Annual Planning Report 2020

OWNED BY the people of WA

westernpower

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Introduction

Who we are

For more than 70 years, Western Power has provided Western Australians with safe, reliable and efficient electricity.

Our vast transmission and distribution network seamlessly connects our homes, businesses and essential community infrastructure to an increasingly renewable energy mix, to build our State and meet the changing energy needs of Western Australians. We're powered by community trust and the passion of our people.

And we have our eyes firmly on the future.

Understanding how the network will function, and unlocking future opportunities for customers, businesses and the State is critical.

New technology, demands for cleaner energy and alternative energy solutions are creating changes in the traditional electricity value chain. Increasingly, the network is acting as a platform for customers to choose how they want their electricity supplied and delivered.

We're already harnessing new technology and are excited about further opportunities to evolve with the changing energy needs of our customers to keep them connected every step of the way.

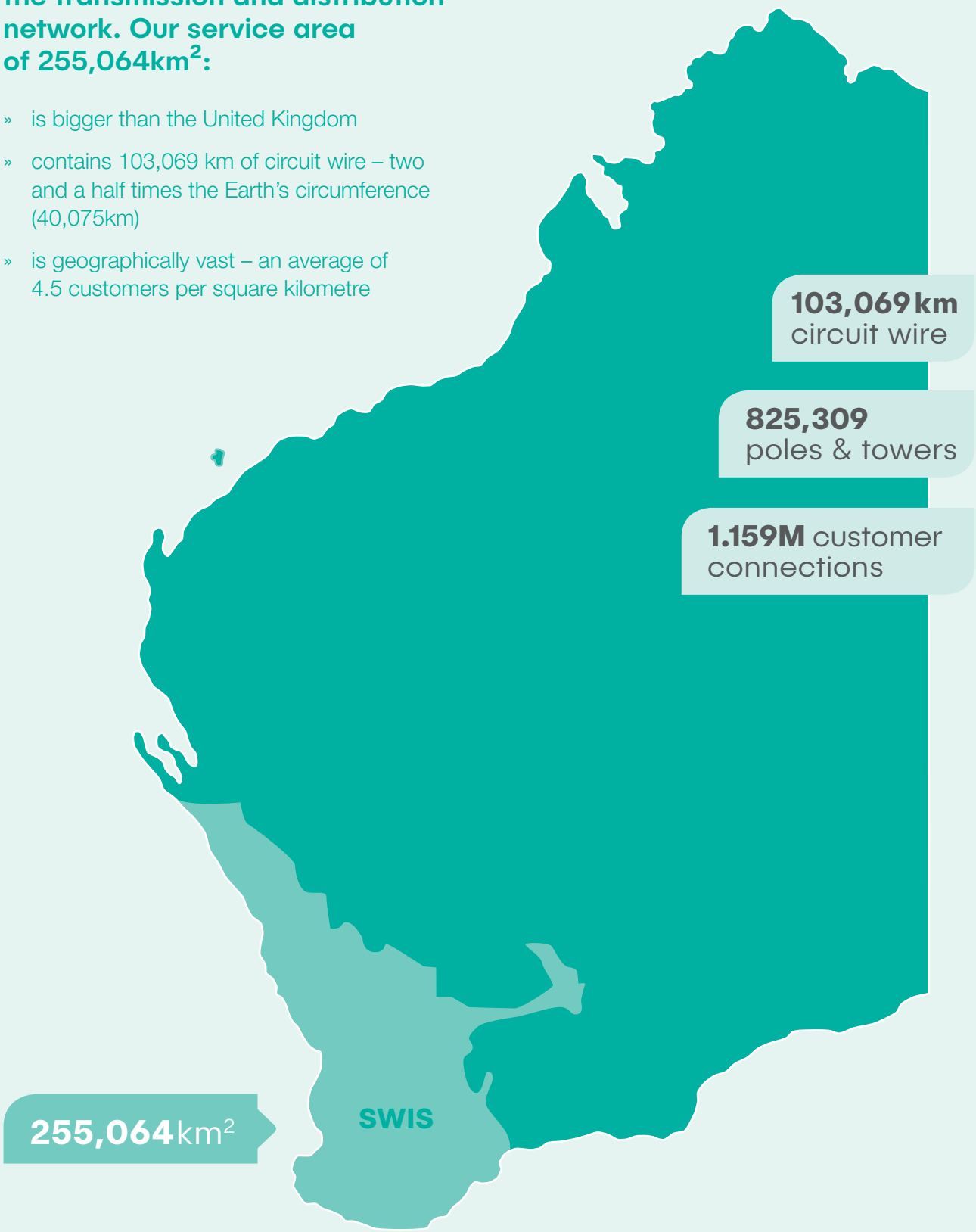
We build, operate and maintain the transmission and distribution networks which cover a service area of over 255,000km^2. The transmission network is shown in the diagram on page 6.

The network is inherently dynamic and complex. Customers' needs change and we regularly receive new connection applications. You should use the information in this report only as a guide and we recommend that you get in touch with us as early as possible when planning your project. We perform detailed system studies to confirm the technical feasibility of connections and having this information early can greatly assist in planning your project.

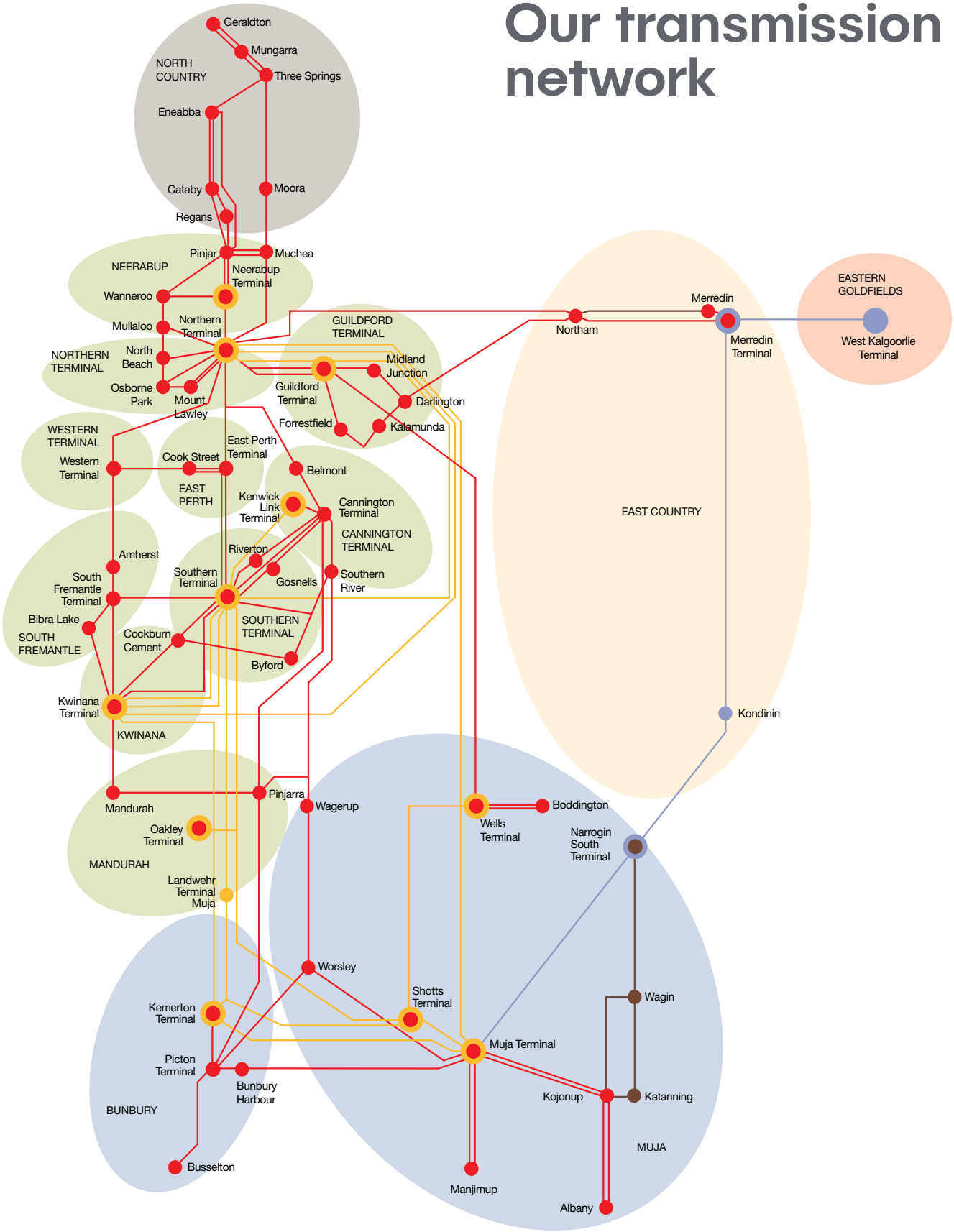
The information presented in this report is as at 30 June 2020 unless otherwise noted.

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

- is bigger than the United Kingdom
- contains 103,069 km of circuit wire – two and a half times the Earth's circumference (40,075km)
- is geographically vast – an average of 4.5 customers per square kilometre



Our transmission network



The Western Power transmission network.
Please note that not all transmission lines and substations are shown.

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Planning considerations

We are planning for the future

Annual planning process

We publish an Annual Planning Report (APR) to:

- outline existing and emerging capacity constraints
- highlight network investment opportunities on the network
- detail how we seek and integrate network solutions to maintain or improve service levels.

If you're planning to connect to the network, we encourage you to get in contact with us as early as possible to discuss your plans.

What information goes into planning?

Our published plans have a five-year outlook and cover:

- load demand forecasts
- generation scenarios
- transmission and distribution network developments and projects
- estimated maximum fault levels.

We have refreshed the estimated maximum fault levels at each substation. The data can be found in Appendix A.

Planning and partnerships

The APR complements the Australian Energy Market Operator's (AEMO) Wholesale Electricity Market (WEM) Electricity Statement of Opportunities (ESOO).

While the WEM ESOO focuses on the overall adequacy of generation capacity over a 10-year timeframe, the APR's focus is to identify emerging network capacity issues and potential solutions in the next five years.

Together these documents provide a valuable insight into current and future opportunities for existing and new generators, large and small businesses, developers and consumers.

An ever-changing environment

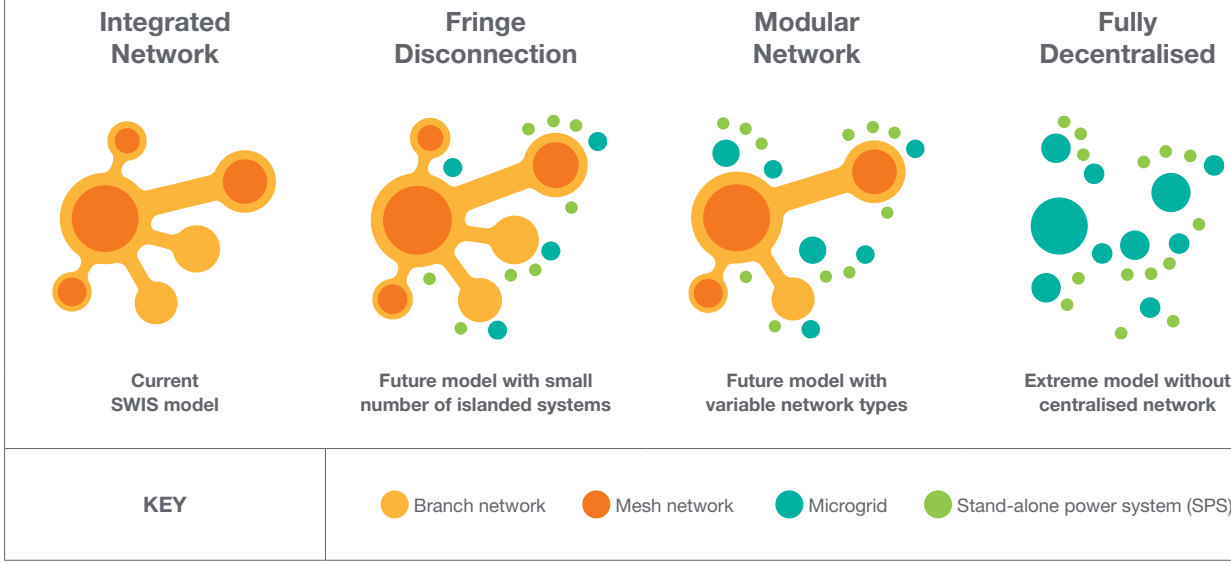
The traditional energy service business model – a network of assets that delivers electricity one-way – is no longer the norm. Now, networks have to facilitate bi-directional flow.

