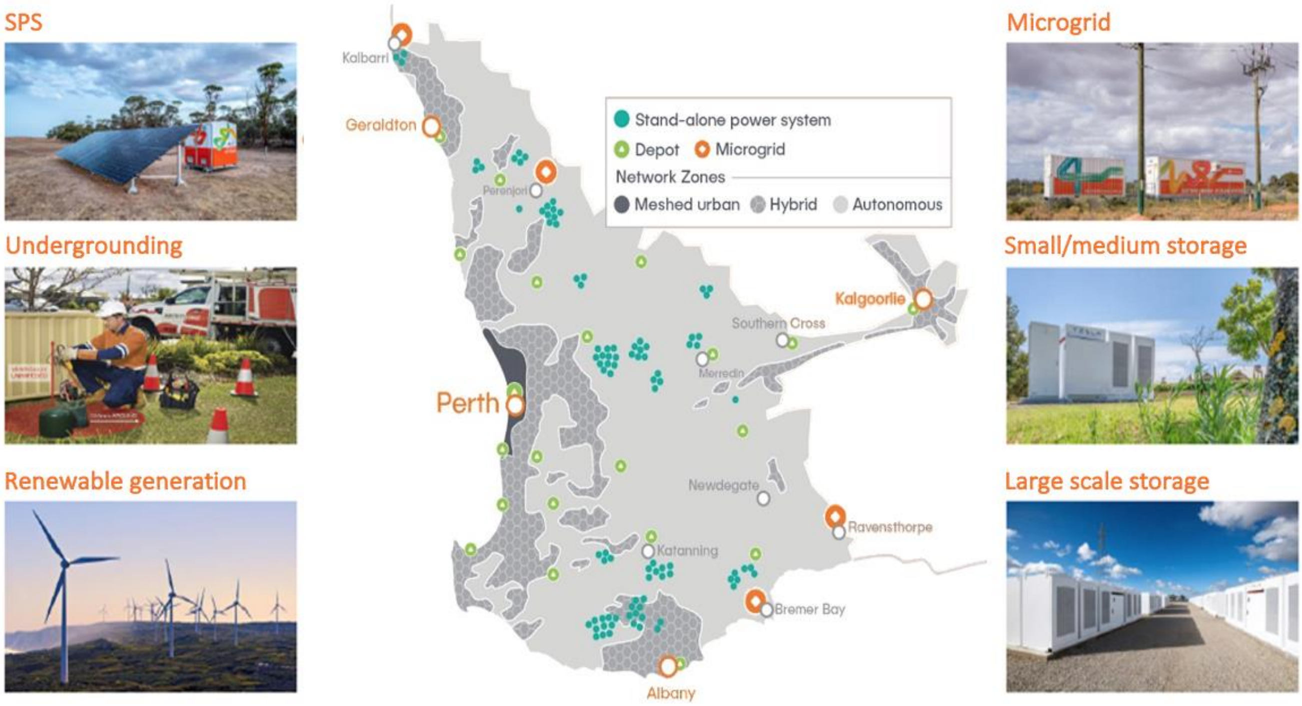


Figure 1.7: Modular grid and main elements of transformation

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 Energy Transformation Strategy (ETS) [7] stage 1 concluded in May 2021 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 the Energy Transformation Taskforce decisions
2. Integrating new technology into the power system
3. Keeping the lights on as the power system transitions
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 patterns and the

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

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

Stand-alone power systems (SPS) are another major emerging technology. These off-grid systems operate independently from the main network and are provided for some rural customers. Each SPS consists of a renewable energy supply such as solar panels, battery energy storage system and a backup generator, making them completely self-sufficient power units.

With 168 SPS units currently installed and 4,000 to be installed by FY 2030, ~13,000 km of overhead lines will be removed. Customers with SPS units have an overall improvement in reliability and 90 per cent of each SPS unit's energy will come from the renewable solar PV system.

1.3.4 Battery Storage

Western Power's PowerBanks are community batteries with the added benefit of virtual solar storage. They allow eligible households access to virtual storage in the battery to store their excess solar power. As of July 2023, there were 13 community batteries (1 x 105 kW capacity, 11 x 116 kW capacity and 1 Behind The Meter (BTM) community battery). Additionally, there were 11,785 approved BTM battery applications with a cumulative storage capacity of 117MWh (95% of which is residential). Battery storage will also have an impact on energy demand forecasting, and scenarios are currently under development for future inclusion in energy demand forecasting.

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. Microgrids can also provide voltage support and frequency support to Western Power's network if required.

Western Power's first reliability microgrid is the installation of a 1MW, 1MWh Battery Energy Storage System (BESS) on the outskirts rural town of Perenjori, north of Perth in 2018. The system 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 second 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 2023/24. 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. More details about the project can be found on the Western Power website's news page.

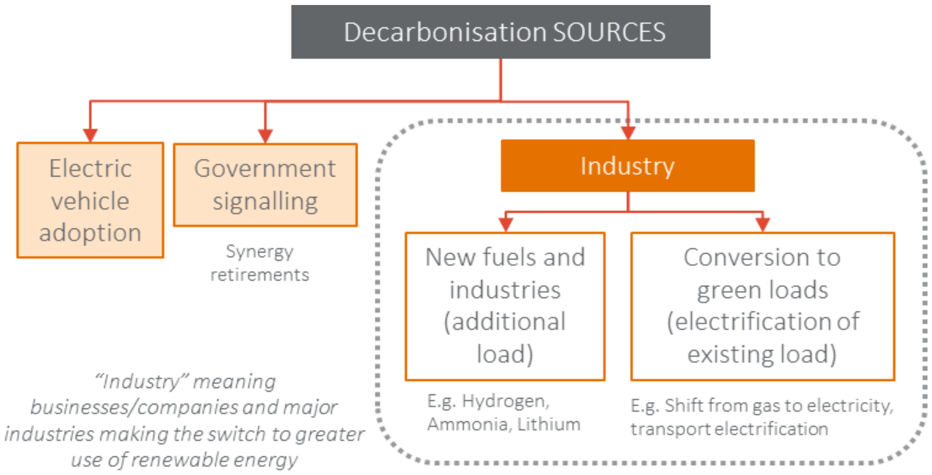
Western Power is also investigating opportunities for small disconnected microgrids for rural towns, similar to the concept of SPS in remote regional locations. Local renewable generation can be utilised to provide a self-sustaining islanded network for towns without reliance on traditional long rural pole and wire assets. It is envisaged that the deployment of many future disconnected microgrids along with SPS would realise the potential of the modular grid in regional areas, providing customer experience benefits in both reliability and power quality.

1.3.6 Electrification/Decarbonisation

Electrification is the shift from non-electric energy sources to electricity at its final point of consumption. It is an emerging trend that is being primarily driven by electric end-use technologies, public interest, and government commitments of net zero by 2050 (globally) and national emission reductions of 43 per cent by 2030[8]. These Government policies 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.



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

Figure 1.8: 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.

1.3.8 Electric Vehicles

There were an estimated 7,046 EVs registered in Western Australia at the end of December 2022, an increase from 4,321 in 2022, making up 0.43 per cent of registered vehicles in Western Australia. The WEM is expected to experience a massive uptake of electric vehicles in the coming decades and under the CSIRO's progressive growth scenario this number would increase to 1.75 million by in 2050, or to 2.6 million in the exploring alternative scenario and 3.6 million in the hydrogen export scenario[9].

1.3.9 Hydrogen

The Western Australian Renewable Hydrogen Strategy[10] sets out ambitious goals to be achieved by 2030 including hydrogen exports, gas pipelines to contain up to 10 per cent renewable hydrogen blend, and renewable hydrogen use in mining haulage vehicles and transportation in regional WA. Western Power continues to receive strong interest in hydrogen facilities, which is anticipated to support decarbonisation and result in large new loads on the SWIS towards the end of the decade.

[9] Source: Graham, P.W. and Havas, L. 2022, Electric vehicle projections 2022, CSIRO, Australia

[10] Western Australian Renewable Hydrogen Strategy and Roadmap (www.wa.gov.au)

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.

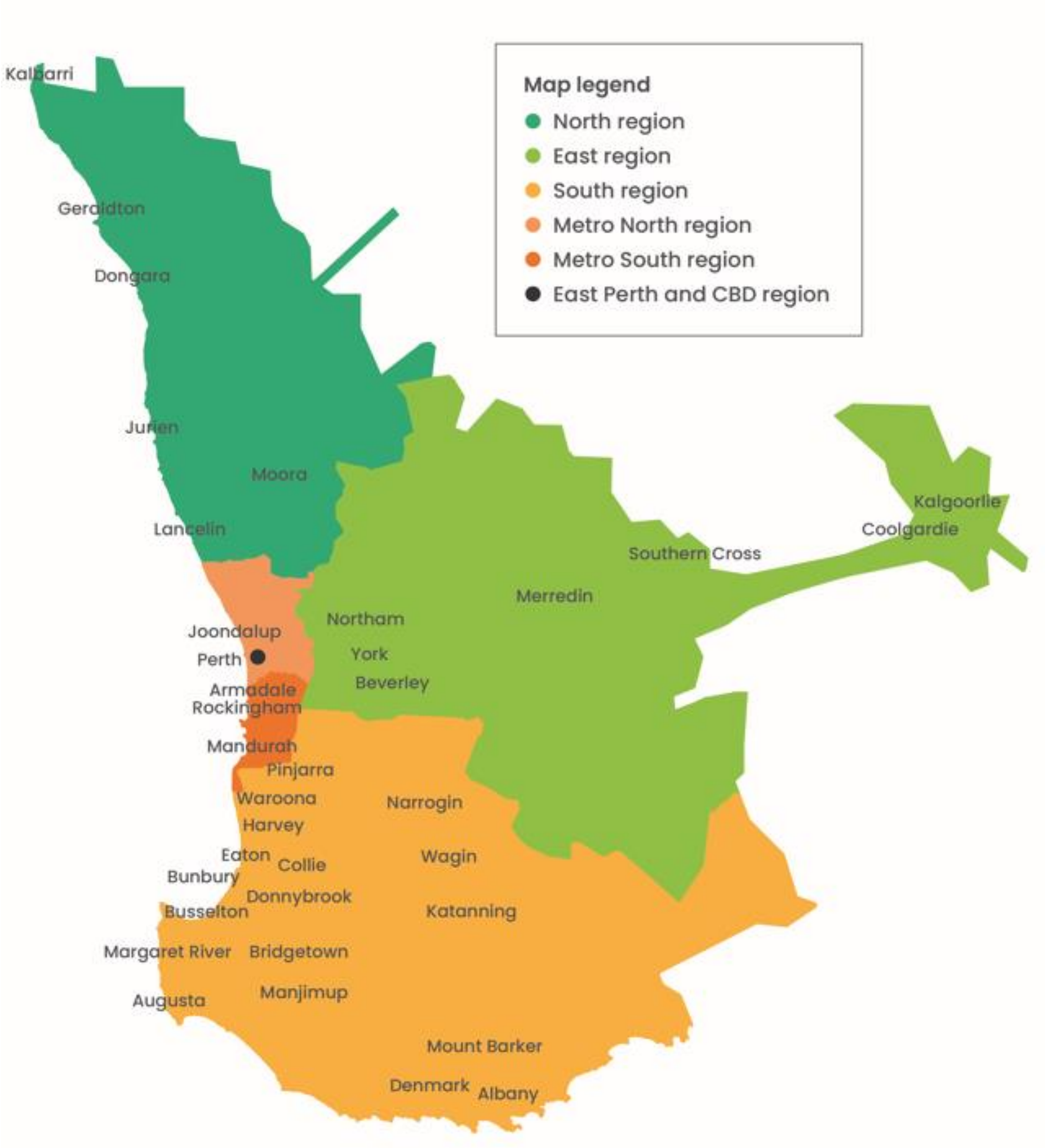


Figure 2.1: Western Power's transmission network regions

2.2 Transmission System Plan

The Transmission System Plan (TSP) is an obligation for Western Power under section 4.5B of the WEM rules and is required to be published annually by 1 October.

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 TSP 2023 covers the 2022/23 to 2032/33 planning horizon to enable alignment with Western Power's latest demand forecast[11] outlook and maintain continuity with existing network planning activities.

2.3 Interaction between the TSP and NOM

The NOM is a regulatory requirement for Western Power outlined in chapter 6A of the Access Code, published together annually with the TSP on an annual basis on or before 1 October[23].

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.

A network opportunity is the presentation of opportunities to providers of potential alternative options (all customers, industry, and market participants) to address transmission and distribution system constraints by providing alternative options to network augmentation.

This year's network opportunities 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. In addition, Western Power has decided to present 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 in planning within the 10-year TSP timescale[12].

2.4 Zone Substation Loading - Historical and Forecast Performance

Information related to the Zone Substation Loading for the period 2022/23 to 2032/33 is available in Sections 10 - 15 of the Transmission System Plan[13].

2.5 Transmission Network Opportunities

Information related to transmission network opportunities is available in Sections 10 - 15 of the Transmission System Plan[13].

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11 Current demand forecasts were produced in 2023, looking forward from the period 2022/23 to 2032/33

12 Where Western Power decides to procure a service in response to a network opportunity, the NCESS framework as outlined in sections 3.11A and 3.11B will apply.

13 https://westernpower-website-content.azurewebsites.net/suppliers/tenders-and-registrations-of-interest/transmission-system-plan-network-opportunity-map/

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[14] (MV) and those below 1 kV as low voltage (LV). A distribution transformer is the voltage step down interface between the MV and LV network. 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.

