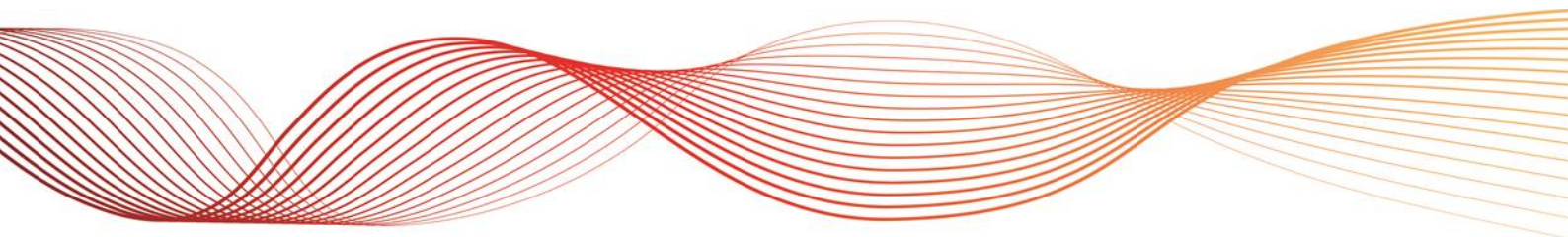




SOUTH AUSTRALIAN ELECTRICITY REPORT

SOUTH AUSTRALIAN ADVISORY FUNCTIONS

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IMPORTANT NOTICE

Purpose

The purpose of this publication is to provide information to the South Australian Minister for Mineral Resources and Energy about South Australia's electricity supply and demand. While some historical price information is provided for completeness, this publication does not present any views on the effectiveness of price signals in the National Electricity Market.

AEMO publishes this South Australian Electricity Report in accordance with its additional advisory functions under section 50B of the National Electricity Law. This publication is based on information available to AEMO as at 1 July 2017, although AEMO has endeavoured to incorporate more recent information where practical.

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EXECUTIVE SUMMARY

AEMO's *Electricity Statement of Opportunities* (ESOO)¹ for the National Electricity Market (NEM) confirmed that for peak summer periods, targeted actions to provide additional reserves are necessary to reduce heightened risks of unserved energy (USE)² and an increased potential for the current National Electricity Market (NEM) reliability standard not to be met in South Australia.

The highest risk of USE in South Australia in the 10-year outlook is in 2017–18. This risk is being addressed by the South Australian Government's Energy Plan³ developing additional diesel generation and battery storage, and AEMO pursuing supply and demand response⁴ through the Reliability and Emergency Reserve Trader (RERT)⁵ provisions. Without these actions, the USE in South Australia could exceed the reliability standard.

The USE risk is forecast (subject to significant uncertainty) to reduce after 2017–18, due to increasing renewable generation. Power system security and reliability will be tested on extremely hot summer afternoons and evenings, when photovoltaic (PV) generation drops to low levels. The risk increases if this coincides with low wind generation, unexpected generation outages, or constraints on electricity imports from other regions.

South Australia's mix of electricity supply sources continues to evolve. South Australia has become increasingly reliant on electricity generation from gas-powered generation (GPG) since the closure of coal-fired generation.

South Australia's reliance on natural gas for energy supply and maintaining system security means gas supplies must be available for GPG during critical times. AEMO considers the gas supply-demand balance across the east coast of Australia to be finely balanced, with continued risks of supply shortfalls. AEMO continues to monitor this balance, and is collaborating with industry and governments so sufficient gas is available to keep meeting demand and minimise the risk of energy supply shortfalls.

The reliability standard specifies expected USE should not exceed 0.0020% of consumption per region in any financial year.

What is the outlook for electricity consumption and demand?

The 2017 NEM ESOO provides updated electricity consumption and demand forecasts⁶ for the NEM for the period to 2026–27.

Over this 10-year outlook period, annual consumption in South Australia is forecast to decline 3.6%, from 12,442 gigawatt hours (GWh) in 2016–17 to 11,989 GWh in 2026–27 under the 2017 NEM ESOO Neutral scenario.

