AUSTRALIAN ENERGY COUNCIL

Energy Networks Australia

Extreme weather and electricity supply

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Extreme weather can place stress on the electricity system. Summer is often the time of heatwaves and bushfires in many parts of Australia.

Other weather patterns or events such as storms or even milder, sunny days usually in spring and autumn can impact the grid. In the latter case we are seeing increasing periods of minimum demand from the dramatic increase in solar PV, with more than three million homes now with solar on their rooftops, which can challenge system security.

Peak Demand

Heatwaves are three or more consecutive days of unusually high temperatures. They place the grid in many parts of mainland Australia under great stress, sometimes resulting in blackouts. These can be caused by several factors including local faults, bushfires or generator faults.

Peak demand is the maximum amount of electricity needed by a state, region, or even a street. To make sure electricity is available for peak events, the grid is built to meet this capacity – even though it won't always be needed. In all Australian states, except Tasmania, peak demand occurs in summer during heatwaves. Peak demand is measured in megawatts (MW). The scorecard for peak demand events and the season in which they occurred are shown on page 3.

The increased spread and reliance on air conditioning caused a rise in peak demand over previous decades. In recent years this has been tempered by an increase in household solar and batteries, and a reduction in demand from large industrial facilities. The chart on page 3 shows the trend for peak demand in summer and winter over the past two decades.

Minimum Demand

We are also seeing record levels of minimum operational demand – that is the level of our electricity sourced from the grid – while it may seem good to have less power coming from the grid and supplying our own, both for our own use and to feed back into the system, it can create serious challenges in managing transmission network voltages. This is discussed further on page 7.

Power systems across the eastern seaboard have interconnections, and normally high demand in one state can be met by extra generation from another. Heatwaves tend to have the biggest impact on the electricity grid in January and February, especially when multiple states have concurrent heatwaves. Multi-region heatwaves, such as those experienced on 30-31 January 2020, increase pressure on the grid as less supply can be drawn from neighbouring regions to meet higher demand. South Australia and Victoria, for example, often have heatwaves at the same time.

The shortage of electricity supply can be the result of several factors. It could be a fault or heat-related stress in a generator (or generators) which reduces supply at critical times.

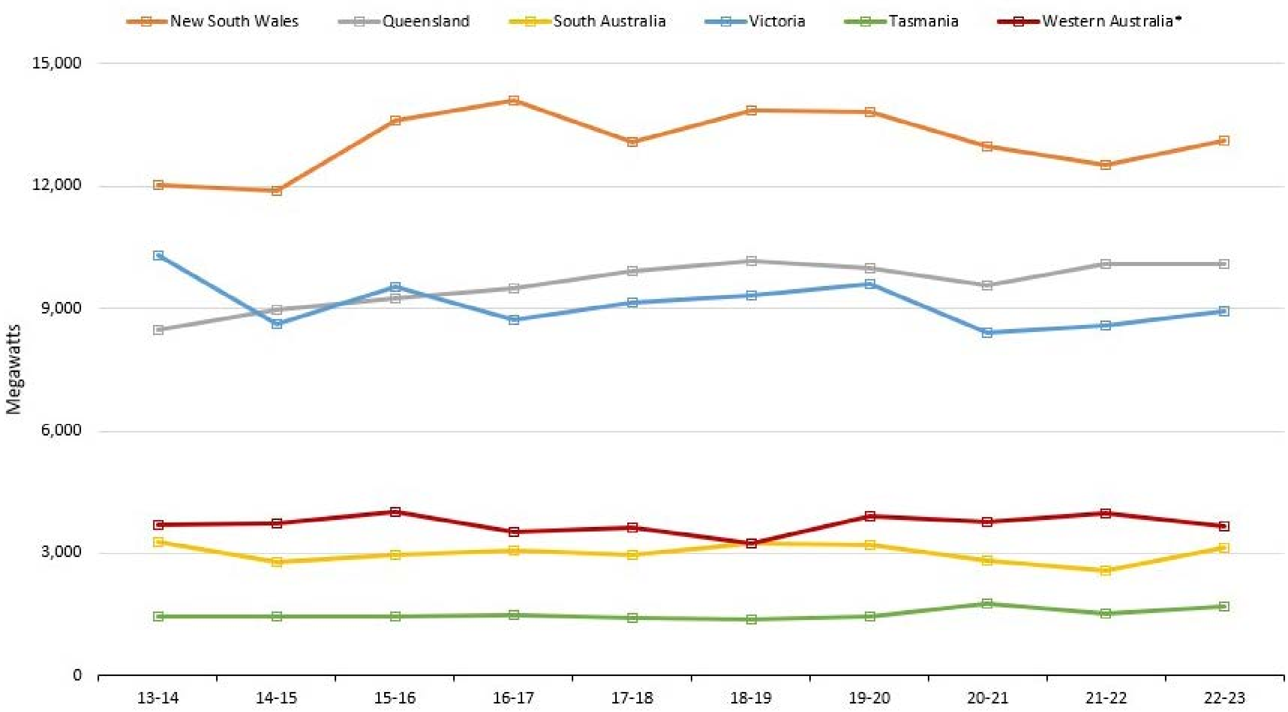
A transmission line may have its capacity reduced to avoid equipment damage resulting from high temperatures (the lines can sag under heavy load and high temperatures) or shut off because of the risk of bushfires. Any of these events, under certain conditions, can increase the risk of outages, but most will affect only localised parts of the grid at any time.

