Independent Review of Christmas 2021 Power Outages

Final Report

March 2022

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Glossary

Term	Definition
Access Code	Electricity Networks Access Code 2005
AEMO	Australian Energy Market Operator
AMI	Advanced Metering Infrastructure
APRQ	Annual Reliability and Power Quality report
BOM	Bureau of Meteorology
Capex	Capital Expenditure
CBD	Central Business District
DFES	Department of Fire and Emergency Services
EMT	Emergency Management Team (Western Power)
EPWA	Energy Policy WA
ERA	Economic Regulation Authority
FDI	Fire Danger Index The FDI is calculated using temperature, wind speed, humidity and vegetation dryness as these parameters influence bushfire risk and severity. The higher the FDI, the higher the fire danger.
FWD	Fire Weather Day
Good electricity industry practice	The exercise of that degree of skill, diligence, prudence and foresight that a skilled and experienced person would reasonably and ordinarily exercise under comparable conditions and circumstances consistent with applicable written laws and statutory instruments and applicable recognised codes, standards and guidelines.
LGA	Local Government Authority
Major Event Day	For an unplanned interruption on the distribution system, a day on which the major event day threshold is exceeded. This method excludes events which are more than 2.5 standard deviations greater than the mean (of the log normal distribution) of five financial years of SAIDI data.
NQRS Code	Network Quality and Reliability of Supply
Review Period	24-28 December, inclusive
SAIDI	System Average Interruption Duration Index – a service standard benchmark
SAIFI	System Average Interruption Frequency Index
SSAM	Service Standard Adjustment Mechanism
SSB	Service Standard Benchmark
SWIS	South West Interconnected System
TFB	Total Fire Ban
WEM	Wholesale Electricity Market
VMB	Vehicle Movement Ban

Reviewer's Foreword

The Western Australian Minister for Energy initiated an Independent Review of the electricity outages that occurred across a number of urban and regional areas over the 2021 Christmas period.

The Review was undertaken in response to community concerns regarding the causes of the outages and Western Power's response. In addition, there has been growing concern in many regional communities about electricity reliability.

The Christmas outages impacted about 107,000 Western Power customers to varying degrees. Around 26,000 customers were without power for more than 12 hours and 40,000 experienced repeated outages over the Christmas holiday period.

Residents in the communities of Mandurah, Wanneroo, Armadale and Greater Geraldton experienced the greatest number and duration of outages. The outages also impacted regional areas such as Chapman Valley, Murray, Capel, Katanning and Gingin.

During this period, Western Australia endured record-breaking high temperatures over consecutive days. The extreme heat resulted in abnormally high use of air conditioners and fans by residents putting pressure on the Western Power network.

To determine the causes and impacts of the outages, a broad range of groups were consulted during this Review, including Western Power, community representatives, the Department of Fire and Emergency Services, the Economic Regulation Authority, Local Governments and the Bureau of Meteorology.

During the consultation process, the Review heard firsthand of the difficulties experienced by different members of the community who were without power at a time when air conditioners and fans became a necessity for most. The greatest impact on customers was felt on Christmas Day and Boxing Day when family celebrations were cut short and large quantities of food spoiled due to the inability to adequately refrigerate. The community also expressed concerns about the mental and physical impact the outages had on people's health.

The Review concluded the main cause for the outages was parts of the distribution network did not have the technical capacity to deliver electricity to meet the unprecedented demand experienced at the time.

In addition, many of the outages were significantly extended due to the fire weather conditions, restricting Western Power's ability to safely restore power until conditions eased.

While the extreme heatwave which led to the outages is historically rare, the Bureau of Meteorology advised similar conditions are likely to occur more frequently in the future due to the impacts of climate change.

It must be remembered, no network can guarantee reliable electricity supply to every customer all the time given the high cost of doing so. However, improvements can be made to ensure the community has confidence in Western Power's ability to prepare for and safely manage future events.

Several recommendations in this Report have been provided to assist Western Power in reducing the frequency and duration of outages in the future, and better manage community expectations when outages occur. The implementation of these recommendations will benefit all customers in the Western Power network, including those in regional communities.

In summary, the recommended changes include improvements to Western Power's planning, forecasting, approach to fire risk management and operational response to extreme events. In addition, improved customer and community communications and greater transparency of reliability issues have also been recommended.

I would like to take this opportunity to thank everyone who contributed to this Review and for their cooperation, transparency and willingness to provide information throughout the process.

During the Review I have been assisted by an exceptional Review team who provided technical engineering expertise and secretariat support. I wish to sincerely thank each member of the team for their hard work, expertise and valuable insights in completing this Review.

Michelle Shepherd

14 March 2022

Executive Summary

Introduction

The Hon Bill Johnston MLA, Minister for Energy commissioned an independent review of the Christmas 2021 power outages. The Review examined and reported on the reasons for the outages and made recommendations on reducing future impacts.

The Review has been conducted at a time when customers in a number of communities in the South West Interconnected System (SWIS) have expressed concerns about the reliability of their electricity supply. At the same time, affordability and safety continue to be matters of critical importance to the community.

The Review assessed the outages that impacted regional and urban communities in the SWIS between 24-28 December 2021, and examined the reasons for those outages. This included an examination of Western Power's:

- network and operational planning and design;
- asset management, maintenance and asset performance;
- load forecasting and historical network performance;
- operational response to the Christmas 2021 outages;
- engagement with customers and the community; and
- compliance and approach to risk.

The Review has assessed the outages through a customer-centric lens with the findings and recommendations in this report being framed in terms of preventing or mitigating customer impacts.

The Christmas 2021 outages

Overview of the outages

In the period between 24-28 December 2021, around 107,000 Western Power customer connections experienced a power outage. Of those:

- 69,469 were without power for longer than 2 hours;
- 26,091 were without power for at least 12 hours;
- 42,604 experienced two or more outages;
- 54% of customers impacted live in rural areas;
- rural customers were more likely to have repeat outages; and
- the majority of customers impacted were households.

The most impacted locations, based on customer numbers and outage length, were the cities of Mandurah, Wanneroo, Armadale, Gosnells, Swan and Stirling. In regional areas, Greater Geraldton, Kalgoorlie and Gingin were also heavily impacted.

The weather conditions during the outages

The Review was advised by the Bureau of Meteorology (BOM) that the Christmas 2021 heatwave was exceptional for its timing, intensity and duration. The Perth metropolitan region experienced four days with maximum temperatures above 40 degrees, which has occurred only 3 times in 123 years, as well as very high overnight minimum temperatures.

The period fell over a long weekend (from Friday to Tuesday), and during a time when COVID-19 travel restrictions were in place. It is therefore likely that much of the State's population remained in their homes during the period.

The combination of persistent and high temperatures, and many people being at home, resulted in electricity demand in some residential areas far exceeding previous historical peaks.

In addition, the extreme weather conditions led to the declaration of Total Fire Bans across the SWIS during the period. The elevated fire risk conditions meant Western Power undertook a number of fire risk mitigation activities before safely restoring customers.

While the weather conditions during the Christmas holiday period were unusual, such extreme events are expected to occur more frequently in the future as a result of climate change.

The causes of the outages

The outages were largely caused by overloads on the distribution network. The combination of weather conditions and high levels of customer demand resulted in electricity demand exceeding the capacity of some network assets.

The extended outages (for example those longer than 12 hours) were largely due to the higher fire risk conditions. Western Power takes additional actions during these conditions to prevent its network starting a fire. The actions are set out in a number of Western Power procedures and are largely based on what has been agreed between Western Power and the Department of Fire and Emergency Services. They apply equally to urban and rural areas.

For example, Western Power's fire risk management procedures include the requirement to inspect the power line to identify the cause of the fault before the line can be reenergised on higher fire risk days. The activities under these procedures can add many hours to the power restoration process.

The reason for repeated outages was Western Power not having sufficient time to fix the underlying cause of the outage before demand peaked again in the same section of the network the following day. The inability to fix the issue led to multiple outages in the same area.

The impact on customers

The Review found the outages had a significant impact on customers because electricity was needed to cool homes in the extreme heat. In addition, the Christmas holiday period meant many households had full fridges in preparation for their holiday celebrations.

The Review was also told by customers and their representatives that outages during extreme heatwaves not only inconvenience customers by the lack of refrigeration, cooling and lighting,

but can also impact on their health and safety. For example, heat related health issues are increased and extreme heat can exacerbate mental health and social issues such as family violence.

Western Power's response to the outages

In the lead up to the 2021-22 summer, Western Power identified and implemented a number of actions to manage and correct forecast network capacity risks. These included switching to shift load away from heavily loaded areas of the network and some capacity expansion projects, all of which were completed prior to December 2021.

In addition, just prior to and during the heatwave, further actions were taken to help minimise and reduce the impact on customers of the outages. This included load switching to shift customer load away from heavily loaded areas of the network, and some use of back-up generators.

- The Review found the strategies employed by Western Power reduced the number of outages and outage lengths, and could be expanded and employed more in the future.

Western Power customer communications

As the outages began to occur, and for the duration of the four-day outage period, Western Power's customer and community messaging and communication channels were regularly updated once information was known, and a number of channels were used to reach customers.

However, the Review was told by customer representatives that despite the considered approach by Western Power, customers wanted more frequent and direct communication during the outages.

The Review found that:

- Western Power's future communication strategy, particularly during a heatwave, could be improved to meet stakeholder expectations.

Western Power's management of its network before and during the outages

Western Power owns and operates the poles and wires which deliver electricity to 1.1 million customers in the SWIS. The SWIS extends throughout the Perth and Peel regions, as well areas north to Kalbarri, east to Kalgoorlie and south to Albany.

Planning and forecasting peak demand

Western Power is responsible for the planning, design, construction, maintenance and operation of its electricity network in order to deliver safe and reliable power to customers.

Network management and investment is planned based on criteria which aims to provide reliable electricity to meet peak demand at a reasonable cost. It's unreasonable to expect a network would be built to provide reliable electricity all of the time, as the cost of doing so would be prohibitive.

At the core of good network planning and investment is robust forecasting of future electricity peak demand in all parts of the network.

Forecasting peak demand has become more difficult as extreme weather events have become more frequent; and customers are changing the way they produce energy (rooftop solar) and consume energy (e.g. air-conditioner use and electric vehicles).

The Review made a number of findings regarding Western Power's network planning and forecasting approach, including:

- The low visibility of customer demand, particularly for households, is impacting the accuracy of Western Power's forecasts, and may result in some network areas being more susceptible to outages as was demonstrated during the Christmas period.
- Western Power is working to incorporate more robust data and improve its forecasting.
- As extreme events become more likely and more severe, the approach to planning and forecasting should also evolve to take into consideration such events, while recognising the cost and reliability trade-off.

Western Power's asset performance and reliability

In regards to Western Power's asset management and maintenance approach, the Review found Western Power meets good industry practice. In particular the Review found that:

- Western Power has developed a sound asset management system and related policies to ensure network infrastructure is maintained and performing as expected.

Currently Western Power is required to report annually on its performance against a range of reliability standards. Western Power generally meets its reliability performance standards except during extreme weather events, such as cyclone Seroja and the Christmas 2021 period.

However, the Review heard there are a number of communities across the SWIS whose reliability falls below these standards. However, it is difficult for these communities to find accessible information about how their reliability compares to other communities and what Western Power is planning to do to address reliability issues in the future.

The Review found that:

- Western Power should improve transparency about which communities are regularly experiencing reliability materially below standards, including during extreme events. It should also publish any plans it has to address reliability in those communities (noting the trade-off between cost and reliability).

Risk approach

In the operation of its network, Western Power manages many network and non-network risks. These include electrical and fire safety, climate related risks and the risk of customer outages.

Western Power's approach to fire risk is reflective of the potentially catastrophic consequences of fires. However, it does not always take into account the fire risk for that specific part of the network nor the safety impacts of prolonged outages on customers during heatwaves.

The Review found that:

- Western Power has a reasonable approach to assessing and managing risks.
- The restoration of power on days of higher fire risk needs to be managed in a way that minimises the risk of starting a fire. However, the procedures to restore power on higher fire risk days often delay restoration of power to customers.

- Western Power's approach to fire risk should be considered in the context of Western Power providing an essential service and reconnecting customers without power is a priority.

Conclusions and Recommendations

Based on the information considered throughout the Review, the following recommendations are made to reduce the likelihood and impact of future outages across the Western Power network.

Summary of review recommendations:

1. Western Power to improve its approach to distribution network forecasting.
2. Western Power to review the planning criteria to ensure it's fit for the future.
3. Western Power to continue to improve its approach to reducing the risk of outages occurring, and the length of any outages.
4. A review of Western Power's fire risk response in light of the community impacts of prolonged outages, particularly during heatwaves.
5. Western Power to engage with the community to improve customer and stakeholder communications in line with customer expectations, especially during extreme events.
6. Increased transparency regarding reliability in communities.

Further detail on the above recommendations is contained below.

1. Improved approach to distribution network forecasting

Western Power has a reasonable approach to forecasting demand at the system-wide and transmission network level. However, at the medium and low voltage distribution level, low visibility of customer peak demand levels and customer rooftop solar generation is affecting the robustness of forecasts.

Recommendation 1:

Western Power should continue to improve its forecasting of the distribution network to account for the:

- **rapidly changing way electricity is produced and consumed by customers in parts of the network. The forecast methodology should continue to improve the use of rooftop solar and other data such as maximum demand. Advanced metering infrastructure (AMI) data, once available at scale, should also be used to better forecast load; and**
- **increased likelihood of extreme weather events (resulting in different supply and demand than has been experienced in the past) reducing the relevance of previous peaks.**

Western Power should report to the Minister for Energy on:

- **identified and implemented improvements to its forecasting methodologies; and**
- **any improvement in accuracy of forecasting of overloads prior to a fault occurring.**

2. Western Power to Review Planning Criteria

Western Power is compliant with the existing planning criteria, which is set at a level that strikes a balance between the costs and benefit of reliability, with safety also a key consideration in investment decisions.

However, the current planning criteria should be reviewed to assess whether it's appropriate for the future given changing and uncertain supply and demand conditions as the network decarbonises, and extreme weather events becoming more frequent.

Recommendation 2:

Western Power should review its approach to network planning, particularly the ongoing appropriateness of its application of distribution network planning criteria, to identify improvements.

This review should recognise the appropriate economic trade-off between customer reliability and cost to supply given greater uncertainties in future demand and supply of electricity. These uncertainties relate to changes in climate (and more frequent and severe extreme events), customer electricity usage and the growing impact of technologies such as solar PV, batteries and electric vehicles.

Western Power should then engage with the Economic Regulation Authority (ERA), through existing approval processes, regarding the implementation of any changes to the Technical Rules.

3. Continual improvement regarding strategies to reduce the risk and length of outages

Western Power applies a number of strategies to reduce the likelihood of unplanned outages as well as strategies to minimise the length of outages, some of which were deployed during the Christmas outages. The Review found that the strategies were successful in reducing the number of outages and outage lengths, and could be expanded and employed more in the future.

Recommendation 3:

Western Power should continue existing strategies and consider improved ways to prepare for and manage outages.

The strategies to be considered include, but are not limited to:

a. **batteries, micro-grids, network undergrounding and standalone power systems;**
b. **demand response, including asking customers to voluntarily reduce demand;**
c. **use of load shifting and last resort load shedding, including increasing interconnection, automation and improved visibility of customer demand; and**
d. **to reduce the length of outages, operational changes such as available fault crew numbers, back-up generation fleet size, and fire risk management as per Recommendation 4.**

Western Power should report to the Minister for Energy on its proposed utilisation, and in due course, the effectiveness of solutions b, c and d, noting that 'a' is incorporated into information which Western Power already publishes.

4. Review fire risk response in light of the community impacts of extended outages in heatwave events

Electricity networks can and have started fires with devastating consequences. Therefore, the restoration of power on days of higher fire risk needs to be managed in a way that minimises the risk of starting a fire. This risk is weighed against the fact that Western Power provides an essential service and reconnecting customers without power is a high priority.

Recommendation 4:

Western Power to work with key stakeholders such as the Department of Fire and Emergency Services and Local Government Authorities, to review Western Power's fire risk management approach with regard to the restoration of electricity supply on higher fire risk days.

It is recommended an Independent Expert be appointed to facilitate the review and identify strategies for customer restoration which balance the community safety impacts of extended outages during extreme heat events and fire risk in that specific area of the network.

The review should support improved community outcomes by considering (but not be limited to) the following areas:

- **Ensure a shared understanding of the roles of Western Power, Department of Fire and Emergency Services (DFES) and Local Government Authorities (LGAs) in managing electricity network related fire risks.**
- **Have a shared understanding of the community impact of power outages and fire, in conditions prone to higher fire risks (such as heatwaves).**
- **Coordination of consumer communication and activities on higher fire risk days where customer safety and power reliability is at risk from extreme weather conditions.**
- **The appropriateness of Western Power's response on Total Fire Ban day and Fire Weather Days.**
- **Empowerment of Western Power to act to restore power on Total Fire Ban days where the risk of fire is low or community impact of the outage is high, including where:**
    - **the cause of an outage cannot be identified but is likely with a high degree of certainty (such as overload outages) to not be a fire ignition risk;**
    - **the network and local conditions are such that the probability of fire occurring and getting out of control is very low;**
    - **a State-wide Total Fire Ban has been called due to DFES resourcing constraints and local conditions (such as weather, Fire Danger Index and network) would not have otherwise triggered a Total Fire Ban; and**
    - **DFES could apply an emergency direction under a Total Fire Ban Exemption.**

The Minister for Energy is encouraged to engage with the Ministers for Emergency Services and Local Government to support a collaborative approach to the understanding and ownership of risks and responsibilities on higher fire risk days.

5. Improve customer and stakeholder communications strategies in line with consumer expectations

The Review heard that stakeholders, particularly customers, want frequent and honest communication before and during an outage event, using a range of communication channels.

Recommendation 5:

Western Power to consult with stakeholders on improvements to customer and stakeholder communications in the lead up to, and during outage events. The consultation should consider, but not be limited to:

- **the type and frequency of information customers want during an outage;**
- **the use of direct communication with customers (if possible) before and during outages;**
- **the use of warnings where an outage can be reasonably forecast and is likely;**
- **communication to customers about how a change in their energy use may reduce the risk of an imminent outage;**
- **communication with sensitive and vulnerable customers;**
- **reinforcing government health messages to customers in extreme heat events; and**
- **engagement and communication with key external stakeholders, including LGAs, when a significant outage event impacts their community.**

Western Power should report to the Minister for Energy on the outcomes of this consultation and the resulting implementation plans, outlining how communication strategies will be evaluated and evolve in line with community expectations.

6. Increase transparency regarding reliability in communities

Improved transparency about which communities are regularly experiencing reliability materially below standards, including during extreme events, would improve stakeholder engagement on what Western Power can do to address reliability in the future (noting the trade-off between cost and reliability).

This is particularly important for many rural communities which experienced outages during the Christmas 2021 period, as well as throughout the year.

Recommendation 6:

Western Power should improve information on its reliability performance, including making it easily understood by its customers, for:

- **communities experiencing performance well below prescribed reliability standards; and**
- **the network during extreme events.**

The following should be reflected in any published information:

- **the reliability performance of the worst performing feeders;**

- **the felt experience of customers, therefore the data should include Major Event Days;**
- **customer friendly language, including feeders being identified by location (e.g. Local Government Authority or suburb); and**
- **the causes of the reliability issues and the plans to address those issues in the future.**

Western Power should report to the Minister for Energy on progress towards this recommendation.

The Economic Regulation Authority and Energy Policy WA should consider the progress made by Western Power before assessing any need for codified prescription to give full effect to this recommendation.

1. Introduction

1.1. The Independent Review of Christmas 2021 power outages

The Hon Bill Johnston MLA, Minister for Energy has commissioned an independent review of the Christmas 2021 power outages, to examine and report on the reasons for the outages and make recommendations on reducing future impacts.

The Review comes at a time when customers in a number of communities in the SWIS are concerned about the reliability of electricity supply. At the same time, affordability and safety continue to be matters of critical importance to the community.

The Review considers the outages that impacted regional and urban communities in the South West Interconnected System (SWIS) between 24-28 December 2021, and examines the reasons for those outages with particular reference to those areas that experienced repeated outages.

The Review was required to assess Western Power's network and operational planning; network design; asset management and maintenance; asset performance; load forecasting and historical network performance in determination of the reasons for outages.

The Review also examined Western Power's operational response to the Christmas 2021 faults compared to good electricity industry practice; how Western Power engaged with the community and stakeholders; and if Western Power complied with its regulatory, statutory and market obligations. Western Power's approach to risk assessment and other internal decision frameworks that informed the restoration approach, including any assessment of community impact, was also assessed.

Since Christmas 2021, many Western Power customers, particularly in the regional areas north of Perth, found themselves subject to power outages, including for repeated or prolonged periods. Some of these customers were also impacted over the Christmas 2021 period. The experience of those customers, and the actions taken by Western Power in response to these further outages, have informed the Review, however detailed assessment of cause of these outages is out of scope.

1.2. Overview of the Christmas 2021 outages

Between 24-28 December 2021, 107,020 Western Power customer connections experienced a Power outage, with most outages lasting more than 2 hours. Many customers also experienced repeated outages.

Customers were impacted by outages in both urban and rural areas across the SWIS.

The Review found a main cause of the outages was electricity demand exceeding network infrastructure capacity in some parts of the Western Power network. This unusually high demand was a result of increased use of air-conditioning and other appliances during an extreme heatwave. Over the period, Perth experienced four days above 40 degrees and very high overnight minimum temperatures.

The outages had a significant impact on customers because of the need for electricity as an essential service to cool down homes in extreme heat; and because holiday celebrations and gatherings were interrupted.

It's important to note that while there was extremely elevated electricity demand over the period, there was sufficient generation available to supply customers. Outages were instead related to issues on the distribution network.

1.3. The approach to the Review

The Review was provided a six-week period in which to assess the Christmas 2021 outages.

In this short timeframe, the Review has analysed a wide body of information and undertaken a range of meetings with stakeholders, community and Western Power representatives.

Over the six-week period, the Review:

- made four substantive information requests of Western Power and several supplementary requests;
- met with Western Power representatives, including the Chair of the Board, Chief Executive Officer, Executives, Heads of Function, and operational staff on more than 15 occasions;
- collected feedback via meetings with multiple stakeholders, including the:

Australian Energy Market Operator	Energy Networks Australia
Bureau of Meteorology	Energy Policy WA
City of Armadale	WA Advocacy for Consumers of Energy Forum & Expert Consumer Panel
City of Gosnells	
Department of Fire and Emergency Services	Western Australian Local Government Association
Economic Regulation Authority	

- considered feedback received from other stakeholders through email, phone calls and media coverage; and
- assessed more than 400 documents, provided by stakeholders or otherwise publicly available.