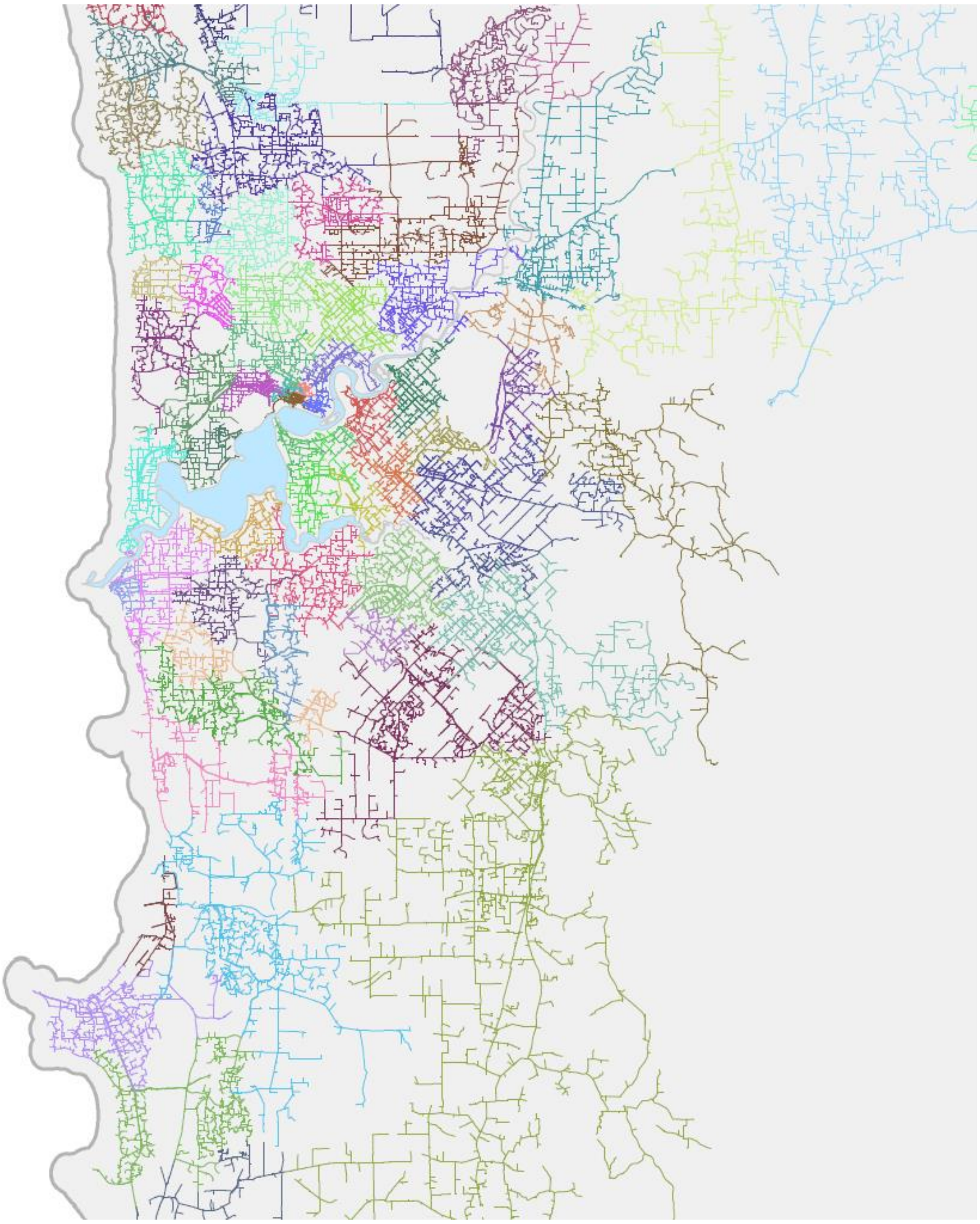

Figure 3.1: A section of Western Power's MV distribution network in the Perth metro area

14 May also be referred to as HV distribution voltage

3.1 Challenges

The recent summer 2022/23 was much milder than the previous summer 2021/22, when an unexpected heatwave in Perth resulted in four consecutive days of 40°C or more over the Christmas period. In conjunction with accelerated network upgrade deployments triggered by summer 2021/22 heatwaves, less pressure on LV and MV networks was experienced during summer 2022/23.

To minimise network risk from high demand days, Western Power continues to expedite high priority capacity works to meet the oncoming summer's projected demand for summer 2023/24 and summer 2024/25 the year after.

Projected overutilisation compared to target planning limits on MV and LV networks in future years will be expected, with some of these being indicated as potential future opportunities in Section 3.4 for providing alterative solutions, as it is foreseen that the impact of climate change driven heatwaves and decarbonisation will continue to drive higher maximum demand and require future capacity mitigation.

In addition, the advance of new technologies creates opportunities against 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. The five strategies described here have very strong relationships between each other and have been the strategic cornerstone for some time.

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[15]. 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

[15] Approved Technical Rules - Economic Regulation Authority Western Australia (erawa.com.au)

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.

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 is 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

There are two distribution feeder types based on the voltage level:

- MV feeder, or
- LV feeder.

The distribution transformer (DSTR) is the voltage step down interface between the MV and LV network and is considered the beginning and part of the LV feeder.

Target MV feeder loading levels are dependent on the type of load being supplied, and the number of interconnections with contiguous MV feeders. Higher MV 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, MV feeder loading can have a significant impact on both MV feeder utilisation and reliability.

MV feeder load fluctuates throughout the day, becoming more apparent during cloudy days as customer 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.

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

The LV network is typically constrained by the distribution transformer, interfacing between the MV feeder and LV feeder. The main difference between the MV feeders and LV feeders is that LV feeders are more radial in topology and have less interconnections, as there are less contiguous LV feeders and a LV feeder supplies significantly less number of customers being the final point of connection.

An MV feeder will supply a numerous amount of LV feeders, and as the MV feeder supplies the LV feeder during maximum peak, the above mentioned MV feeder characteristics are in fact the same and triggered by customers on the LV feeder. Any difference in demand characteristic between the many LV feeders that are supplied by the MV feeder is known as customer's demand diversity.

Some data on selected 200 distribution transformer performance is available in the Network Data link on the NOM webpage, under Distribution Transformer Opportunities.

Feeder Loading Investment Triggers

When considering investments to address high MV feeder loading, a balance is sought to ensure Western Power doesn't over invest in the grid based on projections of maximum MV feeder loadings, as it is unlikely that a fault will occur at the precise peak load time for that MV feeder. Traditional network augmentation that increases MV feeder capacity results in lower MV 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 MV 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 MV network to balance overall MV feeder utilisation in an area.

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

Western Power is currently monitoring high MV feeder loads on MV 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. The top half of Table 3.1 summarises triggers for MV feeder loading investments, the impact of not addressing risks, and an example of how Western Power would traditionally proceed to manage network capacity 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 maximum 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 MV conductor sag etc).	• Installation of new MV feeders or feeder interconnections • Transfer of load to contiguous underutilised MV networks • Conversion of existing overhead MV conductor to higher thermal capacity underground cable.
Feeder Loading (LV Network Thermal Overload)	LV network capacity rating exceeded due to load growth (from new or increased demand)	Typically, during maximum peak load (5-8pm). Seasonal variation depending on location (Winter / Summer peak).	• Equipment failure and loss of customer supply • Accelerated asset aging and increased maintenance costs • Increased safety risk due to clearance issues (excessive overhead LV conductor sag etc).	• Installation of new or higher rated distribution transformer • Transfer of load to contiguous underutilised LV networks • Conversion of existing overhead LV conductor to higher thermal capacity underground cable

When considering investments to address high LV feeder loading, a deterministic approach is taken because if the equipment fails there are generally no alternative supply paths from the radial and reduced interconnection topology of the LV network compared to the MV network. LV switching is generally the only alternative and typically already has been applied to optimise the LV configuration before triggering network investment of upgrading or installing a new distribution transformer. The bottom half of Table 3.1 summarises triggers for LV feeder loading investments, the impact of not addressing risks and an example of how Western Power would traditionally proceed to manage network capacity risk.

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 the SSB, applied from the Service Standard Adjustment Mechanism (SSAM). For more information, refer to the latest version of the AA[16].

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)[17] 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 have been finalised by the ERA and shown in the following table.

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

17 Approved-Access-Arrangement.PDF (erawa.com.au)

Table 3.3: Minimum reliability performance

Measure	Feeder category	Current SSB FY2023-24
SAIDI	CBD	13.7
	Urban	123.8
	Rural Short	202.5
	Rural Long	290.0
SAIFI	CBD	0.21
	Urban	1.25
	Rural Short	2.09
	Rural Long	4.45

Due to the averaging 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 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 major change in network topology is justified 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 MV Feeder Loading

Western Power assesses zone substation MV feeder utilisation across our network annually. In the previous years' NOM 2022, the five priority locations identified to have projected future MV feeder over-utilisation and network risk were the Southern River (SNR), Clarkson (CKN), Meadow Springs (MSS), Yanchep (YP) and Byford (BYF) zone substations. After the summer 2021/22 heat wave, and publishing of NOM 2022, several MV feeders at Beechboro (BCH) and Mandurah (MH) were reviewed and identified as opportunities with similar priority[18] to the forementioned five zone substation.

The refreshed NOM 2023 MV feeder opportunities table identifies these seven zone substation's MV feeders as 'Projects In Progress' in the 'Prioritisation' column although also indicating a 5-year projected utilisation still as 'High Utilisation' for some of those zone substation's MV feeders. It is envisaged that the projects currently in progress will balance and reduce all MV feeder utilisation of the forementioned seven zone substations to 'Target Utilisation' levels after the planned completion date which is before summer 2024/25.

The resulting projected MV feeder utilisation levels can only be reflected in the table upon project completion. When the projects become operational, the realisation of feeder utilisation performance benefits may result in future opportunities to further reduce projected MV feeder utilisation levels on the same MV feeders. This is more likely to occur if maximum demand increases faster than forecast.

As mentioned in section 3.1, this years' summer 2022/23 peak demand was generally lower than the previous summer, resulting in temperature correcting the recent summer's 2022/23 peaks to adjust the

[18] Beechboro (BCH) zone substation had been identified in NOM 2021

projections for MV feeder utilisation prior to including a factor for potential future EV impact to maximum demand. After assessing the latest available forecasts against the target planning utilisation limits, the following ten zone substations were identified as areas of opportunity:

1. Waikiki (WAI)
2. Henley Brook (HBK)
3. Hadfields (H)
4. Padbury (PBY)
5. Yokine (Y)
6. Gosnells (G)
7. Medina (MED)
8. Muchea (MUC)
9. Welshpool (WE)
10. Bibra Lake (BIB)

After assessing the network risk, the projected over-utilised MV feeders will trigger a network investigation to identify the best way to manage any overutilisation issue, concluding with the outline of the required 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 MV feeders identified in Table 3.5 are typical of highly utilised Western Power MV 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.

Table 3.5 indicates the projected MV 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.

Table 3.5: Anticipated distribution MV feeder utilisation

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

Strong Candidate: Highest priority feeders requiring over-utilisation mitigation.

Good Candidate: Secondary priority feeder requiring over-utilisation mitigation.

ZSS (Zone Substation)	MV Feeder	Summer '27-28 Projected Utilisation (with EV projection)[19]	Existing Customer Segment: Residential (%)	Existing Customer Segment: Small Commercial (%)	Existing Customer Segment: Large Commercial (%)	Existing Customer Segment: Large Distribution Generator (Y/N)	Embedded PV (kVA) Existing approx.	Prioritisation	Indicative Future Peak Demand Shortfall '27/28 (kVA)
BIB	BIB 504	High	93%	6%	0%	-	3,737	GOOD CANDIDATE	5,748
BIB	BIB 505	High	90%	10%	0%	-	4,275	GOOD CANDIDATE	473
BIB	BIB 507	High	97%	3%	0%	-	5,759	GOOD CANDIDATE	1,208
BIB	BIB 508	Target	0%	98%	2%	-	901		
BIB	BIB 536	Target	87%	12%	0%	-	2,606		
BIB	BIB 537	Low	54%	46%	0%	-	1,218		
BIB	BIB 539	High	91%	9%	0%	-	6,677	GOOD CANDIDATE	4,258
BIB	BIB 540	Target	97%	3%	1%	-	2,931		
G	G 502	Target	87%	12%	1%	-	2,343		
G	G 504	High	90%	9%	0%	-	4,459	STRONG CANDIDATE	535
G	G 506	High	98%	2%	0%	-	6,585	STRONG CANDIDATE	1,441
G	G 508	Target	93%	7%	0%	-	2,687		
G	G 514	High	97%	3%	0%	-	6,561	STRONG CANDIDATE	1,807
G	G 515	High	93%	6%	0%	-	6,331	STRONG CANDIDATE	1,327
G	G 518	High	97%	3%	0%	-	4,356	STRONG CANDIDATE	4,053
G	G 520	Target	85%	15%	0%	-	1,502		

[19] Projected utilisation prior to investment.