Rooftop solar PV or batteries by themselves will not protect your house from experiencing an outage unless they are configured to do this. At present few systems have this capability, so even if you have a solar PV system installed, you can still be affected and should be prepared.

Peak	QLD	NSW	VIC	SA	TAS	WA
MW	10179	14764	10490	3397	1884	4004
Period	Summer 2018/19	Summer 2010/11	Summer 2008/09	Summer 2010/11	Winter 2008	Summer 2015/16

Source: AEMO; Western Power. WA data covers the South West Interconnected System, with population centres in the state's south-west region. Summer demand refers to the period 1 Nov-31 Mar and winter demand refers to the period 1 May-31 Jul each year.

Peak demand by state, summer 2013-14 - 2022-23



Source: NEOexpress, Australian Energy Council Analysis

**peak demand in the South West integrated system (SWIS)*

Heatwaves and electricity demand

The occurrence and severity of heatwaves can be unpredictable, but there are a number of identifiable factors and patterns that can help us predict the level of electricity demand:

Duration of the heatwave: electricity demand tends to increase in the third and fourth days of consecutive hot days, as air conditioners increase output to manage the accumulating heat in buildings.

School holidays and weekends: demand tends to be higher from mid-January as schools and businesses resume, and weekdays have higher demand than weekends.

Solar PV: increased deployment of rooftop solar PV helps reduce system demand during most summer heatwave peaks (providing there is no cloud cover) but shifts the maximum peak event to later in the day as the sunlight dwindles. In future this is likely to be offset by a higher uptake of batteries to store power generated by rooftop solar.

What happens in a heatwave?

Networks, operators, regulators, governments, retailers, generators and emergency services know when heatwaves are coming and plan accordingly. Ongoing maintenance takes place throughout the year to keep the grid and power stations in good working order before summer. The owners of generators undertake maintenance of plant in the lead up to the summer peak period, investing hundreds of millions. Electricity networks take specific actions in advance of the hottest days to keep customers safe and comfortable while maintaining the reliable performance of the grid during periods of increased demand. They also have emergency crews ready to respond if equipment fails or if there is an emergency, to minimise the time customers are without power.

Leading into summer, **critical maintenance and planned upgrade work has continued**

The industry has worked closely with the Australian Energy Market Operator (AEMO), to mitigate the impacts to customers and prepare for summer. Each year AEMO prepares a summer readiness assessment which considers electricity system availability and grid readiness.

While pressure is placed on the grid by high demand, high temperatures can also impair the operation of key infrastructure like generators and transmission lines. Bushfires can lead to outages on major transmission lines and have the potential to impact solar output if there is extensive smoke haze (see page 7). These impairments can impact on the operation of the system.