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

The diagram below depicts how the network will transition from the existing integrated network to a modular network.

Reshaping our network

Network evolution is reliant on community behaviour, technology advancement rates, regulation and policy



Energy Transformation Strategy

On 20 May 2019, the Hon Bill Johnston MLA, Minister for Energy, established the Energy Transformation Taskforce to deliver the Western Australian Government's Energy Transformation Strategy. The Energy Transformation Strategy is the Government's work program to deliver secure, reliable, sustainable and affordable electricity to Western Australians for years to come. We have a significant role to play in assisting the Western Australian Government to deliver the Strategy.

The Strategy will be delivered under three work streams:

1. Whole of System Planning

A Whole of System Plan (WOSP) has been developed by the Energy Transformation Taskforce. Western Power, along with AEMO, was a key contributor to this plan, which is informed by energy industry stakeholders and market participants. It brings together the important aspects of power system planning under a single umbrella. The Plan for the South West Interconnected System (SWIS) was released by the Minister for Energy in October 2020 and:

- identifies the best options for investment in our power system, to maintain security and reliability at the lowest sustainable cost
- assists in the transition to a lower-emissions power system by guiding the efficient integration of renewable generation and identifying opportunities for energy storage, which will play an increasing role in meeting essential electricity needs
- provides guidance to regulators and industry regarding efficient power system investment, and to policymakers on the future needs of the power system.

The WOSP will be a key influence on the content of future Annual Planning Reports.

2. Foundation Regulatory Frameworks

Improving access to the Western Power network

Current network access arrangements do not make the best use of available transmission capacity and the existing investment in the network, resulting in barriers to entry for new generators. The arrangements have also led to an outcome where generators have different rights to access the network, creating inefficiencies in the dispatch of generators in the Wholesale Electricity Market.

The proposal to adopt a framework of constrained access aims to improve generator access to the Western Power network by providing more equitable access for generators and optimising grid use.

This will help remove barriers to investment and facilitate access to the Wholesale Electricity Market for new low-cost and cleaner generation technologies.

By facilitating more efficient use of available network capacity, the reforms will also provide a greater return on investment in new and existing network infrastructure that is ultimately paid for by electricity consumers. We are working with AEMO and Energy Policy WA towards a 'go live' date of 1 October 2022 for constrained access.

Delivering the future power system

In the face of the rapid transformation being experienced in the electricity sector, the market systems, standards, obligations and frameworks that underpin the operation of the South West Interconnected System are under increasing pressure.

Unless the way the power system is regulated and managed is modernised:

- energy will not be dispatched at the least sustainable cost
- the power system will be limited in its ability to accommodate growing levels of renewable generation and other new technologies (such as battery storage) while maintaining security and reliability, and
- signals for investment in the power system – at the right time and place – will be inadequate.

Following consultation, the Energy Transformation Taskforce will make decisions on elements of market and regulatory design. These decisions will form the basis for changes to market rules and regulations.

3. Distributed Energy Resources (DER)

In April 2020, the Minister for Energy released a DER Roadmap[1] to ensure we can integrate growing levels of DER into the State's electricity systems safely and securely and to make sure customers can continue to benefit from solar PV and other new technologies.

The Roadmap will guide changes to policies, regulations, technical requirements and customer protections to support integrating increasing levels of DER over the short, medium and longer term.

The Roadmap has four main themes:

- Technology integration
- Tariffs and investment signals
- DER participation
- Customer protection and engagement.

1 https://www.wa.gov.au/government/publications/der-roadmap

Roadmap element	Action
Inverter standards	Assess the opportunity to update latent capabilities in the existing inverter fleet.
Distribution storage	Outline opportunities for distribution storage services across the SWIS (either in front of or behind the meter) to meet emerging network needs.
Grid response	Review current requirements of the Under Frequency Load Shedding (UFLS) scheme and assess implications for AA5 investment program.
Grid response	Deliver network technology solutions to provide grid support on low-demand days.
Distribution network visibility	Assess distribution network visibility capability and develop an investment plan for deploying technology to improve that visibility, both static and dynamic, to support Distribution System Operator (DSO) requirements.
Network investment process	Following updates to the Access Code, facilitate better procurement of non-network solutions (using DER where appropriate) to address network issues.
DER Orchestration	Conduct a comprehensive Virtual Power Plant technology pilot to demonstrate the end-to-end technical capability of DER in the SWIS, and its ability to respond in a coordinated manner.
Distribution System Operator (DSO)/ Distribution Market Operator (DMO) Functionality	Enable DSO go-live by 1 July 2023 in the SWIS, with DER able to respond to meet network needs as well as be dispatched into the WEM and be compensated appropriately.

We will be actively involved in delivering all themes over the next 5 years and will be leading a number of the 36 detailed actions, some of which are outlined in the table above.

More information is available from the Energy Transformation Strategy website[2].

2 https://www.wa.gov.au/organisation/energy-policy-wa/energy-transformation-strategy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Demand forecasts and scenario planning

Demand forecasts and scenario planning

Load forecasting

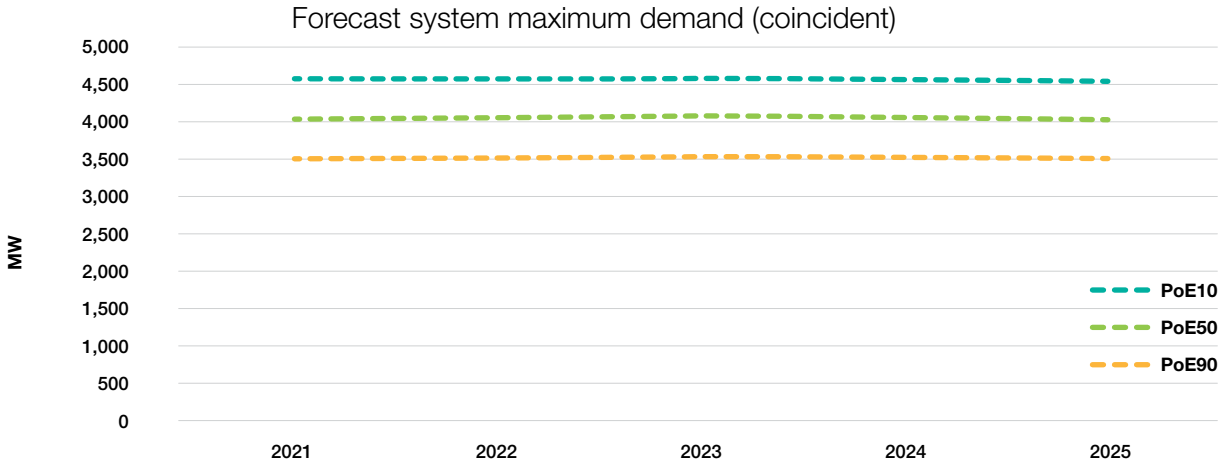
Our forecasting reflects the challenges and opportunities the industry is facing fuelled by the development of alternatives to electricity supplied by the network. Those alternatives include the significant uptake of solar systems, and improved thermal efficiency of buildings and less electricity intensive appliances.

We review our demand forecasts periodically to track changes in generation and demand and reveal network risks and development opportunities. The forecasts are based on both historical trends and key underlying factors such as weather, population growth, economic cycles, changing consumer needs/behaviour and tariffs, and future technological advances.

Annual peak demand on the network has been relatively stable, though the chart below demonstrates the potential future volatility in annual peaks (represented by the forecast band).[3]

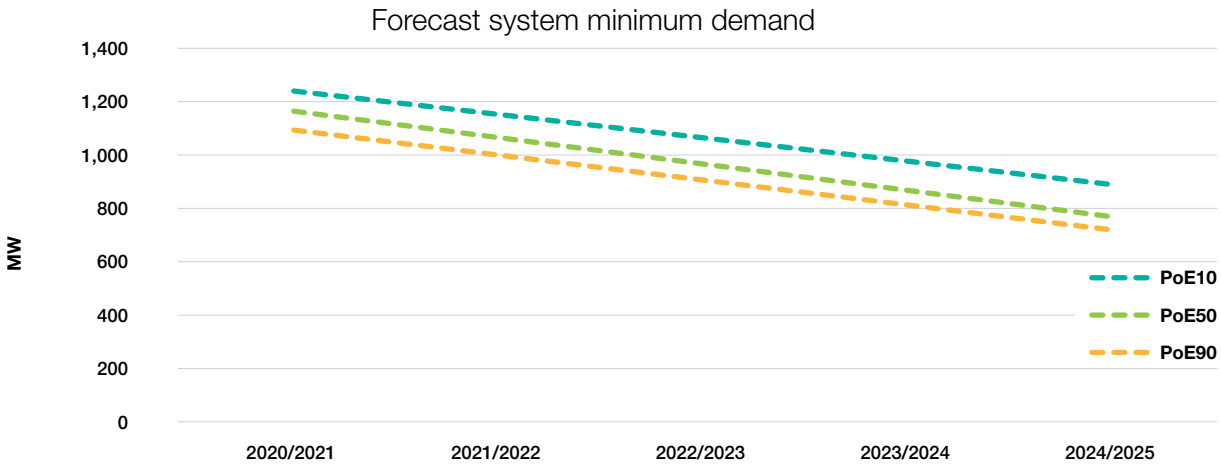
Annual minimum demand on the network has been decreasing and is forecast to continue to decrease. Increasing residential solar PV is driving this decrease with the lowest minimum loads typically seen during the middle of the day on weekends in spring and autumn. The chart on the following page shows the decreasing minimum demand.[3]

Increasingly, minimum demand on the network is creating voltage management and system security challenges which are attracting significant attention.



Note: Probability of Exceedance (PoE). This is the percentage of time that an actual value will exceed the forecast value; e.g. a PoE 10 forecast is expected to be exceeded 10 per cent of the time (i.e. one year in ten); a PoE 50 forecast is expected to be exceeded 50 per cent of the time (i.e. one year in two), and a PoE 90 forecast is expected to be exceeded 90 per cent of the time (i.e. nine years in ten).

3 It is important to note that AEMO's ESOO and Western Power's APR are prepared separately and from distinct forecasts.



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COVID-19 state of emergency

At the time of writing, there had been little discernible impact on total system load from the COVID-19 state of emergency. Most of the impact was observed as a shift across customer groups: commercial and residential. Commercial load decreased modestly, and residential daytime load increased modestly. Some unseasonably hot weather during the 2020 Easter holiday period contributed to the increase in residential load.

Servicing the energy needs of our customers

Once we have established our customers' future energy needs, we determine the most efficient way to service those needs using either traditional meshed network or autonomous (microgrid or stand alone power system) solutions (i.e. "future state").

Scenario planning

We seek to align our network development plans with demand and generation development scenarios, to anticipate future network capacity requirements, and optimise investment plans. Scenario planning also helps align network augmentation and customer project development timelines.

Developing scenarios can be a complex process. It relies on a number of assumptions about the location of new generation based on an understanding of likely new loads and generation sites, expansion plans of incumbent loads and generators and the planning directions of government policy.

Connecting new generators

In the next few years, we expect to connect several hundred megawatts of renewable generation. We are progressing applications for renewable generator connections, particularly in regional areas.

We have worked with AEMO and Energy Policy WA to implement the Generator Interim Access (GIA) solution which was launched in May 2018 with the first generator connected under the GIA in January 2019.

The GIA will support a limited number of new generator connections until constrained network access is introduced in October 2022 (as mentioned in Section 2 of this Report – see "Energy Transformation Strategy").[4]

Demand opportunities are growing

We are continuing to work with large mining and other customers, local government and other stakeholders in the Kwinana, Mid-West, Eastern Goldfields, and South West regions to facilitate their energy needs.

A new transmission cable in the Perth CBD, connecting Hay Street and Milligan Street substations, has been installed and is expected to be commissioned in 2021. We are undertaking a number of projects in the Eastern Goldfields and South West to increase capacity in those regions.