The Review notes the efforts made by Western Power staff to provide timely and fulsome information in response to the Review Team's information requests.

At various stages throughout the Review, Western Power was provided with the opportunity to provide feedback on the Review's interpretation of the information provided.

The Review Team also thanks all individuals and organisations who made themselves available for consultation or provided data and other information. These generous contributions have been invaluable in completing this report.

Lastly, this Review has focused its assessment of the outages through a customer-centric lens – the findings and recommendations in this report have been framed in terms of preventing or mitigating customer impacts.

2. The Western Power network

This chapter explains the role of Western Power and how it undertakes its core network functions. It includes an overview and assessment of Western Power's approach to network and operational planning; asset management; network investment; risk management and historical network performance.

For further information on electricity networks and Western Power's network management, see **Appendix A**.

2.1. Western Power's role

Western Power is wholly owned by the State Government of Western Australia and operates as the monopoly provider of electricity network infrastructure in the SWIS.

Western Power (the *Electricity Networks Corporation*) is a statutory corporation with an independent board. Its principal functions are set out under section 41 of the *Electricity Corporations Act 2005*.

Western Power is responsible for the planning, design, construction, maintenance and operation of its electricity network in the SWIS. The Western Power network services almost 1.2 million customer connections in the southwest of Western Australia. The network covers an area of 255,064 km^2, incorporating the Perth and Peel regions as well as areas north to Kalbarri, east to Kalgoorlie and south to Albany.

Traditionally, electricity networks are the poles and wires that transfer electricity between generators and retailers (and ultimately, their customers).

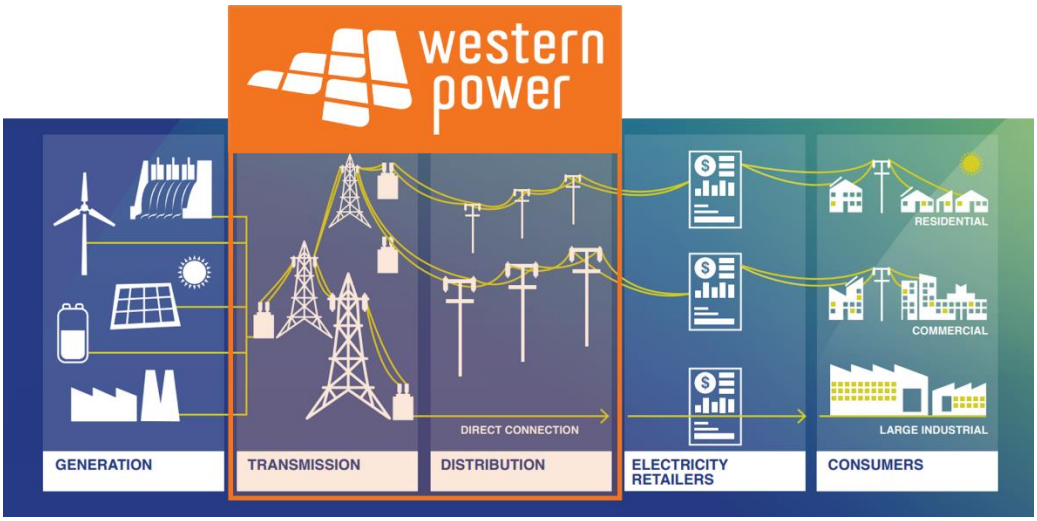

Figure 2.1: Power system overview[1]

In the SWIS, the Australian Energy Market Operator manages the whole power system, including balancing supply and demand between generation and electricity users. There are many generators and retailers that participate in the Wholesale Electricity Market (or WEM, the

[1] Electricity Networks Australia, 2021, *Fact Sheet – What is transmission?*

electricity market in the SWIS), however, almost all residential homes and many small businesses (known as "small use customers") are required to have Synergy as their retailer.

Generally, networks are designed and built to manage a probable level of peak demand. Costs to build and maintain the network are therefore associated with managing peaks, rather than the total amount of electricity customers use throughout the year. The costs associated with building and maintaining the network are passed through to end users via network charges.

Historically, electricity networks have been designed to support the one-way flow of electricity generated at large power stations, transported long distances through very high voltage transmission networks, and then distributed around cities and towns via medium voltage distribution networks before reaching homes and businesses through low voltage distribution networks.[2] This traditional design has been used across the world, and has been effective in supplying reliably energy at a reasonable cost.

In recent years, the adoption of new technologies like rooftop solar has been a positive step for customers and the decarbonisation of the energy sector. However, these technologies present new challenges for electricity networks such as decreasing minimum demand levels. Network operators like Western Power must now manage increasingly variable and less predictable power flows, requiring innovative new approaches such as microgrids and batteries.

2.2. Requirements of Western Power

To ensure the network is operated effectively, Western Power is subject to a complex legislative and regulatory framework that covers network design and planning, investment in assets, asset maintenance, safety and the technical operation of the network. This also includes compliance obligations relating to emergency services. Western Power's revenue – what it can charge its customers – is independently approved by the Economic Regulation Authority (ERA).

Underpinning this regulation is a focus on the long-term interests of consumers[3], including ensuring customers are supplied with safe, efficient and reliable electricity.[4]

"Reliability" refers to the ongoing supply of electricity to customers where the occurrence and duration of interruptions is kept to a minimum.

Appendix B provides a summary of Western Power's regulatory, statutory and market obligations relevant to the Review.

2.2.1. Network design, planning and forecasting

Western Power designs and builds the network according to a range of requirements, many of which are set out under legislation. This section outlines these requirements and assesses how Western Power undertakes network design and load forecasting activities.

[2] Western Power utilises 330 kilovolt 9kV, 220kV, 132kV and 66kV for Transmission; 33kV, 22kV, 11kV and 6.6kV for Medium Voltage Distribution; and 415V 3 phase and 230V single phase for Distribution Low Voltage
[3] S2.1, *Electricity Networks Access Code 2005.*
[4] Ibid.; S9, *Network Quality and Reliability of Supply Code 2005*.

Figure 2.2 outlines the various parts of the network – from extra-high voltage transmission, to medium voltage (MV) and then low voltage (LV) distribution networks that serve most customers.

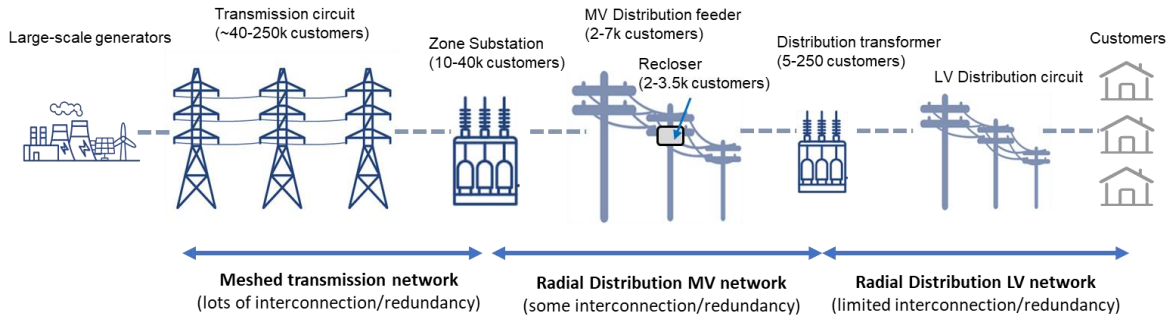

Figure 2.2: Example network infrastructure design

Forecasting

Western Power undertakes forecasting to ensure the network can meet the current and future requirements of customers. Forecasting is a key input into many parts of Western Power's activities, particularly network planning.

Over recent years, peak demand in the SWIS has remained relatively stable, although minimum demand levels have decreased, driven by increasing levels of residential rooftop solar reducing customer demand from the grid during the middle of the day.

At a transmission level, the Review notes Western Power's forecasts for overall demand levels, particularly peak demand, have generally been accurate. This view is supported by the National Institute of Economic and Industry Research (NIEIR), which found that Western Power's system peak forecasts appear reasonable and in line with other industry forecasts.[5]

At the zone substation level, Western Power's forecasts have also been identified to be reasonable.[6]

At the medium voltage distribution feeder level, Western Power firstly allocates its substation load forecast across the feeders and then adjusts this based on previous peak and growth factors for individual feeders.

At the low voltage network level, Western Power forecasts peak demand at each distribution transformer (which can supply several hundred customers). Western Power applies an algorithm that incorporates a sample of connected customers' energy use (i.e. measured in kilowatt hours) which is converted into a peak demand level (i.e. measured in kilowatts) for all connected customers, based on assumptions of customer appliance usage and installed rooftop solar capacity.

This approach is used as Western Power has low visibility of actual customer peak demand levels.[7] The methodology of converting total energy consumption can underestimate peak

[5] National Institute of Economic and Industry Research, 2021, *A review of Western Power's forecast methodology for the AA5.*
[6] Ibid.
[7] For example, most electricity meters are "accumulation" meters, which only provide data on overall energy consumption from the grid, rather than more precise measures of demand.

demand levels if the assumptions of customer use and rooftop solar capacity are understated. Rooftop solar installations reduce customers' total energy requirements from the grid, thereby masking underlying energy use – a key input to estimate peak demand levels. As a result, under Western Power's current low voltage distribution network forecasting methodology, pockets of the network (for example, those with particularly high levels of rooftop solar capacity or very 'peaky' household demand) could be more susceptible to inaccurate forecasts that could lead to capacity-based power outages.

Western Power advised the Review the above approach identifies the majority of overloads before a fault occurs. That is, identifying instances where demand would have exceeded the capacity of a distribution transformer before it happens. However, around 30% of low voltage distribution network asset replacements for overloads are not forecast. These replacements are reactively addressed, for example after a fuse has tripped repeatedly and customers have an outage. Western Power also advised that, historically, approximately only 22 distribution transformers are replaced due to capacity limitations (16 proactively, and six reactively) every two years from a population of approximately 70,000.

Western Power has indicated it recognises there are some shortcomings in its distribution forecasting and planning approach and improvements are underway. This includes development of the Grid Transformation Engine, a software system that will forecast "economic, demographic and technology changes over a 30-year period" to inform investments.[8] Western Power is also trialling an improved rooftop solar factor (including use of rooftop solar application data) to better inform the forecasting algorithm.

Further, the ongoing rollout of Advanced Metering Infrastructure (AMI, also known as "smart meters", with an accompanying communications network) will provide Western Power with substantially more information on customer peak demand. Western Power is currently planning to incorporate this data as the rollout continues.

Review findings

1. Western Power undertakes good practice in forecasting. However, the forecasting methodology for loads deep in the distribution network needs to continue to develop to keep pace with the fast-changing consumer behaviour and climatic changes.
2. The low visibility of customer peak demand in parts of the network, and the impact of rooftop solar masking underlying loads, is impacting the robustness of Western Power forecasting, and likely results in pockets of the network being more susceptible to overloads. The parts of the low voltage distribution network at risk typically serve residential homes and small businesses. As the energy transition continues rapidly, Western Power's forecasting methodologies should be reviewed to ensure they remain relevant and appropriate.
3. Western Power is working to improve its forecasting and planning methodologies, including the incorporation of better customer data received from AMI. This work may improve Western Power's ability to manage the network during times of peak demand.

[8] Western Power, 2020, *Annual Planning Report 2020*.

Network design and planning

Western Power undertakes network design and planning to ensure its network has the capacity to provide reliable electricity to customers into the future.

Key inputs for its planning include: the above forecast of customer demand characteristics; as well as the location of new generation sources; any changing network standards or requirements; and the adoption of new technologies on the system.

Western Power produces and releases a public planning report,[9] outlining its forecasts and plans to meet changing requirements on the network.

Western Power undertakes some of its network planning under obligations in the Technical Rules.[10] In particular, Western Power is required to meet specified "planning criteria" that guide design across its transmission and distribution network. It seeks to strike a balance between high reliability for customers against the cost. The planning criteria in the Technical Rules is independently approved by the ERA.

Under these requirements, Western Power must design the transmission network with redundancies to ensure that if there is a planned or unplanned outage, customers can be supplied by another part of the network.[11]

For the distribution network, Western Power must ensure supply for the maximum "reasonably foreseeable load anticipated".[12] For areas of the distribution network with higher customer density, network design will generally allow for some or all of those customers to be resupplied by switching supply from a different part of the network when faults arise. It's noted for new urban feeders the ability to switch to an alternative feeder must be available. For rural feeders this is required when it is technically and economically feasible.

In general, the level of redundancy decreases from the very high voltage network (which serves a large number of customers) through to the low voltage network (which serves less customers). This approach helps balance reliability with the costs of building and maintaining the network.

In addition to the planning criteria and redundancies specified in the Technical Rules, Western Power then applies a probabilistic approach to design in order to decide what network assets are required in which location.

At the transmission level and zone substation level, Western Power applies a 10% probability of exceedance (10POE) forecast. In other words, the transmission network is designed to supply

[9] Prior to 2021, Western Power released an Annual Planning Report. From 2021, the Annual Planning Report has been superseded by the Network Opportunities Map.

[10] S2.5, *Technical Rules*. A6.1(m), Appendix 6 of the Access Code defines the requirement for the Technical Rules.

[11] In some zone substations there may be a medium duration outage of some customers at peak demand until a mobile transformer can be installed to replace a failed zone substation transformer. Under Western Power's present Access Arrangement proposal, it has proposed a change to the Transmission Planning Criteria to move away from a purely deterministic approach to a hybrid deterministic/probabilistic approach used in many other jurisdictions which then ensures the benefit (e.g. value of customer reliability achieved) outweighs the cost of the augmentation.

[12] Clause 2.6(a), *Technical Rules*.

customer peak demands that are forecast to occur more than once in every 10 years (including an allowance for the relevant redundancy requirements).

At the distribution medium voltage feeder level, Western Power uses a 50% probability of exceedance (50POE), with different thresholds applied for urban and rural feeders, outlined in the table below.

Table 2.1: Design thresholds for urban and rural feeders

Urban - 50POE for 80% peak demand	Rural - 50POE for 100% peak demand
- Western Power designs for a one in two-year chance that 80% of a feeder's capacity will be exceeded. - This approach balances the costs of installing larger capacity infrastructure with the reduced likelihood that a feeder will hit its maximum capacity. - The use of 80% loading allows for load to be switched over to adjacent feeders during an outage.	- Western Power designs for a one in two-year chance that 100% of a feeder's capacity will be exceeded. - Interconnection is only installed where technically and economically feasible (reflecting the lower customer density). - Increased interconnection in rural areas would incur significant costs (impacting on electricity prices). - For long rural feeders there are often other performance criteria (e.g. voltage drop) that becomes the limiting factor such that 100% loading is unlikely to be reached.

The use of probability of exceedance criteria means that the system is built to supply a certain peak demand level. While this approach limits costly investment in the network, it can result in customers losing power supply during extreme, but infrequent, events.

Low voltage distribution networks, including transformers which step down the voltage from medium to low voltage, are designed to meet the forecast maximum average demand of connected customers. Annual reviews are undertaken to assess whether actual connected customers' demand has increased,[13] and if so, if an increase in the network capacity is required.

Western Power is assessing innovative alternatives to network design, including incorporating standalone power systems and microgrids.[14] These options may improve customer reliability and mitigate the impacts of extreme events in future.

Review findings

4. Western Power appears to comply with the prescribed network design criteria specified in the Technical Rules.

5. Western Power applies its own design criteria to inform investment decisions, which uses "probability of exceedance" estimates to determine the design and upgrade of network infrastructure. This approach ensures the network is designed to meet likely

[13] For each annual review, Western Power takes a sample of customers' accumulation meter data on that LV network, and adjusts it for solar PV and to maximum demand. It then scales those sample maximum demands for the number of customers connected to the distribution transformer.
[14] Western Power, 2022, *AA5 information*.

customer demand levels and can limit costly investments. However, it means the network is not designed to supply extremely high levels of demand.

6. As extreme events become more likely, more severe and less reflective of historical events (for example, as a result of climate change), the approach to planning may need to evolve to ensure that network design remains appropriate for providing customers with reliable electricity supply while still recognising the reliability-cost trade off.

Western Power reporting on network design and planning

Western Power applies the above network forecasting and planning criteria to inform the design of its network. On an annual basis, Western Power reports on the outcomes of its analysis including the investments necessary to retain or improve reliability. Further information on these reports is provided in **Appendix C**.

Western Power's most recent reporting outlines a range of completed distribution network projects including works to increase distribution feeder and transformer capacities to manage overloads and increase capacity to supply new or increasing loads.[15]

In its Network Opportunities Map 2021, Western Power identifies opportunities for investment in several zone substations and feeders approaching capacity limits.[16]

The transmission substation locations identified were Wellington St, Black Flag, Bibra Lake, Byford, Henley Brook, Mandurah, Clarkson, Joondalup, Bridgetown, Bunbury Harbour. The Distribution feeders approaching limits were at the Beechboro and Yanchep substations. The report also identified heightened reliability challenges in Eaton, Dongara, Lancelin, Port Denison and Northampton.

This reporting is publicly available on the Western Power website. The requirement for a Network Opportunities Map was implemented through changes to the Electricity Networks Access Code 2005 (Access Code) in 2020, with the intent of requiring Western Power to identify future opportunities for third party alternative network services providers. However, the reporting is generally technical in nature and is not made for a customer audience.

Review findings

7. Western Power appears to have a good understanding of areas approaching network capacity limits, and reports annually on areas with heightened risk of reliability issues.
8. However, reporting on these areas is presented with an industry focus, rather than through transparent and accessible information to customers.

2.2.2. Asset management and maintenance

Western Power is required to manage millions of network infrastructure assets, including "poles, towers, overhead wires, underground cables, switchgear, transformers, protection

[15] Western Power, 2020, *Annual Planning Report 2020*; Western Power, 2021, *Network Opportunities Map 2021.*

[16] Western Power, 2021, *Network Opportunities Map 2021.*

equipment and security fencing",[17] to ensure the network is safe and provides reliable supply of electricity.

As a condition of its electricity distribution licence, Western Power must commission an independent audit of its Asset Management System. Western Power also has an Asset Management Policy,[18] which guides activities involved in the design, construction, commissioning, operation, maintenance or decommissioning of Western Power's network.

The most recent review of Western Power's asset management approach was undertaken in 2020, with independent findings indicating that the Western Power asset operations, maintenance, risk management and contingency planning were all appropriate and performing well.[19] This was supported by the ERA in January 2021, when it stated Western Power's asset management system is "effective".[20]

Western Power also publishes a "State of the Infrastructure Report" which provides an outline of the condition of the network and its assets. The most recent report identified that no asset classes were rated at extreme or high risk for reliability, and that the asset management system is certified in line with international standard ISO55001:2014.[21]

Review finding

9. Western Power appears to have developed a sound asset management system and related policies to ensure network infrastructure is maintained and performing as expected.

2.2.3. Investment in the network

Western Power makes ongoing investments in its network to ensure safe and reliable power is delivered to existing and new customers. It is required to have its investment expenditure allowance approved by the ERA, to ensure it is necessary and efficient.

The ERA currently approves Western Power's overall allowable revenue through a five-yearly access arrangement review process. This process sees Western Power identify expenditure requirements and make proposals for review by the ERA. The ERA assesses and approves Western Power's allowable revenue for a five-year period, based upon a forecast of prudent and efficient capital and operating expenditure. Following approval, Western Power decides which investments will be made following an internal business case assessment for each specific project.

The current access arrangement period (AA4) runs from July 2017 to June 2022. Western Power has recently submitted its proposal for the coming AA5 period (covering 2022-2027). This submission provides an overview of the actual spend across the AA4 period, and proposed spend for the coming period.

Over the AA4 period, Western Power spent 12% ($368 million) less on distribution network asset investment (and overall 3% less across the whole network) than it originally planned for

[17] Western Power, 2020, *State of the infrastructure report 2019/20.*
[18] Western Power, 2019, *Asset Management Policy.*
[19] AMCL Pty Ltd, 2020, *2020 Asset Management System Review.*
[20] ERA, 2021, *2020 performance audit and asset management system review.*
[21] Western Power, 2020, *State of the infrastructure report 2019/20*.

and was approved to spend by the ERA.[22] Western Power notes the lower actual spend was related to an expected lower peak demand compared to that forecast for AA4, as well as improved efficiency of its network design processes.[23] Similarly, during AA3 (2012-2017), Western Power spent 17% less than its allowance for distribution capital investment.

The approval of funding from the ERA appears to have allowed Western Power to make appropriate investment in the network.

As a Western Australian Government Trading Enterprise, Western Power contributes dividend payments to the State Government. The Review found no evidence that the payment of these dividends had contributed to the Christmas 2021 outages or hindered relevant investment in the Western Power network.

Review finding

10. Over the past five years, Western Power, through funding approval processes with the independent regulator and the State Government, appears to have been approved to make all distribution capital investments it identified for the network. There was no evidence that investments were delayed or did not occur due to regulatory or governmental decisions.

2.2.4. Network operations and operational processes

Western Power is required to operate its network in a way that maintains a near continuous supply of electricity with customers only interrupted infrequently and for short times. For example, the supply of electricity may be interrupted under certain circumstances, such as for maintenance or in the event of damage to the network.[24]

At the centre of Western Power network operations is a Control Centre which manages supply to customers in real time. The Control Centre monitors the network and take steps to keep the network secure and reduce the likelihood of customer outages when events occur.

When outages do occur Western Power work to restore power to customers as soon as possible. At times where multiple faults occur, this requires coordination of Western Power resources and the application of operational procedures which guide the order of restoring customers.[25] In the case of an outage on the network the Control Centre will undertake the following activities:

- dispatch Western Power Field Crews to the prioritised faults and oversee their safe access to the network; and
- determine alternative means to supply customers where feasible.

[22] Western Power, 2022, *AA5 information*, Table 5.2.
[23] Ibid.
[24] S63 *Electricity Corporations Act 2005*
[25] These prioritisation procedures direct that Western Power will respond to hazards first, and then other outages ordered by number of customers impacted by each outage, with an escalation process to consider other factors such as outage duration and the number of sensitive customers impacted.

When repairs are complex or might take some time, options to supply customers via other means are explored. These include:

- Implement load switching – that is, isolating the faulted part of the network and then switching the non-faulted parts onto other parts of the network. This uses the meshed network to find another way to deliver electricity to customers; or
- dispatching back-up generators to restore supply.