An annual consumption decrease is also projected in the short term (2016–17 to 2019–20), mainly due to households and businesses managing their electricity use and costs through ongoing investments in

¹ AEMO. *Electricity Statement of Opportunities for the National Electricity Market*, September 2017. Available at <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities>.

² Unserved energy (USE) is the amount of energy that cannot be supplied to consumers, resulting in involuntary load shedding (loss of customer supply), because there is not enough generation capacity, demand side participation, or network capability, to meet demand. See rule 3.9.3C of the National Electricity Rules for the full meaning of the term "unserved energy" in relation to the current reliability standard.

³ Government of South Australia. *Our Energy Plan*. See: <http://ourenergyplan.sa.gov.au/>.

⁴ Demand response, also called demand side participation, is where customers are paid to decrease load during actual or forecast supply shortfalls.

⁵ For more information about the RERT and actions for summer 2017–18, see: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Emergency-Management/RERT-panel-expressions-of-interest>.

⁶ This report provides operational consumption and demand forecasts. This means the electrical energy supplied by scheduled, semi-scheduled, and significant non-scheduled generators (excluding their auxiliary loads, or electricity used by the generator). For further information about demand definitions, see: http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEFR/2016/Operational-Consumption-definition---2016-update.pdf.

rooftop PV⁷ and energy efficiency, along with a short-term reduction resulting from the announced closure of the automotive industry over the next couple of years.⁸

Maximum operational demand is also expected to decrease, at an annual average rate of 1%, over the 10-year outlook period, driven by projected increases in rooftop PV, battery storage, and energy efficiency improvements. Observations for the next 10 years include:

- Maximum operational demand is forecast to continue to occur in summer in South Australia.
- Over the next 10 years, maximum summer operational demand (10% probability of exceedance (POE))⁹ is forecast to shift from afternoon to evening, when PV generation is no longer contributing to maximum demand. The peak is expected to occur at 7.00 pm by the mid-2020s.
- Forecast growth in PV penetration is lower in South Australia than in New South Wales and Victoria, as a percentage of maximum demand, but it starts from a much higher base. Installed PV capacity represented 25% of maximum operational demand in South Australia in 2016–17.

Minimum demand is forecast to continue declining rapidly:

- The 90% POE minimum demand forecast (Neutral scenario) is expected to become negative in 2025–26, due to rooftop PV generation being projected to exceed grid demand in some hours of the day (similar to last year's forecast). At these times, South Australia could store or export its excess generation to the rest of the NEM via the interconnectors, provided they are in service. This, in turn, will provide market participants with greater opportunity to manage their energy use.
- South Australia is the first region in the NEM in which high rooftop PV penetration has caused minimum demand to shift from overnight to near midday. South Australia has been experiencing its minimum operational demand in the middle of the day since 2012–13.

How has electricity been supplied in recent years?

The supply mix in South Australia has continued to evolve, and Table 1 summarises the local electricity supply breakdown for 2016–17. AEMO also notes that:

- Rooftop PV contributes 9.2% of the local generation mix in South Australia, with more than 30% of dwellings in South Australia now having rooftop PV systems installed.¹⁰
- Among the NEM regions, South Australia has the highest proportions of each of gas and wind generation and rooftop PV.
- Combined interconnector net imports to South Australia increased 40% from 2015–16 to 2016–17, from 1,941 GWh to 2,725 GWh.

⁷ Rooftop PV means a system comprising one or more PV panels, installed 'behind the meter' on a residential or commercial building rooftop to convert sunlight into electricity.

⁸ ABC News, "Toyota to close: Thousands of jobs to go as carmaker closes Australian plants by 2017", 10 February 2014. Available at: <http://www.abc.net.au/news/2014-02-10/toyota-to-pull-out-of-australia-sources/5250114>. Viewed: 27 June 2016.