			Existing Customer Segment						
ZSS (Zone Substation)	**MV Feeder**	**Summer '27-28** Projected Utilisation (with EV projection)[19]	**Residential (%)**	**Small Commercial (%)**	**Large Commercial (%)**	**Large Distribution Generator (Y/N)**	**Embedded PV (kVA)** Existing approx.	**Prioritisation**	**Indicative Future Peak Demand Shortfall '27/28 (kVA)**
G	G 522		95%	5%	0%	-	2,872		
H	H 502		96%	3%	0%	-	4,014	STRONG CANDIDATE	2,016
H	H 504		1%	94%	5%	-	927	STRONG CANDIDATE	1,427
H	H 508		91%	9%	0%	-	3,961	STRONG CANDIDATE	4,468
H	H 510		5%	86%	10%	-	148		
H	H 511		81%	19%	0%	-	4,941	STRONG CANDIDATE	1,834
H	H 514		93%	7%	0%	-	4,522	STRONG CANDIDATE	2,438
H	H 516		14%	85%	1%	-	482		
H	H 517		85%	14%	1%	-	2,368		
HBK	HBK 504		96%	4%	0%	-	6,924	STRONG CANDIDATE	1,329
HBK	HBK 505R		97%	3%	0%	-	6,307	STRONG CANDIDATE	3,149
HBK	HBK 507		92%	8%	0%	-	5,226	STRONG CANDIDATE	3,001
HBK	HBK 508		98%	2%	0%	-	5,909	STRONG CANDIDATE	1,674
HBK	HBK 536		99%	1%	0%	-	6,176	STRONG CANDIDATE	1,558
HBK	HBK 537		98%	2%	0%	-	4,772	STRONG CANDIDATE	936
HBK	HBK 539F		96%	4%	0%	-	6,247		
HBK	HBK 539R		89%	11%	1%	-	1,346		
MED	MED 504		0%	95%	5%	-	549		
MED	MED 507		93%	6%	0%	-	7,496	GOOD CANDIDATE	6,644
MED	MED 508		95%	5%	0%	-	1,481		
MED	MED 511		96%	3%	0%	-	5,157	GOOD CANDIDATE	2,850
MED	MED 513		98%	2%	0%	-	5,059	GOOD CANDIDATE	375
MED	MED 517		0%	100%	0%	-	187		
MED	MED 522		86%	14%	0%	-	2,383		
MED	MED 524		96%	4%	0%	-	8,223	GOOD CANDIDATE	3,549

ZSS (Zone Substation)	MV Feeder	Summer '27-28 Projected Utilisation (with EV projection)[19]	Existing Customer Segment				Embedded PV (kVA) Existing approx.	Prioritisation	Indicative Future Peak Demand Shortfall '27/28 (kVA)
			Residential (%)	Small Commercial (%)	Large Commercial (%)	Large Distribution Generator (Y/N)			
MED	MED 526		95%	5%	0%	-	7,968	GOOD CANDIDATE	6,629
MUC	MUC 505		84%	15%	1%	-	2,691	GOOD CANDIDATE	1,953
MUC	MUC 510		84%	16%	0%	-	7,543	GOOD CANDIDATE	1,322
MUC	MUC 511		35%	50%	15%	-	3		
MUC	MUC 536		88%	12%	0%	-	4,894	GOOD CANDIDATE	864
MUC	MUC 537		67%	32%	1%	-	2,177		
PBY	PBY 504		97%	3%	0%	-	4,051		
PBY	PBY 507		97%	3%	0%	-	5,941	STRONG CANDIDATE	80
PBY	PBY 508		98%	2%	0%	-	4,745	STRONG CANDIDATE	1,171
PBY	PBY 516		96%	4%	0%	-	4,366	STRONG CANDIDATE	1,257
PBY	PBY 526		96%	3%	0%	-	5,739	STRONG CANDIDATE	1,548
PBY	PBY 536		98%	2%	0%	-	4,030		
PBY	PBY 537		94%	6%	0%	-	5,828	STRONG CANDIDATE	1,570
PBY	PBY 540		97%	3%	0%	-	4,028		
WAI	WAI 504		98%	2%	0%	-	5,531	STRONG CANDIDATE	5,113
WAI	WAI 505		84%	16%	0%	-	6,366	STRONG CANDIDATE	2,770
WAI	WAI 507		98%	2%	0%	-	8,978	STRONG CANDIDATE	7,550
WAI	WAI 516		97%	2%	0%	-	6,581	STRONG CANDIDATE	944
WAI	WAI 526		98%	2%	0%	-	9,396	STRONG CANDIDATE	2,807
WAI	WAI 527		98%	2%	0%	-	7,211	STRONG CANDIDATE	3,809
WAI	WAI 536		96%	4%	1%	-	2,998		
WAI	WAI 539F		93%	6%	0%	-	4,017	STRONG CANDIDATE	1,524
WAI	WAI 540		96%	3%	0%	-	5,303	STRONG CANDIDATE	1,162
WE	WE 504		97%	3%	0%	-	6,396	GOOD CANDIDATE	1,357
WE	WE 505		86%	13%	1%	-	3,130		

ZSS (Zone Substation)	MV Feeder	Summer '27-28 Projected Utilisation (with EV projection)[19]	Existing Customer Segment				Embedded PV (kVA) Existing approx.	Prioritisation	Indicative Future Peak Demand Shortfall '27/28 (kVA)
			Residential (%)	Small Commercial (%)	Large Commercial (%)	Large Distribution Generator (Y/N)			
WE	WE 508		0%	95%	5%	-	773	GOOD CANDIDATE	843
WE	WE 510		85%	15%	0%	-	1,495		
WE	WE 511		40%	59%	2%	-	1,294	GOOD CANDIDATE	1,986
WE	WE 514		0%	97%	3%	-	103		
WE	WE 519		95%	5%	0%	-	7,276	GOOD CANDIDATE	4,808
WE	WE 523		79%	21%	1%	-	2,485		
WE	WE 524		91%	9%	0%	-	2,344	GOOD CANDIDATE	555
WE	WE 525		0%	98%	2%	-	397		
Y	Y 316F		92%	8%	0%	-	1,561	STRONG CANDIDATE	3,016
Y	Y 316R		93%	7%	0%	-	951	STRONG CANDIDATE	503
Y	Y 317F		79%	21%	1%	-	718	STRONG CANDIDATE	1,080
Y	Y 317R		91%	9%	0%	-	-		
Y	Y 326F		89%	11%	0%	-	1,276	STRONG CANDIDATE	1,190
Y	Y 327F		96%	4%	0%	-	2,166	STRONG CANDIDATE	554
Y	Y 327R		89%	11%	0%	-	1,536		
Y	Y 343F		95%	5%	0%	-	2,830	STRONG CANDIDATE	2,435
Y	Y 343R		91%	9%	0%	-	501		
Y	Y 344R		96%	4%	0%	-	2,036		
Y	Y 345R		94%	6%	0%	-	1,858	STRONG CANDIDATE	428
Y	Y 347R		93%	6%	0%	-	1,391		
Y	Y 348R		95%	5%	0%	-	1,595	STRONG CANDIDATE	192

The following maps from Figure 3.2 to 3.11 show the location of high utilisation feeders for the ten zone substations listed above.

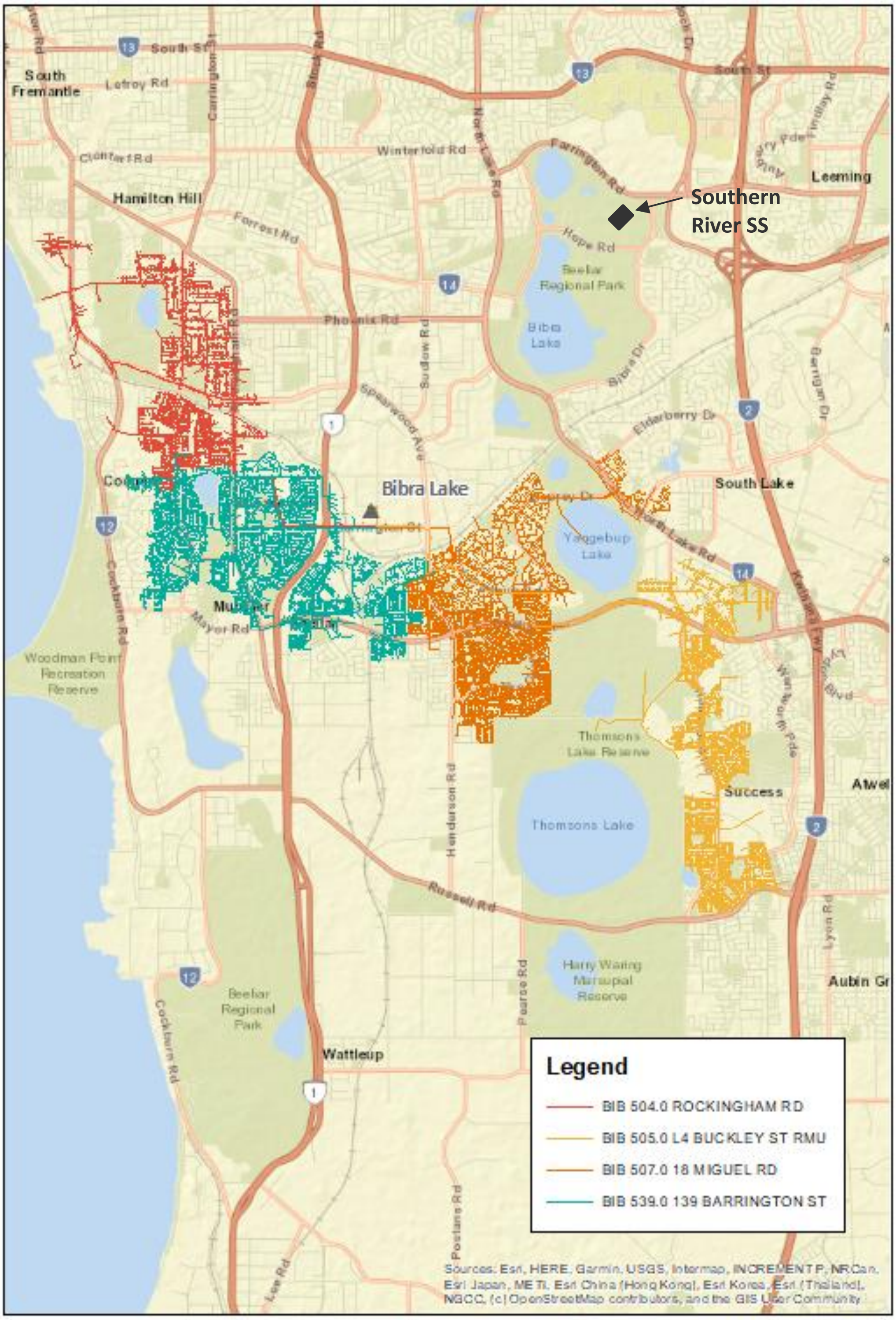

Figure 3.2: Geographical distribution of Bibra Lake high utilisation feeders (BIB 504, BIB 505, BIB 507 and BIB 539)

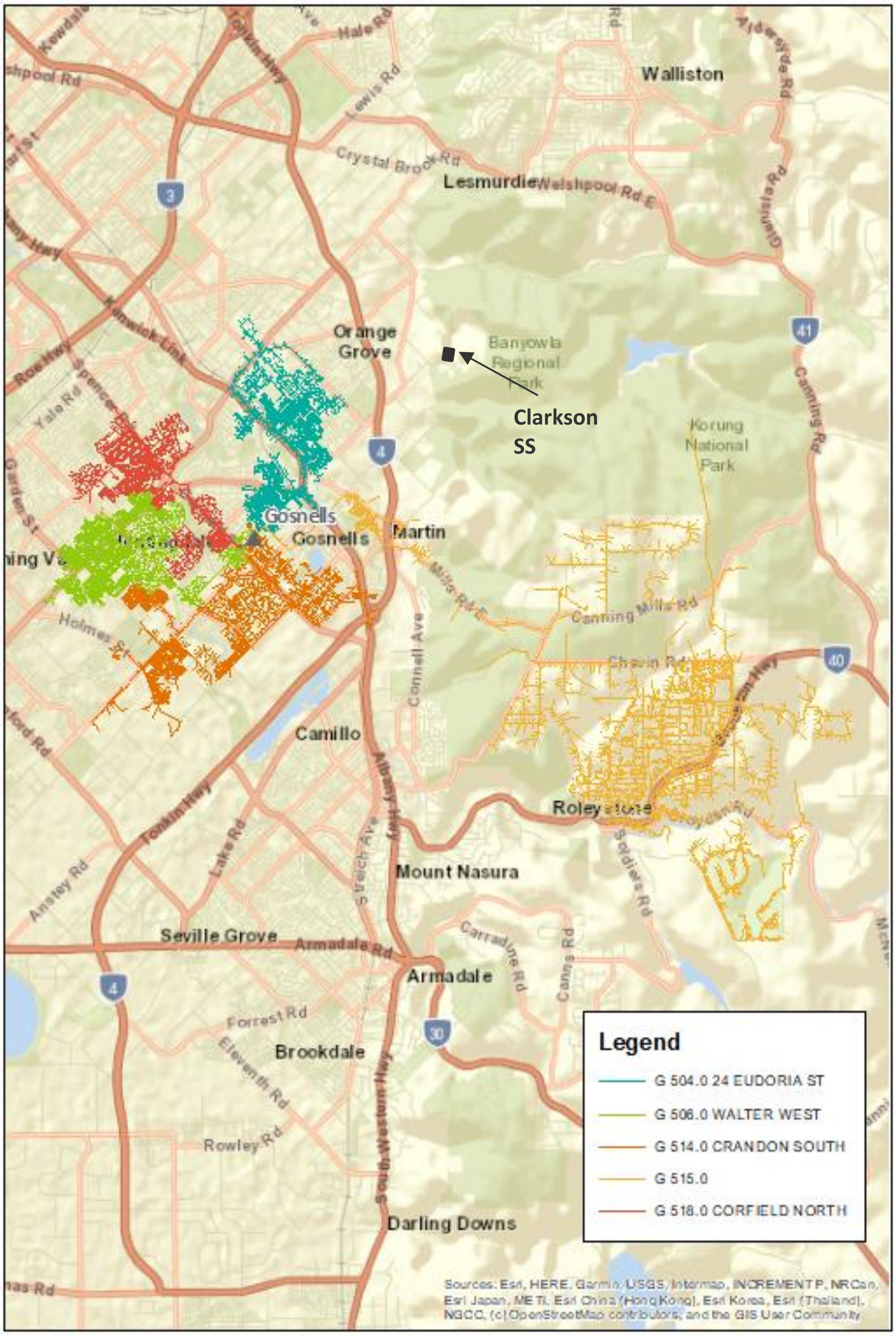

Figure 3.3: Geographical distribution of Gosnells high utilisation feeders (G 504, G 506, G 514, G 515 and G 518)

