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 the past couple of 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 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.

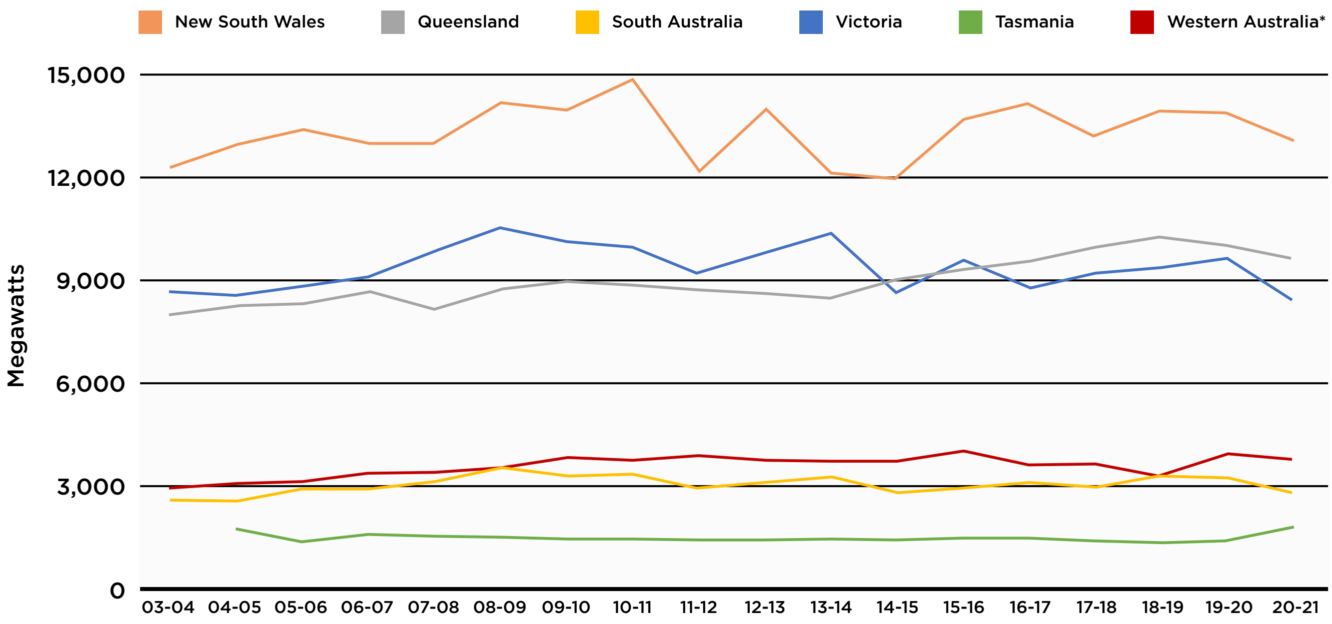
The shortage of electricity supply can be the result of several factors. It could be a fault or heat-related stress in a generator (or generators) which reduces supply at critical times. A transmission line may have its capacity reduced to avoid equipment damage resulting from high temperatures (the 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 2003-04 – 2019-20



*peak demand in the South West intergrated 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 generators in good working order before summer. 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 continued** while managing the impact of COVID-19

The industry has worked closely with the market operator to mitigate the impacts to customers and prepare for summer.

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, Twitter and other 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. This has become more pronounced as more and more rooftop solar has been installed. The occurrence called a 'duck curve' is shown below; the dip in the curve is caused by lower energy demands at that time of the day because of domestic solar supplying household 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.

We are also seeing record levels of minimum operational demand (electricity sourced from the grid) becuase of increased rooftop solar.

There are threshold limits for demand to maintain the stability of the overall grid for a region. If minimum demand levels are reached it will become increasingly necessary to take extreme actions to avoid blackouts.