⁹ Probability of Exceedance (POE) means the probability, as a percentage, that a maximum demand forecast will be met or exceeded (for example, due to weather conditions). For example, a 10% POE forecast is expected to be met or exceeded, on average, only one year in 10, so considers more extreme weather than a 50% POE forecast, which is expected to be met or exceeded, on average, one year in two.

¹⁰ Analysis taken from: Australian PV Institute (APVI) Solar Map, funded by the Australian Renewable Energy Agency, accessed from pv-map.apvi.org.au on 30 May 2017. See <http://pv-map.apvi.org.au/historical#4/-26.67/134.12> (paste url into browser).

Table 1 South Australian local electricity supply breakdown for 2016–17

Local generation	Generation in GWh	Share of total
Gas	5,596	50.5%
Wind	4,343	39.2%
Coal	0	0.0%
Rooftop PV	1,016	9.2%
Diesel and small non-scheduled generation*	122	1.1%
Combined interconnector flows	Flow in GWh	
Imports to South Australia	2,889	
Exports from South Australia	164	

* Small non-scheduled generation is approximate, and is based on a larger list of generators than in the 2016 SAER. It includes data from selected non-scheduled generators less than 30 megawatts (MW) capacity, including PV non-scheduled generation

Table 2 lists the average wholesale electricity prices in the NEM for the past two years. South Australia's average wholesale electricity price for 2016–17 was \$108.66 per megawatt hour (MWh), which was approximately 76% higher than for 2015–16 (\$61.67 per MWh). AEMO's analysis suggests the higher prices in South Australia were mainly due to tighter supply conditions, higher gas costs, and network outages.

Table 2 NEM average wholesale electricity price (nominal)

	2015–16 (\$/MWh)	2016–17 (\$/MWh)	Movement
New South Wales	51.60	81.22	57% ↑
Queensland	59.97	93.12	55% ↑
Victoria	46.14	66.58	44% ↑
South Australia	61.67	108.66	76% ↑
Tasmania	102.71	75.40	-27% ↓

Do AEMO's forecasts show the reliability standard being met?

The 2017 NEM ESOO reported that planned actions to provide additional firming capability¹¹, via the South Australian Energy Plan and RERT provisions, are necessary to reduce heightened risks of USE in South Australia and an increased potential for the current NEM reliability standard not to be met.

For the 2017–18 summer in South Australia, the 2017 NEM ESOO reported that:

- South Australia is at risk of not meeting the reliability standard, with a forecast of 0.0015–0.0025% USE, depending on demand variations.
- The likelihood of a shortfall is between 26% and 33% in South Australia. The average shortfall projected is likely to be between 81 megawatts (MW) and 97 MW, but could reach 243 MW. If USE occurs, it is likely to last for two to four hours.
- The risk of a supply shortfall may be greater if actually supply or demand were to vary from the forecast. If a large thermal unit in South Australia or Victoria was not available over summer, expected USE would be above the reliability standard.
- The risks are forecast (subject to significant uncertainty) to reduce after 2017–18. From 2018–19, the forecast maximum demand is expected to be moderated by increasing PV uptake and energy efficiency, and additional large-scale renewable generation is expected to be developed.

¹¹ Firming capability can be dispatched to maintain balance on the power grid. It can include generation on the grid, storage, demand resources behind the meter, flexible demand, or flexible network capability.

The risks for the coming summer are being addressed by the South Australian Government's Energy Plan¹² developing additional diesel generation and battery storage, and AEMO pursuing supply and demand response through the RERT provisions.

Key changes affecting supply incorporated in 2017 NEM ESOO modelling are:

- The market-operated component of the South Australian Energy Plan's battery.¹³
- The committed Hornsdale Stage 2 Wind Farm (102.4 MW), Hornsdale Stage 3 Wind Farm (109 MW), and Bungala Solar Farm (220 MW).
- ENGIE's advice that Pelican Point (478 MW) was operating at half capacity (239 MW), but the full capacity would be made available to the market as of July 2017.
- Hazelwood Power Station (1,600 MW) in Victoria closing from March 2017.