The options to provide alternative supply to customers before the fault is fixed is not always possible. For example, depending on the network configuration, load switching may not be possible. For backup generation, the time, resourcing and logistical difficulties may make the deployment unsuitable.

2.3. Reliability and service standards

Network operators use a combination of robust network forecasting and planning; network investment; and appropriate operational maintenance to deliver reliable supply to customers.

To ensure accountability for Western Power to meet a reasonable level of reliability, the regulatory framework sets standards which Western Power must meet. These standards are set to strike a balance between reliability, and the capital and operational costs incurred to meet the standard.

Western Power is also required to report regularly on its performance against these standards.

The Review notes there are a number of benefits of network's reporting on their performance, including:

- increasing transparency and accountability of networks to their stakeholders;
- highlighting areas of performance which may need to be managed and addressed; and
- assisting in engaging with stakeholders on future investment needed to address under performance.

There are two standards which Western Power must report against, these are:

(a) the minimum standards that Western Power must comply with as outlined in the Electricity Industry (Network Quality and Reliability of Supply) Code 2005 (NQRS Code); and

(b) benchmarks linked to financial incentives and penalties as detailed in its access arrangements under the Access Code.

Each of these requirements, and Western Power's recent reliability performance, is outlined below. Further information on Western Power's reporting requirements is provided in **Appendix C**.

2.3.1. Minimum standards

The NQRS Code outlines a requirement to "so far as is reasonably practicable, ensure that the supply of electricity to a customer is maintained and the occurrence and duration of interruptions is kept to a minimum".[26] This code assesses all interruptions to power supply, including those caused by events beyond Western Power's control.

The NQRS Code recognises that providing reliable supply becomes more difficult in low density parts of the network. Higher standards therefore apply to customers in urban compared to rural areas.[27]

The NQRS Code minimum standard is that, for no more than one year in 10, a customer must not be interrupted:

- for 12 hours continuously, or
- 9 times in a year for CBD or urban customers, or
- 16 times in a year for customers in other areas.

Regarding the number of outages, Western Power has "consistently reported an annual compliance level of approximately 95%".[28]

In the case of a significant interruption outside of the above limits, Western Power is required to fix the cause of interruption or otherwise find an alternative arrangement to supply electricity.[29]

Further, Western Power must "so far as reasonably practicable", ensure that average length of interruptions do not exceed the number of minutes in the following table:

Table 2.2: Western Power's minimum standard for average interruption length

Area	Minimum standard – average total length of interruptions
Perth CBD	30 minutes
Urban areas (other than Perth CBD)	160 minutes
Any other area	290 minutes

Western Power reports that it has breached the above minimum reliability standards in relation to significant interruptions and length of interruptions due to climate events. In 2020-21, non-compliance was attributed primarily to "bushfires and weather events beyond Western Power's control".[30]

All outages (including those outside of the control of Western Power) are reported through Annual Reliability and Power Quality (ARPQ) Reports. ARPQ reporting outlines the felt experience of customers for all outages, including both faults outside of Western Power's

[26] S9, *Network Quality and Reliability of Supply Code 2005*.
[27] S12(1) & S13(2) *Network Quality and Reliability of Supply Code 2005*.
[28] Assurance Advisory Group, 2020, *2020 Performance Audit.*
[29] S12, *Network Quality and Reliability of Supply Code 2005*.
[30] Assurance Advisory Group, 2020, *2020 Performance* Audit.; and Western Power, 2021, *Annual Reliability and Power Quality Report for the year ended 30 June 2021.*

control (e.g. storms) and those outages more within Western Powers control (e.g. planned outages, some equipment failure).

This data shows over a four-year period a 'materially' worsening customer outage experience trend in CBD and rural areas, with flat performance in urban areas. The causes of the worsening performance include several events which caused material damage to parts of the Western Power network, including Cyclone Seroja, numerous storm events and bushfires.

Excluding the Christmas 2021 outages, six events occurred in 2021 with a combined total of 174 SAIDI minutes. Recent major events have had a particularly significant impact in the northern parts of the SWIS, including Kalbarri, Geraldton and many nearby communities which were severely impacted by Cyclone Seroja.

2.3.2. Service Standard Benchmarks

In addition to these minimum requirements, service standard benchmarks (SSBs) apply additional requirements to Western Power over each access arrangement period. These benchmarks are also linked to the Service Standard Adjustment Mechanism (SSAM),[31] which provides a financial incentive/penalty mechanism for Western Power's performance against SSBs. The SSBs and SSAM are determined through the access arrangement process with the ERA under the Access Code.[32]

The three distribution network SSBs are categorised as:

1. Duration of outages – total average number of minutes a customer is without electricity
    - This is referred to as System Average Interruption Duration Index (SAIDI).
2. Frequency of outages – average number of times a customer is without electricity
    - This is referred to as System Average Interruption Frequency Index (SAIFI).
3. Customer service – average wait time for customers to receive a call centre response.

The frequency and duration of outages is identified for four separate classes of feeder in the Western Power network.

[31] In its *Proposed revisions to the access arrangement for the Western Power Network 2022/23 – 2026/27 Issues paper* the ERA acknowledges the different reliability performance standards that apply to Western Power, and as the NQRS Code is a legislative requirement, Western Power should base its expenditure forecasts on the efficient cost of meeting the NQRS Code. The ERA has sought stakeholder feedback on whether measures focussed on reliability performance in specific areas of the network where reliability is below or tracking below the benchmark should be considered as part of Western Powers access arrangement.
[32] S11.1, *Electricity Networks Access Code 2005*.

Table 2.3: Four classes of feeder identified in the Western Power network

CBD	Parts of the network supplying predominantly commercial, high-rise buildings, usually by underground distribution systems that are highly interconnected. • CBD network supplies about 5,000 connections (0.5%).
Urban	Parts of the network that are not CBD but have high density demand. • Urban network supplies around 745,000 connections (63%).
Rural Short	Network feeders with high voltage route length less than 200km. • Rural short network supplies around 324,000 connections (28%).
Rural Long	Network feeders with a high voltage route length greater than 200km. • Rural long network supplies around 100,000 connections (8.5%).

Western Power must prepare and release a report on its performance against the SSBs annually.[33]

Unlike the minimum standards in the NQRS Code, the measurement of performance for SSBs excludes outages which are deemed outside the reasonable control of Western Power. These excluded events are called 'Major Event Days' and refer to days where natural circumstances beyond Western Power's control, including extreme weather events like storms and heatwaves, result in significant outages.

Recent Western Power reporting on SSBs shows that, generally, Western Power has a record of meeting its benchmarks.[34] The performance over the past five years is shown in the table below.

Table 2.4: Service standard performance summary for 2016-17 to 2020-21[35]

			SSB 2018/19 onwards	2016/17 actual AA3	2017/18 actual AA3	2018/19 actual AA4	2019/20 actual AA4	2020/21 AA4	
								Actual	SSB met
Distribution	SAIDI	CBD	≤ 33.7	13.8	1.3	14.7	22.8	14.1	✓
		Urban	≤ 130.6	104.4	104.5	106.1	134.3	118.0	✓
		Rural Short	≤ 215.4	175.6	151.9	179.3	218.3	210.2	✓
		Rural Long	≤ 848.3	626.2	718.1	712.3	737.7	713.5	✓
	SAIFI	CBD	≤ 0.21	0.11	0.04	0.11	0.20	0.26	×
		Urban	≤ 1.27	1.02	1.03	0.97	1.14	1.13	✓
		Rural Short	≤ 2.34	1.76	1.59	1.79	2.11	1.94	✓
		Rural Long	≤ 5.70	3.95	3.96	4.02	3.77	4.25	✓
	Call Centre Performance - %		≥ 86.8	91.8	91.7	91.7	92.6	91.9	✓

Over the last five years reliability performance on the distribution network has deteriorated slightly (while there has been a slight improvement on the transmission network). Importantly,

[33] S11(3), *Electricity Networks Access Code 2005*.
[34] Western Power, 2021, *Service Standard Performance Report 2020-21.*
[35] Ibid., Table 6.1.

the distribution network SSBs were met in 8 out of 9 categories in 2020-21 with only the CBD SAIDI not being met.

Western Power is incentivised (through the SSAM) to meet more stringent Service Standard Targets (SSTs), which require better performance than that required to meet the SSBs. These are also agreed between Western Power and the ERA.

Historically, Western Power has performed well against SSTs. However, for 2020-21, the SSAM financial penalty was $10.7 million which was mainly due to underperformance of SAIDI in Urban and Rural areas against the targets.

Review findings

Western Power is required, and financially incentivised, to meet standards that balance reliability with costs. Western Power reports on its performance against these various standards on an annual basis.

These standards can be focused on individual customer outages (e.g. a maximum number of outages), but are also related to total system averages for reliability.

11. The use of averages for measuring reliability performance across a very large number of customers means that some customers will naturally experience levels of reliability above or below the benchmark.
12. The NQRS Code and Access Code use differing measures of reliability standards and apply different methodologies for the calculation of reliability performance. Performance against these standards is also reported in separate reporting processes.
13. Recently, Western Power has reported a degree of non-compliance with minimum standards under the NQRS code, with a primary driver being extreme climate events.[36]
14. Western Power has a record of generally meeting its service standard benchmarks, which are set via an independent approval process through the ERA (under the Access Code) and are also linked to a financial incentive framework.

2.3.3. Customers' view of Western Power's reliability

The Review found that customers generally accept that electricity networks can't guarantee 100% reliability. Customers' acceptance of outages is greater when damage to the network can be seen, for example when an extreme storm brings down power lines or there is damage from a bushfire.

Customers' view of Western Power's reliability performance varies depending on their location. Customers in urban areas told Western Power they rate the level of their reliability very high, while regional customers rated it lower. Urban customers are unwilling to pay more for improved reliability but customers in regional areas would pay more, reflecting their willingness to pay for better reliability.[37]

[36] Western Power, 2021, *Annual Reliability and Power Quality Report for the year ended 30 June 2021.*
[37] Western Power, 2021, *Bringing Customer Perspective to the AA5 Submission*

In addition, the value a customer places on reliability will depend on the conditions during an outage. For example, to avoid outages in extreme heat such as that experienced over Christmas, customers may be willing to pay more.

In the future, it's expected there will be more extreme events driven by climate change, which will likely negatively impact electricity reliability. As customers experience more outages, their willingness to pay more for a more resilient network may also change, noting this preference will differ for financially disadvantaged customers who already struggle to pay their electricity bill.

2.3.4. Customer engagement on network reliability

The Review was told that customers and community leaders in areas that experience below average reliability, want to understand how their reliability compares to others; why their reliability is below average; and what Western Power plans are to improve reliability.

However, the Review found the information currently available on reliability performance could be improved to provide for better community engagement.

In particular there are three issues that if addressed, may improve customer understanding and engagement on reliability. These are described below.

Customer friendly information on reliability performance and any plans to address poor reliability. This includes combining in one document the reliability performance including and excluding Major Event Days, that is a combination of the information currently in the APQR and the publication of SSBs.

In addition, where reliability performance may be below the benchmark levels, an explanation for why, and any plans for investment to address issues (where there is a net benefit to customers in doing so) would be helpful to customers. Some of this information is currently in Western Power's Annual Planning Report.

In undertaking this Review, it was found to be difficult to access easily understood information about which communities regularly experience below service standard reliability.

While it's noted Western Power does publish information relating to reliability levels and locations it is not readily accessible to customers.

In contrast, the Review found that in other Australian jurisdictions, regulators require network operators to publish information on the 'worst performing feeders' on the distribution network. As explained in **Appendix F,** where this information is published in a customer friendly way (for example in South Australia) it provides useful information to customers on electricity reliability in their community.

Review findings

15. Western Power appears to be aware of, and reports in some detail, areas of the network facing reliability challenges. However, this information is not readily accessible, and customers may benefit from greater levels of transparency in an appropriate form.

16. Transparent information about which parts of the network are regularly experiencing reliability materially below standards, and the impact of major day events on network performance, would improve stakeholder engagement on the reasons for reliability issues in their community and what Western Power can do to address it. It would also foster a discussion about customers willingness to pay for reliability, including for uncertain events, noting the trade-off between cost and performance. The benefits of transparency apply to urban as well as rural customers, many of whom experience lower levels of reliability.

2.3.5. Risk approach and decision-making

In the operation of its network, Western Power manages many network and non-network risks. These include electrical and fire safety, cyber security and climate related risks.

Its approach to risk management involves a process for the identification, analysis, evaluation, treatment, monitoring, reviewing and reporting of risks that can impact on the achievement of Western Power's objectives.

The Western Power Board has a key role in setting the organisation's risk appetite, and approving the risks and the associated risk management plan. The Executive Management team is involved throughout this process.

In addition, the Review notes Western Power has put in place many procedures and plans to manage key risks, and operationalised these including through communication with staff.

The key risks most relevant to the Christmas 2021 outages are climate risks, the risk of major customer outages, and fire safety risk.

Climate risks

Western Power has recognised extreme climate events as a material risk to its business, including the potential for more frequent extreme weather events that create reliability challenges and is making investments to improve network resiliency.[38]

Western Power notes that climate change will likely increase the risk of extreme weather events like storms and heatwaves, as well as lead to increased fire risk days, all of which can impact customer reliability.

Preventing and managing significant outages

Western Power has strategies in place to reduce the risk of customer outages including investment and network management programs. As detailed in this report, this includes approaches to asset management, forecasting, planning and network design. These strategies are usually employed well in advance of the threat of an outage.

On an annual basis, Western Power prepares for an upcoming summer through a 'Summer Ready Plan'. The plan identified feeders where forecast loads may be approaching design criteria. For heavily loaded feeders, loads were switched to adjacent feeders with spare capacity, and some capacity issues were resolved by other means.

[38] Western Power, 2022, *AA5 information*.

Once a significant outage is considered imminent, Western Power can action its Emergency Management Plan which triggers a number of subordinate plans and procedures, including the activation of the Emergency Management Team (EMT). The EMT consists of senior Western Power staff and its formation provides for the coordination of actions to prevent and manage customer outages in real time.

Fire risk management

Western Power considers fire risk to be a significant risk to its operations. Electricity networks can and have started fires in the past with devastating consequences for human life and property. It is appropriate for Western Power to manage this risk with prudency.

To manage fire risk, Western Power has in place several procedures which aim to reduce the likelihood of its network starting a fire.

The Western Power procedures largely reflect its exemption from the Department of Fire and Emergency (DFES) for it to undertake actions during a Total Fire Ban (TFB) in recognition of it providing an essential service to the community. The DFES exemption outlines a number of activities Western Power must undertake before safely restoring customers on TFB days.

In addition, Western Power's procedures include additional steps to manage fire safety risks beyond that required under the exemption – these reflect Western Power's view of risks and its legal obligations.

For example, under its procedures, on Fire Weather Days (FWD) and TFB days, Western Power undertakes pre-emptive actions to prevent its infrastructure starting a fire. This includes changing network protection settings to minimise network sparking for a fault in high fire risk conditions. These strategies are employed by other network operators in Australia for TFB equivalent conditions (e.g. Victoria and South Australia).

In addition, Western Power undertakes the following additional steps beyond the DFES exemption before restoring customers, including:

- proactively checking pre-existing high-risk defects in high-risk bushfire zones;[39] and
- in lower bushfire risk zones Western Power patrolling the faulted area of the network until a fault is found. In high-risk bushfire risk zones a patrol of the whole faulted section is done even after a fault is found.

Western Power has put these requirements in place to comply with the DFES TFB exemption requirement that "all reasonable endeavours must be taken to identify the fault prior to switching".[40]

In addition to the TFB procedures, Western Power also actions its own FWD restoration procedures on non-TFB days, based on BOM fire danger ratings.[41] Under the FWD restoration

[39] Western Power procedures refer to Bushfire Risk Zone areas with rating of Extreme, High, Moderate or Low. DFES provides a map on its website that only differentiates bushfire prone areas.
[40] Clause 5.1 of DFES Notice of Exemption to Western Power.
[41] The Review understands Western Power apply Fire Weather Day arrangements when the BOM forecast the fire danger rating will be very high, severe, extreme or catastrophic and/or the fire danger index for a particular fire weather district is forecast to be equal to or exceed 32.

procedures, requirements to allow restoration of faulted parts of the network are similar to those imposed under the TFB restoration procedures, although they are not as onerous. This approach appears to go beyond Western Power obligations under the *Bushfire Act 1954*, with Western Power advising that it takes these steps to meet its obligations under the *Energy Operators (Powers) Act 1979* not to be negligent and undertake actions to prevent reasonably foreseeable risk.

The application of fire risk procedures does not appear to overly discriminate between conditions in residential urban areas and those in rural higher fire risk areas.

The Review understands that, for simplicity, TFBs are generally determined based on the worst-case fire conditions for an area. In other words, there will be areas within a TFB declared area where the actual fire risk conditions are much less. Similarly, Fire Danger Index is calculated based on worst case conditions, although there are different indices for forest and grass lands.

Western Power's procedures appear to place a very high weighting on the network fire start risk, with less focus on the safety risk for customers having prolonged power outages, particularly in extreme heat.[42]

As outlined later in this report, Western Power's management of fire risk had a significant impact on the length of the outages over Christmas. The reenergisation of the network was frequently delayed, sometimes for many hours, until the fire risk was considered to be at safer fire danger level.

Review findings

17. Western Power has developed a reasonable approach to assessing and managing risks across its business and includes appropriate governance arrangements.
18. Western Power has developed plans and procedures which are actioned prior to, and during, significant outage events. The operationalisation of Western Power's emergency plans, and particularly its EMT processes, are well executed and effective.
19. Western Power's approach to fire risk is reflective of the potentially catastrophic consequences of fires. However, the approach to managing fire risk does not always take into account the fire risk for that specific part of the network nor the safety impacts of prolonged outages during heatwaves. This issue is explored further in Chapter 4 and Chapter 5.

3. The Christmas 2021 outages

3.1. Conditions in lead-up to, and during, the period

3.1.1. Environmental conditions

Christmas 2021 occurred during an extreme heat wave. While the SWIS can often experience very hot temperatures in December, conditions during Christmas 2021 were highly unusual, occurring in the Perth Metro region three times in the past 123 years.

[42] As detailed in **Appendix H**, power outages during heatwaves can cause serious health issues and increase mortality.

In Perth, maximum temperatures were above 40 degrees for four consecutive days. During the period, minimum temperatures were also very high – easterly breezes in the evening and overnight (rather than the typical sea breeze experienced along the coast) limited the natural cooling effect and contributed to discomfort.

"The Perth Heatwave of 25-28 December 2021 was exceptional for its timing, intensity and duration.

Maximum temperatures exceeded 40C for 4 consecutive days. Daily mean temperatures (the average of maximum and minimum temperatures recorded each day) remained above 31C for 4 days, contributing to what was an Extreme Heatwave event.

Extreme Heatwaves are, by definition, not common. Average temperatures exceeding 31C for 3 or more days have occurred in Perth Metro 3 times in the last 123 years and at Perth Airport 4 times in the last 78 years. Until 2021, Perth had never had an event like this in December; historically they have only occurred in January or February.

The early occurrence of this Extreme Heatwave is likely to have exacerbated its impact, especially since spring 2021 and mid-December 2021 were cooler than average. The rapid onset of Extreme Heat reduced the period during which the community could acclimatise, increasing the scale of adjustment required"

– **Bureau of Meteorology**

The below diagram outlines the extreme nature of the heatwave, comparing distribution of maximum and minimum temperatures for the Christmas 2021 period against other weeks during the 2021-22 summer and Christmas periods in other years. While hot weather is often experienced in late December, the severity of the conditions during Christmas 2021 was extreme.

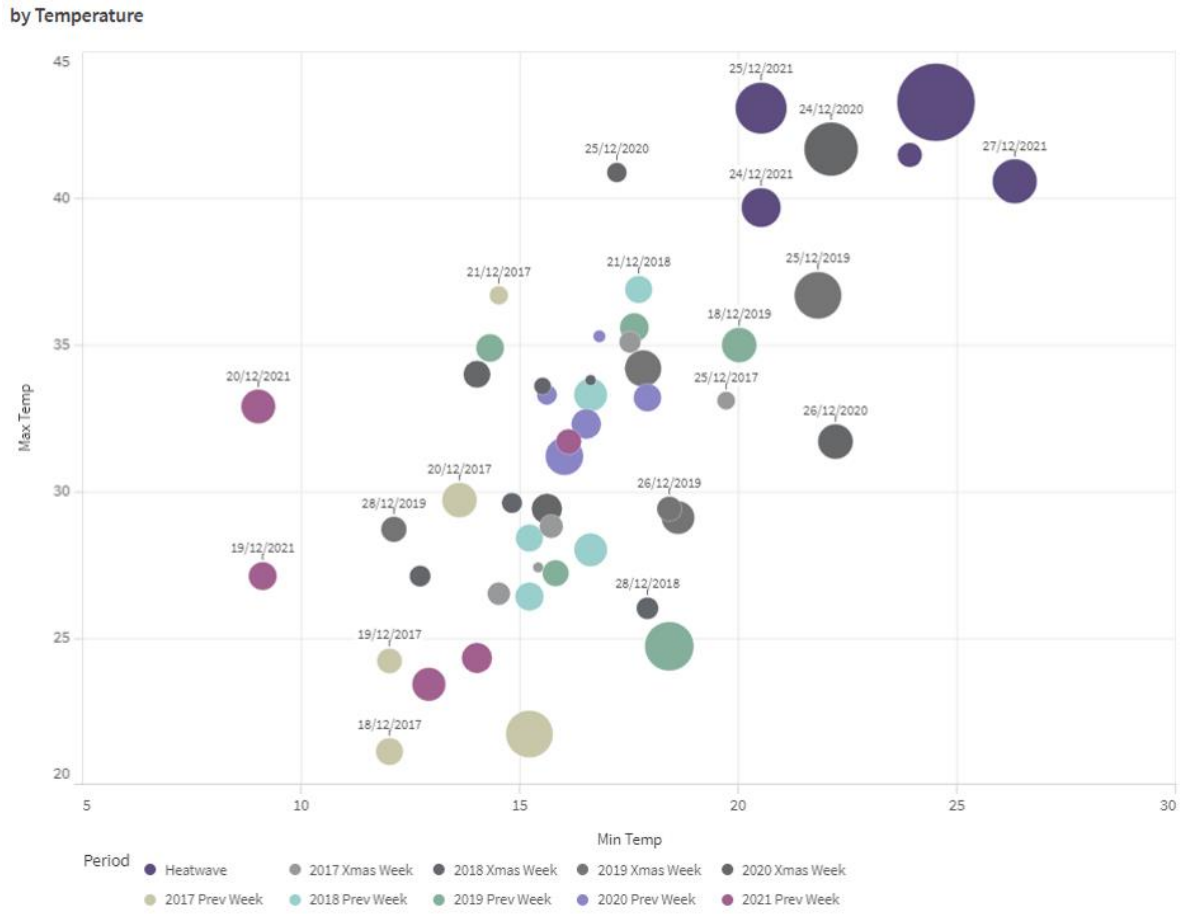

Figure 3.1: Temperature distribution – Christmas 2021 vs historical periods (2017-2020).