Key completed projects are listed in Section 5 of this Report. Key committed and proposed network projects together with connection opportunities are listed in Section 6 for transmission and Section 7 for distribution.

4 See "Improving Access to the SWIS" at https://www.wa.gov.au/organisation/energy-policy-wa/energy-transformation-strategy

4

Emerging technology

Building the network of the future

We are innovating with new technologies that have the potential to make the most of our network and better meet customer needs. Current projects include:

Flexibility Services Pilot

We're partnering with WA businesses to build network support services[5] into commercial and industrial customer solutions as part of our drive to create a more sustainable, reliable and innovative network for the future.

With our customers now not only consuming energy but also supplying energy, we're changing the way we manage our network to enable this two-way flow of energy. We're working proactively with energy retailers and businesses to explore opportunities available to generate, use and supply energy more effectively.

Through network support services, WA businesses can manage their distributed energy resources (such as solar PV, batteries and manageable loads like heating and cooling systems) in a way that provides network support, in return for compensation by Western Power. Our partners will receive financial benefits for modifying their energy use which will enable us to manage the integration of renewables on the network.

It will help build the capability we will need to deliver on the WA Government's Distributed Energy Resources Roadmap.

To find out more about how you can partner with us on the Flexibility Services Pilot, please visit our website.[6]

Grid Transformation Engine (GTEng) – Network infrastructure typically has a long-life span (beyond 50 years in some instances) and requires forward-looking investment planning. The rapidly changing nature of energy consumption and the use of electricity networks requires an update to traditional network planning approaches. The GTEng is a software system which forecasts economic, demographic and technology changes over a 30-year period and informs network planning and investment. Enhanced planning systems like GTEng are an essential part of the suite of capabilities to realise the full benefits of new technology and regulatory changes.

Stand-alone Power Systems (SPS) – SPS units generate and store electricity without being connected to the grid. SPS offers an alternative to poles and wires which require significant upgrade and/or replacement in parts of the network with a low population density. Following a very successful trial of six sites in the Great Southern region, in October 2020 we completed the installation of a further 52 units as part of the ongoing SPS program.

5 https://cdn-au.mailsnd.com/26738/L5R4xFPqN17nj7EitGlOs0c2RShrbKL2pnN4rPRRHOE/3305166.pdf
6 https://westernpower.com.au/our-energy-evolution/projects-and-trials/100mw-industry-challenge/

The Electricity Industry Amendment Bill 2019, passed by State Parliament in April 2020, is a significant milestone for us to provide regional customers with new energy solutions. The resulting regulatory reforms will allow us to add SPS units and storage devices to our regulated asset base and recover the investments via network tariffs. As a result, further large-scale deployment of SPS is proposed in coming years.

Kalbarri microgrid – A microgrid is a small-scale network that can operate independently or connected to the grid. The Kalbarri microgrid will consist of a new 5MW, 4.5MWh utility scale battery, which will supply Kalbarri in the event that network power is interrupted. It will use renewable energy from residential and commercial sources, including the 1.6MW Synergy windfarm, to extend the battery runtime during a network outage. Construction is underway and the microgrid is expected to be operational in 2021.

Perenjori Battery Energy Storage System – Perenjori is the first town to trial a backup battery supply to improve reliability, thanks to a 1MW, 1MWh network battery that has been installed on the outskirts of town. This world-first trial addresses both longer and momentary outages for an entire rural town. The full capability of the system came online in mid-2018.

Community batteries – We have installed 13 'load smoothing' community batteries, with the first in Meadow Springs and others such as those in Busselton and Kalgoorlie.[7] For three of these batteries we have partnered with Synergy using PowerBank products that allow customers to store excess electricity generated by their solar panels in a network-scale battery and draw on this during peak times. We have also partnered with the Shire of Margaret River to install a community battery on the customer-side of the meter. This unique trial will investigate the local network benefits of network-scale batteries installed behind-the-meter. More community batteries are planned to be installed over the next few years.

Advanced Metering Infrastructure – Advanced Metering Infrastructure is now being deployed to homes and businesses across the Western Power network. Advanced meters will enable customers to maximise the benefits of new technologies, provide customers with greater insights into their electricity usage, and create a more stable and safe energy supply. Advanced meters are a key enabler of future-focused Government policy and initiatives that will help create the electricity grid of the future.

Bremer Bay automation – Due to the distance covered by the network supplying the area, Bremer Bay town customers have experienced frequent and lengthy outages in the past. To reduce these outages to under one minute an automated scheme starts the Synergy-owned power station automatically when supply from the network is lost and stops it when supply is restored. The automation scheme, delivered in collaboration with Synergy was successfully commissioned in December 2017.

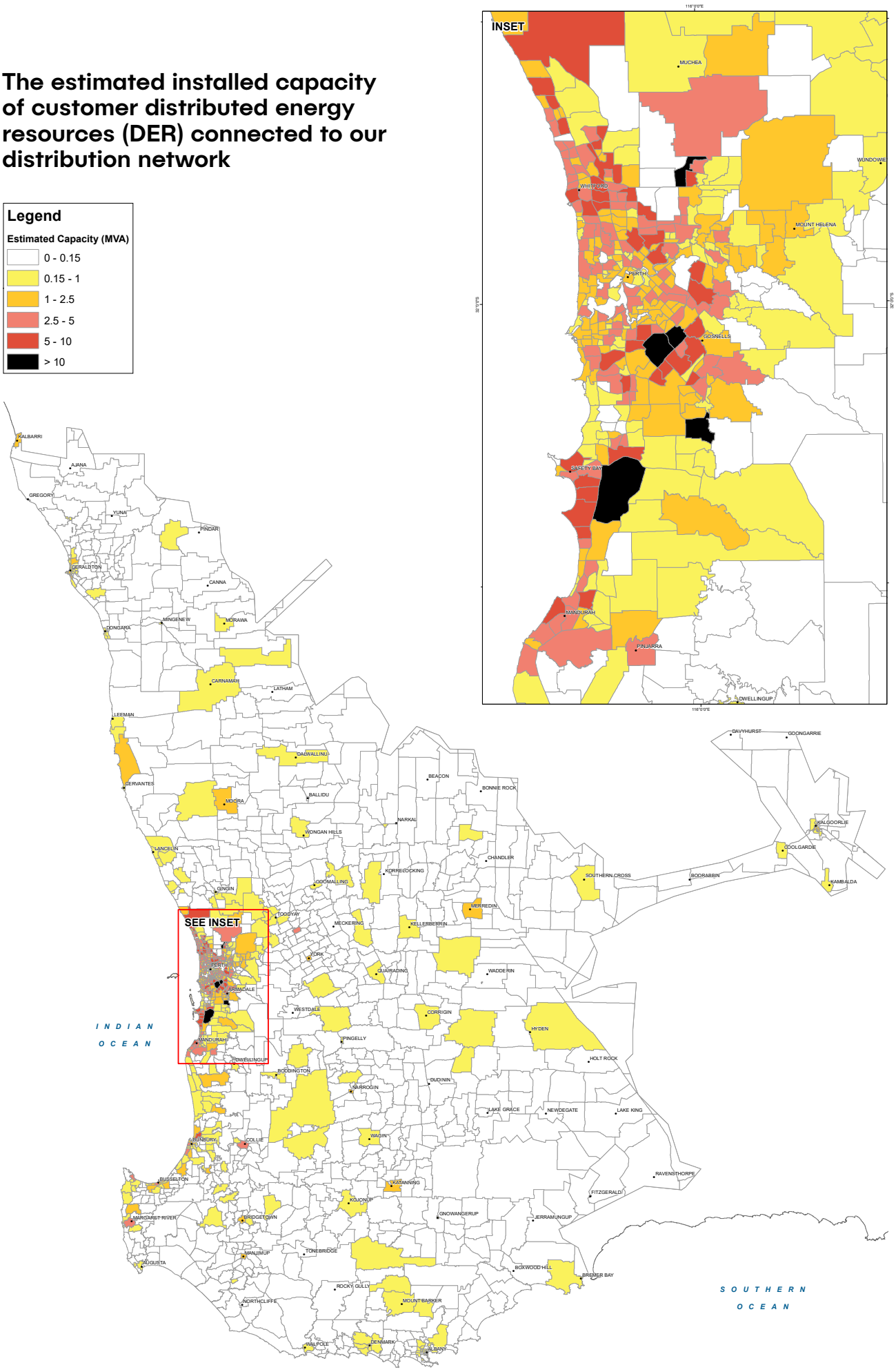
On Load Tap Changers on Distribution Transformers – The ongoing installation of customer solar PV is contributing to substantial voltage variations over the course of a day on some LV networks. Distribution transformers fitted with an On Load Tap Changer (OLTC) can help to actively manage these voltage variations within prescribed limits. As at 31 August 2020, we are trialling 11 separate sites, and if successful, this technology will allow us to address multiple drivers by deploying distribution transformers that are fundamentally the same units as currently used, with additional OLTC functionality.

Distributed Energy Resources (DER)

The estimated installed capacity of customer distributed energy resources (DER) connected to our distribution network as at 30 April 2020 is shown in the map opposite.

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

The estimated installed capacity of customer distributed energy resources (DER) connected to our distribution network



You can connect with us

Increasingly, we are acting as a platform for business and residential customers to choose how they want their electricity supplied and delivered.

During the next five years, we will be making network changes to support customer needs.

Specifically, we are considering not just augmentation of the network, but also non-traditional options such as demand management, local generation and non-standard connections.

We see our role as laying the foundations for industry change and we expect many opportunities for others in the industry to join us.

5

Key completed projects

Key completed projects

This section lists key projects completed in the period between 1 January 2019 and 30 June 2020 (unless otherwise stated). These projects have responded to the drivers of load growth, new connections, and asset condition, as applicable. The key benefit delivered by each project is also listed.

Key completed transmission network projects

Projects	Benefits
Rangeway substation: install an additional 132/11kV transformer	Increased transformer capacity to supply new and increased loads
Meadow Springs substation: install an additional 132/22kV transformer	Increased transformer capacity to supply new and increased loads

Key completed distribution network projects

Projects	Benefits
Rangeway substation: distribution works associated with the installation of an additional 132/11kV transformer	Increased distribution feeder capacity to supply new and increased loads
Meadow Springs substation: distribution works associated with the installation of an additional 132/22kV transformer	Increased distribution feeder capacity to supply new and increased loads
Stand-alone Power Systems Round 1 (52 units at various locations – last unit commissioned in October 2020)	Reduced network cost and improved reliability of supply
Community batteries installed at 13 locations (refer to Section 4 for the list)	Improved network performance with increased Distributed Energy Resources (DER)
Installed distribution transformers fitted with an on-load tap changer (OLTC) at 11 locations (last unit commissioned in July 2020)	Improved network performance with increased Distributed Energy Resources (DER)
Metro, South Country and North Country (various locations): upgrade overloaded transformers	Relieved overloads and provided increased capacity to supply new and increased loads
Metro, South Country and North Country (various locations): correct power quality issues	Improved quality of power supply to customers
Under Fault Rated Conductor and/or Protection Upgrade Programs (on various feeders supplied from the following zone substations: Albany, Beechboro, Black Flag, Busselton, Capel, Clarkson, Eneabba, Hadfields, Moora, Northam, North Perth, Picton, Osborne Park, West Kalgoorlie, Yokine)	Mitigated safety risk and risk of outages due to under fault rated conductor; ensured compliance with the Technical Rules in relation to protection and fault level requirements via either replacement and/or improvement in protection
Decommission Mundaring Weir substation and transfer load to the Sawyers Valley zone substation	Addressed degraded condition of assets