Notably, the 2017 NEM ESOO analysis shows that new renewable generation can provide support to maintain reliability, even without significant firming capability, and continued development of renewable generators can lower the risk of USE. However, if this renewable development was to lead to earlier retirement of existing thermal generation, the risk of USE would increase without additional firming capability.

How might electricity supply be met in the future?

Recent investment interest, reported by industry, is focused around renewable generation, gas generation and supply, new transmission interconnection, and large-scale energy storage.

Renewable generation

Generation investment in South Australia continues to be focused largely on renewable projects (existing wind farm projects and large-scale solar projects). As of 1 July 2017, 1,515 MW of solar generation and 3,178 MW of new wind generation projects are either committed or proposed in South Australia.

Rooftop PV installations are expected to continue over the 10-year outlook period, during which time South Australia is projected to have the highest ratio of rooftop PV generation to operational consumption of regions in the NEM and the Wholesale Electricity Market (WEM) in Western Australia.

Gas generation and supply

Following the September 2016 black system in South Australia, the South Australian government is pursuing developments to incentivise additional GPG for emergency electricity generation. The state government will build its own 250 MW gas-fired electricity generator.¹⁴

In June 2017, AGL announced it will build a 210 MW gas-fired generator, to be known as the Barker Inlet Power Station, to replace two of the four Torrens Island A (2 X 120 MW) turbines and operate from early 2019.¹⁵

In 2016–17, GPG represented 49.1% of the local generation mix in South Australia.

¹² Government of South Australia. Our Energy Plan. See: <http://ourenergyplan.sa.gov.au/>.

¹³ AEMO has modelled the market-operated component of the announced 100 MW/129 MWh battery project in South Australia.

¹⁴ Refer to footnote 13. Government of South Australia. Our Energy Plan. See: <http://ourenergyplan.sa.gov.au/>.

¹⁵ AGL. Media release, "AGL announces development of \$295m power station in SA", 7 June 2017. Available at: [https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2017/june/agl-announces-development-of-\\$295m-power-station-in-sa](https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2017/june/agl-announces-development-of-$295m-power-station-in-sa).

Whether sufficient gas is available to meet demand in the outlook period will depend on:

- The quantities of gas available to the domestic market after liquefied natural gas (LNG) exports.
- The level of domestic gas demand for GPG.

The Australian Domestic Gas Security Mechanism (ADGSM)¹⁶ was implemented on 1 July 2017 by the Commonwealth Government. The ADGSM provides for restriction of LNG exports if a shortfall of domestic gas supply is projected.

In addition, gas producers and pipeline operators made a commitment to the Commonwealth Government to make gas supply available to electricity generators during peak NEM periods. The Gas Supply Guarantee mechanism is being developed by industry to facilitate the delivery of these commitments.

While the ADGSM is intended to provide one means to manage the risks to the annual domestic energy balance, the Gas Supply Guarantee mechanism is directed to short-term deliverability and supply issues for GPG, and as such is most appropriate to address operational risks.

The South Australian government is also sourcing more local gas to increase supply.¹⁷

Interconnection

A project to increase the capacity of the existing Heywood Interconnector between Victoria and South Australia, from a nominal 460 MW to 650 MW in both directions, is nearing completion, and its capability is being progressively increased as testing and commissioning activities continue.¹⁸

ElectraNet is also investigating the feasibility of a potential new high-voltage interconnector between South Australia and the eastern states, to facilitate integration of more renewable generation in the region and improve system security.¹⁹ Since the announcement of the South Australia government's Energy Plan, ElectraNet is engaging with non-network option proponents so an initial assessment of the feasibility and likely benefits of non-network solution options can be progressed.

Large-scale energy storage

On 7 July 2017, the South Australian government announced it would build a 100 MW (129 MWh) battery at the Hornsdale Wind Farm. The energy storage systems from the US sustainable energy company Tesla will be paired with Neoen's Hornsdale Wind Farm and installed before summer 2017–18.