Note: size of bubbles corresponds to number of customer interruptions.

3.1.2. Load conditions

Electricity demand during the period was also extremely high.

As a result of the extreme heat, air-conditioning, fans, fridges and home appliances were working harder over the period leading to very high electricity demand. Peak electricity system demand was close to record levels over the period despite many businesses being closed.

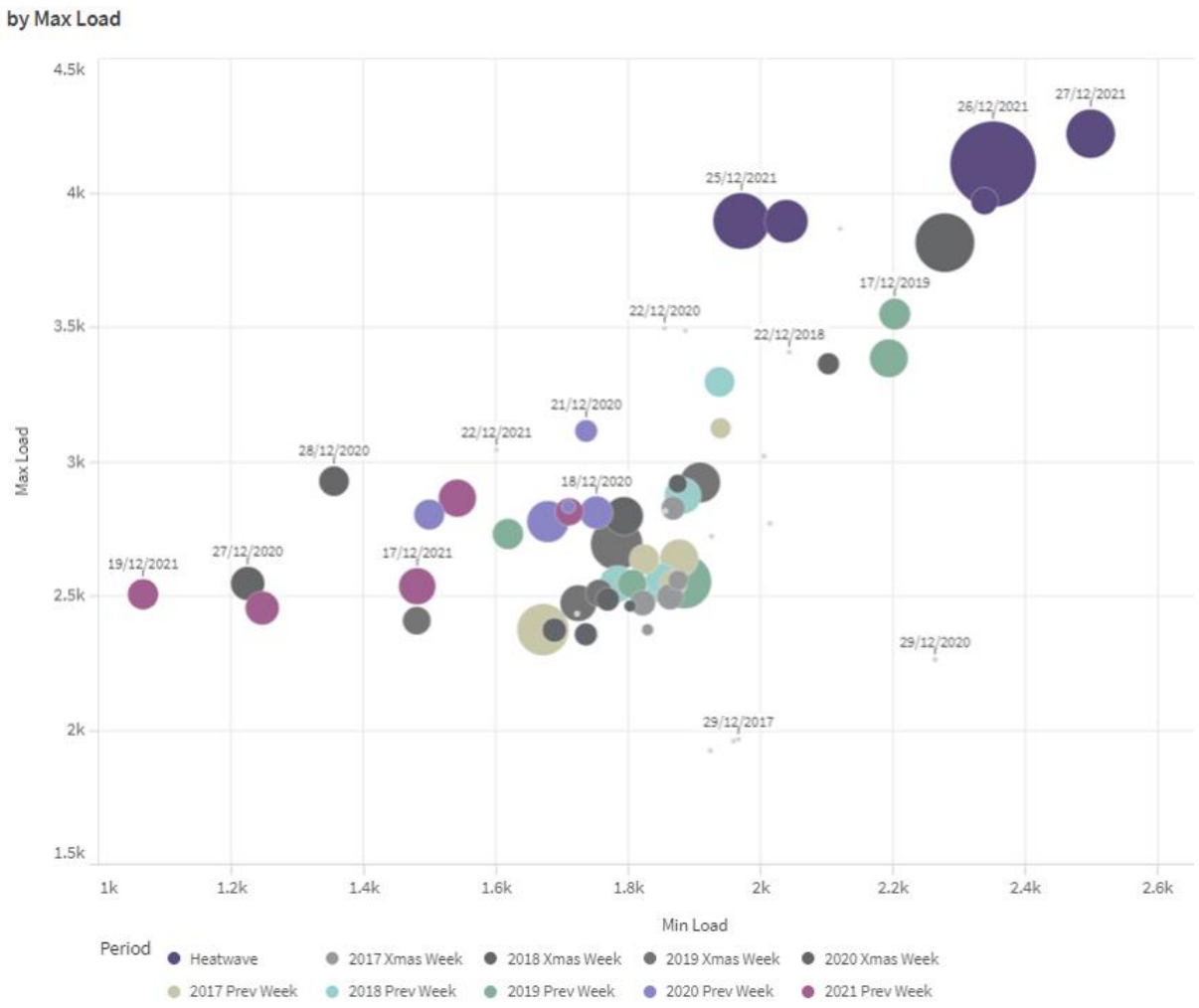

Figure 3.2: Distribution of network load – Christmas 2021 vs historical periods (2017-2020)

Note: size of bubbles corresponds to number of customer interruptions. Y-axis is measured in megawatts (MW), such that maximum load of 3.5k, is equal to 3,500MW.

The 24-28 December 2021 period fell over a long weekend (from Friday to Tuesday), and during a time when interstate and international COVID-19 travel restrictions were in place. It is likely that much of the State's population remained in their homes during the period, rather than attending work or travelling outside the Perth and Peel regions.

As a result, residential loads were significantly elevated (by around 11% from the previous record network peak). These residential loads are typically supplied by the low voltage distribution network.

In addition, many businesses were closed, reducing demand from industrial parts of the network by around 12% from previous record network peak.

The combination of heatwave conditions, and more people being in their homes, resulted in higher peak demand in parts of the distribution network which have not experienced that demand before.

Review Finding

20. The 2021 Christmas period was subject to extreme heat conditions and unusual community activity that resulted in parts of the distribution network experiencing higher demand than previous peaks, and in excess of Western Power's forecast 10POE.

3.2. Outage facts

During the Christmas period (24-28 December 2021):

- **1,120** incidents resulted in a customer outage
- **107,020** customer connections[43] experienced an outage[44]
- **69,469** customer connections experienced outages for longer than 2 hours[45]
- **42,604** customer connections experienced two or more outages
- **45.8 million** customer minutes were lost to outages[46]

3.2.1. Timeline of when outages emerged

Customer power outages began increasing rapidly from late afternoon on Christmas Eve (24 December), with growing numbers of outages occurring on Christmas Day (25 December) before peaking in the evening of Boxing Day (26 December). The largest number of customers were affected on Boxing Day and into 27 December, however a sizeable number of affected customers remained without power until 28 December.

The following diagram shows the number of customer connections subject to an outage and number of unresolved incidents open at any time over the five days in 15-minute intervals.

[43] This report refers to customer connection points, rather than individual people, as this represents the boundary between the Western Power network, and homes and businesses. The number of individuals serviced by any given customer connection is highly variable based on the type of premises and number of occupants.
[44] Outages less than 30 seconds and successfully restored via an automatic auto-reclose scheme are excluded from this analysis.
[45] This cumulative measure of outage length may have occurred across one or many individual outages.
[46] Customer minutes refers to the total measured minutes that customer connections were without power during the period – this measure includes outages of any length and repeat outages.

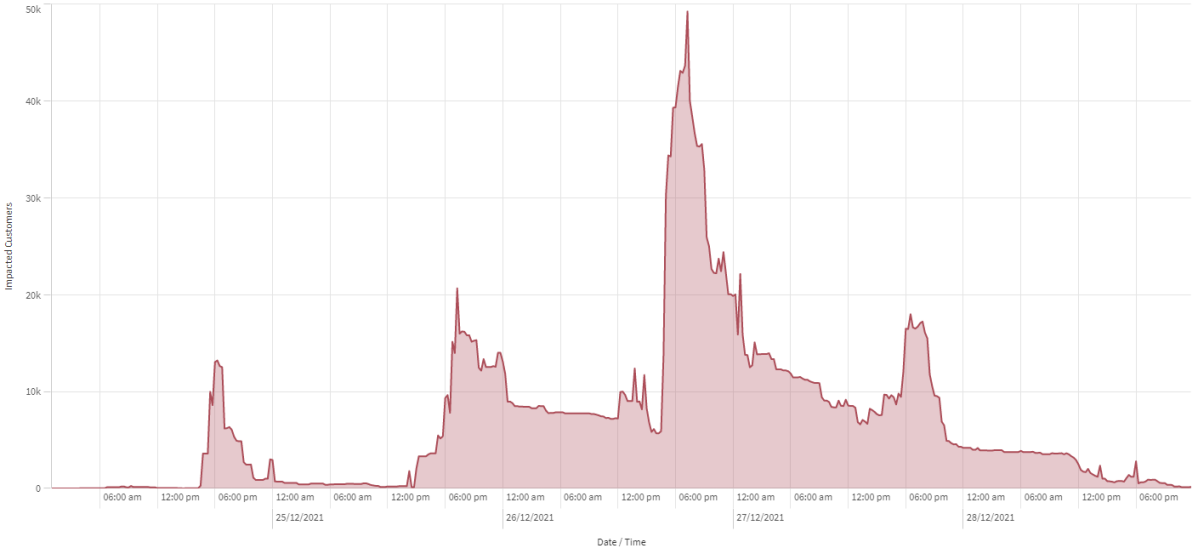

Figure 3.3: Customer connections subject to an outage

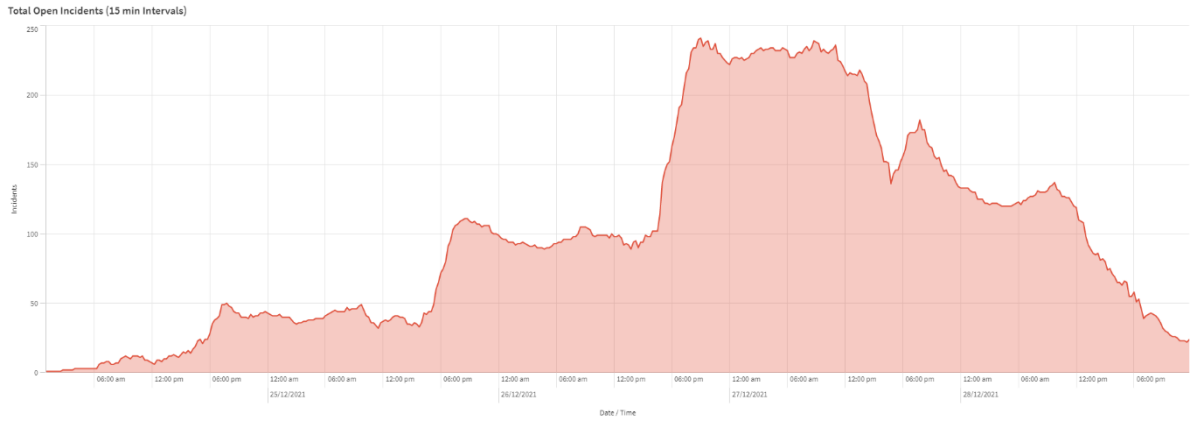

Figure 3.4: Open incidents over the period

The diagram above shows that, on each of the days, outages began and grew rapidly from the early evening – after the hottest part of the day. It is likely that decreasing rooftop solar generation as the sun set contributed to increased customer demand from the network around this time.

The maximum number of customers without power at any point was over 49,000 at 7.15pm on Boxing Day. Temperatures on that day reached 43.5 degrees Celsius in Perth, the hottest of the heatwave period.

In rural areas, temperatures were also high over Christmas. However, the number of outages and their duration remained relatively steady in the regional areas to the north of the SWIS (for example, greater Geraldton) throughout the period, whilst incidents in the south (for example, Bunbury) more closely resembled the total overall outage profile. This is shown in the graphs below.

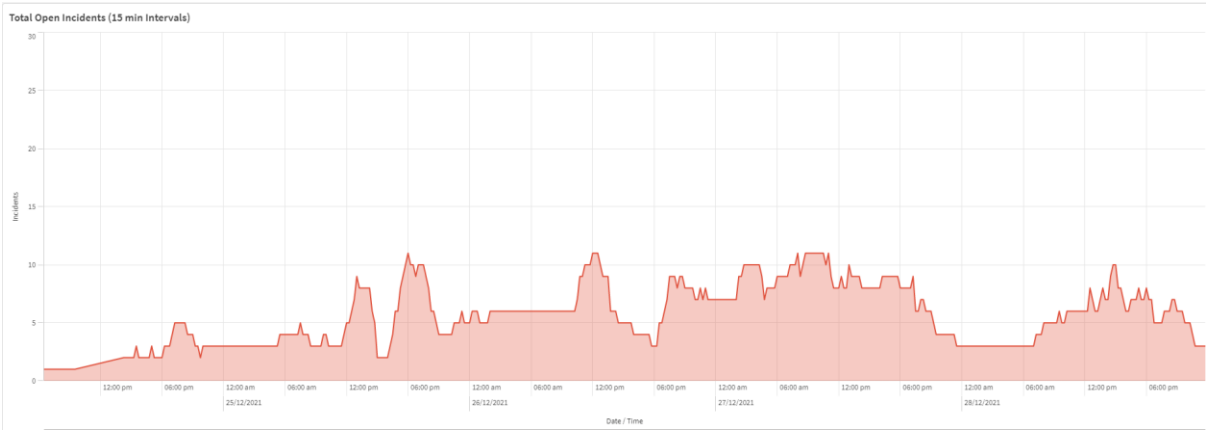

Figure 3.5 Open incident count in North Country

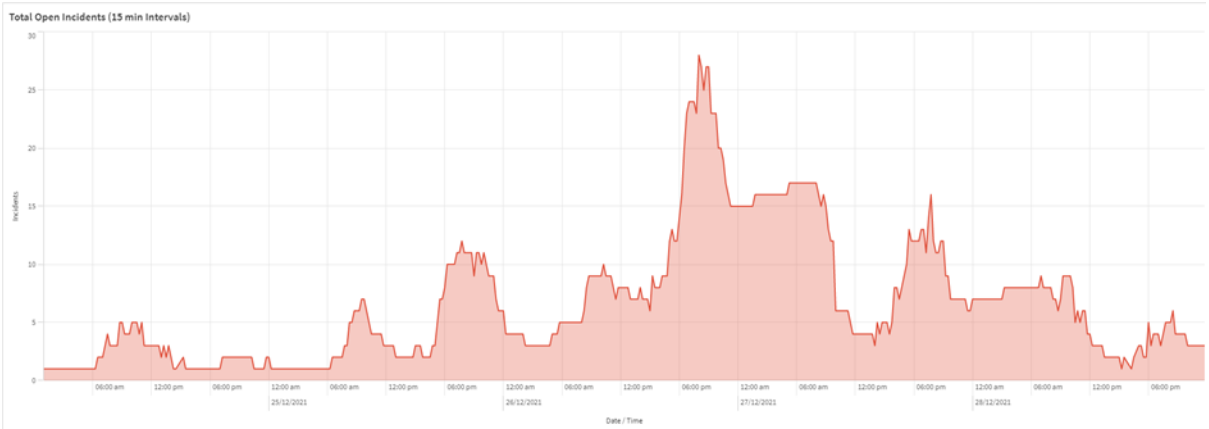

Figure 3.6: Open incident counts in South Country

Review Finding

21. The number of outages grew rapidly from the late afternoon as customer demand from the grid increased to very high levels. This coincided with decreasing rooftop solar generation as the sun set.

3.2.2. Repeat outages

The Christmas 2021 outages saw many customers impacted several times over the period. Analysis indicates 40% (42,604) of customers experienced two or more outages.

Table 3.1: Number of customers by number of repeat outages

	One	Two	Three	Four	Five	Six	Seven
Number of customers	64,416	24,110	10,243	2,896	4,304	1,008	were

Multiple outages disproportionately impacted customers in rural areas, with 65.8% of customers experiencing multiple outages located in rural areas, including semi-rural areas, for example, Dawesville.

3.2.3. Length of outages

Most outages over the period lasted longer than 30 minutes, however, the majority of customer connections were impacted for less than six hours (cumulatively over the period). The table

below outlines the cumulative outage time for individual customer connections, and all outage interruptions experienced by all customer connections in totality.

Table 3.2: Number of customers and interruptions by length of outage

Outage Time	*<2 hours*	*2-4 hours*	*4-6 hours*	*6-12 hours*	*12-24 hours*	*24-36 hours*	*36-48 hours*	*48-60 hours*	*>60 hours*
Customers experiencing outage[(a)]	37,551	20,321	14,824	8,233	18,918	5,425	1,405	128	215
Total number of interruptions[(b)]	47,986	25,836	28,724	19,117	39,006	17,852	3,373	321	603
Sensitive customers experiencing outage[(a)]	320	111	99	72	166	49	16	0	4
Sensitive customer total interruptions[(b)]	369	139	197	188	334	179	19	0	6

(a) The number of distinct individual customers impacted at least once
(b) The total number of all outages experienced, including repeat outages

3.2.4. Location of outages

Impacts were felt by customers over a vast area, with outages occurring across the SWIS.

Over 50,000 (46%) of the affected customers were located in urban areas, around 58,000 in rural (54%), and one in the Perth CBD.

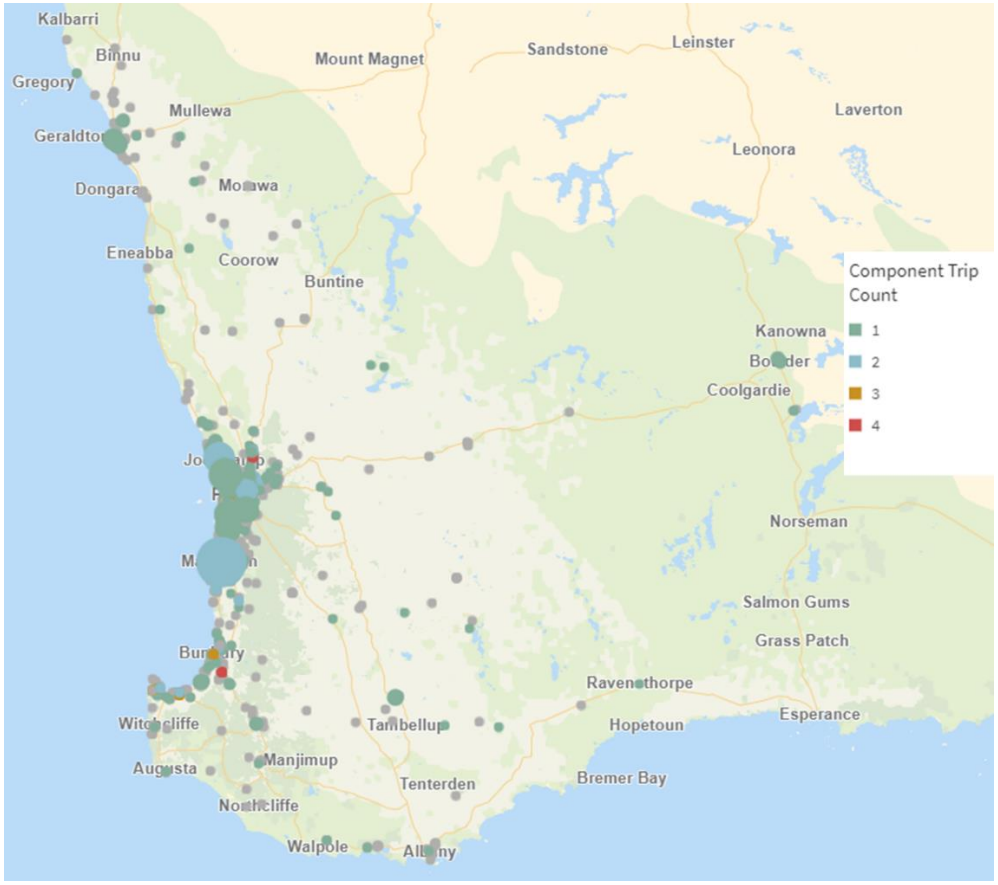

Figure 3.7: Map of all outages, with circle size indicating number of customer connections impacted, colour indicating number of interruptions

The following table identifies the most impacted local government areas based on: customer connection outages, customer connections which had cumulative interruptions longer than 12 hours, and customer connections which had repeat outages.

Table 3.3: Most impacted local government areas

City/Shire/Town	Distinct Supply Points Impacted by an Outage	City/Shire/Town	Distinct Supply Points With Outages More Than 12 Hours	City/Shire/Town	Distinct Supply Points With More Than One Outage
Mandurah	16,344	Gosnells	2,928	Mandurah	14,668
Wanneroo,	15,596	Stirling	2,868	Wanneroo	10,593
Swan	8,941	Armadale	1,694	Swan	4,787
Joondalup	7,526	Chapman Valley	1,383	Stirling	4,453
Gosnells	7,432	Mandurah	1,370	Murray	2,777
Stirling	7,280	Kwinana	982	Greater Geraldton	2,398
Greater Geraldton	6,146	Joondalup	715	Kwinana	1,646
Cockburn	5,200	Vincent	656	Joondalup	1,122
Kwinana	4,466	Greater Geraldton	563	Kalgoorlie-Boulder	1,056
Murray	3,458	Rockingham	543	Gingin	774

Metropolitan local governments are heavily represented as they have higher total populations than those in rural areas. However, those with semi-rural areas such as the Cities of Mandurah, Wanneroo, Kwinana, Swan, Gosnells and Geraldton are particularly highly represented.

More rural areas such as Chapman Valley, Murray, Capel, Katanning and Gingin reflect the wide spread of outages across the SWIS, noting that 28 local government areas experienced customer outages.

Review Finding

22. Outages occurred across the SWIS, impacting both regional and metropolitan customers with lengthy outages and many in repeat locations. However rural and semi-rural customers were more likely to be subject to multiple outages.

3.2.5. Nature of the outages

The vast majority of outages, above and beyond average day summer faults, were related to overloads. That is, during the Christmas period, customer demand in parts of the network exceeded the protection settings or capacity of distribution network infrastructure.

As outlined in Section 3.1.2 the extreme heatwave conditions drove very high electricity demand across the power system. Of Western Power's 53 most heavily loaded substations (of 154 in total), 31 experienced demand above that which occurred during the previous record network peak on 4 February 2020, and 25 had demand beyond Western Power's most recent one in 10 year forecast level.

Type of fault

The Review grouped the types of faults to determine key drivers of the Christmas 2021 outages:

1) Network overload: the outage was caused by very high demand, and the network protection device operating because electrical current exceeded protection settings or the rating of network equipment. These outages were a result of network protections operating as they were set up to do.