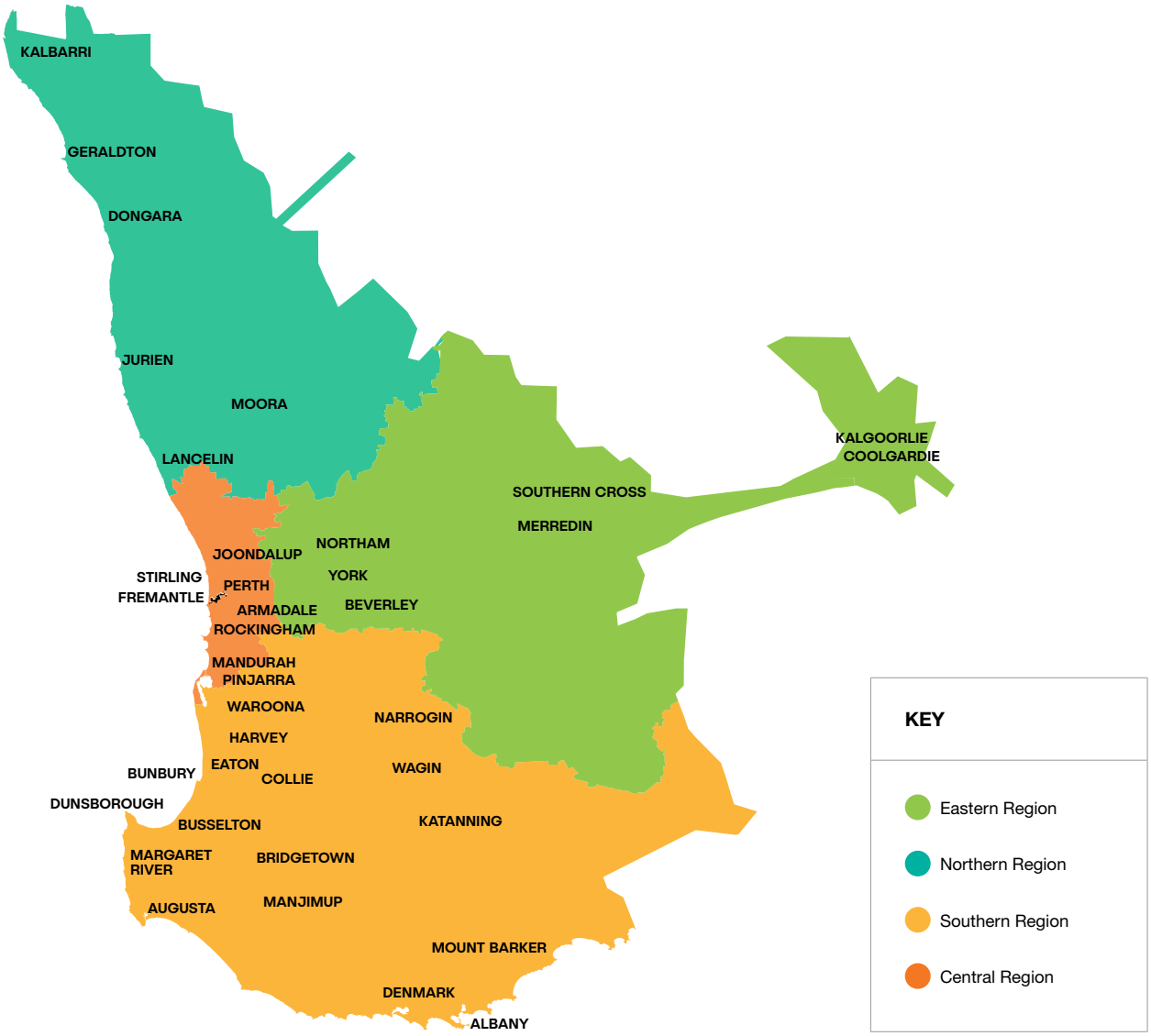
6

Transmission network issues and developments

Transmission network issues and developments

The Western Power transmission network extends from Geraldton in the north to Albany in the south and to Kalgoorlie in the east.

This area covers four major regions, Eastern, Northern, Southern and Central, for transmission planning purposes, as shown in the following map.[8]



8 It is noted that the WOSP uses 11 "transmission network zones" for modelling purposes.

We routinely assess the condition of transmission assets and the ability of the transmission network to supply existing and future demand growth in accordance with the Technical Rules.[9] The Technical Rules specify the level of supply reliability and system security that must be maintained.

This section outlines our committed and proposed projects on the transmission network (66kV and above) developed in response to existing constraints, and those forecast to emerge over the next five years. In addition, it indicates opportunities for future load and generation connections for each of the four regions.

If you have or are planning proposals for new load connection, generation capacity and/or Network Control Services (NCS), capable of providing network support, we invite you to contact us to discuss requirements and opportunities. Please contact our Access Solutions Manager at: network.access@westernpower.com.au

Emerging challenges

The global energy transformation and increasing renewable generation (incorporating inverter-based technologies) has triggered a greater awareness of a power system characteristic referred to as 'system strength'. System strength is a measure of voltage 'stiffness' and it supports the correct and stable operation of renewable generators.

The system strength of a power system has typically been provided by traditional generation technologies such as coal-fired generators and gas turbines. These same generators also provided most of the system rotating inertia.

Today, with the displacement of traditional generators and the connection of large-scale inertia-less renewables at the fringe of the grid, system strength issues and issues relating to a reduction in system inertia are emerging.

We are currently managing the connection of approximately 900MW of renewable generation in the Northern Region and Eastern Region via the Generator Interim Access (GIA) solution. The GIA will eventually be replaced by a Security Constrained Economic Dispatch (SCED) engine to be implemented post market-reforms when the WEM transitions to constrained access.[10] The SCED and additional supporting tools will identify with greater clarity the power system limits, provide spare capacity information to generators and facilitate the connection of renewables, and reduce the overall cost electricity cost for customers.

6.1 Preferred strategies to address emerging transmission network issues by region

Eastern Region

Key existing and emerging transmission network limitations within a five-year study period in the Eastern Region are:

Thermal limits

» Some thermal limitations exist at the West Kalgoorlie 220/132kV Terminal which impacts the ability to connect new loads in the Eastern Goldfields (EGF) load area. These network limitations form part of the Eastern Region Competing Applications Group (CAG) 82 as discussed in Section 6.2.

9 https://www.erawa.com.au/cproot/14411/2/edm%2040518689%20-%20technical%20rules%201st%20august%202016%20publish%20version%20-%20fri.pdf

10 Refer to Section 2 of this Report.

» The existing thermal limitations on the 132kV line between Northam and Merredin may arise under peak load conditions following an outage of a section of the 220kV line between Muja and Merredin Terminals. It could also arise as a result of power exports from the Eastern Region under lighter load conditions. These limitations are currently managed by some protection schemes and runback schemes.

Voltage limits – in the EGF load area the voltage stability limits arise due to insufficient reactive reserve and transient limits are driven, in part, by the relatively low inertia of generating units. These limitations are currently managed through some special control schemes.

Substation capacity – the load forecast indicates the Black Flag substation is expected to exceed its capacity within the study period.

Supply reliability – a supply interruption to the EGF load area could occur following a planned or an unplanned outage on the 220kV network which provides a radial supply to the EGF area. This is currently managed by a Network Control Service (NCS) contract between Western Power and Synergy as discussed in Section 6.4.

Asset condition

» Condition assessment of the saturated reactor components of the SVCs at West Kalgoorlie and Merredin 220/132kV Terminals shows that both are deteriorating and reaching the end of their lives.
» A large number of 66kV transformers at substations (including Cunderdin, Kellerberrin, Merredin, Northam, Southern Cross, Wundowie and Yerbillon) in the Eastern Region 66kV network are in a degraded condition. This requires a staged approach for implementing the potential mitigation solutions (including refurbishment, replacement, mobile transformer, decommissioning, etc.) over the next 10 years.

Eastern Region committed and proposed works

Projects	Benefits	By when
Committed works as at 30 June 2020 *		
West Kalgoorlie: Replace the Static Var Compensators with new STATCOMs	Mitigate safety and reliability risks, maintain dynamic reactive power support/voltage stability and reduce out-of-merit generation costs	2023
Merredin: Refurbish the Static Var Compensator		2021
CAG[11] 82: Install a third 220/132kV transformer at West Kalgoorlie, rated at 250MVA	Increase the available thermal capacity and reactive power support to enable connection of large customers in the EGF load area (refer to Section 6.2)	2022
CAG[11] 82: Install dynamic voltage control devices (STATCOMs) in the EGF area		
Proposed works **		
Northam: Transformer replacement	Address degraded asset condition	2022
Wundowie: Resupply from Sawyers Valley substation	Address degraded asset condition by transferring the load from Wundowie and de-energising the substation	2024
Black Flag: Address substation capacity shortfall	Increase the available substation capacity to enable connection of new customers (refer to Section 6.2)	2023

Note:

* To be considered as committed, transmission augmentations must satisfy all of the following criteria:
- Ministerial approval (if required)
- Board commitment has been achieved (if required)
- funding approval
- the project has satisfied the Regulatory Test (if required)
- for augmentations required to connect a customer, that a customer has unconditionally signed an Interconnection Works Contract (IWC) with Western Power (if required)
- construction has either commenced or a firm commencement date set.
- Any projects that do not meet all of these criteria are classified as 'proposed works'.

** It is important to note that the proposed works are subject to various approvals which must be obtained before works can commence. Expected completion dates are subject to change.

11 Competing Applications Group.

Northern Region

Key existing and emerging transmission network limitations within a five-year study period in the Northern Region are:

Thermal limits

» Thermal limitations could arise on a number of 132kV lines to the south of Three Springs substation following an outage on some sections of the 330kV line between Three Springs and Northern Terminal. This limitation is currently managed by a special protection scheme.

» Thermal limitations could also arise on lines in the Three Springs to Mungarra 132kV corridor under conditions of high generation to the north of Three Springs substation, following the loss of one circuit. This is currently managed by post-contingent generation runback schemes.

Supply reliability

» A supply interruption to Geraldton town could occur following a loss of lines in the Three Springs to Mungarra 132kV corridor. This is currently managed by a Network Control Service (NCS) contract between Western Power and Synergy as discussed in Section 6.4.

Asset condition

» Routine asset condition monitoring has identified the majority of 33kV outdoor switchgear and busbar assets at Geraldton substation are in degraded condition.

Northern Region proposed works

Projects	Benefits	By when
Proposed works ** see note on page 31		
Geraldton: Replace existing 33kV switchyard	Mitigate the safety and network reliability risks associated with the ageing 33kV assets	2024

Southern Region

Key existing and emerging transmission network limitations within a five-year study period in the Southern Region are:

Thermal limits

» A thermal limitation could arise on the Kojonup to Wagin 66kV circuit following an outage of the Kojonup to Katanning 66kV circuit.

» A thermal limitation could arise on the Southern River to Alcoa Pinjarra/Wagerup 132kV circuit following the loss of the Alcoa Pinjarra to Pinjarra 132kV circuit. This is currently managed by a generation runback scheme.

» A thermal limitation could arise on the Alcoa Pinjarra to Pinjarra 132kV line following a number of contingencies under some generation scenarios during peak load conditions. By monitoring the load demands in the Bunbury load area and the embedded loads at the Alcoa Pinjarra 132kV site, the likelihood of event occurrence is considered as low (~1% of year) and it could potentially be managed by runback of 132kV generation. The risk is also expected to reduce further as a result of Muja C units' retirement over the next few years and potential Kwinana 132kV de-mesh works.

» A thermal limitation could also arise on the 132kV network between Kemerton, Marriott Road and Picton substations under some N-1 and N-1-1 contingencies. The maximum power transfer limit on the 132kV network in this region is limited by the thermal rating of the Picton to Marriott Road 132kV line with the critical contingencies being the loss of Muja BTT1 and BTT2 bus-tie transformers. This network limitation forms part of the Southern Region CAG 99 as discussed in Section 6.2.

Voltage limits

» Voltage instability may arise in the 66kV network around Katanning, Wagin and Narrogin following an outage of the Kojonup to Katanning 66kV line.
» High/low voltage violations and excessive voltage step conditions may arise on the transmission network south of Picton, including Busselton, Margaret River and Capel, following the loss of the Kemerton, Pinjarra, Picton and Busselton 132kV line.

Substation capacity

» The load forecast indicates that Marriott Road and Bridgetown substations are expected to exceed their capacity within the study period due to the increase of some major industrial loads in the areas. These industrial customers are connected on a non-reference service basis, and hence the capacity shortfalls can be managed by curtailing the non-reference loads as a result of an outage of a transformer.
» The load forecast also indicates that the Capel substation is expected to exceed its capacity within the study period.