Other solar thermal proposals at Port Augusta propose different storage technologies as part of their power plant. There are also several other initiatives in South Australia, as listed on AEMO's Generation Information page.²⁰

In addition, AGL's virtual power plants (VPP) demonstration orchestrated batteries in homes throughout Adelaide to simultaneously aggregate battery discharge via smart software in a cloud-based platform.²¹

¹⁶ For more information on the ADGSM, see: <https://www.industry.gov.au/resource/UpstreamPetroleum/AustralianLiquefiedNaturalGas/Pages/Australian-Domestic-Gas-Security-Mechanism.aspx>.

¹⁷ Government of South Australia. Our Energy Plan. See: <http://ourenergyplan.sa.gov.au/>.

¹⁸ Refer to information available on AEMO's website: <http://www.aemo.com.au/Stakeholder-Consultation/Consultations/Heywood-interconnector-upgrade--program-for-inter-network-tests>.

¹⁹ For more information on this project and ElectraNet's Regulatory Investment Test for Transmission (RIT-T), see: <https://www.electranet.com.au/projects/south-australian-energy-transformation/>.

²⁰ AEMO, Generation Information. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>.

²¹ ARENA, *Virtual Power Plants*, Feb 2017. Available at: <https://arena.gov.au/projects/virtual-power-plant/>.

How might power system security be managed with the changing generation mix?

The September 2016 black system in South Australia highlighted challenges associated with extreme circumstances as the NEM generation mix changes. AEMO has acted, with industry and government, to implement the recommendations it made after investigating the black system.²²

These actions aim to reduce risk in five key areas:

- Reduce the risk of the South Australia region islanding (separating from the rest of the NEM).
- Improve forecasting of events that could cause islanding.
- Increase the likelihood, in the event of islanding, that a stable electrical island in South Australia can be sustained.
- Improve the system restart process, so supply to customers can resume as quickly as safely possible.
- Improve market and system operations processes during periods of market suspension.

To reduce the energy supply risk to South Australian consumers:

- For this summer, AEMO will have completed its recommended actions to support measures needed to identify, minimise, and manage islanding risks for South Australia.
- Critical improvements to operational tools and processes have been implemented.
- AEMO is working with ElectraNet to complete a range of actions to expand available capacity (including necessary upgrades to hardware and secondary systems).

Actions to better manage power system security

AEMO supports the position of the Finkel review²³ that the design of the grid of the future must be fit-for-purpose to deliver the key outcomes of increased security, future reliability, rewarding consumers, and a lower emissions trajectory.

AEMO is working collaboratively with the energy industry and governments to:

- Prepare for next summer.²⁴
- Strengthen transmission network.
- Increase South Australia's power system security through managing the frequency response and maintaining the level of inertia in the region.

As the generation mix continues to change across the NEM, it is no longer appropriate to rely solely on synchronous generators to provide essential non-energy system services such as voltage control, frequency control, inertia, and system strength. The system services required for the power system in transition also go beyond those currently procured, potentially including services such as fast frequency response (FFR).

The transitioning power system will also need services from non-traditional sources like utility-scale solar PV, wind farms, batteries, and importantly from distributed energy resources (DER), such as 'behind the meter' facilities installed on customers' premises.

AEMO is working actively with the energy industry and government to increase South Australia's power system security by additional means of procuring these services from all generators and network or non-network services (such as demand response and synchronous condensers).

²² AEMO. *Black System in South Australia, 28 September 2016 – Final integrated report*, 28 March 2017. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/Power-System-Operating-Incident-Reports>

²³ *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future*, June 2017. Available at: <http://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf>

²⁴ AEMO's preparations for summer 2017–18 focus on generation and the availability of generation fuel (coal, gas, and water), completion of generation and transmission maintenance before summer, facilitating new generation and storage, and encouraging greater utilisation of consumer-owned energy resources through demand response initiatives, as well as seeking offers of additional reserves through the RERT provisions.