2) Faults within Western Power's control: these faults were caused by asset failures, vegetation encroaching upon network infrastructure, or network switching errors.

3) Non-avoidable faults: these fault causes include damage to the network from acts of vandalism, vehicles, fauna (e.g. birds), wind-borne debris. This also includes incidents from customer-installed electrical equipment. These faults are unpredictable and can occur at random.

4) Unknown faults: insufficient information available on site to determine cause of fault, or further investigation required.

The type of fault resulted in variable customer impacts. The following table outlines the impact each fault type had in contributing to total customer minutes lost.

Table 3.4: Contribution of type of fault to number of incidents and customer minutes lost by type of fault

	Number of incidents	Share of customer minutes lost
Network Overload	34%	64%
Faults within Western Power's control	4%	13%
Non-avoidable faults	35%	4%
Unknown	27%	19%

In summary, overloads (while not the most common occurrence of a fault) led to outages with the largest impact on customer minutes lost. In addition, overloads generally did not result in an observable fault cause and (as outlined in Section 4.2) during TFBs if no cause can be found then restoration must be delayed until safer fire weather conditions prevail. As a result, overloads were likely to result in outages with extended restoration times.

For all fault causes, the number and length of outages were exacerbated by procedures Western Power enacts to manage fire risk conditions. For example, during the period, the Western Power network feeder and recloser[47] settings were changed to reduce risks of an electric spark starting a fire, but this resulted in some faults not being automatically resolved, resulting in a customer outage. This is discussed further in section 4.2.

Western Power indicated that the nature of outages changed over the period, as illustrated below. While there were generally elevated levels of faults over the period, the main impacts of the outages were felt from overload-related faults on Boxing Day and into 27 December when temperatures were at their highest.

[47] Reclosers are devices that are used to split the medium voltage distribution network into smaller protection sections – if a fault occurs on the network, a recloser will isolate that part of the network, preventing more customers from losing power upstream of the fault. Reclosers are typically set to automatically resolve transient faults, but during high fire risk periods, these settings are turned off.

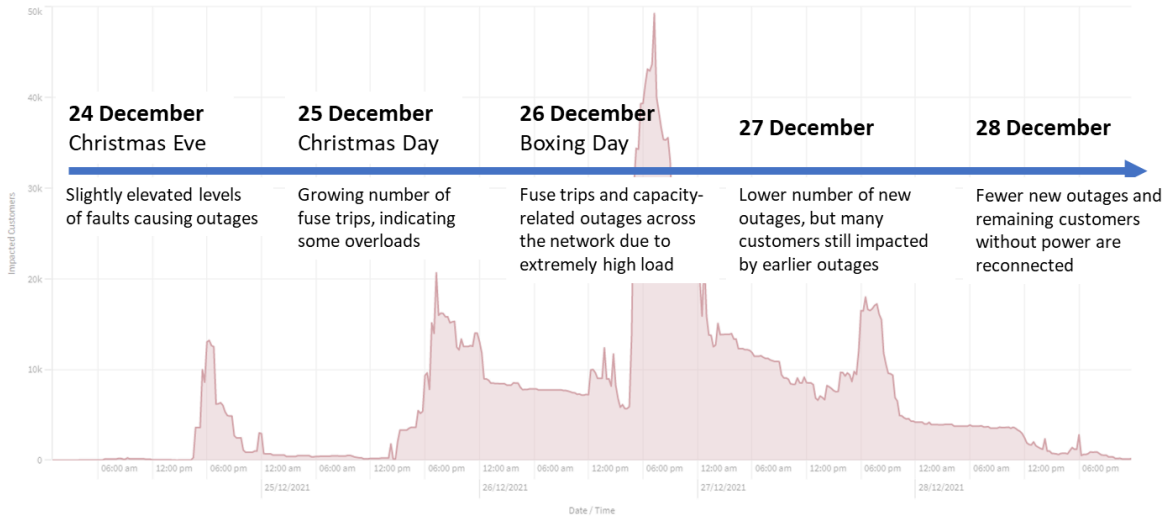

Figure 3.8: Customer outage profile by fault type

Review finding

23. While overloads were not the most common fault cause, they led to outages with the largest impact on customer minutes lost.

3.3. Western Power's preparation and response

There are a number of activities Western Power undertakes to prepare and avoid outages on the network. The activities undertaken relevant to the Christmas outages are outlined below.

3.3.1. Western Power preparation

On an annual basis, Western Power develops a summer readiness plan to ensure key bushfire mitigation and peak demand actions are implemented.

The 2021-22 Summer Ready plan identified numerous actions to manage network capacity risks over summer. These included switching to shift load away from heavily loaded areas of the network and some capacity expansion projects, all of which were completed prior to December 2021.

In addition, a 40 degree maximum temperature day on 8 December 2021 identified

> We live on a property in Baldivis. On Christmas Eve we had planned a dinner with 15 people. It was in excess of 40 degrees when the power went out before dinner. Being a rural property, we pump our own water to the house so no electricity also means no running water and no flushable toilets as well as no air conditioning or lights. Dinner was a nightmare to prepare and the heat was intolerable. The power was restored at approximately 10.00pm but went out again 6.30pm on Christmas day. On Boxing Day electricity had still not been restored. My daughter and I gave up and went to the shopping centre seeking a cooler environment – incurring extra expense and inconvenience. With no water pumps we struggled to get water to our animals, and our swimming pool started to turn green in the heat without filtration. Finally late in the afternoon of Boxing Day, the power was restored.
>
> Customer feedback provided to the Review

some additional areas of the network where there was a risk of an overload. Western Power implemented seven of ten identified actions to correct the issues prior to the Christmas period.

On 20 December 2021, when a heatwave became known to be imminent, Western Power operationalised its pre-emptive EMT. Several meetings were held, and responsible Western Power senior managers developed and implemented strategies for minimising the likelihood and impact of outages during the heatwave.

As part of the EMT activities, Western Power made an assessment of likely fault levels and staffing, including Field Crews, required to respond to the expected workload. This was supplemented by a list of additional resources who may have been prepared to come into work should fault numbers escalate. Other actions included obtaining two additional back-up generators, assessing network outages (planned and unplanned) to determine if they were likely to be an issue during the heatwave, and assess whether actions could be taken to address the outstanding three capacity issues identified from the 8 December 2021 event.

Western Power also undertook a range of activities to prepare for customer impacts, and to ensure customers received the information they required. These activities and the customer experience are outlined in Chapter 5 – The customer experience.

Review finding

24. Western Power undertook preparations for the summer period and heatwave event commensurate with their expected potential demand for the period.

3.3.2. Western Power's response during the outages

During 24-28 December 2021, while the outages were occurring, Western Power undertook a number of activities to manage the outages and their impact.

Additional Field Crews were deployed to assist with restoration activities. Despite the long weekend and holiday period, and therefore fewer personnel being available, Western Power told the Review it had the resources needed to manage the restoration activities.

Western Power deployed six back-up generators during this period, with two retained for emergency purposes. Western Power stated even if additional generators were available, they were unlikely to have been used. This is because of the time required to deploy the generators, as well as the diversion of resources required to deploy them (instead of repairing faults), and TFB limitations made it infeasible.

Where possible, load shifting was employed throughout the Christmas period where it was determined an overload could occur. Load shifting involves Western Power switching load to other parts of the network that have spare capacity. These actions resulted in around 4,000 customer connections avoiding an outage during 24-28 December 2021.

Where load shifting wasn't possible, sections of remotely visible overloading parts of the network were tripped (called controlled load shedding) to enable supply to be retained for the majority of customers on that part of the network. However, this meant customers on the de-energised section lost supply until demand dropped away and they could be restored (in most cases this was a few hours). Load shedding is therefore used as a last resort action to minimise outages where these is a very high degree of certainty an overload is imminent.

An example of the use of controlled load shedding was at Clarkson substation where around 2,500 customer connections were tripped to avoid overloading a substation transformer. By doing so, around 17,500 customer connections remained supplied. The additional benefit of this action was that as the outage was a controlled action by Western Power, the network was deemed to be in a safe state and Western Power could re-instate power irrespective of the fire weather conditions on the day. This action avoided the lengthy procedures that would have been required if the transformer had tripped and a cause not officially confirmed.

The Review has retrospectively identified a very small number of overloading trips during the period that potentially could have been avoided through controlled load shedding. However, the majority could not have been managed through load shedding.

Importantly, Western Power was able to prevent the same overload trips from occurring on the next day in all but one case. This preventative action did include some manual load shedding of smaller parts of the overloading network (and thus some of the same customers) to limit the overall impact.

Review findings

25. Additional resource availability such as personnel and back-up generators would not have materially reduced the instances or length of the Christmas period outages.
26. Where it was possible and throughout the Christmas period, Western Power deployed load shifting to reduce the number of customers impacted by a possible overload.
27. Controlled load shedding was used as a last resort to avoid medium voltage distribution overload trips during the Christmas outages. A small number of outages could have been avoided if this was used to its fullest potential.

3.3.3. Preparation of other agencies

AEMO

AEMO advised the Review that its preparation for the period included typical operational planning for a period of high demand. AEMO's role of system manager relates to operations at the transmission system level, and to this end it reviewed generator and transmission outages. AEMO determined that no specific or additional actions were required to manage power system security.

In the days leading up to the heatwave, AEMO undertook daily internal discussions to review system status. AEMO and Western Power also discussed likely Western Power actions during Total Fire Ban conditions, insofar as it impacted the security of the SWIS.

As further preparation, AEMO also engaged with its staff in its other Australian offices for advice on their experience with wind farm cut-off temperatures, and issued a Dispatch Advisory to inform generators that all facilities may be required to meet demand.

During the period, a large generator trip on Boxing Day resulted in a short drop in frequency that briefly impacted a single large customer who is paid to trip off if frequency drops. Otherwise, no other major system events (such as Under Frequency Load Shedding) occurred during the period.

Department of Fire and Emergency Services

On 22 December 2021, DFES called an All Hazards Liaison Group meeting for 23 December 2021. The purpose was to provide all relevant agencies an update on the heatwave weather forecast and agency preparations. The following agencies attended the meeting and provided the following updates:

Table 3.5: Agencies which attended the All Hazards Liaison Group meeting and updates provided

AEMO	advised generation reserves were tight but it did not expect system outages, and noted a bushfire could impact generation availability
BOM	confirmed a forecast extreme heatwave will extend down the coast between 24-27 December, with winds exacerbating fire danger conditions on 25-26 December
Department of Health	activated the State Hazard Plan Heatwave as a response stage as of 24 December for Metropolitan and the South West
DFES	advised Total Fire Bans were likely during the heatwave and it was preparing for possible fires
Energy Policy WA	attended the meeting and noted the other agency updates
Western Power	stated that should power outages occur, restoration times may be prolonged due to the Total Fire Bans

No follow up meeting was scheduled, however DFES requested that agency contacts were made available in case of an incident.

Department of Health

On 21 December, the Department of Health advised the State Emergency Management Committee of forecasts indicating a heatwave would occur over Christmas. This was confirmed in a Department of Health advisory on 23 December that Perth and surrounds would experience a heatwave from 24-27 December 2021.

Energy Policy WA

Energy Policy WA (EPWA) received an email from AEMO on 21 December 2021 highlighting the upcoming likely high loads due to forecast heatwave conditions. It noted that whilst generation margins were tight the power system as a whole was expected to remain secure.

EPWA continued to receive updates from AEMO on subsequent days with the same message on generation reserves, and notification of the large generator trip on 26 December 2021.

EPWA did not receive any direct notice of the outages from Western Power once they started to occur.[48]

Under the broader State Emergency Management Plan framework, State Hazard Plans have been developed for a variety of key hazards (see **Appendix D**). These outline arrangements to manage specific hazards and when escalation to the State Emergency Coordination Group may be necessary. EPWA did not declare an alert response level under the Energy Supply State Hazard Plan at any point during 24-28 December 2021 as it did not consider the incident level indicators had been reached.

[48] Western Power attempted to make contact with the EPWA Emergency Management team on either 25 or 26 December, however the team member called (who was not the appropriate contact) was on leave and missed the call.

4. What caused the outages and exacerbated their severity?

Customer demand from the grid, particularly in residential areas, was at very high levels during the Christmas 2021, driven by persistent high temperatures over the long weekend holiday period.

As a result, parts of the distribution network infrastructure were overloaded, leading to significant customer outages.

Weather conditions also exacerbated issues by increasing the risk of fire. In order to manage these risks, fire risk mitigation procedures both increased the likelihood that a fault of any kind caused an outage, and also resulted in outages lasting much longer than they might otherwise.

4.1. The main causes of the outages

Overloads

Western Power did not forecast the unusually high level of peak demand during the 2021-22 summer. However, it had previously identified many of the impacted areas as facing capacity risks in the future.

In accordance with its planning criteria, action to relieve capacity issues would only be taken when the load forecast exceeded the criteria. Therefore, the future timing of planned investments meant the Christmas outages were not avoided.

For example, Clarkson Substation was anticipated to face capacity risks in coming years and had a project planned for 2025 to manage these risks. During Christmas 2021, this substation experienced demand well above Western Power's 10POE load forecast and one of its transformers experienced overloads.

Another example was the Katanning feeder, which had forecast load at 84% of its capacity, but it tripped due to an overload during the Christmas period.

Fire risk mitigation

The use of fire risk mitigation measures is discussed in 4.2 below, and it is likely that application of fire risk procedures contributed to more, and longer outages.

> "We lost Power at 7.30pm Christmas day until 3pm on Boxing day as did many in Martin. Many in this area have no scheme water and rely on pressure pumps and were without water for all this time in the heat."
>
> Customer comment on social media (Western Power supplied)

4.1.1. What was identified to not cause the outages?

The outages were not caused by insufficient electricity generation on the system.

In addition, Western Power's asset performance does not appear to have materially contributed to the Christmas outages. An engineering assessment of a randomly selected subset[49] of the assets that did fail identified:

[49] Reflecting time constraints in which to complete the Review, a random subset of asset failures was assessed as a representative sample of asset performance.

- Asset failure rates were only marginally higher than an average day, with a higher failure rate expected given the very hot temperatures and noting that 24-28 December 2021 only represents a very small sample set.
- Asset failures were not a material driver of customer outages during the period.
- Assets that failed had all been inspected on time, only one had an outstanding defect that was relevant to the outage (but the asset was assessed to be fit for service).
- There was a small correlation of asset failures during the period with the previous 15 years of defects on those failed assets. However, high demand and high temperatures over the period were the main factor in contributing to asset failure.

Western Power is not aware nor has been notified of any possible breaches of its regulatory, statutory and market obligations, including those related to Emergency Services, in relation to the Christmas 2021 outages. The Review understands that a breach of these obligations did not occur, and was therefore not a cause of the outages.

Review Findings

28. The outages were not caused by insufficient electricity generation on the system.
29. Western Power is not aware nor has been notified of any possible breaches of its regulatory, statutory and market obligations, including those related to Emergency Services, in relation to the Christmas 2021 outages.
30. Western Power's asset performance does not appear to have materially contributed to the Christmas outages.

4.2. Why did the outages last so long?

4.2.1. Fire ban conditions

As outlined in Chapter 2, on higher fire risk days Western Power employs fire risk management procedures to reduce the likelihood of its network starting a fire and to restore customers as safely as possible.

During the Christmas period a TFB was called by DFES across large areas of the SWIS. TFBs were in place from the Mid West region down to the Perth Hills from 24-28 December 2021, and included Greater Perth on 25-26 December 2021 (the days with the highest number of customer outages).

This triggered Western Power applying its TFB procedures, which requires significant checks and other activities to

> "Our power went out around 8.30pm on the 26th December and came back on at 9.30pm on the 27th December. We were to be holding a family function on the 27th and therefore had a very full fridge. We went on to the website immediately which said that our power would be back in that evening which it was not, had we known that it was going to be off longer we would have gone to try to buy ice etc to preserve our food. This was VERY poor as not only did our food ruin but we had a newborn litter of puppies to keep cool on a 42 degree day"
>
> Customer comment on social media (Western Power supplied)

be undertaken before restoring power to customers. Even in areas where TFBs were not issued, fire danger forecasts were often elevated, triggering Western Power procedures that apply additional measures to reduce bushfire risks.

Before and during the Christmas outage, Western Power undertook the two following activities, which significantly reduced the risk of Western Power's network starting a fire, but materially delayed power restoration to customers.

Western Power network protection equipment was made more sensitive and auto-reclose settings were disabled.

On a lower fire risk day, normal network protection settings will operate slower and allow a fault to be cleared through 'burning off'. For example, slower protection or multiple auto-reclose attempts will allow energy to remain in a power line and enable some fault-causing material (such as a tree branch on the line) to burn and fall off the line. Slower protection and multiple auto-reclose attempts also gives time for fault causing material (such as wind-borne debris) to be naturally removed from the line. While this can clear a fault, it can also cause sparks or burning material to fall to the ground and potentially start a fire. Therefore, Western Power alters these settings on fire risk days.

Making network protection equipment more sensitive and disabling auto-reclose reduces the risk of the network starting a fire. However, it also results in an increased likelihood of power outages because transient faults (i.e. faults that clear naturally without maintenance crew attention) don't have the chance to self-resolve. As these faults must now be manually checked, they take longer to resolve as a crew must attend the site. Outages may also involve more customers and longer sections of the network as grading between adjacent protection equipment on the network is impacted.[50] Full inspections can also be extended by additional fire risk procedures (below), which can further lengthen outages.

Western Power applied its TFB procedures, which require significant checks and other activities to be undertaken before restoring customers.

As discussed earlier in this report, Western Power has a number of procedures it follows to respond to an outage under TFB conditions.

TFB conditions applied during the Christmas 2021 period, and the procedures Western Power followed before restoring customers in higher bushfire risk zones is outlined below.

- An outage occurs and a maintenance crew is dispatched to the device location.
- The crew patrols the entire faulted section of the network to identify the fault cause, and to ensure there are no potential fire-causing pre-existing defects.
    - If the outage occurred in the evening, crews can only complete the patrol with sufficient light and are delayed until daylight hours.

[50] Grading refers to network protection equipment settings that allows a downstream protection device to operate before an upstream device for a fault in the downstream device's zone of protection such that only the faulted section of the network is isolated.

- If the outage (or affected parts of the network) is located in a Local Government Authority which has imposed a vehicle movement ban (VMB),[51] the crew may only be able to inspect the off-road parts of the network by foot, drone or helicopter.[52] Western Power advised that VMBs were not a material issue during the Christmas outages.

- If the fault cause is identified – the crew repairs it, but prior to reconnecting customers, Western Power puts in place fire management strategies, including fire suppression units if using open air switchgear and in areas with combustible materials.
    - This requires the availability of appropriate equipment and relevant personnel resources to attend the site.
- If no cause is identified – reenergisation is not allowed until the Fire Danger Index (FDI) drops below 32 and is falling. For many parts of the SWIS over 24-28 December, the FDI remained high from early afternoon to late at night, and in a few cases from early in the day to early the next morning. Importantly, the FDI tends to rise with increasing temperature, so in the mornings the FDI may be well below 32 but will be rising as the day heats up, thus preventing restoration.
    - The Western Power DEFS TFB exemption does allow DFES to request re-instatement of power in an emergency however this appears to be rarely used and there are no documented procedures on how to apply that request.

Western Power's TFB procedures significantly reduces the risk of the network starting a fire due to a network fault (noting no fires were started by Western Power assets during 24-28 December 2021). However, the procedures can be onerous and often result in a delay to restoration, as was the case in the Christmas 2021 outages. In addition, complying with the procedures requires material resources in terms of employees and equipment.[53]

Western Power believes more resourcing for operational maintenance would not have materially reduced the number of outages, and would not have materially impacted outage lengths. For many outages a fault cause couldn't be found so Western Power had to wait until the FDI dropped to safer levels.

4.3. Why were there repeated outages?

Of the 1,120 customer outage incidents over 24-28 December 2021, 456 (40%) incidents resulted in a repeat outage.

[51] Vehicle Movement Bans are issued by the Local Government Authority and places restrictions on driving vehicles off road, undertaking works off road and generator usage. A local Fire Control Officer can authorise these activities if there are 'urgent' works, subject to specific conditions. These settings can necessitate patrols to be undertaken by foot or helicopter, and can require permission to undertake switching or utilising a back-up generator.

[52] Helicopters may also be used to speed up patrols, especially on long feeders or for difficult to traverse terrain.

[53] A case study outlining an example of the additional resourcing approach is included in **Appendix G**.

As outlined in Section 4.1, many outages were caused by distribution fuses tripping due to overloading. Western Power advised that, typically, when a distribution transformer overload is suspected, a load logger will be installed for a week, its data reviewed and (if it is determined a repeat overload is likely to occur) then action is taken to resolve it. Some of these actions may be quick to implement (e.g. switch customers to another part of the network with spare capacity) while others, such as replacing the transformer, may require significant effort (e.g. network engineering design, ordering equipment, arranging a planned network outage, scheduling field crew, and installing and commissioning the new transformer). As a result, many repeat outages were not able to be avoided.

> "I live in Dawesville and my power was lost on Christmas Day, Boxing Day and 27th December for hours during 42 degrees, with no sleep. This has been extremely stressful especially with my 1 year old granddaughter here. We have lost our food to add to the stressful situation."
>
> Customer comment on social media (Western Power supplied)

While Western Power undertook some load switching during 24-28 December, this was limited due to high loads across many parts of the network, limited interconnection in affected areas of the network, and limited load visibility on those parts of the distribution networks. A few back-up generators were also deployed but had a small impact.

During 24-28 December 2021, the main solution left at Western Power's disposal was to replace the blown fuse, which then tripped as soon as loads reached high levels again on subsequent days. If the fuse was put back in on the same day while the load was still high, it would also trip – this occurred occasionally during 24-28 December 2021.[54]

Another cause of repeat outages impacting a small number of customers included fault switching - where a part of the network is turned off to enable another part to be turned on. These outages are generally of a shorter duration.

4.4. Which areas were impacted?

> "This is 3rd day with no power, I have expensive fish dying, my fridge is rotten and I'm getting sick every night from heat. How much longer is this going to go on for".
>
> Customer comment on social media (Western Power supplied)

This Review has identified that, because of timing and conditions, much of the electricity demand during the outage period was located in residential areas where demand was at record peak levels. Impacted areas for overloads were mainly urban areas, where there was unusually high demand given the heatwave occurring during COVID-19 travel restrictions and a holiday period, coupled with high levels of rooftop solar PV penetration."