Asset condition

» Routine condition-based monitoring and assessments have identified the Kemerton T1 Terminal transformer and Wagerup T1 transformer are in a degraded condition.
» Many 66kV assets, including terminal/zone substation transformers and primary plant, in the Bunbury load area between Picton, Capel and Coolup are in a degraded condition and require mitigation within the study period.
» Some 66kV transformers in the Muja 66kV network (including Wagin, Katanning and Kojonup substations) are in a degraded condition, requiring a staged mitigation solution over the next 10 years.

Southern Region committed and proposed works

Projects	Benefits	By when
Committed works as at 30 June 2020 * see note on page 31		
Picton: Replace two existing 66/22kV transformers with two new 132/22kV transformers	Address the degraded condition of the assets and accommodate increasing demand	2022
Capel: Replace existing 66/22kV transformer with a new 132-66/22kV 33MVA transformer	Address the degraded condition of the asset and accommodate increasing demand	2021
Wagerup: Replace existing transformer with a new 132/22kV transformer	Address the degraded condition of the asset	2022
Kemerton: Install a new 330/132kV 490MVA terminal transformer	Address the degraded condition of one of the existing transformers. This will also increase the available capacity to enable connection of large customers	2022
Coolup: Decommission substation after transferring load to Wagerup zone substation	Eliminate the risk of asset failures including the two existing transformers with the de-energisation of the substation under Phase 1, and the de-commissioning in Phase 2	Phase 1: 2022 Phase 2: 2024
Proposed works ** see note on page 31		
Katanning, Wagin and Narrogin: 66kV network reinforcement	Address the associated thermal and voltage limitations	2022
Katanning: transformer replacement	Address the degraded asset condition issues	2025
Wagin: transformer replacement	Address the degraded asset condition issues	2024
Picton South Transmission Reinforcement – Stage 1	Address the degraded asset condition issues	2024 (Stage 1)
CAG[12] 99: Establish a new 132kV line between Kemerton and Picton	Increase the available capacity to enable future load connections	2022

12 Competing Applications Group.

Central Region

Key existing and emerging transmission network limitations within a five-year study period in the Central Region are:

Thermal limits

- A thermal limitation could arise on the Pinjarra to Meadow Springs/Cannington Terminal 132kV circuit following the loss of the Mandurah to Pinjarra 132kV circuit under a certain generation scenario during peak load conditions. The likelihood of event occurrence is considered as low and the risk is also expected to reduce further as a result of Muja C units' retirement over the next few years and potential Kwinana 132kV de-mesh works.
- A thermal overload could also arise on the Northern Terminal to East Perth/Belmont circuit following the loss of the Northern Terminal to Shenton Park 132kV circuit. This overload is predominantly triggered by the high renewable generation outputs from the Northern Region, which were connected under the Generator Interim Access (GIA) arrangement. It can be managed by generation curtailment via GIA Limit Equations.
- Similarly, some thermal limitations exist in a few sections of the 132kV network to the north of Northern Terminal, Pinjar and Muchea following N-1 contingencies under peak load conditions. These sections are the main limiting components to the power transfer capability from the Northern Region to the Central Region.
  The extent of overloading on these 132kV lines is highly dependent on the status of the Neerabup 330/132kV transformer, the generation outputs from Newgen Neerabup and Pinjar units, and the renewable generation outputs from the Northern Region. These limitations can be managed by operating the Neerabup 330/132kV transformer as out-of-service and curtailing the output of GIA renewable generators in the Northern Region via Limit Equations under some load and generation conditions.
- However, it is anticipated that the full retirement of Muja C units by 2024 could introduce some complications to this situation. To prevent the potential overloads on these 132kV lines, generation outputs from various units may need to be maintained at a certain range potentially under the future constrained market.

Voltage limits

- High voltage violations have recently been identified as an emerging issue in Western Power's network under light load conditions. The high voltage issues are anticipated to arise in a few parts of the network across the Central Region. These issues are proposed to be addressed by installing a number of reactors across the networks in the short-term, with the DER Roadmap including a range of measures to support voltage control in the medium to long term.

Substation capacity

- The load forecast indicates that Henley Brook substation is expected to exceed its capacity within the study period. As an interim solution, the Henley Brook substation can be offloaded to the surrounding substations via switching operations. The load demand at this site will be continuously monitored and assessed to determine if any permanent solutions are required.
- The load forecast also indicates that some substations may have either a minor capacity shortfall or will approach their capacity limits within the study period. These sites include Byford, Bunbury Harbour, Clarkson, Joondalup, Mandurah and Southern River. The risk is considered as low due to the sufficient distribution transfer capability available to the surrounding substations.

Equipment fault rating

» Due to the heavily meshed 330kV and 132kV networks in the Central Region, the fault levels at a few parts of network (including Kwinana, Southern Terminal and Northern Terminal load areas) are high and potentially can exceed the fault rating of some primary plant and earth grids. These issues have been effectively managed by the following operational measures under some conditions to reduce the fault levels on the relevant networks.
  - Operate the Kwinana 330/132kV bulk transformer out-of-service
  - Reconfigure the South Fremantle to Southern Terminal 132kV line and the Southern Terminal to Kwinana 132kV line to bypass Southern Terminal
  - Operate Northern Terminal 132kV buses under a split arrangement
  - Operate Mount Lawley Substation 132kV buses under a split arrangement.
» With the proposed establishment of a 132kV cable link between Hay Street and Milligan Street substations, the fault levels in the surrounding networks are expected to increase. A study is underway to investigate the operational measures to manage the potential inadequate equipment fault rating issues.
» A number of 66kV disconnectors at Collier and Clarence Street substations have inadequate fault rating. Further risk assessment will be required, and an associated mitigation plan will be considered in conjunction with the proposed long-term 66kV retirement strategy in the Cannington Terminal load area.

Asset condition

» Routine condition-based monitoring and assessments have identified a number of switchboards at Hay Street, Milligan Street, Osborne Park, Yokine and Manning Street substations that are in a degraded condition, requiring mitigation within the study period.
» It has also been identified that the deteriorated condition issues for some transformers at Mullaloo, Tate Street and Yokine substations require mitigation within the study period.
» There are a number of 66kV assets, including transformers, transmission cables and primary plant in East Perth/CBD load area between Wellington Street, Forrest Avenue and East Perth substations that have been assessed in a degraded condition. The proposed mitigation plan and timing are being considered in conjunction with DevelopmentWA's proposal to redevelop the East Perth Power Station Precinct.
» North Fremantle substation has been safely de-energised. The plan is to remove all the redundant assets from the site and return the land to the Fremantle Port Authority.
» Some 66kV assets in the South Fremantle 66kV network (including Australian Paper Mills, Edmund Street, Myaree, O'Connor and South Fremantle substations) are in a degraded condition. It is anticipated that a staged approach to implement the mitigation plans will be required over the next 10 years.

Central Region committed works

Projects	Benefits	By when
Committed works as at 30 June 2020 * see note on page 31		
Perth CBD: Hay Street and Milligan Street substation supply reinforcement – installation of a new 132kV circuit between the sites	Facilitates the rationalisation and replacement of assets in the Perth CBD and compliance with the planning criteria in the Technical Rules	2021
Perth Metro: switchboard refurbishments at Hay Street (HAY) and Milligan Street (MIL) substations and replacements at Osborne Park (OP) substation	Address the degraded condition of the switchboards and increase network reliability	HAY: 2021 MIL: 2020 OP: 2020
Mullaloo: Transformer replacement	Address the condition of the existing transformer	2021
Tate Street: Substation de-energisation	Address the condition of the existing two transformers by offloading onto adjacent substations to minimise loss of supply to customers	2021
Yokine: Switchboard and transformer replacement	Address the condition of the existing switchboard and transformer noise issue	2023
Forrest Avenue: Off-load substation to adjacent substations and decommission substation	Address asset condition and transformer noise issues	2022
Various sites in the metropolitan area: Reactive support	Address system high voltage issues during low load conditions with the installation of reactors at Yanchep, Clarkson, Henley Brook, Wanneroo, Joondalup, Southern River, Neerabup Terminal, Guildford Terminal, Southern Terminal and Northern Terminal substations	2021
Various metro and country sites: Feeder monitoring	Provide for distribution feeder measurements to allow for identification and analysis of voltage issues on the distribution network. Also facilitates an improved under-frequency load shedding (UFLS) scheme	2021

Central Region proposed works

Projects	Benefits	By when
Proposed works ** see note on page 31		
North Fremantle: Decommission substation	Remove the degraded and redundant assets	2022
Manning Street: Switchboard replacement	Address degraded asset condition	2024
Wellington Street: Substation decommission	Address degraded asset condition	2024[13]

6.2 Opportunities for future load connections

This section indicates locations where network constraints exist and can be used to identify opportunities for future load and generation connections.

It is important to note that the network is inherently dynamic and complex, customers' needs change and we regularly receive new connection applications.

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

Our Applications and Queuing Policy (AQP)[14] sets out how connection applications and access offers are managed. It is designed to manage applications in an orderly, transparent, and fair manner, especially where network capacity is scarce. The AQP underpins and regulates the connection process, which progresses customers along a pathway consisting of several milestones, leading to an Access Offer for connection to our network.

To discuss the AQP, the connection process and specific opportunities to connect to our network, please contact the Access Solutions Manager at: network.access@westernpower.com.au

Non-competing load application thresholds

We use thresholds to help determine 'competing' load applications as part of the AQP. We consider load applications which meet the following two criteria to be non-competing for the purpose of the AQP.

- the total load must not exceed 1.5 MVA for its National Metering Identifier (NMI)
- the load application must be eligible for network tariffs RT1-RT6.

13 The required work completion date is highly dependent on Development WA's proposal for the redevelopment of the East Perth Power Station Precinct.

14 Applications and Queuing Policy, at https://www.erawa.com.au/electricity/electricity-access/western-power-network/western-powers-network-access-arrangements/western-power-access-arrangement-period-2017-2022

Customers on network tariffs RT1-RT6 best represent customers that are considered part of 'natural load growth'. All load applications deemed to satisfy the test criteria will be granted firm access to the Western Power network. All other load applications will be subject to further assessment to determine if they are behind network constraints.

Strategies to increase network capacity

We have progressed a number of applications for block load connections in the Eastern Region as part of CAG 82 to deliver additional capacity to the Eastern Goldfields. Some works are underway and the key works are listed in the table on page 31.

Ahead of the project in-service date, we have successfully implemented interim supply arrangements for a number of customers participating in the CAG, and we continue to work with other customers to investigate interim supply arrangements, where feasible. This includes the work performed in 2019/20 on the EGF Load Permissive Scheme where spare network capacity is made available to EGF customers on a non-reference basis via an automated control system. Both new customers and existing customers are engaging with us at present to better understand how this non-reference spare capacity can be used by their businesses.

In addition to the work in the Eastern Region, we continue to work with large mining and other customers, local government, and other stakeholders including those in the Southern Region to facilitate their energy needs. We are in the process of developing revised transmission network strategies for these and other regions.

Spare capacity at zone substations

Based on a forecast of the underlying load growth and the processed block load connections, we have reviewed the capacity of all the Western Power zone substations to assess if there are any capacity shortfall issues over the next five years.

The existing zone substation capacities, utilisation in 2019 and the forecast utilisation in 2025 (based on PoE50 load forecast) are outlined in the substation capacity table on page 40. With respect to the substation sites with high utilisation (highlighted in red), the proposed plans to mitigate capacity issues are described in Section 6.1.

Our Network Capacity Mapping Tool (NCMT) is available on our website[15] and provides a visualisation of network capacity. Its primary objective is to give you an insight into our forward-looking network capacity based on all planned network changes and growth plans. This enables you to view our current and proposed electrical network and understand how this may affect your development plans and investment options. The NCMT provides a more granular forecast of remaining spare capacity at each zone substation than provided in the substation capacity table. The information in the NCMT will be updated following publication of this APR and the update is expected to be completed by the end of March 2021.

Disclaimer: It is important to note that the table only presents the spare capacity at zone substation level. The connection assessment and associated reinforcement requirements will need to consider the availability of capacity at transmission network level in the wider load area and the localised distribution feeder network.