AEMO has worked with the Australian Renewable Energy Agency (ARENA) and others on proof-of-concept trials of promising new technologies (starting with use of the new Hornsdale Stage 2 Wind Farm to demonstrate grid stabilisation services) to deliver engineering solutions to make the grid more resilient and protect customer supply.

As the transformation of Australia's energy system continues, the technical challenges of the changing generation mix must be managed with the support of efficient and effective regulatory and market mechanisms, to deliver the most cost-effective measures in the long-term interest of consumers.

Other regulatory and strategic initiatives being progressed include:

- Exploring options to procure inertia and improve system strength in South Australia.
- An integrated framework for emergency frequency control schemes and protected events. In March 2017, the Australian Energy Market Commission (AEMC) made its final determination on the South Australian Minister for Mineral Resources and Energy's Emergency Frequency Control Scheme rule change request. This framework will facilitate a more secure electricity supply for consumers.



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1. INTRODUCTION

This *2017 South Australian Electricity Report (SAER)* is an executive briefing report, summarising information from the suite of South Australian reports regularly produced by AEMO, as summarised in Table 3. The other reports to be published over the next six months will provide more detailed information on topics discussed in this report.

Table 3 Suite of South Australian reports, 2017

Report	Content	2017 publication month
<i>South Australian Demand Forecasts</i>	Demand forecasts and insights for South Australia, from the <i>2017 Electricity Forecasting Insights</i> .	June
<i>Independent Review of ElectraNet's Preliminary Capital Expenditure Projects</i>	Independent technical assessment of emerging transmission network investment requirements in South Australia over ElectraNet's regulatory period 2018–19 to 2022–23.	August
<i>South Australian Historical Market Information Report (SAHMIR)</i>	Generation, interconnectors, spot price, FCAS price, demand, basic wind performance, historical electrical energy requirements.	September
<i>South Australian Electricity Report (SAER)</i>	Consumption and demand, generation, interconnectors, spot price, FCAS price, basic wind performance, supply developments and withdrawals, supply adequacy, system security in a changing generation mix.	November
<i>South Australian Renewable Energy Report (SARER)</i>	Advanced wind performance, rooftop PV performance.	November
<i>South Australian Generation Forecasts</i>	Forecast electrical energy requirements.	November

The 2017 SAER reports on South Australia's electricity supply and demand situation, focusing on:

- Consumption and demand, and the impact of rooftop photovoltaic (PV) generation, battery storage, and electric vehicles (EVs).
- Existing and committed supply, including generation and interconnector capacities and historical performance.
- Historical electricity spot market and frequency control ancillary services (FCAS) pricing information.
- Supply adequacy and system security initiatives and programs in South Australia.

Information used in this report is sourced from other AEMO reports, notably the *Electricity Statement of Opportunities (ESOO)* for the National Electricity Market (NEM), the *South Australian Historical Market Information Report (SAHMIR)*, and AEMO's Generation Information web page. AEMO has also used information from data provided by market participants and potential investors as at 1 July 2017.

Throughout this report, time is expressed in Australian Eastern Standard Time (AEST) with no daylight savings applied. This is referred to as NEM time (or market time).

The pricing analysis for five-year and 10-year trends has been presented in real June 2017 dollars, using the Adelaide Consumer Price Index (CPI) as the basis for adjustment. Where analysis has been undertaken within only the most recent two financial years, nominal dollar values are presented.

Summer is defined as the period from 1 November to 31 March, and winter from 1 June to 31 August. The data that supports the tables and figures in this report is published on AEMO's website.

Chapter 7 provides links to these and other supporting information sources.

2. CONSUMPTION AND DEMAND

2.1 Introduction

AEMO updated its forecasts for annual consumption and maximum demand for the entire NEM and each region in the 2017 NEM ESOO. These forecasts differ from those published in June 2017 in AEMO's 2017 *Electricity Forecasting Insights*²⁵ and 2017 *South Australian Demand Forecasts*²⁶ reports.