Networks use smart technology and demand response to manage demand on the hottest days. The energy sector is also seeing new services and technology working with the grid to allow customers to make the most of their solar and batteries, and to engage and incentivise them to shift their electricity usage.

In preparation for an extreme heatwave, some large industrial customers will undertake voluntary load reductions, known as demand response. That is, they agree to switch off part, or all, of their operations. This helps reduce demand on those days. Some industrial customers have greater flexibility than others in being able to voluntarily reduce their electricity demand on these days.

During hot days, it is not unusual to see high spot prices in that particular state's wholesale electricity market. This is a sign of an efficient market. Higher prices provide signals to generators to invest and enter the market to help meet supply when there is a shortfall. Peak plants, such as hydro or gas, are built specifically for these types of events, and can sometimes run on only a few days a year.

These higher wholesale prices do not translate into higher retail electricity prices during a heatwave, because retail prices are fixed across a year and retailers manage the price risk for their customers.

Loss of Supply

There are three basic types of power interruptions that can occur during a heatwave:

1. **Localised outages:** these can be for any number of factors – i.e. a tree branch on a line, a truck hitting a pole, or equipment failure. Some may be due to heat and high demand. These are generally communicated by local network operators to customers via SMS, websites and social media. They can involve a handful or a few thousand households depending on the cause, and supply is restored once repairs take place.
2. **Power system disturbance:** When a major event has disturbed the security of the larger power system, customers may be interrupted over a wide area. There are many possible causes, but most frequently it is caused by a larger weather event which creates a sudden interruption to critical transmission lines. For example, on 4 January 2020 transmission lines in southern NSW tripped due to bushfires.
3. **Involuntary load shedding:** in the unlikely event there is still not enough supply to meet demand, the AEMO will order sections of the grid to be switched off until increased supply can be provided or demand reduces, generally in the evening. These are known as rolling blackouts, as different parts of the grid take turns being without power. These are infrequent and efforts are taken to minimise their frequency and duration.

Impact of increased renewables

Rooftop solar PV contributes to the supply of electricity on hot sunny days. Wind generators may also contribute to supply during heatwaves, depending on the amount of wind blowing.

Renewable generation, particularly from rooftop solar, is changing the shape of daily energy demand from the grid. This has become more pronounced as more and more rooftop solar has been installed (see graph page 7). There is an increasing dip in the demand curve during the middle of the day (known as a duck curve) because of domestic solar supplying household energy needs.

Historically peak hot day demand was typically experienced in the early afternoon; however, it has now shifted to late afternoon/early evening. During the day when the sun is shining there is less reliance on the grid due to the increased use of rooftop solar. While daytime demand is considerably lower, there is now a sharper spike in grid demand as the sun goes down.

Some rooftop solar can also disconnect when there are power system disturbances and this too can affect things like network limits and frequency (or voltage) on the grid. AEMO has produced an **information sheet** that outlines some of the other implications of minimum demand and steps being taken to try and address this issue.

As renewable energy further grows and coal plants retire, grid demand in the middle of the day is expected to continue to shrink further, moving to later in the evening once the sun sets. It is expected that large-scale, long duration storage and pumped hydro will also play a part in maximising renewable energy generation by storing energy produced by solar during the day and discharging it at night.

This demand peak, and subsequent quick drop, requires careful planning to ensure supply risks are managed. The shifting demand requires firm generation to start up and shut down more often, and in a very short space of time to meet the population's energy needs.

Distributed energy resources (DER) are devices like rooftop solar, batteries, and electric vehicles. All of them help the grid have less reliance on fossil fuels and harness the power of our natural resources like the sun.

However, these 21st century devices are being plugged into a 20th century grid and regulatory framework built to only support the traditional one-way flow of electricity. With more and more customers owning DER, we now have a two-flow system with power also being fed back into the grid. As a result, "traffic jams" can occur.

Network companies are working with regulators to ensure we are using these devices smarter and can choose when they are able to export energy into the grid and when they can't.