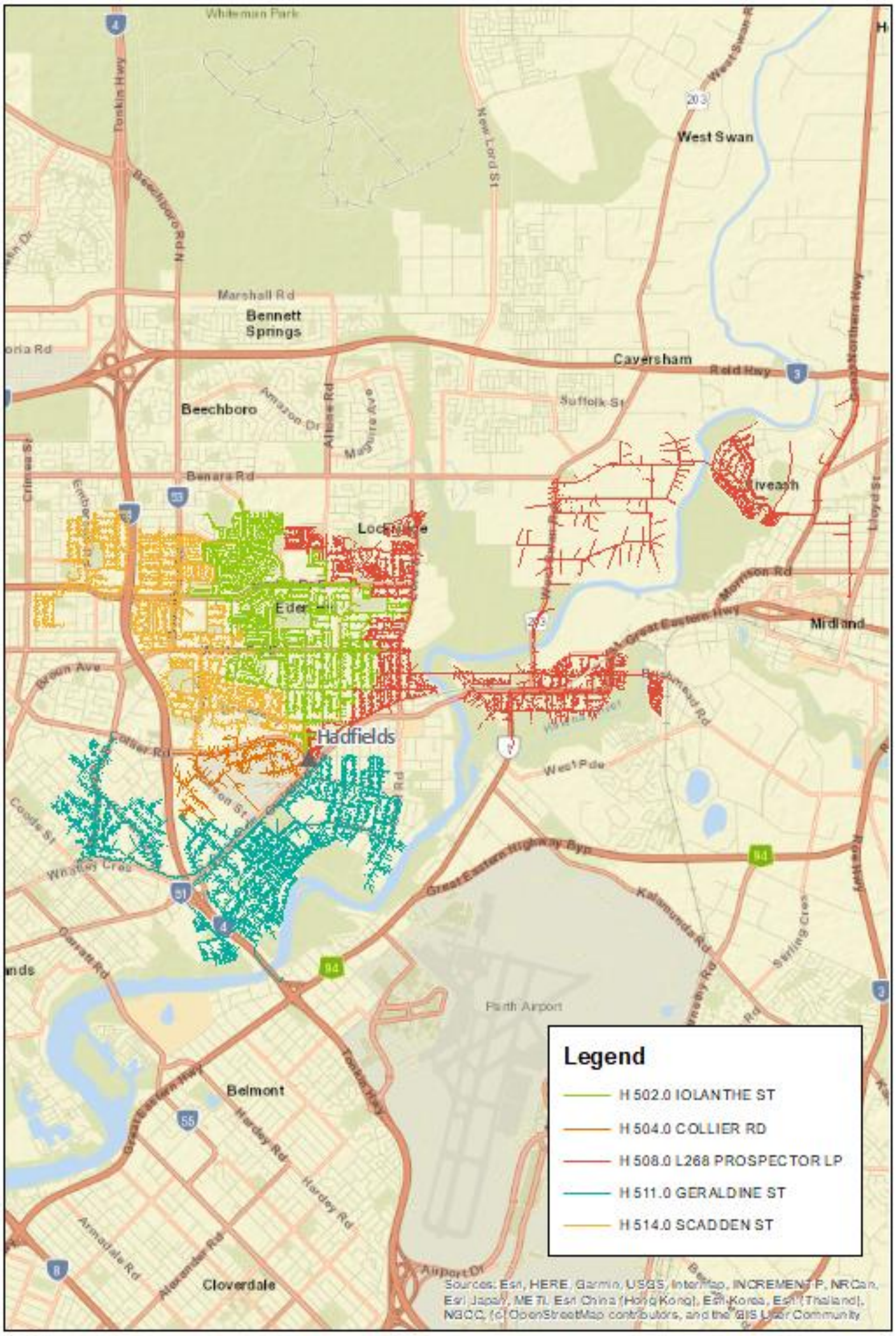

Figure 3.4: Geographical distribution of Hadfields high utilisation feeders (H 502, H 504, H 508, H 511 and H 514)

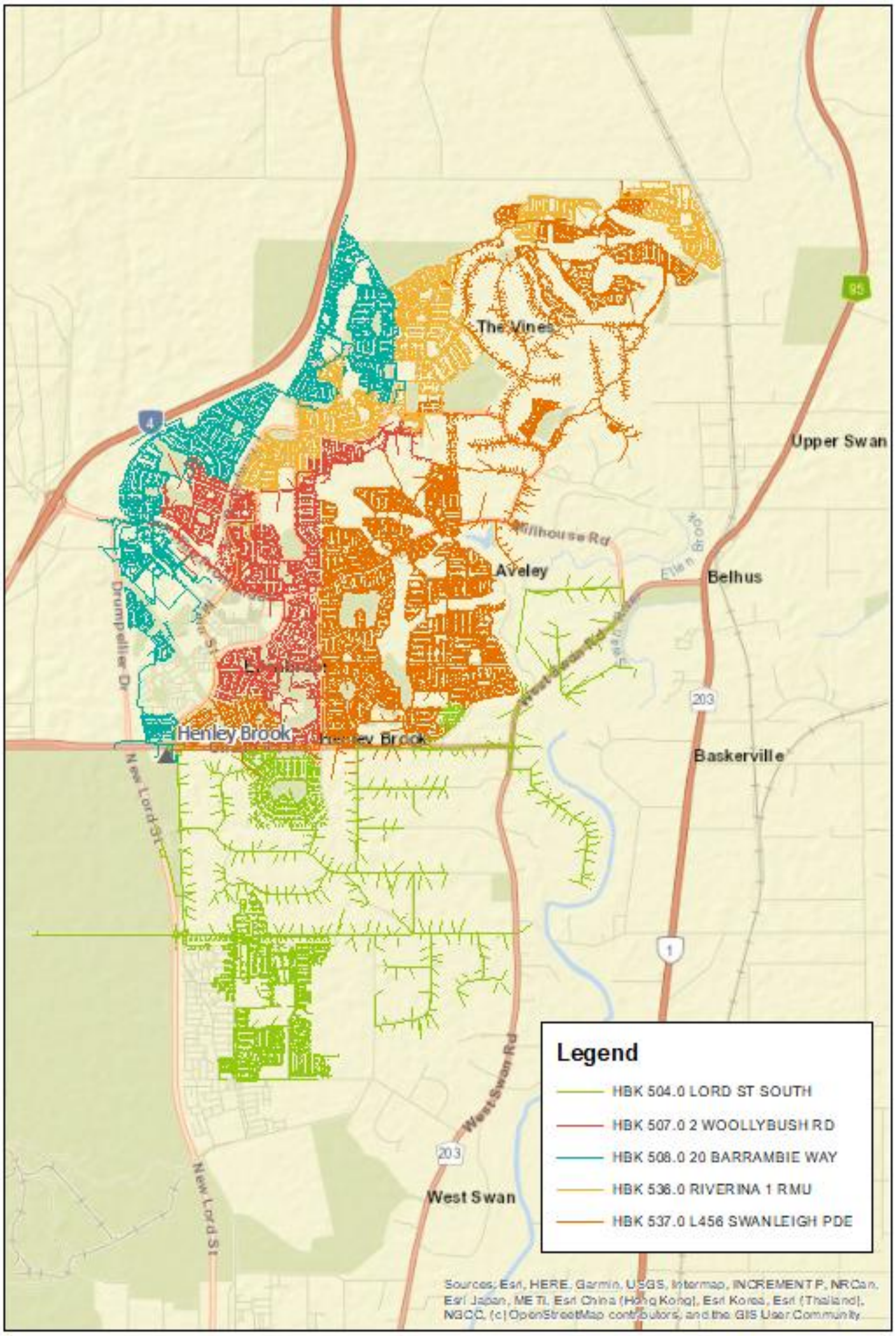

Figure 3.5: Geographical distribution of Henley Brook high utilisation feeders (HBK 504, HBK 505R[20], HBK 507, HBK 508, HBK 536 and HBK 537)

[20] At time of publication, HBK feeder catchment representation impacted as network data for HBK 505R unavailable for mapping.

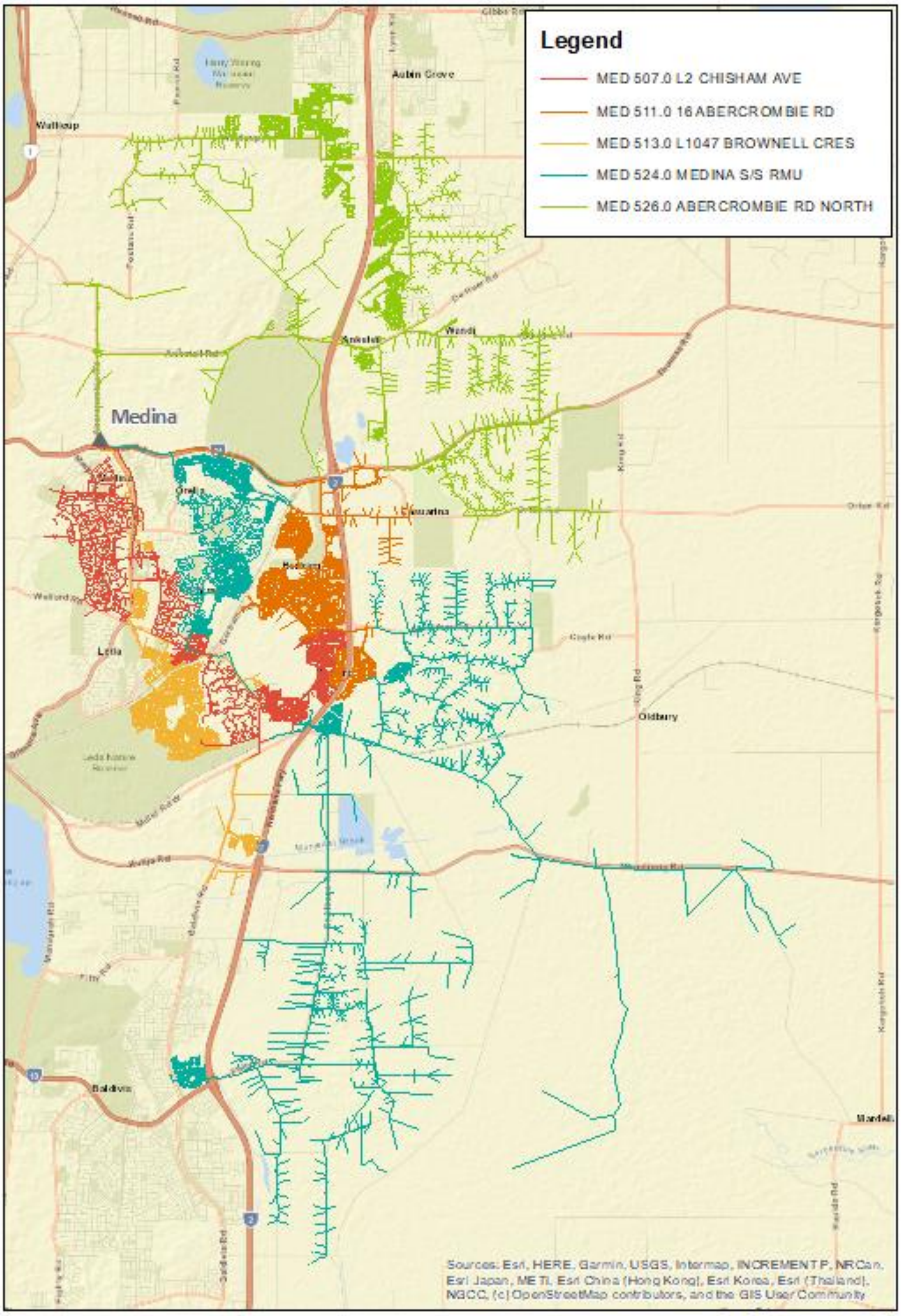

Figure 3.6: Geographical distribution of Medina high utilisation feeders (MED 507, MED 511, MED 513, MED 524 and MED 526)