Rural and semi-rural areas were disproportionately impacted by the outages. This is not uncommon due

[54] Western Power was able to address a number of these overloads prior to the 18-23 January 2022 heatwave. Western Power also identified an alternative response which was utilised during the 18-23 January 2022 heatwave, which involves contacting customers in areas of potential overloads and advise them of methods to safely reduce their power usage at peak times.

to the longer length of overhead network lines and the greater exposure to environmental issues.[55] It also reflects the reduced opportunities for interconnection which provides redundancy in the case of a fault and allows for proactive load shifting to reduce risks of overload outages.

Fire procedures are also more likely to impact rural areas, particularly as these areas tend to be in higher fire risk zones with longer networks per customer.

4.4.1. Historical outages in the affected areas

Western Power provided information to the Review on the areas in the SWIS which had historical repeated issues with network protection device operations.

The information showed that compared with the previous 5 years[56] there were only a few regions where there was a concurrence with the location of outages during 24-28 December 2021. Impacted suburbs were in the Cities of Mandurah and Joondalup, as well as pockets in the eastern urban suburbs. Areas around Bunbury, Katanning and Kalgoorlie are also represented.

Significantly more analysis would have been required to determine areas where there had been concurrence at individual customer connection level. However, given the outages over the Christmas 2021 period were predominantly overload issues which have been found to be addressed,[57] any concurrence wouldn't have impacted the findings of the Review.

The Review examined maintenance and defect history of network assets that failed during 24-28 December (in Section 4.1.1) and found over this period overloads were the main cause factor.

5. The customer experience

5.1. Overview

The Christmas outages occurred during an extreme heatwave event with the majority of customers impacted being households and small businesses. In addition, more than 800 sensitive loads were without power.[58]

The heatwave conditions meant air-conditioning and fans were a necessity for most customers. The Christmas holiday period made the conditions even more challenging as many customers had family events planned and fully stocked fridges.

[55] Whilst Western Power is undertaking an undergrounding program supported by part funding from the State Government and Local Governments, this is predominantly in urban areas as the cost to do so in rural areas due to the lower customer densities is more difficult to justify.
[56] Examined where that protection device had operated more than twice or resulted in an outage longer than two hours.
[57] Where overloads occur, Western Power has processes in place to prevent reoccurrence, provided there is sufficient time between high load events to implement solutions.
[58] This includes life support customers (who are at high risk if a power outage occurs) and customers where material economic, health or safety issues could occur if a power outage occurs.

Small businesses also suffered due to lost stock that needed refrigeration and having to close because of no power. It also meant people in the impacted communities could not access local services and supplies.

5.2. Customer impacts of power outages

The impact of outages on customers can be significant. Customers are not only inconvenienced by the lack of refrigeration, heating, cooling, lighting and access to cooking, communications channels, and electronic appliances, but impacts can also include health and safety issues. For example, outages affecting traffic lights may increase the chance of traffic accidents, affected hospitals may delay elective surgeries, and life support customers that rely on electricity can be at risk.[59] There is also a risk of food poisoning if spoiled food is consumed.

Extreme heat conditions, such as those experienced in the Christmas 2021 period, create a heighted risk of people experiencing heat stress and heat stroke, particularly for the vulnerable including older and very young people, and those with pre-existing health conditions.[60] In a report commissioned by AEMO in 2019, it was found that outages occurring during extreme heat events can lead to increased mortality. In addition, extreme heat can exacerbate existing mental health and social issues such as family violence. See **Appendix H** for further information on the health and safety impacts of outages during extreme heat.

The longer an outage continues, the greater the risk to a community's health and safety, particularly during a heat wave.

5.3. Customer expectations during an outage

During the Review, customer representatives were consulted about customer expectations during unplanned outage events.[61]

Consumer representatives advised that customers understand that unplanned outages can occur. Customers are particularly understanding where there is damage to the network caused by storms or fire, and where the cause can be clearly seen.

During an outage, customers' key interest is that power is restored as soon as possible. Customers also have a strong preference that the network operator communicates regularly and honestly with them before and also during an outage.

[59] Life support customers are encouraged to have a back up plan that can be activated in the event of an unplanned outage.

[60] People in the community who are most at risk during heat waves include those: 65 years and older; taking multiple medications e.g. diuretics, antihistamines; chronically unwell with conditions such as diabetes, heart disease, Parkinson's disease, respiratory disease; unable to adapt their behaviour to keep cool due to dementia, disability, substance abuse, being overweight or obese, being pregnant or breastfeeding; impacted by environmental factors e.g. homeless, outdoor workers, sports people, Aboriginal people living in remote areas, https://ww2.health.wa.gov.au/Articles/F_I/Heatwave.

[61] The Western Australian Advocacy for Consumers of Energy Forum and Expert Consumer Panel were consulted by the Review. The fora are convened to provide broad based representation of consumer views to share into the development of products and solutions for, and to otherwise contribute to debate in, the Western Australian energy sector.

Initial consultation on effective customer communication around outages has suggested the following points of communications are valuable before and during outages:

- Where Western Power deems an outage is probable,[62] direct messages sent to customers warning that an outage is likely.
- Communication on actions a customer could take to prepare for an outage, or to adjust behaviour to decrease the risk of an outage (for example, where excess load is likely to cause an outage). According to research by Energy Consumers Australia, Western Australians would be willing to reduce their usage at times of need.[63]
- During an outage, providing affected customers with specific reasons for the outage and the expected restoration time.
    - Where the restoration time is unknown, communication could share the reasons for any delay and what is being done to restore power (for example, informing customers that crews are currently assessing the site).
- Communication of an acknowledgement that, particularly during heatwaves, customers can be suffering and offer links to information and support where appropriate. This is particularly important for vulnerable, including life support, customers.

The Review was told that direct customer communication was a preferred method (e.g. through SMS or email). This included in the lead up to, and immediately upon, an outage occurring, as well as regular updates throughout an outage.

Customers saw this as important for their own preparation and planning for the duration of the outage. For example, if the customer was not at home and received a message that their power was out, they could stay out until being notified that their power was back on.

In addition to direct messaging, other varied communication channels were also considered vital, including radio updates. Radio was considered particularly important given the outage may impact mobile phone towers, and a customer may not have a charged device able to receive an SMS or check social and online media.

For high-risk customers including those on life support, regular and timely individual communication is particularly important. High-risk customers should feel they can contact Western Power for support, or be directed to other services if required.

[62] The Review notes that many outages are not predictable. Examples of where an outage could be predicted is where potential overloading is apparent to the Control Centre, particularly potential of repeat outages during heatwaves. The Review is aware that Western Power actioned such messages in response to demand escalation during the January 2022 heat wave.

[63] Customer representatives told the Review that where too much load on the network is likely to cause an outage, Western Power could ask customers to reduce demand thereby reducing the risk of an outage. For example, Western Power could request customers turn off pool pumps, have air-conditioning set at 24 degrees and only on in the room being used, defer washing machine and dishwasher use. Research by Energy Consumers Australia (Behaviour Survey October 2021, https://ecss.energyconsumersaustralia.com.au/behaviour-survey-oct-2021/) has confirmed that Western Australians would be willing to reduce their usage at times of need.

Customer representatives thought that high risk customers would particularly appreciate a direct message warning if a power outage was likely (but not certain) to occur. For example, on days where Western Power considers there is a high risk of an outage due to weather (including fire) conditions, high-risk customers should be notified in advance so they can make plans to prepare for a potential outage. Customer representatives thought that customers should be able to self-identify as high-risk for any reason (e.g. a customer may consider themselves high risk for physical and mental health reasons or being at risk of family violence) and that that self-identification would mitigate any concerns over false alarms or over-informing.

> "I was forced to connect my mobile to the usb in my car and drive around to get some charge in the battery. Food from the freezer and fridge were spoilt and not fit for consumption. Prescribed medication that required refrigeration was no longer safe".
>
> Customer comment on social media (Western Power supplied)

Customer representatives also noted that an outage in a heatwave has a far greater impact on customers than at other times of the year. Regular and honest communication during a heatwave was vital for customers to manage their health and safety, including customers making alternative accommodation arrangements to manage their own circumstances.

What the Review heard from customer representatives about customer communication aligns with Western Power's own research for AA5. This research found that customers want to hear from Western Power about the things that affect them, including unplanned outages. The preferred method of communication from Western Power was stated as being via SMS and email. [64]

5.3.1. Customer complaints

Customer complaints were received directly by Western Power through its call centre, social media (e.g. Facebook and Twitter); and indirectly through local Members of Parliament and the Minister for Energy.

The complaints largely fell into the following categories:

- Dissatisfaction with Western Power's service, reliability, and lack of information about restoration times.
- Complaints about wastage of food in fridges and freezers and the inadequacy of the Extended Outage Payment to cover the loss.[65]
- Concerns about Western Power stating the fire risk conditions were the reason for the delay in restoration times, especially in metro areas.

[64] Western Power, *Bringing Customer Perspective to the AA5 Submission Executive Presentation*.
[65] The scope of this Review does not relate to the Extended Outage Payment, which is set at $80 for customers who are without power for more than 12 hours. Western Power, with the support of the State Government, doubled that payment to $160 for those impacted for more than 12 hours by the Christmas 2021 outages.

- Following the event, complaints followed rejections of the Western Power claim process for loss or damage.[66]

Western Power recorded 207 complaints relating to the outages.

5.4. Western Power's preparation for communications

When Western Power became aware of the potential heatwave it arranged a 'pre-Emergency Management Team' (pre-EMT) meeting for 20 December to prepare for possible issues. Consequent to planning activities, Western Power actioned its customer and stakeholder communications plan.

Western Power communication resources and strategies were adjusted to reflect potentially widespread outages. This included additional call centre staff, and communications and stakeholder team members were rostered on.

A media release was issued and published on the Western Power website on 23 December stating it was preparing for a heatwave and higher fire risk conditions. This media release also advised customers how to prepare for an outage and directed them to the Healthy WA website for information, including on food spoilage.

5.5. Customer communications

As the outages began to occur and for the duration of the four-day outage period, Western Power customer messaging and communication channels were regularly updated.

The communication messages were developed in conjunction with network operations to provide the most up to date information on the status of the outages and restoration times.

The overall messages to customers during the heatwave were as follows:

- Western Power crews were working to locate and repair faults that were affecting power supply to homes and businesses and they were working as quickly and safely as possible to restore power.
- The causes of the outages were stated in general terms once known. For example, "we have had unusually high demand for power in your area during this prolonged heat wave, which is causing repeated power outages. We have redirected load where possible and are looking at network solutions to address the issue."
- The high fire weather risk was highlighted as restricting Western Power's ability to locate faults and restore power. Delays to restoration were often attributed to the fire risk conditions.
- When an outage first occurred, customers were advised of an estimated restoration time. This is automatically calculated based on an algorithm which uses historical data to

[66] Western Power's website outlines that Western Power "can help you with the reasonable cost of repairing or replacing damaged property if the loss or damage was caused by incorrect action by Western Power, or inappropriate operation of Western Power equipment". Customers make applications after outages of length, to recover the cost of spoiled food and similar. As many outages are outside of Western Power's control, many claims are dismissed.

estimate the work involved to restore power. Restoration times were updated throughout the outage as new information came to light.

  - Estimated Restoration Times are updated as field crews attend the site, assess repairs and update the Estimated Restoration Times from their on-site computers.
  - The cause of fault is usually included, if known, but this relies upon field crews attending site to provide this information.

- Western Power provided updated information on the number of customers without power and where they were located.
- Western Power acknowledged the frustration and inconvenience caused but noted safety for the community and crews was their number one priority.
- Western Power encouraged customers to manage appliances, for example minimising opening and closing fridges and unplug all electrical appliances.
- Safety messages for customers related to electrical safety, urging people to stay eight metres away from any fallen power lines, and for heat stress tips directing customers to the Department of Health website for heat stress.

The Review notes Western Power may use general terms to explain cause of outages once known (otherwise listing it as "unknown"), and estimated restoration times, to avoid providing inaccurate information that may frustrate customers.[67]

To convey the key messages to customers a number of channels were used including SMS (for opt in customers only), Western Power's call centre, Facebook, Western Power's website, Twitter and mainstream media.

Customers that proactively contacted Western Power via social media or the call centre were provided with specific information about the outage at their premise. The average wait time for a customer calling the call centre was 3 minutes.

[67] Provision of information about the cause of an outage supports customers in managing their expectations of restoration and builds an understanding of the work that the network operator needs to undertake to affect that restoration. Research undertaken by the UK Energy Research Centre *Resilience of the Future Energy System: Impacts of Energy Disruptions on Society* identifies that "Communication is key for reducing both anxiety and strain on public services. People's first need in a crisis is to know why it is happening, how long it is expected to last, and to be able to check that loved ones are safe" highlighting the need to know 'why' even before they want to know 'how long'. UKERC_WP_Resilience-Energy-System_Impacts-of-Disruptions-on-Society.pdf (d2e1qxpsswcpgz.cloudfront.net).

High-risk customer communications

There was some interaction between Western Power and high-risk customers.

> "I need to know how long the outage will continue. I am an invalid pensioner, with brain tumours. I am suffering Migraines etc due to the heat and would like to know how long it will continue so I can make plans to go to Hospital or elsewhere. Also I was not notified."
>
> Customer comment on social media (Western Power supplied)

For example, customers on life support were called by Western Power after their power was out for 12 hours.

The Review found that where Western Power became aware that a high-risk customer needed power restored for safety reasons, it was able to include this consideration in its priority restoration approach. For example, in one instance an aged care facility raised concerns for residents' safety due to the facility's backup generator having failed. Due to the extreme heat, the safety of residents was considered at risk. Upon notification of the back-up generator failure, Western Power was able to identify the facility could be supplied by another part of the network, and reconnect that customer quicker than it may have done if they did not proactively contact Western Power.

5.5.1. Communications with other agencies

Direct communications to 34 impacted Local Government Authorities (LGAs) were sent by Western Power via email and, in some cases, phone calls.

One LGA noted they relied on Western Power's social media posts to stay up to date on what was happening in their community. Another LGA contacted Western Power through their call centre, as they did not have a direct contact.

Western Power directly contacted some Members of Parliament in affected areas. In the weeks following the event, customer complaints received through a Member of Parliament received a personalised response reflecting that customer's issues.

Western Power participated in the All Hazard Liaison Group meeting on 23 December 2021, where a number of stakeholders were present.

During the outages, Western Power did engage with AEMO to discuss likely Western Power actions during Total Fire Ban conditions, insofar as it impacted the security of the SWIS. Western Power's direct interaction with DFES was in relation to the routine notice of works undertaken under the TFB exemption. There was no direct interaction with EPWA other than through the All Hazard Liaison Group meeting.

A comprehensive summary of Western Power's communication activities during the period and the people reached through those communications, is included at **Appendix I**.

5.5.2. Assessment of Western Power's community communications

Below is the Review's assessment of the effectiveness of Western Power's community communication strategy against what the Review heard were stakeholder expectations.

Table 5.1: Review's assessment of the effectiveness of Western Power's community communication strategy

What customers want	What Western Power did	Findings
Reason for the outage	Where the reasons were known they were provided. However, reasons were general in nature.	Reasons were provided to customers once known but were not as detailed as customers stated they would like.
Timely and regular communication	Broad external messaging was updated regularly. However, more regular communication to assure customers that the network issues were being worked on would have helped.	Communication was regularly updated, however more frequent and detailed information about what was being done to fix the outage may have helped. For example, (a) crews have arrived on site; (b) crews are currently determining the cause of the outage etc.
Direct communication, for example SMS and email	7,000 customers were sent a direct SMS message. There was limited external promotion of customers registering for direct messages (except through the Western Power website and call centre).	Customer communication would have been improved by increased use of direct communications.
Multiple communication channels including radio	Multiple channels were used.	Multiple channels were used but use of emergency radio messaging, eg through the ABC network may have helped some customers.
Accurate and honest information	Western Power provided general information to customers once known.	Where information is unknown, the reason for this should be explained so customers can understand.
Restoration times, or the reasons why the times can't be given	Initial restoration times provided were often an average time and so may be misleading.	Where Western Power doesn't know the restoration time or is using an average, the reasons for this should be explained.
Acknowledgement that customers can be suffering and offer support where appropriate	Health messaging focussed on fire safety and very limited information was provided recognising heat related health and societal issues. Western Power proactively provided limited support to individual customers. However, did respond when customers contacted them directly. Life support customers were contacted after their outage duration was 12 hours.	Western Power could improve their approach to community safety messaging when outages occur in extreme weather. Engagement on this issue with the community in advance of a future event is vital. This may involve sharing health messages from other organisations or referring customers to other providers (eg Department of Health).
A warning message to customers if power supply is at risk and anything that could be done to prevent the outage	There was limited communication to customer before the event advising customers in high-demand areas that an outage was probable and no information about what customers could do to help prevent it.	Direct communication to customers in areas where an overload was likely, would have helped customer prepare and also may have reduced consumption and therefore the risk of an overload.

Review findings

31. Customers experienced the Christmas outages with more severity than might otherwise be felt, due in combination to the sensitive time of year, the sustained high temperatures and the length of the outages.

32. At the time of the Christmas 2021 outages, Western Power had in place a considered communications strategy. It used a number of channels to provide frequent updates to affected customers and communities. The coordination between different parts of Western Power resulted in up-to-date information for customers. The Western Power call centre was well resourced and wait times on average were reasonable given the nature of the event.

33. However, the Review found through stakeholder consultation that Western Power's communication strategy could be improved to meet stakeholder expectations. These improvements include: more regular and detailed communication during an outage; greater use of direct customer communication before and during an event; distinct communication strategies for vulnerable customers (including those on life support); recognition of the health impacts during a heatwave and appropriate health messaging/referrals; and greater engagement with impacted LGAs.

6. Conclusions and Recommendations

This Review has made several findings regarding the causes and impact of the outages during Christmas 2021.

In the course of its assessment, the Review has identified some issues related to how customer reliability is managed generally across the Western Power network.

Based on the information considered throughout the Review, the following recommendations are made to mitigate the likelihood and impact of future outages across the Western Power network.

6.1. Improved distribution network forecasting

Forecasting is a key input into many parts of Western Powers activities, particularly network planning to ensure network capacity is sufficient to meet the level outlined in the planning criteria.

Western Power has a reasonable approach to forecasting demand at the system-wide and transmission network level. However, at the medium and low voltage distribution level, low visibility of customer peak demand levels and customer rooftop solar generation is affecting the robustness of forecasts.

Western Power has advised improvement to its forecasting methodology is already underway, including plans to incorporate robust data regarding rooftop solar installations.

The Review recommends incorporating this data into Western Power's forecast methodology as a priority, as well as any other data which better reflects changing load patterns.

Further, Western Power's network planning is undertaken on a probabilistic (i.e. a probability of exceedance) basis. Modelling methodologies appear to use actual demand during historical peak occurrences and adapt it for potential future events.

In this period of both rapid transition in the energy sector and changing climate, the Review recommends Western Power explore the adoption of event or weather scenario-based forecasting to inform the likelihood, severity and location of future network issues.

Recommendation 1:

Western Power should continue to improve its forecasting of the distribution network to account for the:

- **rapidly changing way electricity is produced and consumed by customers in parts of the network. The forecast methodology should continue to improve the use of rooftop solar and other data such as maximum demand. AMI data, once available at scale, should also be used to better forecast load; and**
- **increased likelihood of extreme weather events (resulting in different supply and demand than has been experienced in the past) reducing the relevance of previous peaks.**

Western Power should report to the Minister for Energy on:

- **identified and implemented improvements to its forecasting methodologies; and**
- **any improvement in accuracy of forecasting of overloads prior to a fault occurring.**

6.2. Western Power to review planning criteria

Western Power is compliant with the existing planning criteria set out in the regulatory framework. The planning criteria is set at a level that strikes a balance between the costs and benefit of reliability, with safety also a key consideration in investment decisions.

However, the current planning criteria should be reviewed to assess whether it's appropriate for the future given changing and uncertain supply and demand conditions as the network decarbonises, and extreme weather events becoming more frequent. In addition, the value a customer places on reliability during extreme events such as heatwaves will likely be higher than other times of the year and should also be part of the consideration.

Recommendation 2:

Western Power should review its approach to network planning, particularly the ongoing appropriateness of its application of distribution network planning criteria, to identify improvements.

This review should recognise the appropriate economic trade-off between customer reliability and cost to supply given greater uncertainties in future demand and supply of electricity. These uncertainties relate to changes in climate (and more frequent and severe extreme events), customer electricity usage and the growing impact of technologies such as solar PV, batteries and electric vehicles.

Western Power should then engage with the ERA, through existing approval processes, regarding the implementation of any changes to the Technical Rules.

6.3. Continual improvement to reduce the risk and length of outages

Western Power applies a number of strategies to reduce the likelihood of unplanned outages as well as strategies to minimise the length of outages, some of which were deployed during the Christmas outages. These activities included:

- Load shifting;
- Limited backup generation deployment;
- Working with a LGA to restore customers safely from a fire risk management perspective; and
- As a last resort, some manual load shedding.

The Review found that the strategies were successful in reducing the number of outages and outage length, and should be expanded and employed in the future. For example, the Review notes that in hindsight, controlled load shedding could have been used to avoid some medium voltage overloads tripping during the Christmas outages.

Other considerations include increased interconnection, automation and improved visibility of customer demand.

In addition, Western Power should continue to explore the application of strategies like batteries, standalone power systems, microgrids, undergrounding, AMI utilisation and demand response activation as ways to manage future peak load events. The further use of drones and electric vehicles to circumvent some of the Vehicle Movement Bans could also be explored further.

Recommendation 3:

Western Power should continue existing strategies and consider improved ways to prepare for and manage outages.

The strategies to be considered include, but are not limited to:

a. **batteries, microgrids, network undergrounding and standalone power systems;**
b. **demand response, including asking customers to voluntarily reduce demand;**
c. **use of load shifting and last resort load shedding, including increasing interconnection, automation and improved visibility of customer demand; and**
d. **to reduce the length of outages, operational changes such as available fault crew numbers, back-up generation fleet size, and fire risk management as per Recommendation 4.**

Western Power should report to the Minister for Energy on its proposed utilisation, and in due course, the effectiveness of solutions b, c and d, noting that 'a' is incorporated into information which Western Power already publishes.

6.4. Review of fire risk response in light of the community impacts during heatwaves

Electricity networks can and have started fires with devastating consequences. Therefore, the restoration of power on days of higher fire risk needs to be managed in a way that minimises the risk of starting a fire. This risk is weighed against the fact that Western Power provides an essential service and reconnecting customers without power is a high priority.

Western Power has several procedures it follows to minimise the risk of its network from starting a fire, particularly when restoring customers on high fire risk days. The procedures largely reflect the exemption conditions provided by DFES, with some extensions.