This chapter summarises key points from the 2017 NEM ESOO forecast and 2017 SAHMIR regarding actual and forecast operational consumption and demand in South Australia. It focuses on:

- Average daily historical demand trends over the last five summer and winter seasons.
- Relevant historical changes and drivers for forecasts.
- The impact of rooftop PV, battery storage, and EVs.
- Differences in forecasts between the 2016 *National Electricity Forecasting Report* (NEFR) and the 2017 NEM ESOO forecasts, where possible.

An explanation of the data reporting terms used in this chapter, as well as important differences in reporting methods, can be found in Appendix A.

Operational consumption and operational minimum and maximum demand reported in this chapter (excluding Section 2.2) are presented on a 'sent-out' basis, net of auxiliary power station loads.

AEMO's forecasts explore a range of sensitivities that represent the probable pathway for Australia across Weak, Neutral (considered the most likely), and Strong economic and consumer outlooks. The forecast sensitivities reported in this chapter are taken from the 2017 NEM ESOO forecast. The key underlying drivers of these forecasts are described in the 2017 *Electricity Forecasting Insights*, and summarised in Table 4 below.

Table 4 AEMO 2017 forecasting and planning scenarios

Driver	Weak sensitivity	Neutral sensitivity	Strong sensitivity
Population growth	Weak	Neutral	Strong
Economic growth	Weak	Neutral	Strong
Technology uptake, including rooftop PV, energy efficiency and electric vehicles	Slower – hesitant consumer in a Weak economy	Moderate – Neutral consumer in a Neutral economy	Rapid – confident consumer in a Strong economy

2.2 Forecast scenarios and uncertainty

Forecasts have been produced for three scenarios – Strong, Neutral, and Weak – representing different futures with diverging outlooks for economic growth and consumer sentiments.

In recognition of the tight supply-demand balance projected over the next few years, affecting both the gas and electricity sectors, AEMO has reviewed the near-term demand dynamics expected as a consequence to changing energy prices. This has required a prudent treatment of forecast risk related to the timing and extent of response to price changes. AEMO has limited visibility of price change response, because data in the terms of bilateral contracts, and strategies employed by commercial operations of industry, are not typically shared with AEMO.²⁷