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

Table legend	
Target utilisation	≥ 40% and ≤ 90%
Low utilisation	< 40%
High utilisation	> 90%

Substation capacity

Regions/substations	Existing substation capacity (MVA)	Utilisation in 2019	Forecast utilisation in 2025 based on PoE50 load forecast
Eastern Region			
Black Flag	31	117%	134%
Bounty	10	104%	97%
West Kalgoorlie Terminal 33kV	30	80%	60%
Merredin	13	72%	78%
Wundowie	16	65%	72%
Northam	41	63%	60%
Cunderdin	14	52%	51%
Piccadilly	64	50%	48%
Kellerberrin	6	49%	51%
Yilgarn	29	42%	44%
Boulder	62	39%	50%
West Kalgoorlie Terminal 11kV	31	33%	32%
Sawyers Valley 132kV	56	31%	32%
Kondinin	29	30%	30%
Carrabin	6	15%	17%
Southern Cross	13	14%	9%
Northern Region			
Moora	16	79%	78%
Rangeway	34	72%	67%
Regans 22kV	19	51%	43%
Three Springs	16	51%	47%

Substation capacity

Regions/substations	Existing substation capacity (MVA)	Utilisation in 2019	Forecast utilisation in 2025 based on PoE50 load forecast
Geraldton	65	46%	54%
Chapman	31	40%	37%
Regans 33kV	19	38%	39%
Durlacher Street	29	36%	40%
Eneabba	31	26%	24%
Southern Region			
Bunbury Harbour	62	91%	91%
Capel	22	89%	95%
Albany	60	87%	84%
Wagin	6	87%	87%
Katanning	20	72%	71%
Picton	60	64%	68%
Bridgetown	29	63%	111%
Marriott Road	67	60%	105%
Busselton	71	58%	63%
Coolup	12	45%	47%
Collie	30	43%	44%
Beenup	14	43%	45%
Boddington	10	43%	48%
Margaret River	37	42%	41%
Manjimup	29	41%	45%
Narrogin	40	39%	37%
Wagerup	30	35%	41%
Kojonup	10	25%	25%
Mount Barker	44	17%	17%
Central Region			
Henley Brook	53	101%	105%
Clarkson	56	95%	85%
Byford	77	91%	89%
Mandurah	76	85%	90%
Joondalup	53	82%	81%
Wembley Downs	43	81%	85%

Substation capacity

Regions/substations	Existing substation capacity (MVA)	Utilisation in 2019	Forecast utilisation in 2025 based on PoE50 load forecast
Hazelmere	27	81%	79%
Waikiki	80	80%	76%
Southern River	85	79%	87%
Willetton	26	76%	76%
Padbury	82	74%	67%
Wellington Street	29	74%	80%
Bibra Lake	56	73%	66%
Landsdale	88	72%	74%
Beechboro	87	72%	81%
Forrest Ave	39	71%	68%
Osborne Park	63	71%	82%
Gosnells	79	71%	71%
Cottesloe	54	71%	73%
Wangara	28	70%	63%
Welshpool	90	67%	70%
Murdoch	54	67%	70%
Yokine	70	67%	73%
Riverton	81	65%	70%
Maddington	26	64%	73%
Rockingham	78	64%	72%
Manning Street	43	63%	60%
Cook Street	81	62%	66%
Wanneroo	84	62%	69%
Arkana	72	62%	64%
North Beach	75	61%	62%
Kewdale	56	61%	42%
Australian Paper Mills	46	60%	58%
Yanchep	61	59%	66%
Meadow Springs	86	59%	64%
Mullaloo	66	58%	72%
Medina	81	58%	56%
Amherst	85	58%	62%

Substation capacity

Regions/substations	Existing substation capacity (MVA)	Utilisation in 2019	Forecast utilisation in 2025 based on PoE50 load forecast
O'Connor	70	57%	61%
Milligan Street	134	57%	55%
Morley	79	55%	62%
Cockburn Cement	77	55%	51%
Canning Vale	93	55%	54%
Midland Junction	94	55%	56%
Hadfields	77	54%	56%
North Perth	79	54%	56%
Mason Road	74	53%	53%
Medical Centre	83	53%	57%
Myaree	65	53%	61%
Shenton Park	71	53%	53%
Tate Street	72	52%	50%
Clarence Street	43	51%	56%
Collier	69	51%	55%
Rivervale 132kV	83	51%	55%
Edmund Street	43	51%	58%
Belmont	72	49%	49%
Muchea	51	46%	45%
Darlington	48	46%	48%
Hay Street	143	42%	38%
Pinjarra	57	41%	37%
Malaga	81	40%	41%
Munday	54	39%	45%
Kalamunda	81	37%	39%
Forrestfield	80	37%	39%
Bentley	56	36%	36%
Joel Terrace	76	32%	37%
Balcatta	53	26%	32%

6.3 Opportunities for future generation connections

Non-competing application thresholds

Inverter connected generators with a total installed capacity less than 10 MVA connecting to the distribution network may be deemed as not constrained and non-competing for capacity on the transmission network. Please refer to Section 7 ("Connecting to our distribution network").

GIA generator connections

Several areas in the network have very limited network capacity to support new generator connections on a reference service basis without significant network augmentation while an unconstrained network access model is in place.

We are currently progressing applications for generator connections, particularly in the Northern Region and Eastern Region.

Generator access to our network and dispatch under the Wholesale Electricity Market (WEM) are currently unconstrained.[16] As discussed in Section 2, the State Government proposes to adopt a constrained network access regime in the SWIS as part of the Energy Transformation Strategy (ETS).

The development of a new network access regime under the ETS will consider:

- Existing network constraints/congestion
- The effect of the new regime on existing generators
- Generator dispatch outcomes
- Revenue projections
- Generation supply adequacy.

While the ETS is being progressed, the Generator Interim Access (GIA) solution was launched in July 2018, with the aim of providing an interim, constrained access connection for a limited number of generators to facilitate further connections to the SWIS.

The objectives of the GIA are to:

- curtail new generators (only) to maintain system security (i.e. not affect the contracted unconstrained access of existing generators)
- have a dispatch objective of least-cost dispatch using a 'minimise-runback' approach based on contribution to network constraint (or coefficient).

We have progressed a number of generator applications in the last two years that are subject to the GIA. These generators are predominantly located in the Northern and Eastern Regions due to the abundance of renewable resources in the areas.

16 Except in situations where customers have agreed to connect on a non-reference basis to avoid network augmentation.

Generators connected and committed to be connected

Projects	Region	By when
Completed works as at 30 June 2020		
Badgingarra Wind and Solar Farm (130 MW)	Northern Region	2019
Beros Rd Windfarm (9.8 MW; distribution connected)	Northern Region	2019
Committed works as at 30 June 2020 * see note on page 31		
Yandin Wind Farm (210 MW)	Northern Region	2020
Warradarge Wind Farm (180 MW)	Northern Region	2020
Merredin Solar Farm (100 MW)	Eastern Region	2020

Future generation connection opportunities

The Whole of System Plan, as mentioned in Section 2, provides an optimised view of network and generation in the SWIS over the next twenty years. This plan provides guidance on which network zones offer the best connection opportunities for new generation.

We are also developing our process and documentation regarding opportunities for future generation connection. Information will be published in future APRs for interested parties.

At present, we have some network reinforcement proposals, predominantly located in the Kwinana load area in the Central Region, to facilitate and encourage the future generation connections in the area.

6.4 Network Control Service and other opportunities

With the rapid changes brought about by energy transformation, new and emerging system challenges will create new opportunities for the companies to provide services to Western Power via the Network Control Service and other mechanisms.

At present we have a Network Control Service (NCS) contract with Synergy operating in the Northern Region and the Eastern Goldfields (EGF). This NCS provides a mechanism to dispatch Synergy's generation facilities to enable us to:

» continue providing reliable supply to customers in the Geraldton town and its surrounds in the Northern Region, and customers in the towns of Kalgoorlie-Boulder and Coolgardie in the EGF, which is compliant with the requirements in the Electricity Industry (Network Quality and Reliability of Supply) Code 2005.[17]

17 Refer to https://www.legislation.wa.gov.au/legislation/statutes.nsf/main_mrtitle_1349_homepage.html for details of the obligation.

» secure sufficient planned outages to be able to deliver customer and network driven works, including maintenance in the same areas.

The NCS contract will expire in 2022, with an option to extend by one year. We may seek bids from the market for the replacement of services provided under the NCS contract to continue to safeguard the supply to these two areas.

As outlined in Section 4, our Flexibility Services Pilot aims to demonstrate how network support services[18] may help commercial and industrial customers realise the value of their distributed energy resources while supporting the network.

18 https://cdn-au.mailsnd.com/26738/L5R4xFPqN17nj7EitGlOs0c2RShrbKL2pnN4rPRRHOE/3305166.pdf

Network Control Service and other opportunities						
Area of network limitation	**Issues**	**Capacity shortfall**	**Peak demand growth rate (MVA pa)**	**Occurrence of capacity shortfall**	**Proposed network solution**	**Comment**
Geraldton	Supply interruption during planned or unplanned outages	Up to 50MW	Varies	Subject to assessment	Augment 132kV transmission network	We have contracted for NCS in the Geraldton region to provide up to 50MW of supply to the Geraldton Town and surrounding areas (i.e. supplied by 11kV feeders)
Kalgoorlie	Supply interruption during planned or unplanned outages	Up to 45MW	Varies	Subject to assessment	Augment 220kV and 132kV transmission networks	We have contracted for NCS in the EGF to provide up to 45MW of supply to the Kalgoorlie Town and surrounding areas (i.e. supplied by 11kV feeders and a WKT 33kV feeder)
Whole of network	Help build the capability needed to deliver on the WA Government's Distributed Energy Resources Roadmap	Up to 100MW	Varies	Subject to assessment	Varies	Refer to our website[19] for more information

19 https://westernpower.com.au/our-energy-evolution/projects-and-trials/100mw-industry-challenge/


YAGAN

7

Distribution network issues and developments

Distribution network issues and developments

This section outlines key committed projects and preferred network strategies on the distribution network (less than 66kV) developed in response to existing constraints, and those forecast to emerge over the next five years. This information is provided for the same four regions listed in Section 6.

Key approved distribution network projects

Projects	Benefits	By when
Kalbarri Microgrid	Improve reliability of supply to customers in Kalbarri	2021
Decommission Forrest Avenue zone substation and transfer loads to Joel Terrace zone substation	Address degraded condition of assets and provide increased distribution network capacity	2023
Decommission Coolup zone and after transferring load to Wagerup zone substation	Addresses degraded condition of assets	Phase 1: 2022 Phase 2: 2024
CBD: Hay/Milligan Zone Substations Supply Reinforcement	Facilitate the rationalisation and replacement of assets in the Perth CBD	2021
Perth City Link – install ducts and cables	Increased distribution feeder capacity to supply new and increased loads at Perth City Link	2020
Feeder loading and Power Quality (various locations)	Improve distribution feeder and distribution transformer loadings and improve quality of supply to customers	2021
Over-voltage (various locations)	Improve voltage supplied to customers at eleven zone substations and associated distribution feeders	2020
Reliability (Bridgetown and Perth CBD)	Improve reliability of supply to customers	2020/21
Improve customer reliability at Mason Road and Rivervale zone substations	Improve zone substation flexibility to minimise outage to customers during switchboard outages	2020

Key approved distribution network projects (cont)

Projects	Benefits	By when
Southern Region network loading imbalance	Mitigate load imbalance on five single-phase spurs	2020
Under fault rated conductor and protection systems (Amherst Street, Clarkson, Padbury, Mandurah, Meadow Springs, Rangeway)	Mitigate safety risk and risk of outages to customers due to under fault rated conductor and protection system compliance; ensure compliance with the Technical Rules in relation to protection and fault level requirements via either replacement and/or improvement in protection settings	2020/21

Distribution network strategies to address emerging issues by region

Eastern, Northern and South Regions

The following table lists the distribution network strategies applicable to the region based on the anticipated network issues and the expected benefits for the Eastern, Northern and Southern Regions over the next five years. The expectation is that the issues in these regions will be similar. It is important to note that projects arising from the strategies will be subject to various approvals which must be obtained before works can commence to ensure prudent network investment.