On Fire Weather Days and TFB days, Western Power's procedures impose requirements which often delay power restoration and hence prolong outages for customers.

The above requirements apply even when the localised bush fire risk is low or the customer impact of a prolonged outage is high. For example, in urban sections of the network with limited vegetation, or where there is a strong ability to monitor for a fire and/or there is fire suppression equipment available at the site. The customer impact of a prolonged outage during very hot conditions can be high, particularly for sensitive and vulnerable customers.

There are a number of possible improvements that could be made to fire risk management which could have an overall benefit to customers by still minimising the risk of fire but recognising the health and safety impacts of prolonged outages on the community. Such improvements should be explored, including those outlined in the recommendation below.

Recommendation 4:

Western Power to work with key stakeholders such as the Department of Fire and Emergency Services and Local Government Authorities, to review Western Power's fire risk management approach with regard to the restoration of electricity supply on higher fire risk days.

It is recommended an Independent Expert be appointed to facilitate the review and identify strategies for customer restoration which balance the community safety impacts of extended outages during extreme heat events and fire risk in that specific area of the network.

The review should support improved community outcomes by considering (but not be limited to) the following areas:

- **Ensure a shared understanding of the roles of Western Power, Department of Fire and Emergency Services (DFES) and Local Government Authorities in managing electricity network related fire risks.**
- **Have a shared understanding of the community impact of power outages and fire, in conditions prone to higher fire risks (such as heat waves).**
- **Coordination of consumer communication and activities on higher fire risk days where customer safety and power reliability is at risk from extreme weather conditions.**
- **The appropriateness of Western Power's response on Total Fire Ban day and Fire Weather Days.**
- **Empowerment of Western Power to act to restore power on Total Fire Ban days where the risk of fire is low or community impact of the outage is high, including where:**
    - **the cause of an outage cannot be identified but is likely with a high degree of certainty (such as overload outages) to not be a fire ignition risk;**
    - **the network and local conditions are such that the probability of fire occurring and getting out of control is very low;**

- **a State-wide Total Fire Ban has been called due to DFES resourcing constraints and local conditions (such as weather, Fire Danger Index and network) would not have otherwise triggered a Total Fire Ban; and**
- **DFES could apply an emergency direction under a Total Fire Ban Exemption.**

The Minister for Energy is encouraged to engage with the Ministers for Emergency Services and Local Government to support a collaborative approach to the understanding and ownership of risks and responsibilities on higher fire risk days.

6.5. Improved customer and stakeholder communications strategies in line with customer expectations

The Review heard that stakeholders, particularly consumers, want frequent and honest communication before and during an outage event, using a range of communication channels.

Western Power had a reasonable communications strategy in place during the Christmas outages, which utilised different communication channels to reach consumers and sought to provide information once it was known.

However, the Review heard from customer representatives that improvements should be made to better meet consumer expectations in the future.

Recommendation 5:

Western Power to consult with stakeholders on improvements to customer and stakeholder communications in the lead up to, and during outage events. The consultation should consider, but not be limited to:

- **the type and frequency of information customers want during an outage;**
- **the use of direct communication with customers (if possible) before and during outages;**
- **the use of warnings where an outage can be reasonably forecast and is likely;**
- **communication to customers about how a change in their energy use may reduce the risk of an imminent outage;**
- **communication with sensitive and vulnerable customers;**
- **reinforcing government health messages to consumers in extreme heat events; and**
- **engagement and communication with key external stakeholders, including LGAs, when a significant outage event impacts their community.**

Western Power should report to the Minister for Energy on the outcomes of this consultation and the resulting implementation plans, outlining how communication strategies will be evaluated and evolve in line with community expectations.

6.6. Increase transparency regarding reliability in communities

Western Power is required to report annually on its performance against a range of reliability and customer services standards. Western Power generally meets its reliability performance standards (with the exclusion of extreme weather events).

However, there are a number of communities across the SWIS whose reliability falls below these benchmarks.

Improved transparency about which communities are regularly experiencing reliability materially below standards, and the impact of Major Event Days on network performance, would improve stakeholder engagement on what Western Power can do to address reliability in the future (noting the trade-off between cost and reliability). This is particularly important for many rural communities which experienced outages during the Christmas 2021 period, as well as throughout the year.

Recommendation 6:

Western Power should improve information on its reliability performance, including making it easily understood by its customers, for:

- **communities experiencing performance well below prescribed reliability standards; and**
- **the network during extreme events.**

The following should be reflected in any published information:

- **the reliability performance of the worst performing feeders;**
- **the felt experience of customers, therefore the data should include Major Event Days;**
- **consumer friendly language, including feeders being identified by location (e.g. Local Government Authority or suburb); and**
- **the causes of the reliability issues and the plans to address those issues in the future.**

Western Power should report to the Minister for Energy on progress towards this recommendation.

The Economic Regulation Authority and Energy Policy WA should consider the progress made by Western Power before assessing any need for codified prescription to give full effect to this recommendation.

Appendix A: Summary of Western Power's network management

This Appendix provides an overview of the technical aspects of Electricity Networks and the various activities undertake to create it and keep it operational with particular focus on aspects relevant to this Review.

The network operator's role

Electricity networks are the poles, wires, cables, substation and other electrical equipment that transfer electricity between the generation source and customers.

Electricity Network Operators are responsible for the design, maintenance and operation of its electricity network. Networks are referred to as "natural monopolies", due to long asset lives and very high costs to duplicate network infrastructure, and generally do not face strong competition. As a result, existing networks are regulated to ensure capital and operating costs are efficient and that service levels (e.g. safety and reliability standards) are maintained.

Networks incorporate the extra high voltage transmission network and the distribution network, outlined in Figure A.1.

Generally, payments for network services are made by Retailers, who then recover those costs from consumers.

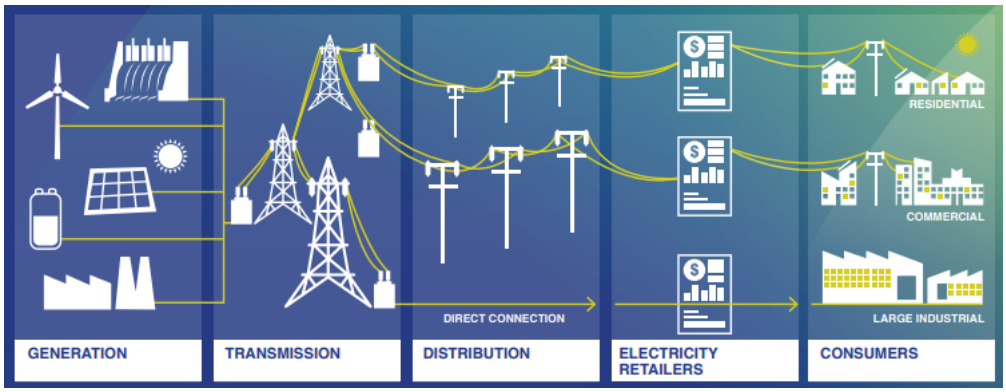

Figure A.1: Power system overview[68]

A key group not shown in the above figure is the System Operator which oversees the whole system to ensure sufficient generation is dispatched to supply the power demand on the system and sufficient ancillary services allocated to keep the system secure, such as having generation with spare capacity on-line which can quickly increase output in the case of another generator tripping.

Electricity Network Overview

Electricity networks have historically been designed around one way flow of electricity from large generation stations (e.g. coal, gas, hydro), transported over long distances via meshed, extra high voltage transmission networks (that can efficiently transport bulk energy), then distributed around cities and towns via a lesser meshed, medium voltage distribution network

[68] Electricity Networks Australia, https://www.energynetworks.com.au/resources/fact-sheets/fact-sheet-what-is-transmission/

(slightly lower efficiency and lower capacity), and finally into businesses and homes generally by low voltage, often un-meshed distribution (capacity only for that local area). This is shown schematically in the diagram below.

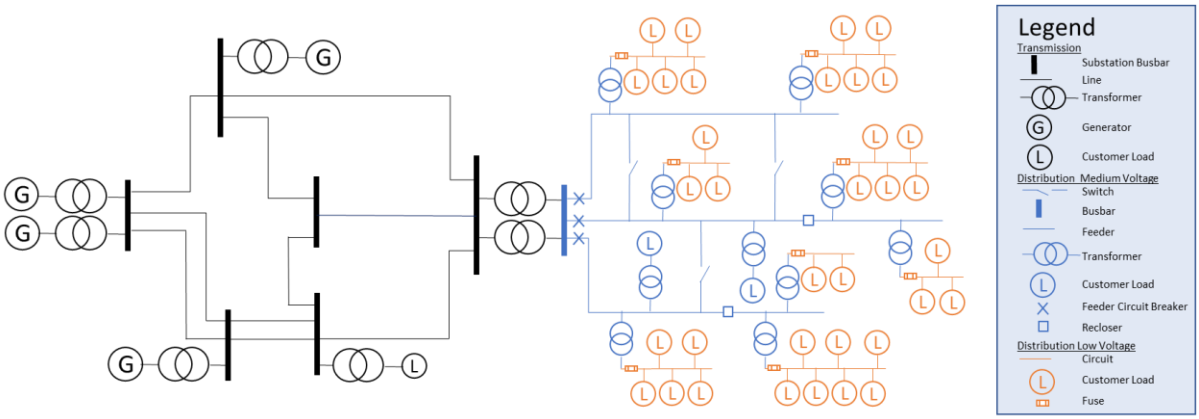

Figure A.2: Schematic Overview of Electricity Networks

The advent of new technologies such as rooftop solar, home batteries and electric vehicles in recent years is resulting in increased complexity and variable, two-way flows of electricity on the network. However, this high-level design has largely remained in place[69], due to the long life and high cost of electricity network assets, and that they are still able to adequately function.

At a high level the basis of this electricity network design is to balance cost vs reliability (safety is generally taken as a requirement at a base level). This is summarised in generalised form in the table below.

Table A.1: network infrastructure overview

Network	Description	Characteristics (meshed, cost, remote visibility, remote switching, protection)
Transmission Extra High Voltage	Provides bulk power interconnection between utility scale generators and load areas. Some (large) transmission connected customers.	Extra high voltages so reduce losses in the (often long) lines. However, higher cost to build due to additional insulation levels. Highly meshed so loss of a single line doesn't impact supply (i.e. back up line of sufficient capacity available) to large numbers of customers. Remote visibility of power flows (as large amount of varying two way flows so greater need to monitor) and remote control so can quickly make changes on the network when needed. Protection schemes (identify and initiate isolation of just the faulted part of the network) are very complex and duplicated for safety and reliability, but they are designed so that the loss of one transmission line due to a fault doesn't normally result in loss to customer supply.

[69] New technologies are resulting in material challenges to power system and network operation (e.g. see AEMO 2019 Integrating Utility Scale Renewables and DER in the SWIS Report) requiring multiple actions to enable the ongoing adoption of these new technologies. On the network this includes challenges such as voltage control and impacts on protection schemes requiring investment to resolve. These challenges are most prevalent on mild, sunny days when rooftop PV (in particular) reduces the demand on the power network to very low levels.

Distribution Medium Voltage	Distributes power from the transmission network to local areas (towns, suburbs). Some medium voltage connected customers.	Medium level voltage representing an efficiency point between cost to build and network losses of moderate power flows over (generally) moderate distances. Limited interconnection[70] between distribution feeders operating as a radial and generally require on-site switching, so in the event of a fault the power supply is lost to those customers on that part of the network until switching is completed around the faulted area. Those customers connected to the faulted area will tend to remain off until repairs are completed and that section of the network can be restored safely. Limited visibility, limited remote control and simpler protection schemes reflecting generally less ability for power flows above equipment ratings other than for network faults.
Distribution Low Voltage	Distributes power from the medium voltage network to end customers.	Low level voltage representing an efficiency point between cost to build and network losses of small power flows over generally short distances. Very limited interconnection between low voltage circuits (generally none in regional areas, very capacity limited in metro areas) almost exclusively requiring on-site switching so if fault occurs on that part of the network customers will generally stay off until repairs and safe restoration can be undertaken. Very limited visibility and very limited remote control and the simplest of protection schemes (majority are fuses which require a site visit to replace once the fuse is blown) reflecting generally less ability for power flows above equipment ratings other than for network faults.

In some ways, electricity networks could be compared with road networks where the highways and freeways are like the transmission network (enabling bulk flow of many vehicles), main roads are like the medium voltage distribution network (enabling high flow of vehicles) and suburban streets (e.g., cul-de-sacs) are like the low voltage network (serving only localised areas for a low flow of vehicles).

Network Design

Network design refers to the schematical design of the network and its key component parts. Generally, regulation in the form of Technical Rules outline "planning criteria" that guides design across the transmission and distribution network. These criteria help to set the cost vs reliability trade-off point that customers accept, often using inputs such as the Value of Customer Reliability.[71]

Regulations, standards and guidelines are also in place to outline the detailed engineering design and construction requirements for the network and its equipment which then assist in achieving that level of reliability, as well as safety.

[70] Distribution medium voltage feeders are often categorised by the types of areas they supply and often have differing reliability of supply requirements. For example CBD is densely populated and critical to an economy so may have full automated back-up, Urban is densely populated and feeders aren't too far apart which facilitates more economic connection to switchable back-up networks, whilst Rural feeders run long distances in low population density areas so back-up is often uneconomic.

[71] For example, see Australian Energy Regulatory 2019 Value of Customer Reliability Report which was developed by surveying different types of customers on the value they put on reliable electricity supply.

Key considerations in network design include the following, which are often interdependent:

1. Overhead or Underground: Electricity networks tend to be overhead[72] at the higher voltages due to the materially higher costs to underground[73] than at low voltage. Land impacts, aesthetics, maintenance, bush fire risks, susceptibility to faults and repair time are other aspects that network companies consider when deciding underground vs overhead networks. At lower voltage levels in urban areas, the difference between overhead and underground costs per customer is much less, therefore undergrounding can be justified. In regional networks, the customer density makes the undergrounding cost more prohibitive.
2. Centralised vs Dispersed: The lower cost of new technologies such as rooftop solar, batteries and load controllers are providing an alternative means to supply customers through a combination of these technologies in arrangements such as Microgrids and Standalone Power Systems. These arrangements can be a lower cost and a more reliable way to supply customers compared to a traditional network, especially in regional areas. They can also lower bushfire risks. However, where network assets still have a useful life, then they will tend to remain the most efficient means of supply.
3. Deterministic vs Probabilistic: Deterministic frameworks set a trigger point for network infrastructure investment decisions, for example, when the load forecast exceeds the capacity of the electricity equipment. Probabilistic frameworks look at the likelihood of the installed capacity being exceeded, the cost to install new infrastructure, and the benefit that provides to consumers. Even in the Deterministic approach there is still a probabilistic element as forecasts use a probability of exceedance element (e.g. forecasting the likelihood of actual load exceeding a level one year out of ten). These frameworks are used because it is uneconomic, and consumers will be unwilling to pay, for an electricity network that is 100% reliable.
4. Level of redundancy: This involves considerations of whether to duplicate network equipment so that if one item fails then supply is retained without any outage (or provide two lots of redundancy for particularly important parts of the network such as supply to CBDs) or provision of a back-up network so supply can be restored by switching to another part of the network (so will be a short interruption[74]) or no back-up provided. These concepts are outlined in more detail in Table 1 above.

Electricity Network Operations

Network Operations oversee the operation of the electricity network, providing access to the network for maintenance and responding to network incidents, including outages.

Network maintenance is often safest with the impacted part of the circuit de-energised. When faults occur on the network, that part of the network will generally automatically disconnect. As

[72] Electricity conductors are held up in the air by structures (e.g. poles, towers) with insulation achieved by an air gap and insulators used to connect the conductors to the structures.
[73] Underground cables require insulation encompassing the conductor, and are materially more expensive to install.
[74] Duration will depend on whether the switching can be done remotely (which has an additional capital cost but can be done in minutes) or requires a switching operator to manually operate network switches in the field (which may take hours depending on operator availability and remoteness).

such, a large part of Network Operation activity is about planning for and then responding to operating the network in an incomplete state.

In the vast majority of cases the network is designed to operate to handle maximum forecasted electricity demand flows (e.g. maximum generation, maximum customer load) such that when there isn't maximum flows there is capacity to have network components out of service without impacting customers.

In addition, there is the potential for network operators to reduce or eliminate impacts on customers of an outage. This includes switching so customers are supplied by another part of the network if interconnection is available or back-up generators can be deployed[75].

During very high demand periods, the ability to supply customers via other parts of the network may be limited depending on the design capability of the back-up. For example, on the low voltage network due to the small number of customers connected, capacity is often designed to match that of the peak load of the connected customers so there is limited capacity to supply other parts of the network during peak conditions. Also, low voltage networks will often require disconnected customers to be off for planned maintenance and for fault repairs to that low voltage network.

When faults occur on the network and come to the attention of the Control Centre (either via its own monitoring systems or customers ringing up and advising of power outages), the first priority is to ensure safety of the public. Automatic systems update websites so customers can see the extent of the outage and an indicative repair time based on statistics of historical repair times.

On-site inspection will be required to determine what caused the fault, whether immediate action is required to make it safe (e.g. a conductor is down over a road) and the extent of the repair required (e.g. equipment, people, vehicles). Interaction between the fault crew and the Control Centre then updates the information on estimated restoration time for customers, and is further updated if unforeseen circumstances arise. In some cases, if the repair is fairly simple (e.g. a tree branch in the conductors), the fault crew can also initiate supply restoration. If the repair is more involved, the fault crew may at least be able to limit the impact of the fault by isolating the faulted section and restoring customers outside the isolated section by connection to other parts of the network.

On days with lots of fault activity, fault response crews will be stretched and will prioritise attendance to those faults where there are reports of hazards such as conductors are down or pole top fires. Due to the number of faults this will also likely lead to more occurrences of the fault crew minimising their attendance at site by just making the site safe, reporting on the repair required and then quickly moving on to the next critical fault rather than doing any repairs or switching.

[75] Network operators have fleets of back-up generators to deploy both proactively as part of planned maintenance and reactively in response to faults. They can generally only be used if the maintenance activity or fault repair can be isolated from the generator. Deploying a generator imposes additional cost on the network operator (e.g. cost of the generator, fuel, maintenance, deployment) and there are other issues with generator use (e.g. aesthetics, noise, emissions, fuel top ups) so there will normally be set criteria for their use.

When there are more faults than crews available, generally the repairs are prioritised by number of customers impacted by the fault, conscious of the benefits electricity provides to the community. Other factors may also be considered such as expected time to repair, outage duration and number of sensitive customers impacted.

Appendix B: Western Power and the regulatory framework

The following table provides a summary of the regulatory arrangements that Western Power works under that are particularly relevant to the Review.

Table B.1: Summary of Western Power regulatory framework

1. Instrument	Description	Sections Particularly Relevant to the Review
Electricity Networks Access Code 2004	establishes a framework for third party access to electricity networks with the objective of promoting the economically efficient investment in, and operation and use of, networks and services of networks in Western Australia in order to promote competition in markets upstream and downstream of the networks	Chapter 11: Service Standard Benchmarks 11.1 Western Power must supply based on SSBs, 11.2 ERA must publish Service Standard Benchmark Performance
Technical Rules	standards, procedures and planning criteria governing the construction and operation of the network. Obligations for NSP (and customers).	Section 2 Transmission and Distribution System Planning Criteria
Electricity Industry (NRQS) Code	Supply, reliability and quality standards for electricity network operators in relation to voltage fluctuations, harmonics, unplanned or planned interruptions and complaints	Section 9: ensure supply maintained, duration/occurrence of interruptions kept to minimum Section 12: prescribed actions for WP to take in event of interruption Section 13: specified locational areas must not have total duration lengths greater than specified levels. Section 18/19: outage payments
Electricity Licences (Distribution and Transmission)	outlines the terms and conditions for Western Power to meet with respect to constructing or operating a new electricity system or operate an existing electricity system	Section 13: Individual Performance Standards Section 14: Performance Audit Section 17: Publishing of Information Section 20: Asset Management System Section 29: Priority Restoration Register
Small Use Customer Code of Conduct	regulates and controls the conduct of retailers, distributors and electricity marketing agents who supply electricity to residential and small business customers. The Code was developed to protect the interests of customers who generally have little or no market power.	Part 7 – Disconnection and Interruption

WEM Rules:	govern the market and the operation of the South West interconnected system, including the wholesale sale and purchase of electricity, Reserve Capacity, and Ancillary Services	Section 3: Power System Security and Reliability Section 4: Reserve Capacity Rules
Electricity Transfer Access Contracts (ETAC)	access contract that Western Power proposes for each of the reference services in its Access Arrangement (AA)	Section 25: Curtailment
Electricity (Network Safety) Regulations 2015	designed to ensure the safety of the public, consumers and electricity workers in the vicinity of electricity supply infrastructure.	Part 2 – Network Safety Part 3 - Notification
Electricity Industry Act 2004	an Act to govern the operation and regulation of the Western Australian electricity industry and for related purposes	Part 2 — Licensing of electricity supply Part 3 — Supply of electricity to certain customers Part 6 — Code of conduct for supply of electricity to small use customers Part 9 — Wholesale electricity market
Electricity Distribution Licence Performance Reporting Handbook 2019	informs electricity distribution licensees about: the performance indicators that distributors are required to provide data for; the definitions that apply to the performance indicators; how to calculate the performance data (where applicable); how and when the data must be provided to the ERA.	Section 4.2: Network Reliability Section 4.3: Complaints Section 4.4 Compensation Payments Section 4.6 Call Centre Performance
Energy Operators Powers Act 1979	an Act that vest powers in energy operators, to make other provision in respect of the functions of those operators, and for related and other purposes	Section 28: Powers of energy operators Section 46: Powers of entry generally Section 48: Rights as to entry on lands etc. in emergency Section 50: Restrictions on the exercise of general powers Section 57: Distribution system emergencies Section 58. Energy operator may not be bound to supply Section 62: Charges for supply, conditions of supply, and termination of supply
Electricity Corporations Act 2005	to establish three corporations in place of Western Power Corporation, each with particular responsibilities relating to the provision of electricity in the SWIS, and a corporation in place of Western Power Corporation with responsibility for the provision of electricity outside the SWIS	Part 3 — Functions and powers of corporations Section 63: Interruption or restriction of supply
Electricity Distribution Regulations 1997	covers network access, pricing, regulation	Section 28: Distribution Technical Code Section 29: Network planning criteria Section 31: Interruption and curtailment powers Section 32: Safety and security of system

Appendix C: Western Power reporting

Western Power Network Performance Reporting Requirements

Western Power is required to report on its network performance on a regular basis. The key Western Power documents that report on SWIS performance relevant to the Review are outlined in the table below.