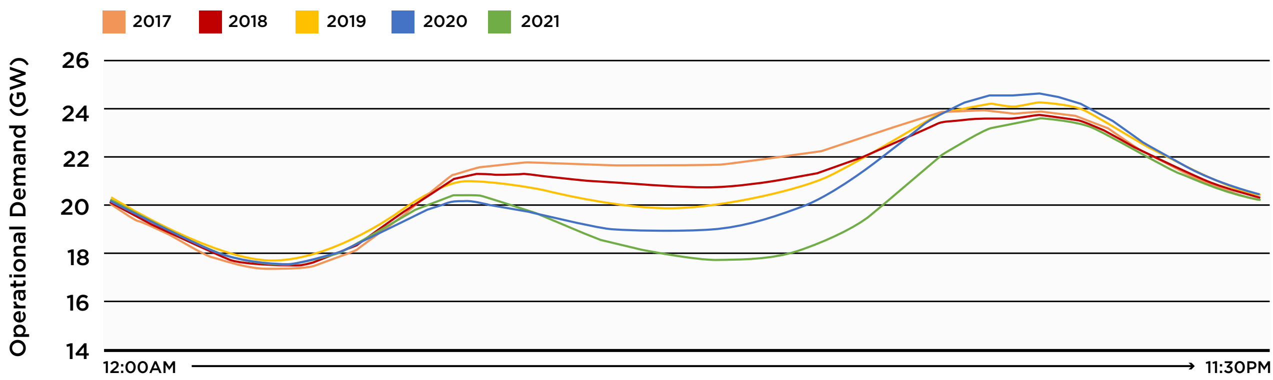
Steps taken could include selectively disconnecting whole distribution feeders when too much electricity from solar panels is exported back into the grid. Disconnection of those feeders means customers along the line lose power and could be without it for an extended period. If feeder shedding is not enough it could lead to a general trip or network faults leading to cascading failure and blackouts.

Some rooftop solar can disconnect when there are power system disturbances and this too can affect things like network limits and frequency on the grid (the grid has to operate within certain tolerance levels and if it can't, that can lead to load shedding).

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.

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



Source: AEC analysis, NEOexpress

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.

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. The 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.

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.

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. Overall, the market operator also notes that this solar generation availability is generally over-forecast, while wind generation is generally under-forecast. A major focus is on improving the forecasting as the grid continues to transition away from traditional generation.

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 led 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. Last year 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. Last year the Yallourn Power Station in Victoria's Latrobe Valley was impacted by extremely heavy rainfall which led to flooding and cracks appearing in the Morwell River Diversion that runs through the plant's coal mine. The Victorian Government declared an energy emergency and subsequently approved water diversion activities to allow Yallourn to undertake a comprehensive damage assessment of the Morwell River Diversion and resume standard coal mining in late June following detailed geotechnical risk assessment.

This Summer

The Bureau of Meteorology has declared a La Niña for eastern and northern Australia over summer. It means this season is expected to have less extremely hot days (compared to 2019/20), but there is also an increased chance of prolonged, less intense heatwaves particularly in southern Australia. It's predicted the number of days above 35ºC will be slightly below average for most capital cities in southern and eastern Australia. To the north tropical cyclone activity is expected to be slightly above average. The widespread rain, thunderstorms and flooding that Australia experienced during spring, is expected to continue into early summer for most of the country.

La Niña is usually associated with wetter than average conditions for northern and eastern Australia. While no two La Niña events are the same, typically 'La Niña' means:

- Increased rainfall across much of Australia
- Cooler daytime temperatures (south of the tropics)
- Warmer overnight temperatures (in the north)
- Shift in temperature extremes
- Decreased frost risk
- Greater tropical cyclone numbers
- Earlier monsoon onset

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La Niña years in Australia, tend to see **cooler than average maximum temperatures** across most of mainland south of the tropics, particularly during the second half of the year. The cooler than average daytime temperatures is often associated with a decreased frequency of extreme daily high temperatures.

However due to increased cloud cover which tends to act as an insulator it can result in warmer than average minimum temperatures across northern and eastern Australia.

In the warmer half of the year, southern coastal locations such as Adelaide and Melbourne experience fewer individual daily heat extremes during La Niña years, but an increased frequency of prolonged warm spells.

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 wet and very windy. In a La Niña summer like this year[1] it is quite likely the grid will experience extreme weather of a much different nature.

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.

No one likes to be stuck in the dark, especially during a storm, but it's important to remember that during any severe weather event field crews must prioritise resupplying electricity to vulnerable and life support customers above others. This can result in delays to power restoration for non-life support customers.

In our connected society it is common to expect to be constantly informed and this is no different with outage notifications. Networks strive to ensure customers are kept informed, but delays to notifications can occur as it takes time for damage to be assessed, restoration times to be calculated and field crews dispatched.

In extreme circumstances, additional field crews from networks in other parts of the country will fly in and lend a hand. Rest assured that your network is working as hard as possible to restore power to all customers as safely and as quickly as it can.

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.**

In Australia, **La Niña tends to bring more rain and lower temperatures** across much of the country, while we see increases in heavy rain, flooding, and severe tropical cyclones making landfall.

1 www.bom.gov.au/climate/enso/