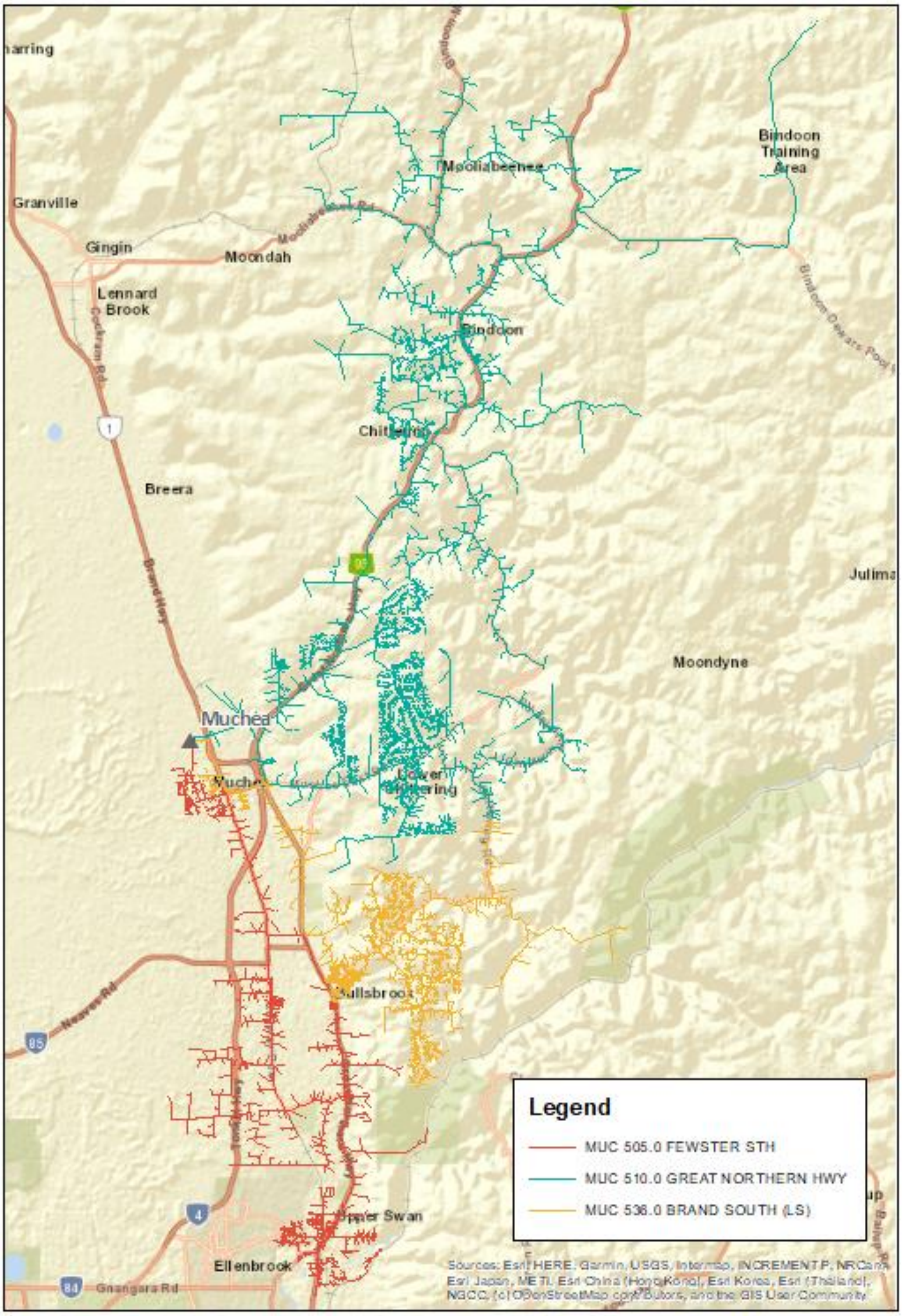

Figure 3.7: Geographical distribution of Muchea high utilisation feeders (MUC 505, MUC 510 and MUC 536)

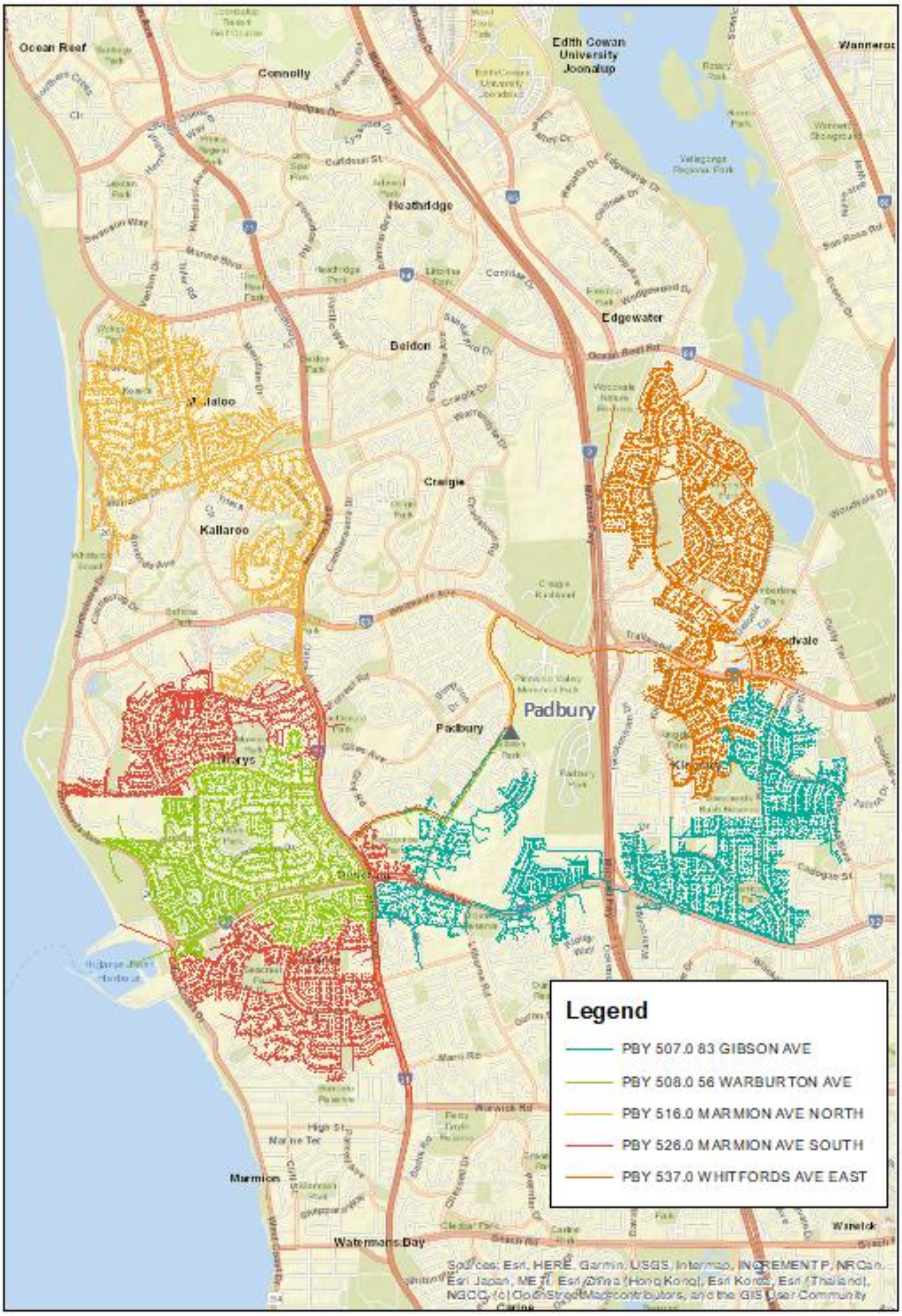

Figure 3.8: Geographical distribution of Padbury high utilisation feeders (PBY 507, PBY 508, PBY 516, PBY 526 and PBY 537)

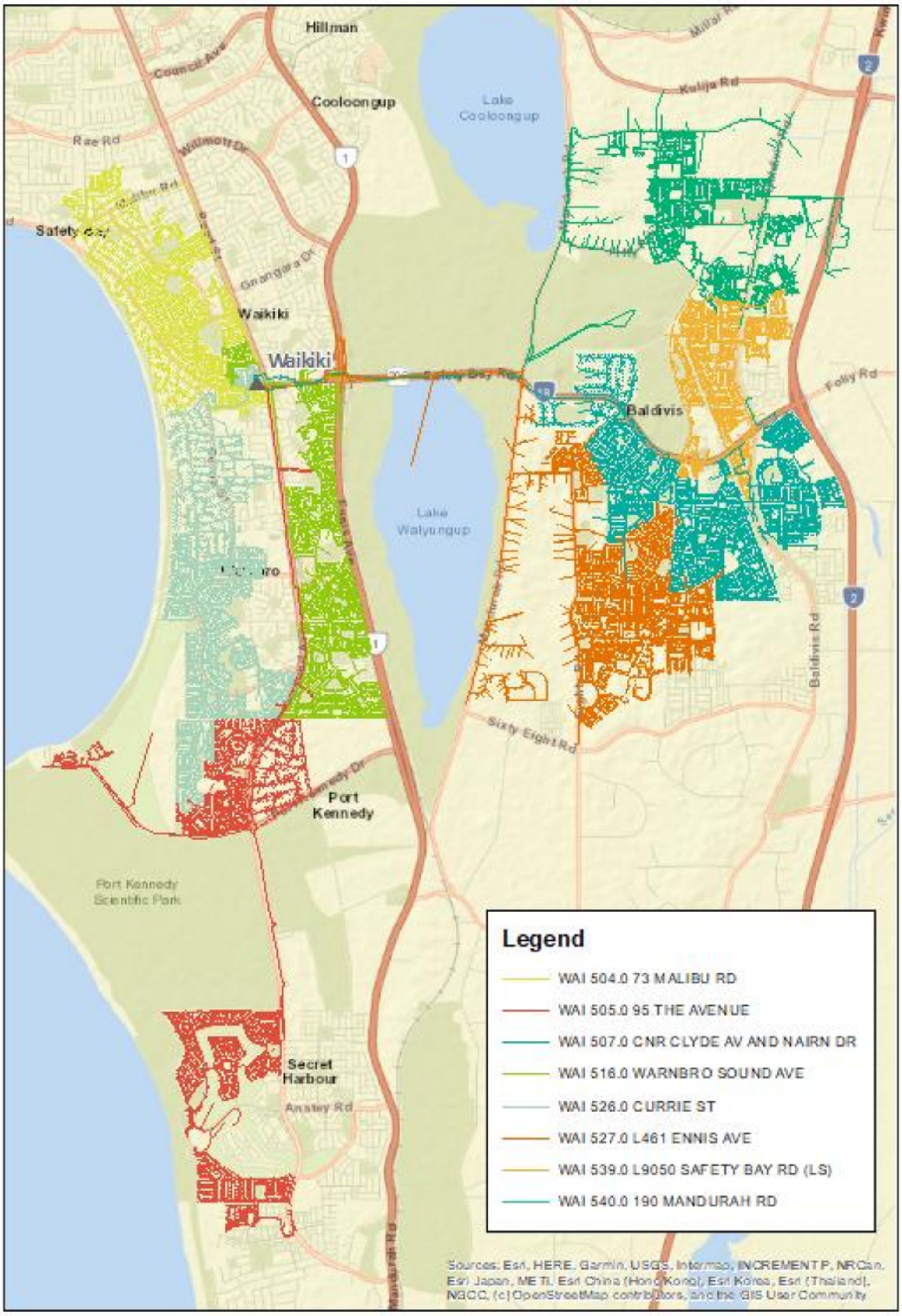

Figure 3.9: Geographical distribution of Waikiki high utilisation feeders (WAI 504, WAI 505, WAI 507, WAI 516, WAI 526, WAI 527, WAI 539F and WAI 540)

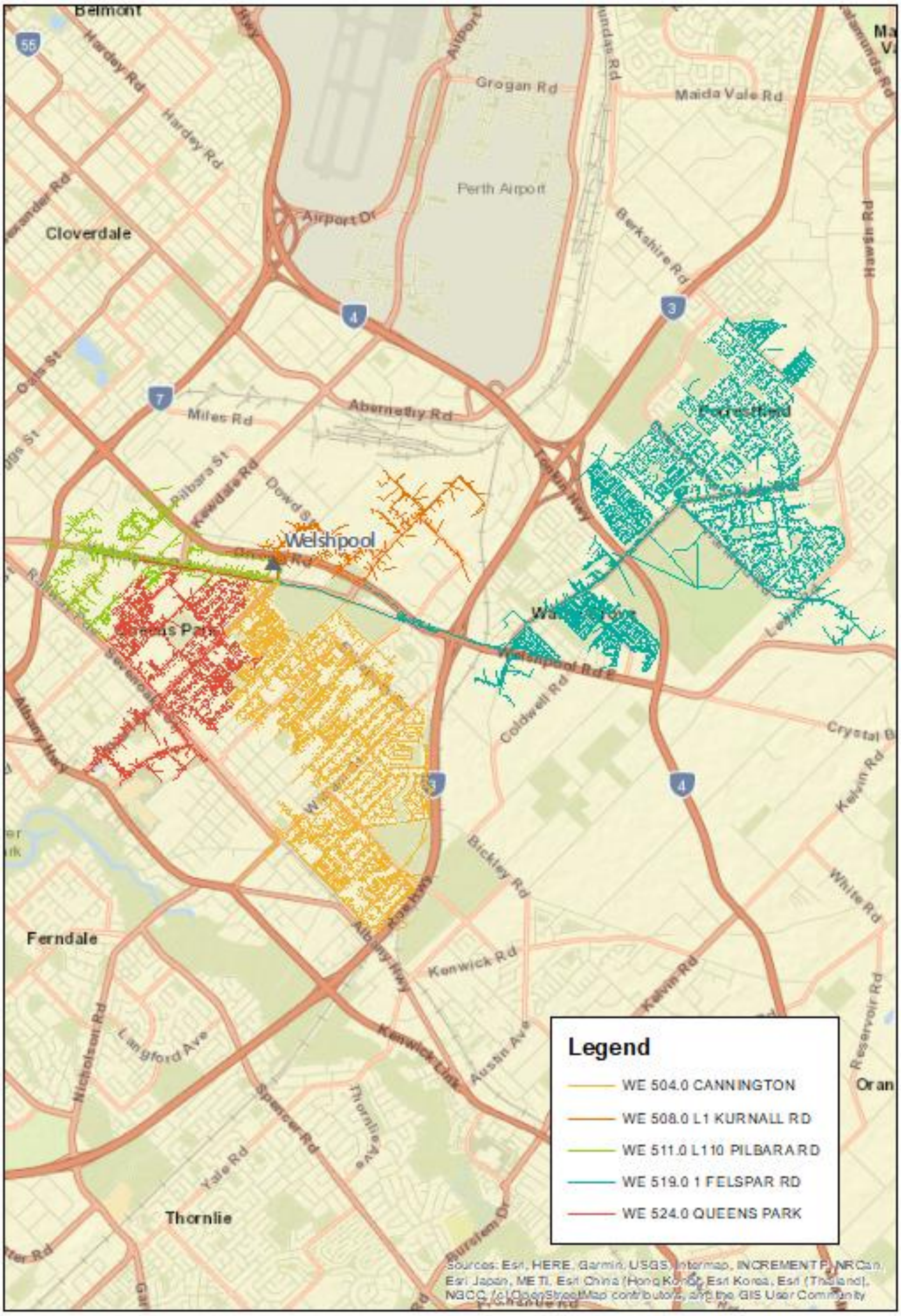

Figure 3.10: Geographical distribution of Welshpool high utilisation feeders (WE 504, WE 508, WE 511, WE 519 and WE 524)