With solar PV operating "behind the meter" demand forecasting has become more challenging because this output is not visible to the market or grid operators and can only be estimated. As more rooftop solar comes into the system it is also increasing the ramp up in the late afternoon peak demand as solar output falls and households draw on the grid. The forecasting of this demand is based on the estimate of the total rooftop solar generation in the system. Weather forecasting also becomes a more critical element – the timing of peak temperatures (which will drive use of air conditioners, for example), when cool changes are expected, and when wind and sunshine is available.

Minimum Demand a growing problem

Minimum operational demand (the amount of electricity we source from the grid) occurs in the shoulder months in all regions but Tasmania, where it occurs in summer. It is most common on sunny, mild weekends with high rooftop solar output substituting grid-scale generation, like traditional power stations and wind farms. We are seeing new records being set for minimum demand as more solar PV is installed on our rooftops.

Both minimum and maximum operational demand are shifting to later in the day, driven by increasing contribution from rooftop PV. Since 2018-2019 it has become increasingly evident, according to the market operator, minimum demand is now occurring between midday and 2:30pm. In some scenarios distributed rooftop solar can supply 100 per cent of underlying demand at times. Minimum operational demand is shifting to the middle of the day in NEM regions.

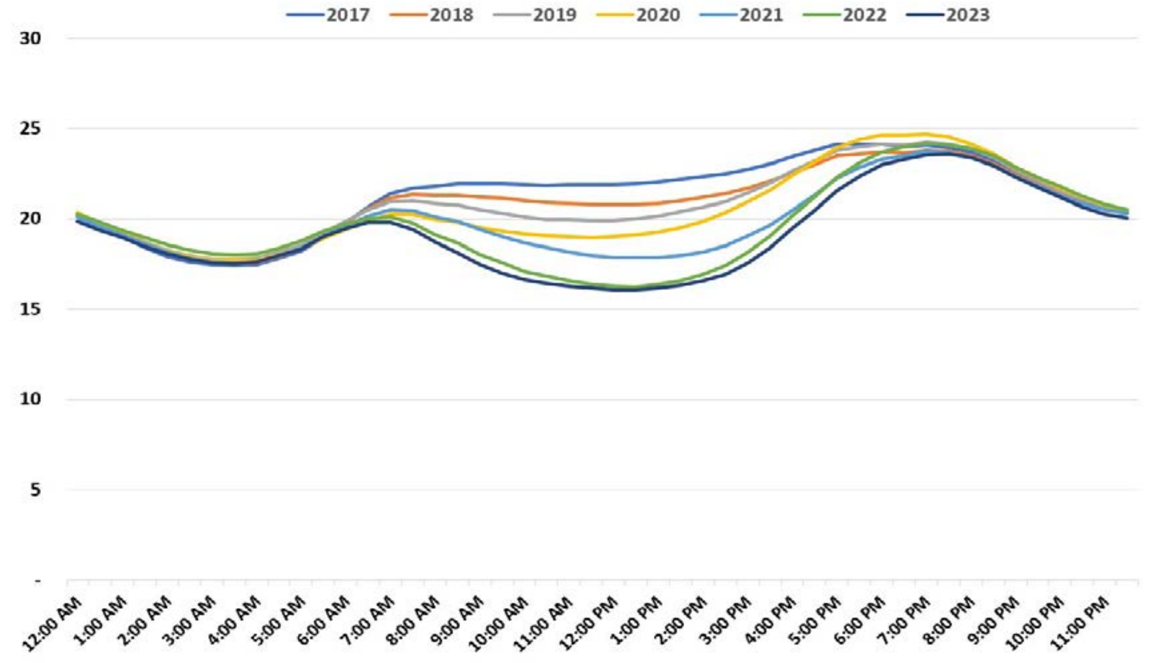
While it may seem good to have less power coming from the grid and supplying our own electricity – both for our own use and to feed back into the grid – as demand drops, it can create serious challenges, like voltage fluctuations, on the grid. There are threshold limits for demand to maintain the stability of the overall grid for a region. If minimum demand levels continues to fall it will become increasingly necessary to take action to avoid blackouts.