Issues/strategy	Project benefits	By when
Reliability (various locations)	Improve reliability of supply to customers. Address medium-term and long-term reliability opportunities to target compliance to required reliability service standard benchmarks. The concept of establishing microgrids and using DER and SPS are being assessed as these non-traditional network options begin to gain regulatory acceptance and economic parity.	Annual review with monthly performance assessments

Issues/strategy	Project benefits	By when
Over/under voltage (various locations)	Improve supply voltage range to customers. Address long term and short term voltage range deviations from required voltage standard. Improving voltage range compliance will assist higher penetration of DER connection on the system. This may be in the form of residential DER connection or larger commercial scale applications. An example of this type of project is the implementation of On Load Tap Changers for distribution transformers, applying telemetry and setting changes to voltage regulating transformers and community battery installations	Annual review with monthly performance assessments
Feeder loading (various locations)	Application of appropriate feeder loading depends on feeder type to primarily ensure asset life is not severely impacted from overloading, which can result in asset failure and customer outages. Feeder loading addresses long term and medium term needs based on peak demand load forecasts. Examples of this type of project is offloading to networks that have capacity, upgrading single phase networks to three phase, creating feeder interconnections and establishing new feeders (if peak demand load growth is present), upgrading overloaded distribution transformers and the installation of community batteries	Annual review
Protection systems and Under Fault Rated Conductor (UFRC) (various locations)	Protection systems are built to safely supply electricity to customers under normal operating conditions while providing sufficient operational flexibility under planned, unplanned and emergency operating conditions. Compliance to the Technical Rules manages the safety risk and minimises the risk of further customer outages from an unplanned event. To mitigate the risk of isolation transformer protection reach issues, the replacement of sectionalisers with Fuse Savers not only resolves protection reach compliance, but also improves reliability performance of the network in the long-term. Traditional methods to mitigate UFRC are protection device setting changes and reconductoring. Investigations are underway into adopting recloser technology with pulse closing. This is envisaged to avoid costly reconductoring	Annual review

Issues/strategy	Project benefits	By when
Power quality (various locations)	Improve quality of power supply to customers. Addresses medium-term and short-term compliance via an annual proactive response and a program to resolve imminent identified issues, as required. The outcome typically results in sections of LV conductor being upgraded	Annual review, and program of works as required

Central Region

The following table lists the distribution network strategies applicable to the Central Region based on the anticipated network issues and the expected benefits for the Central Region over the next five years. It is important to note that projects arising from the strategies will be subject to various approvals which must be obtained before works can commence to ensure prudent network investment.

Issues/strategy	Project benefits	By when
Reliability (various locations)	Improve reliability of supply to customers. Address medium-term and long-term reliability opportunities to target compliance to required reliability service standard benchmarks. The increasing use of device telemetry and automation in the Central Region aims to improve the speed of automated network restoration. In addition, undergrounding the network where financially viable reduces external factors impacting the network. Furthermore, there is a program earmarked to interconnect some large radial underground spurs.	Annual review with monthly performance assessments
Over/under voltage (various locations)	Improve supply voltage range to customers. Addresses long-term and short-term voltage range deviations from required voltage standard. Improving voltage range compliance will enable higher penetration of DER connections on the system. This may be in the form of residential DER connection or larger commercial scale applications. Examples of this type of project is the implementation of On Load Tap Changers for distribution transformers, increasing network variable parameter monitoring, applying telemetry and setting changes to voltage regulating transformer, community battery installations and leveraging voltage information from the Advanced Metering Infrastructure installations. Furthermore, a non-network approach is underway to incentivise shifting or increasing load consumption during midday when PV generation is high. In addition, trials are underway to replace end-of-life overhead network with underground network (where financially viable), resulting in improved DER hosting capacity of the new LV network	Annual review with monthly performance assessments

Issues/strategy	Project benefits	By when
Feeder loading (various locations)	Application of appropriate feeder loading depends on feeder type to primarily ensure asset life is not severely impacted from overloading, which can result in asset failure and customer outages. In the Central Region, feeder loading also provides a secondary need of sufficient operational network flexibility for planned and unplanned events. Feeder loading addresses long term and medium term location needs based on peak demand load forecasts. Examples of this type of project is offloading to networks that have capacity, creating feeder interconnections and establishing new feeders (if peak demand load growth is present), upgrading overloaded distribution transformers and installing community batteries	Annual review
Protection systems and Under Fault Rated Conductor (UFRC) (various locations)	Protection systems are built to safely supply electricity to customers under normal operating conditions while providing sufficient operational flexibility under planned, unplanned and emergency operating conditions. Compliance to the Technical Rules manages the safety risk and minimises the risk of further customer outages from an unplanned event. To mitigate the risk of protection reach issues, additional protection devices can be added to the network. The addition of Fuse Savers to the network not only resolves the protection reach compliance but also improves reliability performance in the long term. Traditional methods to mitigate UFRC are protection device setting changes and reconductoring. Investigations are underway into adopting recloser technology with pulse closing. This is envisaged to avoid costly reconductoring	Annual review
Power quality (various locations)	Improve quality of power supply to customers. Addresses medium term and short term compliance via an annual proactive response and a program to resolve imminent identified issues, as required. The outcome typically results in sections of LV conductor being upgraded	Annual review, and program of works as required

Connecting to our distribution network

There are also opportunities to connect to our distribution network.

We have made changes to our policies regarding the capacity threshold for generators deemed as not constrained and non-competing for transmission capacity. This improves distribution application processing times and cost, while maintaining network reliability and safety.

We have a threshold of less than 10MVA (but greater than or equal to 1MVA) installed capacity to be applied to inverter connected distribution and transmission generators, such as many commercial solar systems.

This threshold is in addition to the existing threshold of less than 1MVA installed capacity. Specific eligibility criteria apply to each threshold.

Further technology types (synchronous, induction, etc.) may be considered under these thresholds but they will be assessed individually due to the potential for higher impact on transmission network fault levels.

Specific substations are limited in accommodating a significant capacity (≤2.5MW) of inverter connected distribution embedded generators and may require further assessment.

It is important to note that the network is inherently dynamic and complex, customers' needs change and we regularly receive new connection applications.

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

Information on connection opportunities and applications can be obtained from our Access Solutions Manager at: network.access@westernpower.com.au

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Conclusion

Let's work together

A shared understanding of the industry's future is crucial to ensuring we all not only succeed at our individual business goals, but together build a bright and sustainable future for Western Australia.

We would appreciate your feedback and ideas about forecasting, planning and changes impacting your business and customers, so that we can improve our planning and future versions of the APR.

Contact our team:

Head of Grid Transformation
GPO Box L921
Perth Western Australia 6842
Telephone: 13 10 87

Comments can also be submitted by email to apr@westernpower.com.au or through our website (westernpower.com.au/contact-us/).

Appendix A

Estimated maximum short circuit levels for 2019/20

This appendix lists estimated maximum short circuit levels at each of the Western Power network's major nodes for 2019/20. This information should only be used as an approximate guide. Please contact us for further information.

The short circuit level calculations were determined in accordance with the following:

- the IEC 60909 method was used for the calculations; this is the source standards upon which the current Australian and New Zealand standards (AS/NZS 3851) is based
- for maximum fault levels, the C factor (as defined by IEC 60909) is set at 1.1 pu at the fault bus
- zero fault impedance is assumed
- all generation machines and step-up transformers are turned on
- all lines are assumed in service
- the expected fault current shown is IKSS.[20]

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
Bunbury load area				
APJ	ALCOA Pinjarra	330	15.04	12.95
APJ	ALCOA Pinjarra	132	14.79	14.87
BDP	Binningup Desalination Plant	132	11.49	9.29
BSI	Barrack Silicon Smelter	132	14.92	13.43
BSN	Busselton	132	2.59	3.02
BSN	Busselton	66	4.28	5.24
BSN	Busselton	22	3.44	3.91
BUH	Bunbury Harbour	132	9.67	9.42
BUH	Bunbury Harbour	22	5.48	5.38
CAP	Capel	66	5.33	4.79
CAP	Capel	22	3.68	4.05
CLP	Coolup	66	1.02	0.70

20 AC component of the initial symmetrical short circuit current which occurs directly after the initiation of the fault (RMS value).

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
CLP	Coolup	22	1.74	2.21
KEM	Kemerton	330	21.06	19.47
KEM	Kemerton	132	20.38	22.25
KMP	Kemerton Power	330	20.07	18.43
MR	Margaret River	66	1.57	1.83
MR	Margaret River	22	2.54	3.11
MRR	Marriott Road	132	16.87	16.40
MRR	Marriott Road	22	6.56	5.52
OLY	Oakley	330	17.13	14.91
PIC	Picton	132	11.41	11.25
PIC	Picton	66	9.62	12.03
PIC	Picton	22	7.36	6.18
WSD	Westralian Sands	66	5.17	4.79
Cannington load area				
BEC	Beckenham	132	26.64	28.69
BEL	Belmont	132	18.90	18.34
BEL	Belmont	22	4.34	0.99
BTY	Bentley	132	19.53	17.03
BTY	Bentley	22	4.40	0.99
CL	Clarence Street	66	8.96	7.16
CL	Clarence Street	11	7.81	8.05
COL	Collier	66	9.00	7.21
COL	Collier	11	9.39	10.65
CT	Cannington Terminal	132	28.40	30.51
CT	Cannington Terminal	66	14.61	17.61
KDL	Kewdale	132	18.28	16.87
KDL	Kewdale	22	4.38	0.98
KNL	Kenwick Link	330	16.42	15.62
KNL	Kenwick Link	132	25.88	26.64
RVE	Rivervale	132	17.75	16.50
RVE	Rivervale	22	4.57	0.98
TT	Tate Street	66	12.69	13.69
TT	Tate Street	22	4.95	6.35
VP	Victoria Park	66	12.07	12.53
WE	Welshpool	132	21.12	21.05

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
WE	Welshpool	22	4.50	1.03
East Country load area				
BDE	Bandee	66	1.85	1.55
BNY	Bounty	132	0.67	0.86
BNY	Bounty	33	1.75	2.50
CAR	Carrabin	66	1.27	0.97
CAR	Carrabin	22	1.69	2.01
CGT	Collgar Terminal	220	3.36	4.45
CGW	Collgar Wind Farm	220	3.36	4.45
CUN	Cunderin	66	1.12	0.83
CUN	Cunderin	22	1.78	2.29
KDN	Kondinin	220	3.12	2.91
KDN	Kondinin	132	1.53	1.69
KDN	Kondinin	33	2.88	4.05
KEL	Kellerberrin	66	1.19	0.91
KEL	Kellerberrin	22	1.43	1.92
MDP	Merredin Power Station	132	6.17	8.36
MER	Merredin	132	5.32	6.39
MER	Merredin	66	3.90	5.25
MER	Merredin	22	3.36	3.57
MRT	Merredin Terminal	220	3.73	4.97
MRT	Merredin Terminal	132	6.17	8.36
MW	Mundaring Weir	66	3.73	2.60
NOR	Northam	132	5.28	4.93
NOR	Northam	66	4.65	4.43
NOR	Northam	22	7.15	5.14
SVY	Sawyers Valley	132	7.85	6.92
SVY	Sawyers Valley	22	4.13	4.56
SX	Southern Cross	66	0.63	0.44
SX	Southern Cross	33	1.85	1.38
WUN	Wundowie	66	2.89	2.06
WUN	Wundowie	22	2.67	3.10
YER	Yerbillon	66	1.17	0.88
YLN	Yilgarn	220	2.54	2.53
YLN	Yilgarn	33	4.13	5.49

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
Eastern Goldfields load area				
BKF	Black Flag	132	2.56	2.81
BKF	Black Flag	33	5.01	4.98
BLD	Boulder	132	4.57	5.70
BLD	Boulder	33	6.52	8.76
JAN	Jan	132	2.01	2.11
LEF	Lefroy	132	2.21	2.46
PCY	Piccadilly Street	132	4.47	5.68
PCY	Piccadilly Street	11	10.45	2.07
PKS	Parkeston Substation	132	4.48	5.44
WKT	West Kalgoorlie	220	2.46	3.09
WKT	West Kalgoorlie	132	4.48	5.91
WKT	West Kalgoorlie	33	4.06	5.39
WKT	West Kalgoorlie	11	10.37	1.84
WMK	Western Mining Kambalda	132	2.74	3.10
WMS	Western Mining Smelter	132	4.17	4.75
East Perth and CBD load area				
CK	Cook Street	132	23.17	22.92
CK	Cook Street	11	10.09	1.83
EP	East Perth	132	25.22	26.42
EP	East Perth	66	5.65	7.05
EP	East Perth	20.6	9.04	1.04
F	Forrest Ave	66	5.22	5.65
F	Forrest Ave	11	10.22	12.07
HAY	Hay Street	132	21.78	21.14
HAY	Hay Street	11	11.46	2.19
JTE	Joel Terrace	132	24.86	25.32
JTE	Joel Terrace	11	8.62	1.85
MIL	Milligan Street	132	19.53	20.26
MIL	Milligan Street	11	12.21	2.17
NP	North Perth	132	21.36	20.47
NP	North Perth	11	9.00	1.84
SUM	Summers Street	132	24.94	25.74
W	Wellington Street	66	5.39	6.05
W	Wellington Street	11	8.39	9.53