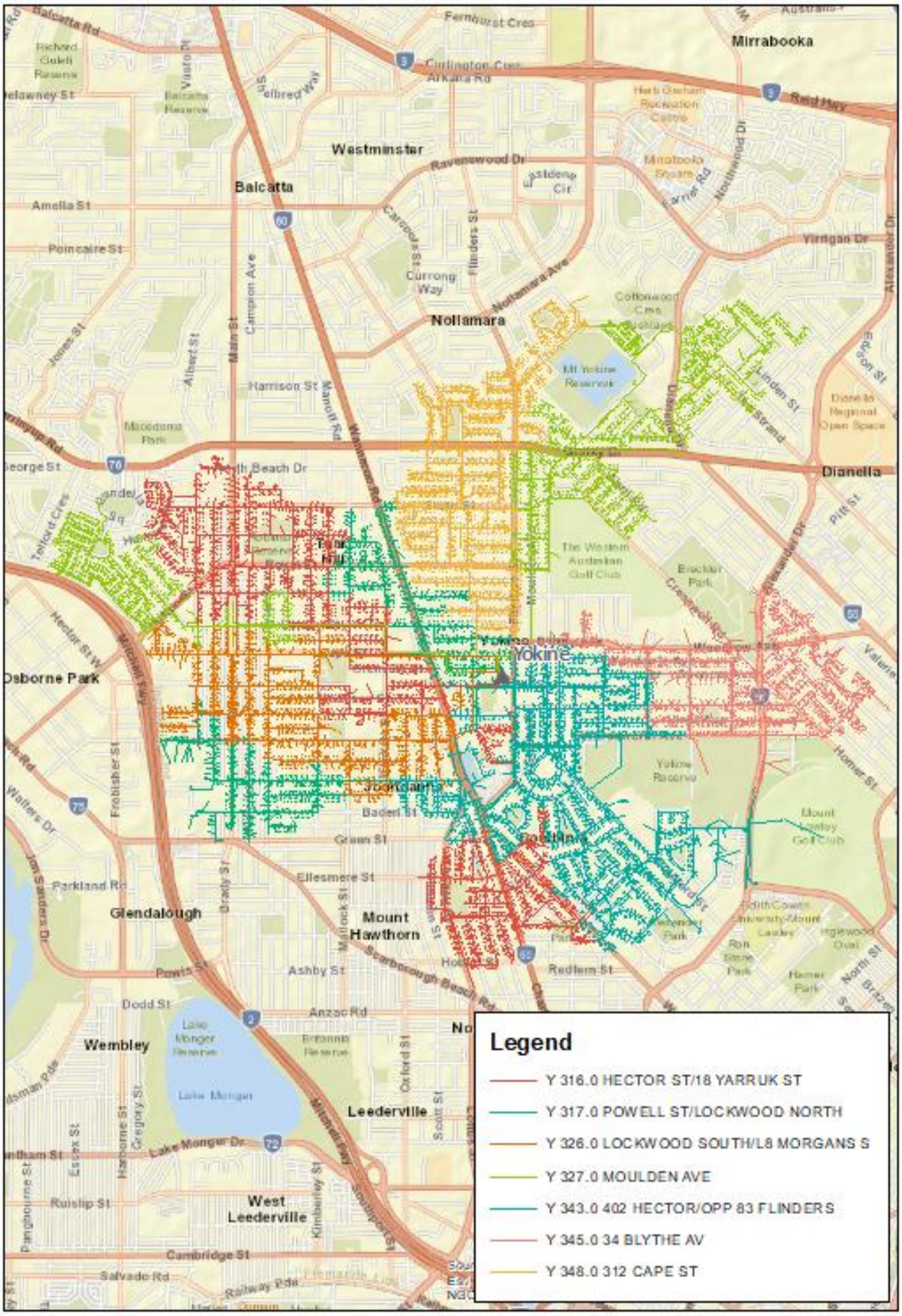

Figure 3.11: Geographical distribution of Yokine high utilisation feeders (Y 316F, Y 316R, Y 317F, Y 326F, Y 327F, Y 343F, Y 345R and Y 348R)[21]

[21] Both Front and Rear legs of Double Cable Terminated feeders shown, as unable to map individual legs of a double cable termination at time of publication.

Network investigations will be triggered based on the escalating risk profile that feeder over-utilisation poses. For a geographical representation of where MV feeders are located, use Western Power Network Capacity Mapping Tool (NCMT)[22].

3.4.2 Distribution Transformer (LV Feeder) Loading

Loading of Western Power's Distribution Transformers (DSTR) are estimated annually as there is currently no remote monitoring of all these assets. To promptly manage the network risk, the identified highly loaded distribution transformers will have a typical network solution applied.

To trial network opportunities identification at the DSTR level, data on selected 200 distribution transformer performance is available in the Network Data link on the NOM webpage, under Distribution Transformer Opportunities.

These 200 DSTR currently are low/medium network risk, but depending on connection of new customers, or increased demand from existing customers from temperature response, these DSTRs may require mitigation within the five-year medium term outlook, and an alternative non-network option sought if economically viable to Western Power.

3.4.3 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 the same remote and rural locations.

Table 3.6 shows Western Power's nine reliability focus MV feeders, 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.

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

Table 3.6: Western Power's nine reliability focus MV feeders

Feeder Name	Feeder Category	ZSS Name	ZSS Abbreviation	Feeder Abbreviation	Customer Numbers	Customer Segment			
						Residential (%)	Small Commercial (%)	Large Commercial (%)	Large Distribution Generator (Y/N)
TS 611.0 MORAWA	Rural Long	THREE SPRINGS	TS	TS 611	774	44%	56%	0.5%	N
MOR 612.0 WATHEROO	Rural Long	MOORA	MOR	MOR 612	284	26%	74%	0.0%	N
GTN 602.0 NORTHAMPTON	Rural Long	GERALDTON	GTN	GTN 602	1696	68%	31%	0.4%	N
RGN 610.0 MOGUMBER	Rural Long	REGANS	RGN	RGN 610	355	35%	65%	0.3%	N
TS 613.0 MINGENEW	Rural Long	THREE SPRINGS	TS	TS 613	436	36%	63%	0.9%	N
GTN 665.0 NARNGULU WEST	Rural Long	GERALDTON	GTN	GTN 665	2493	84%	16%	0.4%	N
KAT 509.0 GNOWANGERUP	Rural Long	KATANNING	KAT	KAT 509	1117	30%	70%	0.4%	N
RGN 604.0 LANCELIN	Rural Long	REGANS	RGN	RGN 604	1913	82%	18%	0.3%	N
GTN 610.0 DONGARA	Rural Long	GERALDTON	GTN	GTN 610	1180	64%	36%	0.3%	N

Figure 3.12 to Figure 3. illustrate the geographical location of these nine MV feeders, demonstrating their significant distances from zone substations. The NCMT can be used for a more detailed view of the topology of Western Power's MV network in the area.