The NEM as a whole set a minimum demand record level of 11,393MW on Sunday 17 September 2023. South Australia, Queensland and New South Wales all had minimum demand records during the third quarter of 2023. South Australia's minimum demand was only 21MW on 16 September 2023, when rooftop solar provided 98.7 per cent of power needs.

From December 2021 the Australian Energy Market Commission introduced new inverter standards for rooftop solar systems to ensure they won't "trip" or disconnect when there are voltage disturbances.

Another factor that was evident in the 2019-2020 summer because of the extensive bushfires in eastern Australia was the impact on output from large-scale solar farms. AEMO estimates its output fell by between six and 13 per cent at times as a result of smoke plumes.

Changes in demand by time of day (Nov) since 2017



Source: AEC analysis, NEOexpress

Dunkelflaute and other weather events

Dunkelflaute is German for "dark lull" and is the term used to describe periods of cold, dark and windless winter months which can lead to almost no renewable energy output from that nation's installed wind and solar capacity. As Australia increasingly calls on renewable generation there is the same potential for this kind of weather pattern to impact our electricity system. In 2020 South Australia experienced two days (on 11 and 12 June) when wind power contributed around 9 per cent of total demand. On June 9-10 June, wind farm output contributed 63 per cent of electricity generation.

Droughts can impact electricity generation from our hydro capacity and was most dramatically seen in Tasmania in 2016 when low rainfall and earlier exports of electricity to the mainland left the state's dam levels too low to generate power. The subsequent loss of the interconnector cable with the mainland led to what was described as an energy crisis for Tasmania.

Heavy rainfall that leads to flooding can impact coal mines and coal-fired generation. As an illustration of the significant variance that can occur with wind, a record wind output in the NEM was set on 7 July 2023 (8040MW) while on 15 September 2021 wind output was 163MW.

This Summer

The Bureau of Meteorology expects El Niño and a positive Indian Ocean Dipole (IOD) to influence weather patterns for Australia.

For this summer (December 2023-February 2024) the BoM has forecast below average rainfall for north-east Australia, most of our northern coastline and small parts of south-east Australia. Large parts of inland Australia have a near equal chance of above or below average rainfall. If there is above average it is not expected to be widespread.

Maximum and minimum temperatures are very likely to be above average and are more likely to be unusually high for most of Australia.

The chance of unusually high maximum temperatures is much higher for parts of western WA, and the far north of the Northern Territory and Queensland. The Bureau also expects the chance of unusually high minimum temperatures is heightened this summer for most of northern Australia (excluding north-west WA and central coastal Queensland) and extending into the southern interior of WA, and the north-eastern half of NSW.

Above average minimum temperatures are anticipated for most of Australia except western parts of WA's Pilbara and Gascoyne regions as well as central coastal areas of Queensland.

According to the summer autumn outlook provided for AEMO[i] there is an increased chance of grass and scrub fires and increased bushfire risk this season with Queensland, New South Wales, eastern Victoria and the Northern Territory at most risk of above average bushfire conditions.

The Bureau of Meteorology **expects El Niño and positive Indian Ocean Dipole** to influence weather patterns for Australia.

i. Weatherzone Outlook for AEMO November 2023

Wind, storms, cyclones and floods

Sometimes it's not just hot, dry summer heatwaves that grid operators must prepare for, but also when things get very windy and very wet. In a El Niño summer strong winds may become more frequent, with heavy rainfall events less likely.

There is also a slightly increased risk of thunderstorms in some regions this summer[ii].

These other forms of extreme weather events can cause damage that is comparable to bushfires, leaving tens of thousands of customers without power and cause millions of dollars' worth of damage in just a few hours.

Powerful storms, cyclones and flash flooding can also cause disruptions to transmission and distribution networks which make it impossible to supply electricity safely. It is therefore crucial that customers are prepared and know how to contact their local provider in the event of an emergency.

More information on how to prepare for and what to do during an emergency can be found on all electricity providers websites. Depending on the weather events that are common in each service area, they might have specialised advice on things like cyclones or flooding. To find your distributor, visit **www.aer.gov.au/consumers/who-is-my-distributor**

i. ibid