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
Guildford load area				
D	Darlington	132	13.64	12.80
D	Darlington	22	4.27	0.94
FFD	Forrestfield	132	13.33	13.19
FFD	Forrestfield	22	5.76	1.05
GLT	Guildford Terminal	330	16.60	16.09
GLT	Guildford Terminal	132	23.06	25.10
HZM	Hazelmere	132	22.45	23.86
HZM	Hazelmere	22	4.36	0.96
K	Kalamunda	132	11.35	10.85
K	Kalamunda	22	5.62	1.05
MDY	Munday	132	13.27	13.13
MDY	Munday	22	5.23	0.97
MJ	Midland Junction	132	21.63	23.28
MJ	Midland Junction	22	4.86	1.00
Kwinana load area				
AFM	Australian Fused Materials	132	20.61	18.81
AKW	ALCOA Kwinana	132	31.46	33.92
BHK	Broken Hill Kwinana	66	6.39	7.34
BP	British Petroleum	66	6.51	7.34
BPR	BP Refinery	132	25.64	26.49
CBP	CSBP	132	24.30	24.13
CKB	Cockburn Power	132	30.88	33.75
TLA	Tianqi Lithium Australia	132	23.12	22.66
KDP	Kwinana Desalination Plant	132	27.80	29.71
KMK	Kerr McGee Kwinana	132	28.76	31.83
KND	Kwinana Donaldson Road	132	27.69	30.63
KPP	Kwinana Power Partnership	132	26.45	27.92
KW	Kwinana	330	20.53	20.89
KW	Kwinana	132	31.80	34.57
KW	Kwinana	66	6.75	8.28
MED	Medina	132	22.73	20.38
MED	Medina	22	4.41	1.05
MSR	Mason Road	132	28.76	31.83
MSR	Mason Road	22	4.57	0.98

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
RO	Rockingham	132	20.08	18.92
RO	Rockingham	22	7.12	1.03
TPP	Tiwest Pigment Plant	132	28.76	31.83
WM	Western Mining	132	22.88	21.82
Mandurah load area				
MH	Mandurah	132	10.52	10.21
MH	Mandurah	22	4.37	0.99
MSS	Meadow Springs	132	11.07	11.05
MSS	Meadow Springs	22	4.76	0.98
PLD	Parklands	132	11.06	11.05
PNJ	Pinjarra	132	14.01	12.84
PNJ	Pinjarra	22	4.30	4.60
WAI	Waikiki	132	15.31	13.76
WAI	Waikiki	22	4.34	1.01
Muja load area				
ALB	Albany	132	1.61	1.86
ALB	Albany	22	6.16	6.89
BGM	Boddington Gold Mine	132	9.96	9.99
BLW	Bluewaters Terminal	330	21.48	20.47
BNP	Beenup	132	1.24	1.23
BNP	Beenup	22	2.25	2.76
BOD	Boddington	132	9.96	9.99
BOD	Boddington	22	4.95	6.80
BTN	Bridgetown	132	4.48	4.47
BTN	Bridgetown	22	4.59	5.97
BWP	Bluewaters Power Station	330	21.48	20.47
CO	Collie	66	2.12	1.67
CO	Collie	22	2.42	3.24
CPS	Collie Power Station Terminal	330	19.57	18.65
KAT	Katanning	66	1.46	1.69
KAT	Katanning	22	2.73	2.63
KOJ	Kojonup	132	3.81	4.17
KOJ	Kojonup	66	2.58	2.83
KOJ	Kojonup	22	4.33	5.86
LWT	Landwehr Terminal	330	16.50	15.63

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
MBR	Mount Barker	132	1.64	1.73
MBR	Mount Barker	22	3.70	4.92
MJP	Manjimup	132	2.99	3.07
MJP	Manjimup	22	4.13	5.59
MU	Muja	330	21.55	20.72
MU	Muja	220	8.39	9.26
MU	Muja	132	17.73	19.91
MU	Muja	66	3.64	3.80
NGN	Narrogin	66	1.22	1.59
NGN	Narrogin	22	2.27	2.26
NGS	Narrogin South	220	3.72	3.02
NGS	Narrogin South	66	1.24	1.63
SHO	Shotts	330	21.21	20.28
WAG	Wagin	66	1.19	1.04
WAG	Wagin	22	1.38	1.83
WAPL	Worsley Alumina Pty Ltd	132	14.54	16.69
WAPL	Worsley Alumina Pty Ltd	66	4.03	4.53
WCG	Worsley Co Generation	132	14.63	16.73
WCL	Western Colleries Limited	132	13.66	11.93
WGP	Wagerup	132	8.55	6.92
WGP	Wagerup	22	4.01	4.35
WLT	Wells Terminal	330	7.08	6.69
WLT	Wells Terminal	132	11.39	12.30
WOR	Worsley	132	14.63	16.73
Neerabup Terminal load area				
CKN	Clarkson	132	15.29	13.51
CKN	Clarkson	22	5.07	0.98
EDG	Edgewater	132	19.41	19.07
GNN	Newgen Neerabup	330	13.41	13.51
JDP	Joondalup	132	18.87	18.11
JDP	Joondalup	22	4.38	0.97
LDE	Landsdale	132	17.89	17.41
LDE	Landsdale	22	4.37	1.00
MUC	Muchea	132	17.90	15.31
MUC	Muchea	22	4.36	0.85

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
MUL	Mullaloo	132	19.41	19.07
MUL	Mullaloo	22	4.27	0.99
NBT	Neerabup Terminal	330	13.79	13.94
NBT	Neerabup Terminal	132	21.60	21.63
NOW	Nowergup	132	15.29	13.51
PBY	Padbury	132	17.72	16.47
PBY	Padbury	22	4.35	0.97
PJR	Pinjar Power Station	132	29.86	32.41
WGA	Wangara	132	17.22	16.33
WGA	Wangara	22	4.31	0.99
WNO	Wanneroo	132	20.33	19.95
WNO	Wanneroo	22	4.51	1.03
YP	Yanchep	132	15.07	13.23
YP	Yanchep	22	4.52	1.00
North Country load area				
BGA	Badgingarra	132	5.56	4.61
CPN	Chapman	132	3.27	3.85
CPN	Chapman	11	8.79	9.77
CTB	Cataby	132	6.63	6.43
EMD	Emu Downs	132	5.21	4.80
ENB	Eneabba	132	6.41	5.98
ENB	Eneabba	33	3.27	4.23
ENT	Eneabba Terminal	330	3.80	4.60
GGV	Golden Grove	132	1.26	1.56
GRS	Greenough River Solar Farm	132	5.98	6.91
GTN	Geraldton	132	3.56	4.25
GTN	Geraldton	33	5.65	6.60
KMC	Kerr McGee Cataby	132	6.63	6.43
KRA	Karara Mine	330	2.16	3.06
MBA	Mumbida Wind Farm	132	4.45	4.81
MGA	Mungarra	132	5.98	6.91
MOR	Moora	132	2.76	1.84
MOR	Moora	33	2.78	3.32
RAN	Rangeway	132	3.28	3.90
RAN	Rangeway	11	8.83	11.66

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
RGN	Regans	132	5.99	5.79
RGN	Regans	33	3.25	3.09
RGN	Regans	22	4.08	1.01
TS	Three Springs	132	7.82	8.16
TS	Three Springs	33	1.88	1.79
TST	Three Springs Terminal	330	3.34	3.90
TST	Three Springs Terminal	132	7.75	8.48
WDW	Warradarge Wind Farm	330	3.60	4.49
WWF	Walkaway Wind Farm	132	4.53	5.07
YDT	Yandin Terminal	330	5.16	5.96
YDW	Yandin Wind Farm	330	4.96	5.82
Northern Terminal load area				
A	Arkana	132	19.79	19.80
A	Arkana	22	5.69	1.07
BCH	Beechboro	132	19.59	18.74
BCH	Beechboro	22	4.40	1.01
BCT	Balcatta	132	18.97	18.01
BCT	Balcatta	22	4.36	1.00
H	Hadfields	132	16.59	15.54
H	Hadfields	22	4.38	0.99
HBK	Henley Brook	132	12.83	10.52
HBK	Henley Brook	22	4.36	0.98
KMM	Kerr McGee Muchea	132	14.27	11.22
MA	Manning Street	132	17.90	17.32
MA	Manning Street	11	11.59	2.03
MLA	Mount Lawley	132	21.35	21.83
MLG	Malaga	132	28.85	33.66
MLG	Malaga	22	5.50	0.97
MO	Morley	132	17.42	18.32
MO	Morley	11	12.00	2.00
NB	North Beach	132	19.44	19.25
NB	North Beach	22	5.66	1.03
NT	Northern Terminal	330	17.95	18.23
NT	Northern Terminal	132	28.85	33.66
OP	Osborne Park	132	19.61	19.83

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
OP	Osborne Park	11	11.84	1.94
Y	Yokine	132	19.46	19.33
Y	Yokine	11	11.78	2.00
South Fremantle load area				
AMT	Amherst	132	19.75	16.91
AMT	Amherst	22	4.38	0.99
APM	Australian Paper Mills	66	9.30	8.01
APM	Australian Paper Mills	22	4.77	6.11
BIB	Bibra Lake	132	21.26	18.39
BIB	Bibra Lake	22	4.38	0.99
E	Edmund Street	66	10.83	10.48
E	Edmund Street	11	8.13	8.22
MYR	Myaree	66	8.70	7.41
MYR	Myaree	22	4.62	4.90
OC	O'Connor	66	9.87	9.75
OC	O'Connor	22	4.80	5.42
SF	South Fremantle	132	26.74	24.33
SF	South Fremantle	66	13.93	17.12
SF	South Fremantle	20.6	14.55	1.04
Southern Terminal load area				
BYF	Byford	132	13.21	11.59
BYF	Byford	22	6.95	1.01
CC	Cockburn Cement	132	23.83	21.24
CC	Cockburn Cement	22	8.43	0.98
CCL	Cockburn Cement	132	23.72	21.15
CVE	Canning Vale	132	18.85	18.54
CVE	Canning Vale	22	4.50	1.01
G	Gosnells	132	22.37	21.61
G	Gosnells	22	5.91	1.05
GNI	Glen Iris	132	26.53	28.24
MDN	Maddington	132	22.71	20.73
MDN	Maddington	22	4.40	0.96
MUR	Murdoch	132	25.15	23.21
MUR	Murdoch	22	4.75	0.94
RTN	Riverton	132	20.56	17.91

Substation		Voltage (kV)	2019-20	
			3-phase (kA)	1-phase (kA)
RTN	Riverton	22	4.53	0.99
SNR	Southern River	132	20.57	18.97
SNR	Southern River	22	4.80	0.99
ST	Southern Terminal	330	21.76	22.55
ST	Southern Terminal	132	34.52	38.15
WLN	Willetton	132	19.47	19.07
WLN	Willetton	22	4.35	0.96
Western Terminal load area				
CTE	Cottesloe	132	18.31	15.68
CTE	Cottesloe	11	8.71	1.88
MCE	Medical Centre	66	10.30	11.49
MCE	Medical Centre	11	10.97	1.89
N	Nedlands	66	11.02	11.36
SPK	Shenton Park	132	20.63	20.04
SPK	Shenton Park	11	10.17	1.92
WD	Wembley Downs	66	9.62	8.07
WD	Wembley Downs	11	9.48	10.72
WT	Western Terminal	132	21.91	21.98
WT	Western Terminal	66	13.21	16.71

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