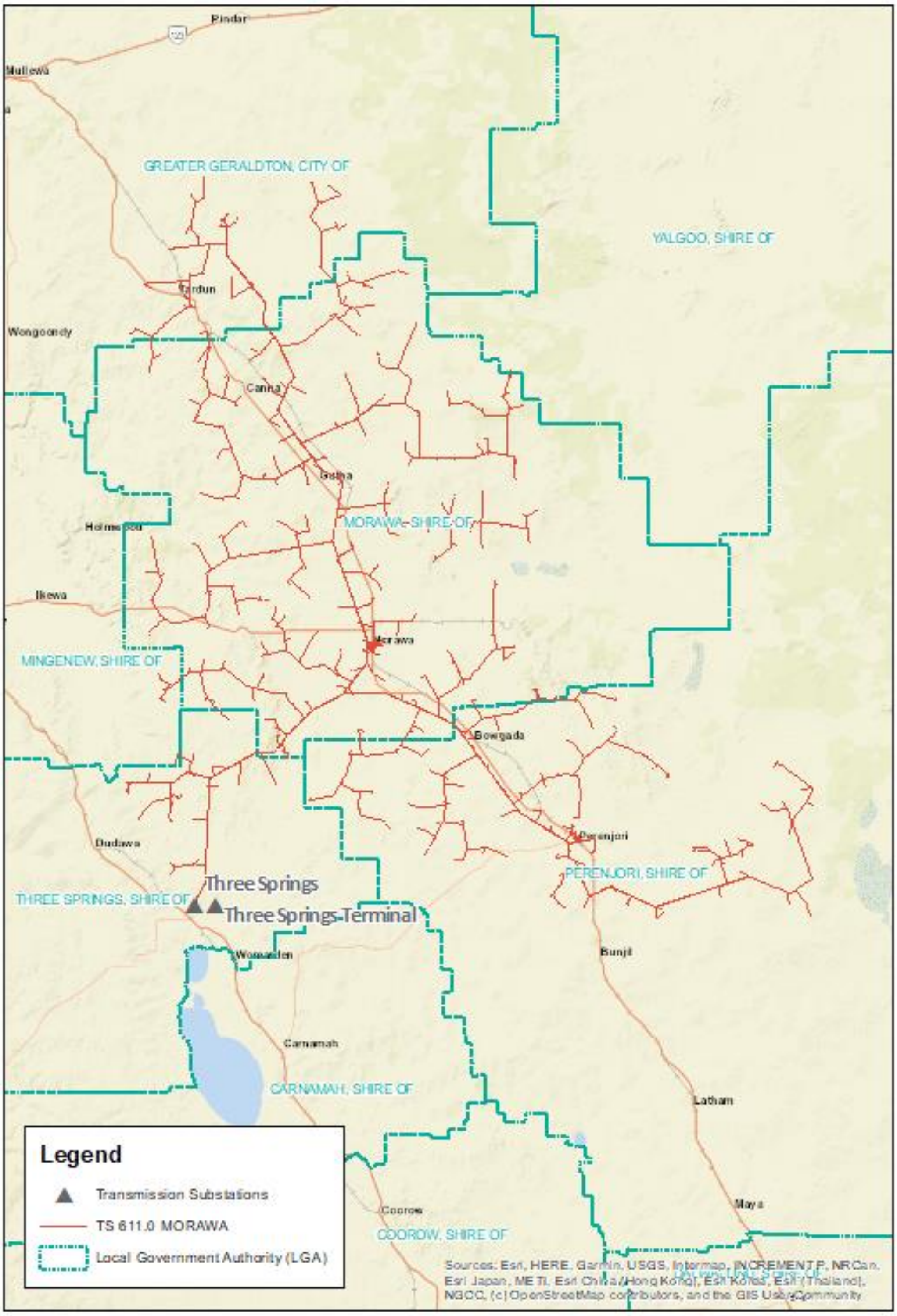

Figure 3.12: TS 611.0 MORAWA

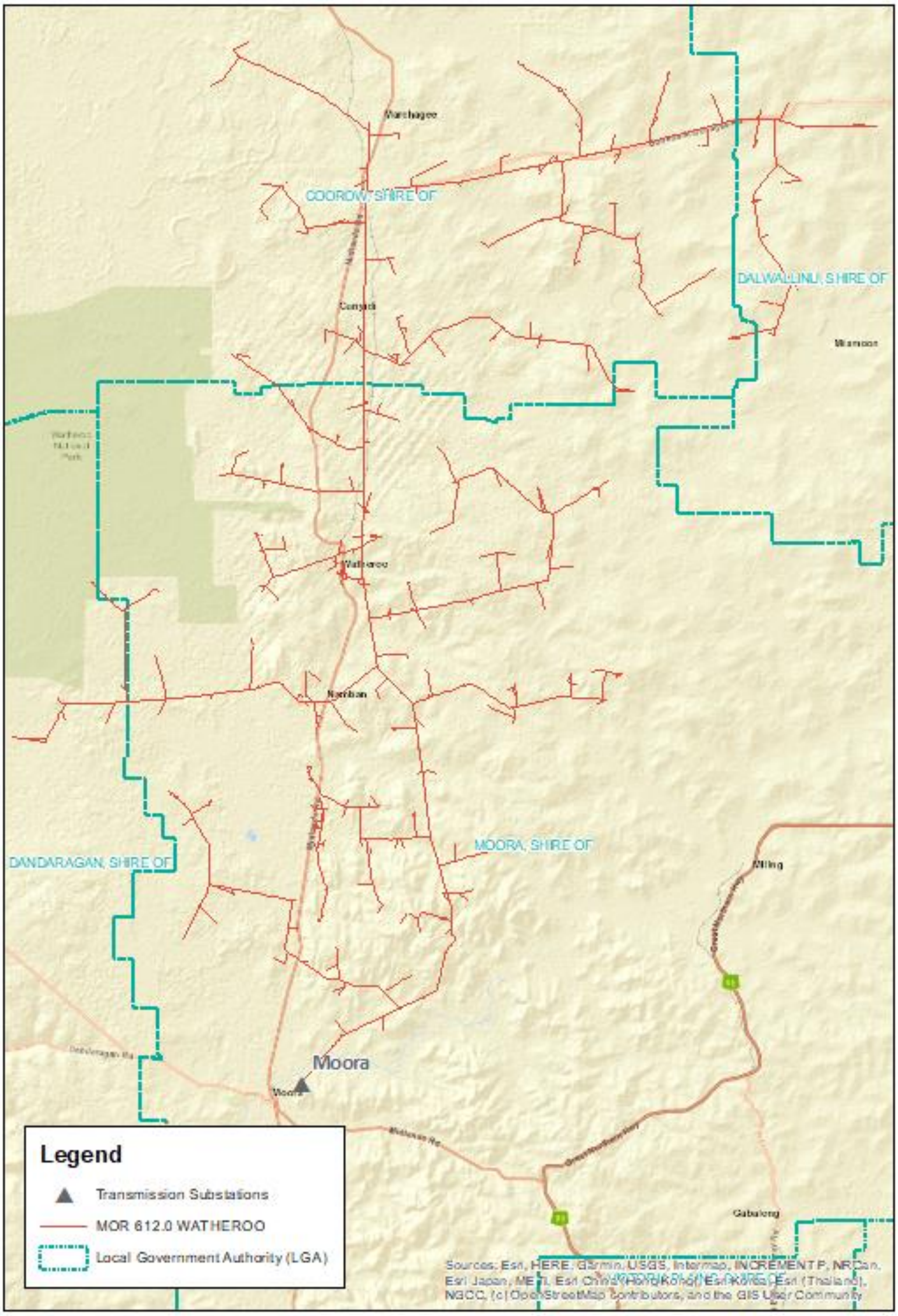

Figure 3.13: MOR 612.0 WATHEROO

Figure 3.14: GTN 602.0 NORTHAMPTON

Figure 3.15: RGN 610.0 MOGUMBER

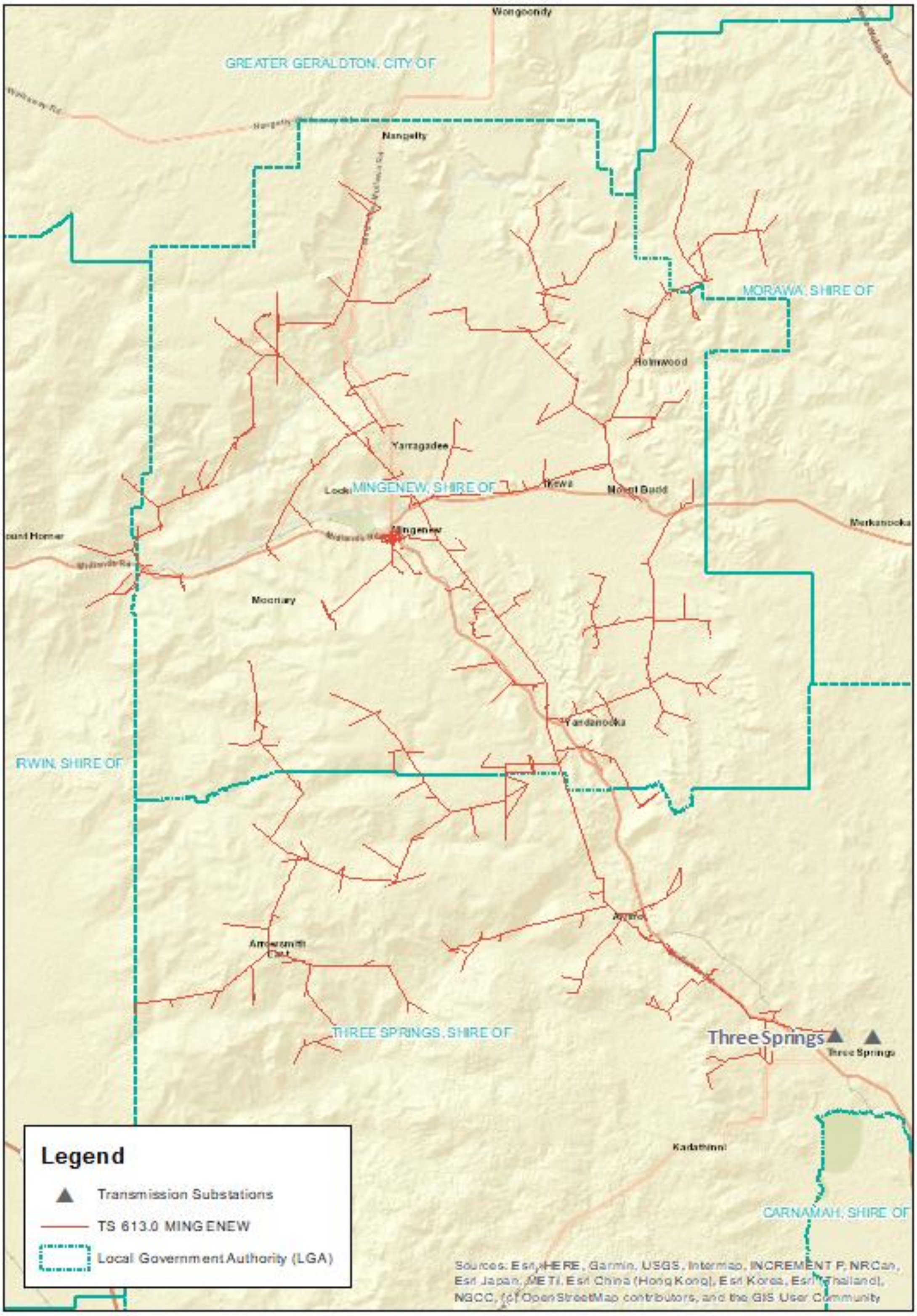

Figure 3.16: TS 613.0 MINGENEW

At time of publication, network data for Narngulu West feeder unavailable for mapping.

Figure 3.18: KAT 509.0 GNOWANGERUP

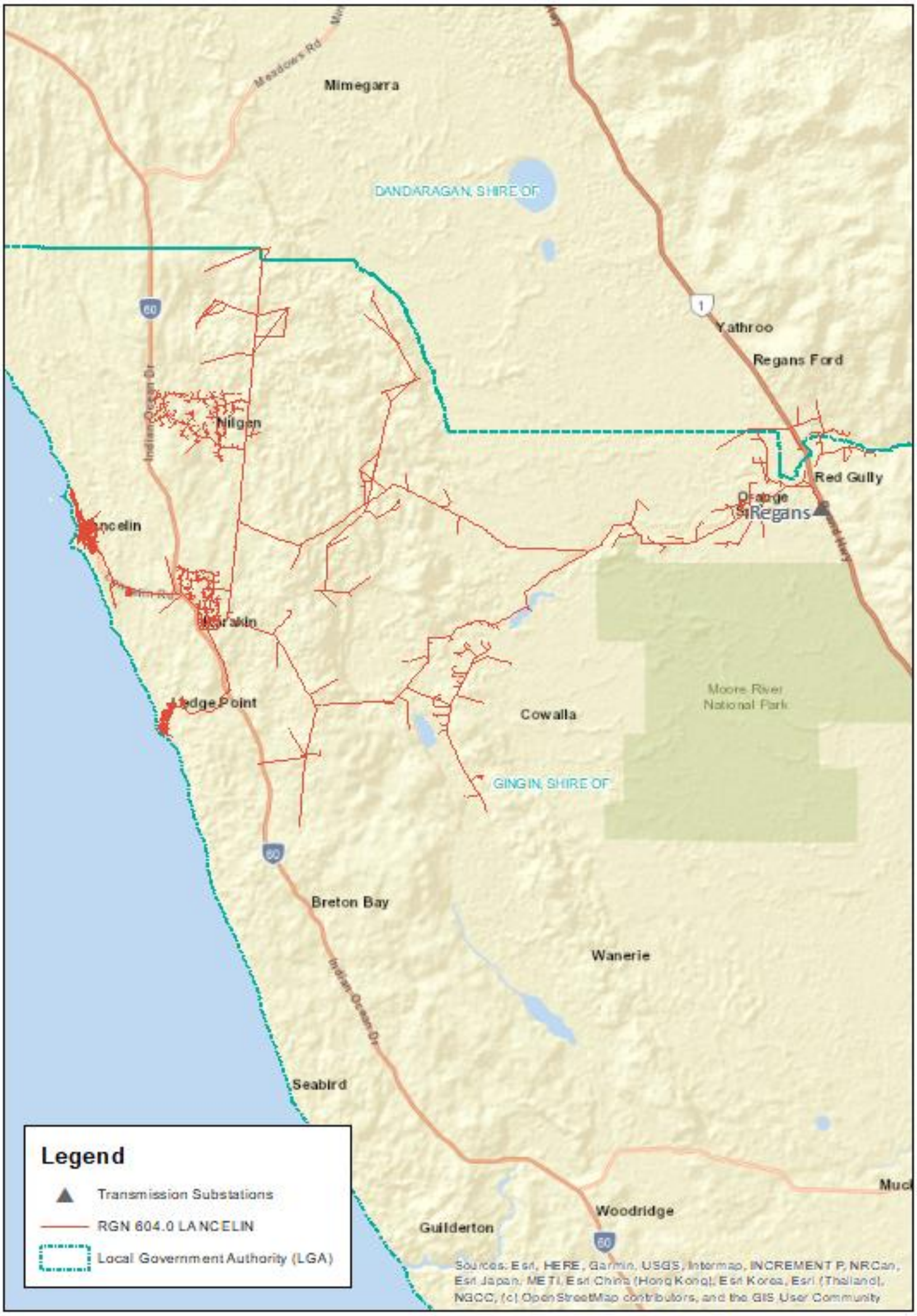

Figure 3.19: RGN 604.0 LANCELIN

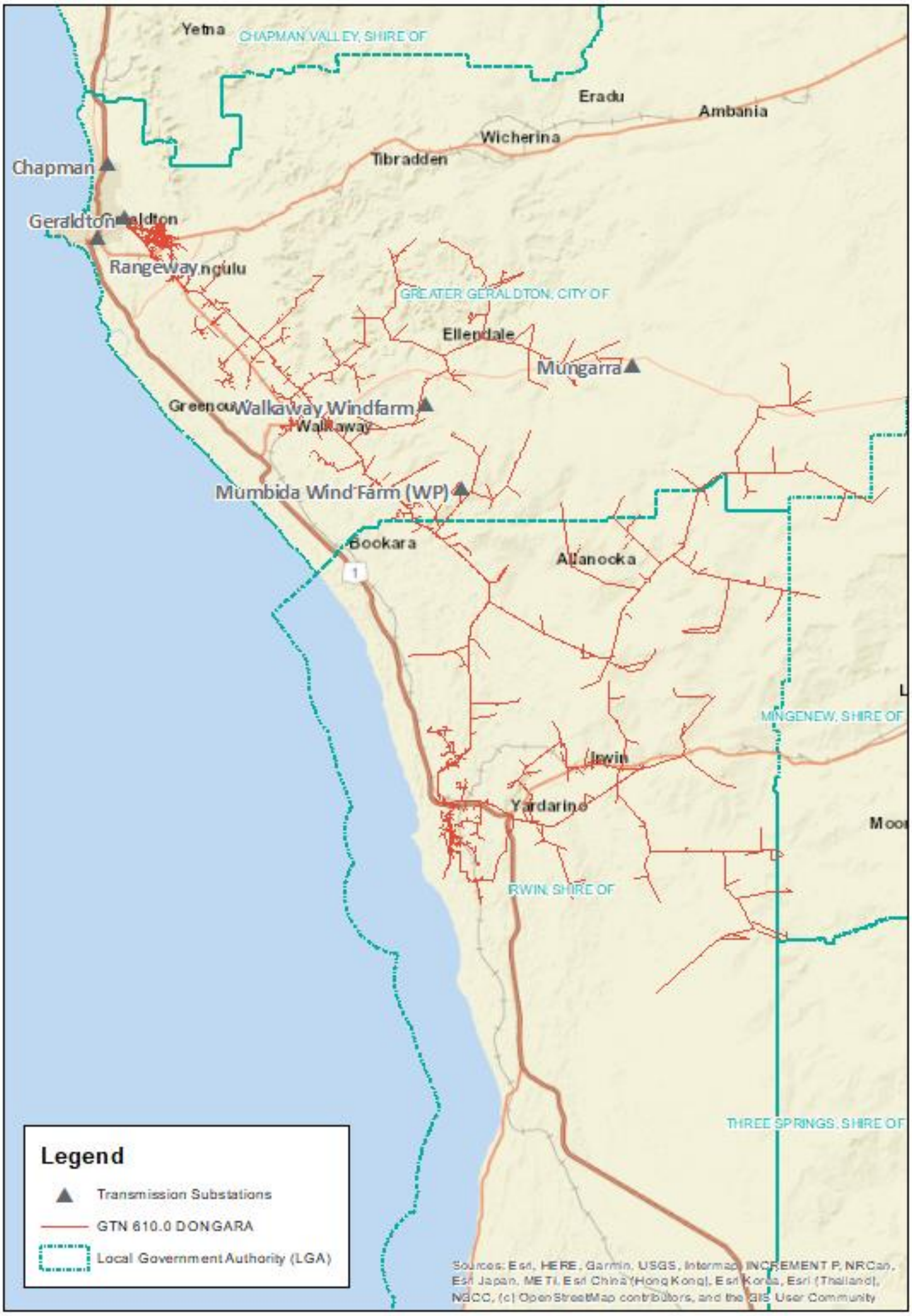

Figure 3.20: GTN 610.0 DONGARA

3.4.3.1 Alternative options for Reliability

As mentioned in section 1.3.5, the town of Kalbarri has been equipped with a BESS, 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 long and the BESS is depleted. In conjunction with the BESS, other greener solutions are invited to improve duration response at Kalbarri when battery storage is depleted.