Table C.1 – Western Power reporting on performance

Reporting	Purpose	Frequency
Access Arrangements	Independent ERA review of Western Power's proposed services, service standards, investment to provide services and prices to be charged	Every 5 years
Service Standard Report	Western Power reports on its performance against its services standards (published on ERA website)	Annually
Annual Reliability and Power Quality Report	Western Power reports on its performance against its NQRS standards	Annually
2020 Annual Performance audit and Asset Management System review	Independent audit commissioned by Western Power into asset management systems and processes	3 to 4 years, as determined by the ERA
State of the Network Infrastructure Report	State of the Infrastructure Report is a Western Power report outlining the condition of the network and its assets. It applies a risk-based assessment of network asset classes against safety, environmental and service (including reliability and power quality) risks	Annually
Annual Reports	Financial reporting on performance against Western Power key performance indicators, and audited financial reports.	Annually
Electrical licence report	Western Power report on the functions required to construct and operate new distribution system assets or operate the existing distribution system assets and the system as a whole in accordance with the terms and conditions of the licence	Annually

Western Power reporting on network capacity utilisation

Western Power's Annual Planning Report 2020 identified a number of zone substations that are nearing capacity limits over the coming years to 2025.[76] The location of these substations included Clarkson, Byford, Mandurah, Joondalup, Mandurah/Waikiki, Henley Brook and Southern River. Western Power considered risks in these areas as low "due to the sufficient distribution transfer capability available to the surrounding substations".

In its Network Opportunities Map 2021, Western Power identifies several Beechboro and Yanchep zone substation distribution feeders which were approaching capacity limits.[77] Zone substations approaching capacity limits, and proposed solution in parenthesis, were: Wellington St (replace substation), Black Flag (new transformer), Bibra Lake (distribution transfer), Byford (distribution transfer), Henley Brook (new transformer), Mandurah (distribution transfer), Clarkson (distribution transfer), Joondalup (distribution transfer), Bridgetown (demand side management), Bunbury Harbour (distribution transfer). Five reliability focus localities, which are

[76] APR 2020, p35
[77] Network Opportunities Map 2021

susceptible to more frequent and longer duration supply interruptions, are also identified for further attention:

Table C.2 – Reliability focus localities

Locality	Feeder Category	Customer Number
Port Denison	Rural Long	1088
Lancelin	Rural Long	1063
Dongara	Rural Long	867
Eaton	Rural Short	3455
Northampton	Rural Long	530

Appendix D: State hazard and emergency plans

State-wide Hazard and Emergency Plans

Two State Hazard Plans were particularly relevant to the 24-28 December 2021 period:

1. Heatwave: The responsible Agency is the Department of Health. A heatwave is defined as a period of abnormally and uncomfortably hot weather (maximum daily and minimum night, duration, humidity), that is unusual for the location and which could impact on human health, infrastructure and services. Different incident levels are defined based on the severity of the heatwave and if there are power supplies affected compounding the heatwave impacts, with EPWA the agency responsible to advise on that. The plan notes that heatwaves could affect utility assets and their staff.
2. Energy Supply Disruption: the Responsible Agency is EPWA, who is responsible for the overall strategic coordination of the response to the incident and the subsequent consequence management. The Plan outlines incident level indicators to be considered for various alert levels and is dependent on energy market participants reporting to EPWA any pending or actual energy supply disruptions. The Plan also outlines response actions at the various alert levels, including activation of an energy industry specific coordination team and a broader operations support group with a specific focus on community and essential services impacts.

Appendix E: Analysis of outages

Western Power creates a log for each incident that it needs to respond to. This includes information such as the time of the incident (start, finish), the network component involved, how many customers impacted, comments enter by controllers and field staff and a preliminary assessment of the cause.

For the outages over 24-28 December 2021 Western Power undertook a more detailed review of some of the outages to improve the understanding of the fault causes.[78] Using this analysis, the Review grouped the fault causes into the following categories to determine key drivers of the increased outages over 24-28 December 2021:

1) Network Overload: the outage was caused by a network protection device (eg: fuse, feeder circuit breaker, recloser, etc) operating due to the electrical current flowing through it exceeding its trigger point; or a network asset failing due to excessive electrical current flowing through it (and then the asset failure causing a protection device operation).
2) Non-avoidable faults: this includes damage to the network from vandalism, vehicle accidents, fauna and flora (e.g. birds) and wind-borne debris.
3) Faults largely within Western Power's control: this includes asset failures (excluding those due to overloads caused by extreme peak demand), vegetation encroaching on the network, and switching errors.

[78] When comparing outages to previous periods the preliminary fault cause information was used as this more detailed analysis was not undertaken on the earlier periods.

4) Customer Installation: for single customer outages, the incident was caused by the customer's electrical equipment.

5) Unknown: insufficient information available to determine cause or further investigation required.

The following table summarises the findings of the outage incidents during 24-28 December 2021:

Table E.1 – Summary of the findings of the outage incidents during 24-28 December 2021

Network component	Feeder or Recloser	Distribution Fuse	Other distribution device	Single customer impacted
Network Overload	24	321	23	4
Faults outside of Western Power control	9	15	2	19
Faults within Western Power control	8	10	5	14
Customer Installation	-	-	-	354[79]
Unknown	20	5	2	285[80]

Outages were primarily caused by faults or overloads resulting in network protection equipment de-energising parts of the network.[81]

These faults include fuse and feeder trips, which relate to protection equipment working as intended. Feeder trips (18) impacted a large number of customers (47,500), as feeders provide power to wider areas of the network, but these faults were restored relatively quickly.

Recloser trips – which split the medium voltage distribution network into smaller protection sections – were relatively few in number (43) but resulted in very long outages affecting large numbers of customers (47,500). The incidence and length of outages caused by recloser trips is related to the fire risk conditions at the time – this is explored in greater depth in section 4.2.

Importantly, there was a large volume (351) of distribution fuse[82] trips which supply smaller sections of the network. These trips impacted fewer customer connections (approximately 55) per incident. The vast majority of distribution fuse trips (321 of 351) have been attributed to overloads based on high demand.

Outages can be a single-customer outage (usually relating to issues on a customer premises or network only supplying that customer), or a multiple customer outage. Of the 1,120 incidents, 676 involved single customer outages.

[79] Review of field crew comments suggests a large number of these outages were likely due to overloads within a home from excessive demand during the heatwave, however insufficient information to confirm.
[80] It is probable that a large number of these outages were also due to overloads, however insufficient information to confirm.
[81] Other outage causes were in line with average summer fault rates.
[82] A fuse is a protection device that creates an open circuit when a designed electrical current threshold is breached (potentially due to a fault such as due to vegetation touching a wire or an overload due to demand higher than expected), in turn isolating that part of the network and deenergising all connected customers. Generally, these fuses require a fault crew to attend to replace the blown fuse.

Outages affecting single customers were largely due to customer equipment failure (354), of which a large number likely related to excessive customer demand, or unknown causes (285), where insufficient information was available to make an assessment.

Appendix F: Reliability performance transparency in Australian Jurisdictions

Transparency of network reliability performance has been a focus in the National Electricity Market (NEM).

The Australian Energy Regulator (AER) publishes the Distribution Reliability Measures Guideline[83] which sets common definitions of reliability measures that can be used to assess and compare the reliability performance of NEM distributors. These requirements are similar to that in WA, particularly regarding the publication of SAIDI, SAIFI and CAIDI. However, in addition the AER Guideline requires network operators to publish the top five feeders or feeder sections with the most inadequate level of customer service.

Further, Jurisdictional regulators in the NEM also require publication of data regarding the worst performing parts of the distribution network. For example, the Queensland Competition Authority requires networks to monitor and annually report on their Worst Preforming Feeders and to implement programs to improve their reliability performance.

In South Australia, the Essential Services Commission of South Australia (ESCOSA) publishes easily understood information about reliability at a regional level.[84] See below.

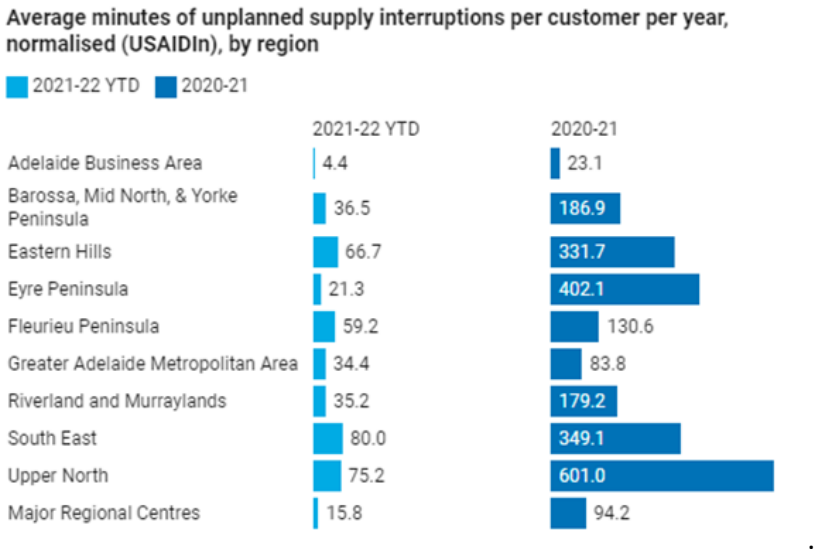

Figure F.1: ESCOSA regional reliability information

Customers in South Australia can look at the table above and assess the change in their reliability over time and how reliability in their area compares with other parts of the State. In addition to the above table, ESCOSA publishes monthly tracking of reliability by region.

SA Power Networks (SAPN) also publishes customer friendly information about reliability concerns on occasion. This allows engagement with customers about the reasons for relatively

[83] Australian Energy Regulator, 2018, Distribution Reliability Measures Guidelines 2018, https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/distribution-reliability-measures-guideline-2018

[84] Essential Services Commission of South Australiahttps://www.escosa.sa.gov.au/industry/electricity/regulatory-performance/sa-power-networks-operational-performance-monitoring/sa-power-networks-year-to-date-operational-performance

low reliability and what SAPN is doing to address this issue. This example for Adelaide is shown below and can be found on the SAPN website.

In 2017, Adelaide's CBD saw a spike in power outages inconveniencing the 140,000 people living and working in the area. Generally, our city centre usually has one of the most reliable power supplies in South Australia.

Identifying the cause

We've identified the unusually high number of outages in 2017 were mostly due to a series of random faults within the 200 kilometres of underground cables in the area, with no specific pattern or consistent cause responsible. While there were more faults among sections of older, lead-covered and paper-insulated cables, other sections of older cable continued to operate reliably.

How we're responding

With most of these faults occurring at random, it's not necessary or feasible to replace all older underground cables at once. Instead, we're developing a predictive model that will identify those cables that are more likely to fail so that they can be replaced in a timely manner. Not only is this approach more time and cost-effective, but will ensure reliability of supply too.

We've also committed to other short-term actions:

- Establishing a depot within the CBD and relocating crews there during peak times such as Christmas Shopping and 'Mad March', reducing the travel time to site.
- Installing more remote sensing within the CBD's network. This allows us to identify the location of a fault more quickly and switch customers to other power sources.

You can read about these outages and our response in more detail in the fact sheet: Ensuring reliable electricity supply for Adelaide's CBD.[85]

[85] SA Power Networks, 2019, Ensuring reliable electricity supply for Adelaide's CBD, https://www.sapowernetworks.com.au/public/download.jsp?id=310351

Appendix G: Roleystone Case study

About the Roleystone power line

The Roleystone power line is around 60 km long and supplies electricity to mostly residential customers. The Roleystone network is typical of a rural-short network which is often exposed to fault risks due to the overhead network and the inherent risks associated with a heavily vegetated area, wildlife and strong winds. The high fire risk of the Roleystone area is apparent.

Outage history

Roleystone has a history of power outages. In 2020, the Roleystone area experienced 4 outages, with durations between 40 minutes and 1 hr 15 mins, all identified as being due to environmental contact with the power line.

In late 2021 a number of outages impacted the community:

- In November, a number of momentary interruptions (resulting in less than 30sec outages) impacted residents in the Roleystone area. These interruptions were caused by a fault on the network, and the network automatically reenergising when the fault was cleared. While the customer impact was relatively low, given the frequency with which these outages were occurring, Western Power patrolled the area and identified an issue with birds short circuiting high voltage connections on a transformer. A new transformer was installed with bird spikes.
- On 7 December, the same section of the power line tripped as a result of a tree coming down in strong winds. This outage lasted 2 hrs 15 mins.
- On 15 December a bird short circuit caused a 1 hour outage and on that same date a possum fault was cleared along the feeder in Martin.

Christmas outage

At 19:20 on Christmas day, a section of the medium voltage distribution feeder supplying 2,787 customers in the Roleystone and surrounding areas tripped.

A TFB was in place for the City of Armadale and City of Gosnells and a TFB was similarly set for the following days 26-27 December 2021. Fire Danger Rating forecasts for the Lower West Inland Fire District on 26 December 2021 were Severe, with FDI forecasts above 50 all day.

In such conditions, and for high-risk areas such as Roleystone, Western Power's automatic processes to restore power are disabled, and restoration protocols require that a full patrol of the overhead network is required before any attempted restoration can take place.

Western Power dispatched a faults response unit at 19:31, however this unit was diverted to a priority house fire response called in by DFES at 19:41. As the house fire location was within the outage affected area, Western Power also sought to identify if this had been the source of the wider fault.

Western Power text message to customers at 8pm on 26 December 2021

"Unfortunately due to the fire weather conditions, our efforts to restore power continue to be delayed. We are attempting to restore power section by section and hope to have this completed by tonight We apologise for the ongoing delays. Please check here for updates http://WP.tnycc.pro/dkgnj2"

The fault unit remained at the housefire site until 23:30, at which time fatigue management protocols did not allow any continued efforts on the major outage. No root cause of the wider outage could be identified at the housefire site.

A daylight patrol was set for the following morning given the poor night-time visibility made a reliable assessment of the tripped feeder lines difficult, limiting any opportunity to reenergise under the more favourable night-time TFB conditions.

By 10:50 on 26 December 2021, Western Power had been able to patrol the full length of the feeder and no root cause for the trip was identified. Under Western Power's TFB Exemption this required the line to stay deenergised unless the FDI was less than 32 and falling. The actual FDI from the closest weather station was 40 at 11:00 and as such Western Power did not proceed with restoration. Western Power assessed, based on FDI forecasts and other information, that a reconnection would not be possible until 27 December at the earliest.

The role of Volunteer Fire Brigades

The feeder line that services Roleystone runs through Martin and connects to an emergency services communications repeater tower. By the morning of 26 December, back-up power for the communications tower was beginning to run low, and alternative power sources were investigated.

In the process of confirming if installation of a diesel generator would be allowed under TFB conditions, and armed with the awareness that TFB conditions prevented reenergisation of lines when the FDI was greater than 32 or rising, the City of Gosnells Volunteer Bush Fire Brigade reached out to Western Power to suggest alternative options for restoring power to the communications tower.

Once the right people within Western Power had been reached, Western Power was willing and able to work with the local fire brigade to methodically reinstate power to the Martin line. The assessment of local conditions and the staged and considered approach to reenergisation resulted in shorter outages for customers and the timely return of power to critical communications infrastructure.

The Brigade believed that, based on weather and fuel parameters, the local fire conditions presented at levels lower than 32 FDI (noting Western Power utilise FDIs for worse case conditions over a large geographical area). As such restoration was deemed to not pose a

significant fire risk, particularly if the network was restored in small sections, with Western Power personnel patrolling and Western Power and fire brigade personnel located along the network section with fire suppression equipment. The Volunteer Bush Fire Brigade contacted DFES to inform them this was the action they would be taking.

Western Power and the local City of Gosnells fire brigade worked together for 5-6 hours to reinstate the section of the line within the Gosnells local government area.

Western Power and City of Gosnells fire fighters swapped radios to support better communications, and gradually went about patrolling the line and reenergising in small sections (200-500m). Once the communications tower had been reached, the two teams continued along the line until the boundary with the City of Armadale was reached. At this point, the Review understands that the City of Gosnells Volunteer Bush Fire Brigade handed over to fire response personnel located in the City of Armadale.

Using this uncommon, resource intensive approach, an earlier restoration of customers was achieved:

- By 14:20 on 26 December 2021, 1,091 customers had been restored (outage duration: 18-19 hours).
- A further 1,257 customers were restored by 22:00 that night (outage durations: 21 - 26 hours).
- The final 439 customers were restored between 9:50 and 17:30 on 27 December 2021. (Outage duration: 1 day 14 hrs - 1 day 20 hours).

Impact of the outage

The outages impacted customers through food spoilage, which was amplified by the expense of food purchased for Christmas. Shops were closed, so customers were not able to replace their food. Food waste resulted in calls by residents for a special bin collection so rotting food waste was not left outside for too long. Given the Christmas period, only a small additional bin collection route could be managed at short notice.

Impacted customers suffered from the effects of heat and the inability to cool down. Properties not on scheme water, including orchards and residences, were not able to distribute water for their homes, animals and crops.

Some mobile phone communications were lost, inconveniencing customers but also restricting access to emergency messages and power restoration updates.

The City of Armadale advised the Review that the community impact of the outages over Christmas, and prior to Christmas, was significant. This is particularly due to the number of vulnerable people in the community, including elderly and financially disadvantaged. The health and financial impacts were therefore particularly acute.

The City understands that currently there is not an adequate trigger mechanism for the State to declare an emergency when there are combined conditions such as extended power outages during an extreme heatwave and total fire bans. The City would have preferred if an emergency was triggered by the conditions during the Christmas outages which would have led to the WA

Department of Communities activating evacuation centres to provide a cool place for residents to go.

The City of Armadale also implemented a vehicle movement ban to protect against the risk of fire. This restricted the use of internal combustion engines, preventing customers from deploying their own back-up generators. However, the City noted they believe the current DFES material regarding when a generator is permitted during a TFB is ambiguous and confusing to the general public. The Review understands back-up generators can be used during a TFB provided they are in an enclosed space, which can have public safety risks unless designed for this purpose due to emissions.

Appendix H: Heatwave and health and safety risks

The Review heard from consumer representatives that power outages during heatwaves can have serious consequences for peoples mental and physical health and safety.

This Appendix outlines some of the research which confirms the risk to customers during outages.

1. AEMO report into power outages and mortality [86]

In 2019 AEMO engaged researchers from the Bureau of Meteorology and University of Adelaide to investigate additional mortality expected on the third day of an extreme heatwave in major Australian cities if power supply ceased.

The Review concluded that loss of power and air-conditioning for a single day in an extreme heatwave scenario in Adelaide, Melbourne or Brisbane will likely result in additional loss of life.

It was estimated that a single day power loss occurring on day 3 of extreme heatwaves could have resulted in 10-21 additional deaths in Adelaide during its 2009 heatwave; 24-47 in deaths in Melbourne's 2014 heatwave; and 7-13 deaths in Brisbane's 2004 heatwave.

2. Victorian Council of Social Services, Feeling the Heat report [87]

In 2021, the Victorian Council of Social Services released a report on the impact of extreme heat and the risk factors that exacerbate heat vulnerability. The below extracts are taken from that report and illustrate the impact of heatwaves, particularly where people do not have access to air-conditioning, on community health and safety.

"Extreme heat can cause heat cramps, heat exhaustion, heat stroke, dizziness, and dehydration. It also exacerbates chronic medical conditions such as heart disease and asthma and plays havoc with medication. The impact worsens when heat stress is prolonged by high night-time temperatures that prevent people from cooling down and recovering."

"People unable to keep cool during heatwaves can feel stressed about being trapped in a hot home. Extreme heat also exacerbates existing mental illnesses such as depression and anxiety. Hospital admissions for mental health conditions increase during heatwaves."

"The irritability and frustration caused by unrelenting heat is a dangerous mix, especially when combined with alcohol and drug use. Family violence increases during heatwaves due to high household tension and women and children being forced to spend more time at home with a perpetrator."

[86] AEMO, 2019, *Power outages during heatwaves: Predicting mortality burden in Australian cities,* https://aemo.com.au/-/media/files/initiatives/strategic-partnerships/2020/power-outages-and-mortality-burden-australian-cities.pdf?la=en/.

[87] Victorian Council of Social Services, 2021, *Feeling the Heat,* https://vcoss.org.au/policylibrary/2021/06/feelingtheheat/.

Appendix I: Summary of Western power communications activities

The table below lists the communication activities implemented by Western Power over the Christmas outage period and the number of people reached.

Table I.1 – Communication activities implemented, and the number of people reached

Channel	Details	People reached
Direct SMS communication	Customers that registered for outage information from Western Power may have received a direct SMS message about the status of the outage. Proactive SMS messages were sent to customers where Western Power had additional information to share. There was limited external promotion of the direct messaging service for customers during the outages except through the Western Power web pages and the call centre. During the 4 days, 18,574 people registered for direct updates. Of these 17,842 registered through the Western Power website and 732 through the virtual assistant when customers reported faults to Western Power.	Over 47,000 direct SMS messages were sent to registered customers with outage updates over the period. Approximately 7,000 customers were reached.
Western Power Call Centre	Customers contacting the call centre had 2 options. Firstly, they could key in their postcode and get the latest information regarding their outage, or they could speak to an operator.	40,561 people accessed the automated message. 6,045 people spoke to a call centre operator and calls were answered on average within 3 minutes.
Mainstream Media	13 media releases and responses were made. 10 media interviews including 2 press conferences were conducted.	Western Power estimates the audience reach to be 11 million people (4.7 exposures per person).
Western Power Website	Outage update information; Outage faults and map.	26,559 people viewed the outage information. 409,209 people viewed the outage faults / map.
Social Media	11 posts to Facebook by Western Power. 9 posts to Twitter by Western Power.	163,393 people accessed the Facebook or Twitter posts. 1,671 people wrote a direct message to Western Power through social media. Western Power responded to 1,670 direct messages.
Community Engagement	Daily emails were sent to update some affected regional and metro Local Government Authorities on challenges and progress to restore power. Some phone calls were also made.	Communications were sent to 69 personnel, representing 35 organisations (including 34 LGAs). Most individuals received multiple updates.
Members of Parliament	Proactive updates to Members of Parliament during the outages. Response to complaints received via Member of Parliament.	44 proactive updates. 48 letters sent to MPs in response to a customer complaint received through their office.