The town of Walpole will be equipped with a pumped hydro microgrid with the objective of providing cleaner and greener energy and improved reliability for customers in the area. When the project is operational the realisation of reliability performance benefits may result in future opportunities to further enhance customer reliability outside of the existing microgrid catchment.

3.4.4 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.

There is an existing 1.8 MVA power station in Bremer Bay that provides network control services (NCS) to Western Power. Connected to a 33kV ALB 514.0 feeder of the Albany Zone Substation, this power station can form a microgrid to improve reliability performance. Western Power is looking for alternative option with similar capacity and capability to connect at 33KV with synchronising capabilities.

Appendix A

ACCESS CODE 2020 REQUIREMENTS

A.1 Access Code Requirements Indexed to Network Opportunity Map 2023

The following table is based on amendments to the Access Code 2004[23] 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

23 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 a Network Service Provider (NSP) it is Western Power's role to provide transmission and distribution services to generators and load customers within the South West Interconnected Network (SWIN). In providing these services Western Power operates the existing network and undertakes planning activities to ensure that new generator connections can be accommodated, with new and growing existing loads supplied according to established standards.

B.1.1 Network Planning Process

The Network Plan considers all relevant corporate objectives and network strategies and corporate objectives and follows a process to produce an optimised plan which meets known constraints.

This process includes an initial consideration of non-network solutions and application of new or emerging technologies.

B.1.1.1 Step 1 – Identify the Issues

Western Power routinely assesses the condition of the network and its ability to supply existing and future demand against a range of requirements and obligations including the Technical Rules[24], WEM Rules[25], Network Quality and Reliability of Supply Code (NQRS)[26], Access Code and asset management requirements and objectives.

Key inputs to these assessments include:

- changes in forecast load and demand
- introduction of new loads or generation sources
- change in asset condition
- past reliability, safety or other network performance characteristics.

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

B.1.1.2 Step 2 – Solutions

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

In planning to meet peak transmission demand levels, system studies are 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. In planning for minimum demand levels, Western Power uses a one-in-two-year demand forecast. For distribution studies, feeder capacities are compared with a one-in-two-year future load forecast.

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

25 https://www.wa.gov.au/government/document-collections/wholesale-electricity-market-rules

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

For all demand conditions, strategic direction will be considered along with long-term network plans, corporate performance measures such as reliability and safety, operational experience, and asset condition, to identify issues that are present on the network and deliver better and more efficient long-term outcomes.

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

Contingency analysis is then undertaken with the credible contingencies based on the Technical Rules and Planning Guidelines. All the credible contingencies are considered for any single contingency (N-1), a single contingency and outage (N-1-1) and a double contingency (N-2) analysis (Perth CBD).

The outcome of this analysis is a set of high-level options that will be developed based largely on network solutions, but also include consideration towards various alternative options and non-network solutions. Western Power uses discounted cash flow techniques to assess the feasibility of all options and make recommendations.

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 'bottom up' approach is an unconstrained scenario which 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
- outputs from condition assessments
- verification of the lowest-cost option
- 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, or taking into account utilisation and decommissioning of 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.

B.1.1.4 Step 4 – Prioritisation

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[27].

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.

Steps 1 to 4 provide a plan based on the least cost sustainable option and optimised across multiple network drivers and delivery.

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 Service Standard Benchmarks, anticipated safety performance, and movements in risk indices.

B.1.2 Annual Planning Cycle

The Annual Planning Cycle (APC) includes all the activities required to produce or update the 10-year Network Plan. The Network Plan includes all the network-related expenditure proposed over a 10-year period to meet a range of objectives and regulatory obligations, while maintaining an acceptable level of risk and performance for customers. It commences with the acquisition of latest telemetry and metering data, and culminates in a (constrained) list of risks and constraints that require addressing within the 10-year time horizon and publication of the NOM. The process takes approximately 12 months to complete with ad-hoc updates for any significant departures from anticipated results.

The Network Plan is usually finalised mid-way through the calendar year and provides a baseline for all network related expenditure across a 10-year outlook. It includes all committed projects, as well as candidates to address various risks and constraints in the network.

The delivery of the NOM is a key component of the APC.

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

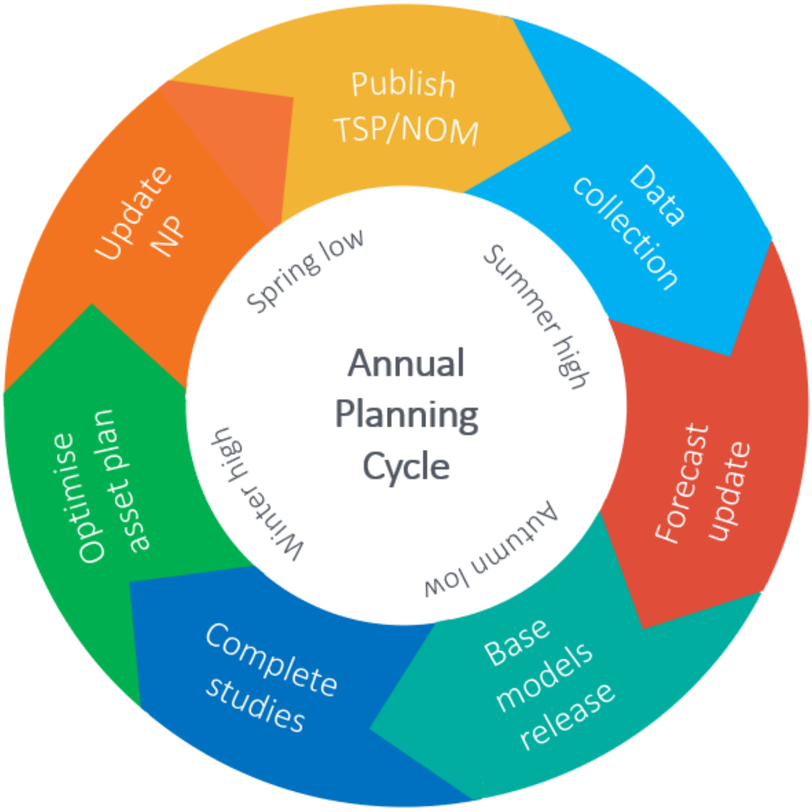

Figure B.1.2: Annual planning review and reporting cycle

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 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 approach 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.

Western Power’s Asset Management System (AMS) has undergone a range of independent assessments for maturity, adequacy and application. Western Power's Asset Management System is certified to the International Standard for Asset Management ISO 55001. The certificate was first issued in 2019 and is currently applicable to August 2025.

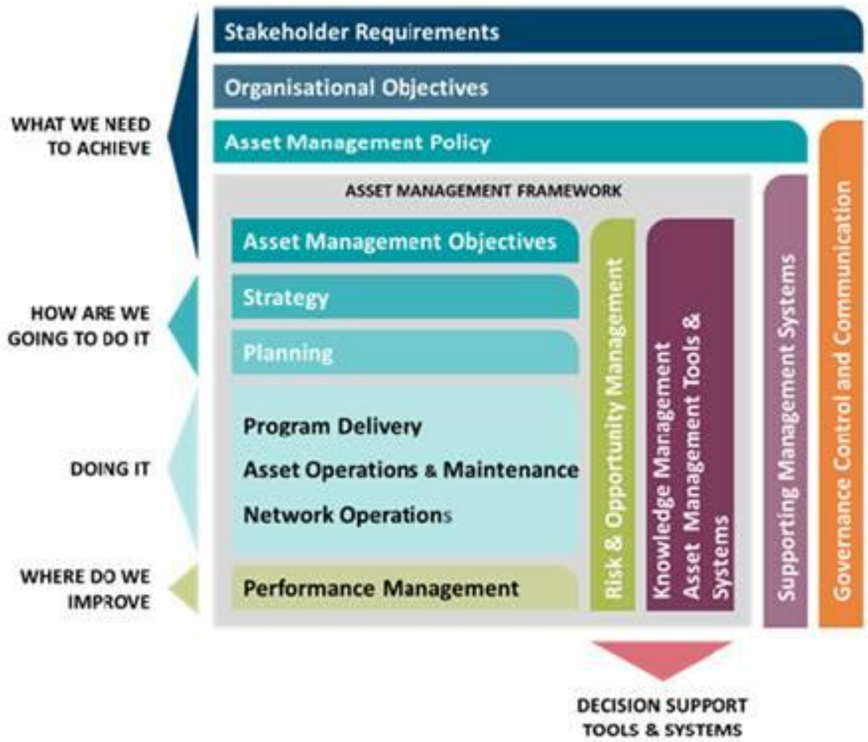

Figure B.2.1: Western Power’s Asset Management Framework components

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 2021.

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. • Aging of insulators on critical lines • 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. • Introduce Remote Piloted Aircraft (RPA) line top inspections for no-fly zones and replace insulators based on risk.

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. • Roll-out online condition monitoring for a sub-set of critical assets.
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

Distribution Focus Area	Challenges	Strategies
Distribution Overhead (OH) Network	• Ageing distribution overhead network with approximately half of the assets reaching end of life maturity in the next 10 years. • Wood poles and bare overhead conductors form the majority (over 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. • Pole top fires on the distribution overhead network are the leading cause of all ground fires in the distribution network over the past five years, impacting both safety and reliability.	• 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 insulator replacements or 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.
Distribution Underground Network	• Failure of distribution underground cables over the past five years have lead 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. • Replace cables where condition indicates end of life. • Use insights gained from testing regime to enhance understanding of condition of the cable fleet.

Distribution Focus Area	Challenges	Strategies
Service Connections	• Service connections continue to be the highest (%) contributor to the electric shock count due to Western Power's network. • 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.
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 luminaires.	• 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, defined by the AEMO Data Communications Standard and Technical Rules (Sections 2.2, 2.3.9, 3.2.1, 3.3, 5.3.1).	• Replace non-compliant, end-of-life and obsolete assets on a risk priority basis. Recover decommissioned assets to increase strategic spares holdings. • Enhance remote monitoring and management of assets. • Grid Automation Asset risks are assessed within the guidelines on the Network Risk Management Standard (NRMS) which is a key component within Western Power's Asset Management System.

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. • The lifecycle of electronic assets is significantly impacted by the supportability driven by product obsolescence. The obsolescence risk is assessed and addressed by a planned program of work. 60% of Telecommunications Network Access assets are obsolete (end of life with no manufacturer support) resulting in the depletion of electronic spares and performance 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).	• Real time monitoring of Network Access assets. • Plan prioritised, proactive 'whole of family' replacement on service withdrawal, technology obsolescence, type defects, endemic degraded performance, or reduced capacity. • Recover decommissioned assets to increase strategic spares holdings. • 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. • 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.

SCADA and Telecommunications Asset Class	Challenges	Strategies
Radio System	• Frequency spectrum embargoes limit the availability of microwave radio licences. Embargo 49 has the most impact by limiting the use of most of the microwave frequency spectrum (2 to 52 GHz) in the Mid-West region. 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. • 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). •	• Real time monitoring of Radio assets. • Plan prioritised, proactive 'whole of family' replacement on service withdrawal, technology obsolescence, type defects, endemic degraded performance, or reduced capacity. • Recover decommissioned assets to increase strategic spares holdings. • Meet all regulatory and contractual obligations and prepare supporting documentation. • Radio systems risks are assessed within the guidelines on the Network Risk Management Standard (NRMS) which is a key component within Western Power's Asset Management System.

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 reliability performance better than SSBs 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 Network Safety 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 personnel, and the environment, 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 and including impact on flora and fauna.
- Loss of supply in context of safety is an incident that involves loss of supply to essential services (e.g. life support system, traffic lights, hospitals, water supply).

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/upgrade of the 66kV network. This strategy highlights the opportunities that are available to reduce costs when replacing the 66kV networks with a higher capacity 132kV assets. In the long term, it is anticipated that all the 66kV assets in the SWIS 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 beyond their useful design life. 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 volume 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.
- Address existing ageing asset condition issues with optimised long-term benefits.

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 Energy and Demand Forecasts

Information relating to the Energy and Demand forecasts is available in section 6 of the Transmission System Plan[13].

Appendix C

INVESTMENTS

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.

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 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.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)
- Infrastructure WA approval (if required)
- Board commitment (if required)
- Western Power funding approval in the form of an approved 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 NOM2023. 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 two 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 NOM2023, 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.