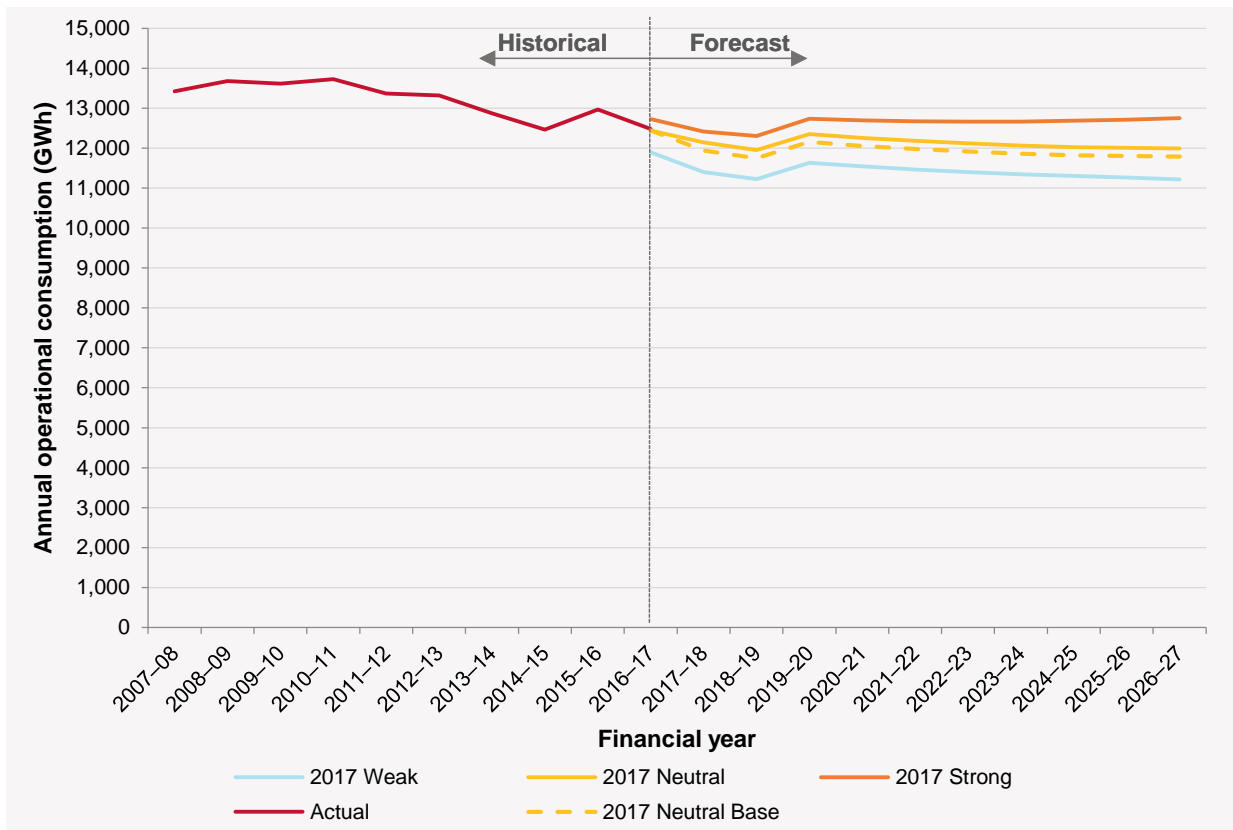
²⁵ AEMO, 2017 *Electricity Forecasting Insights* June 2017. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/EFI/2017-Electricity-Forecasting-Insights.pdf.

²⁶ A summary of demand forecasts for South Australia, from the 2017 *Electricity Forecasting Insights*, was published as *South Australian Demand Forecasts*, June 2017. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions>.

²⁷ The duration of energy supply contracts for example, may delay price increases until the time of contract renewal.

In response, AEMO has adjusted the Neutral and Strong scenario annual consumption and maximum demand (MD) forecasts to account for this risk, with a delayed and reduced response to price changes incorporated. Figure 1 shows the resulting adjustment to the base Neutral scenario forecast. Throughout the SAER, the Neutral adjusted forecast are used and referred to as ‘Neutral’.

Figure 1 Annual operational consumption and forecast with adjustments



Major methodological updates in AEMO’s most recent demand forecasts (produced for the 2017 NEM ESOO) included:

- Reviewing how energy prices may impact energy demand, and how this can be best accounted for in modelling methods. Of particular concern to AEMO is how the demand forecasting system should account for near-term supply-demand tightness, and the impact on shorter-term dynamics on peak demand that may be less transparent to AEMO. This includes competition dynamics, contractual terms in energy supply agreements, and operational responses to short-term supply scarcity.
- The findings of interviews with large industrial consumers in each region to update price response assumptions, including short-term behavioural responses by industry and households as well as long-term structural responses via investments in energy efficiency and rooftop PV.
- Recalibrating annual consumption forecasts, to have the starting point reflect actual demand levels observed in 2016–17. This accounts for more up-to-date information regarding major industrial production shifts, including, for example, the long-term outage impacting the Portland Aluminium smelter, as well as dynamics since January 2017 (which formed the basis of the *2017 Electricity Forecasting Insights* starting point).

AEMO has also accounted for a range of plausible risks and uncertainties in its demand forecasts, given the major transformations expected to continue for major industry, the broader economy,

technology, regulation, and consumer behaviour. The approach to these uncertainties is discussed in the 2017 NEM ESOO.²⁸

2.3 Average daily demand

Average daily demand profiles represent the demand, in megawatts (MW), for each 5-minute dispatch interval of a day, averaged over the relevant days of the selected period.

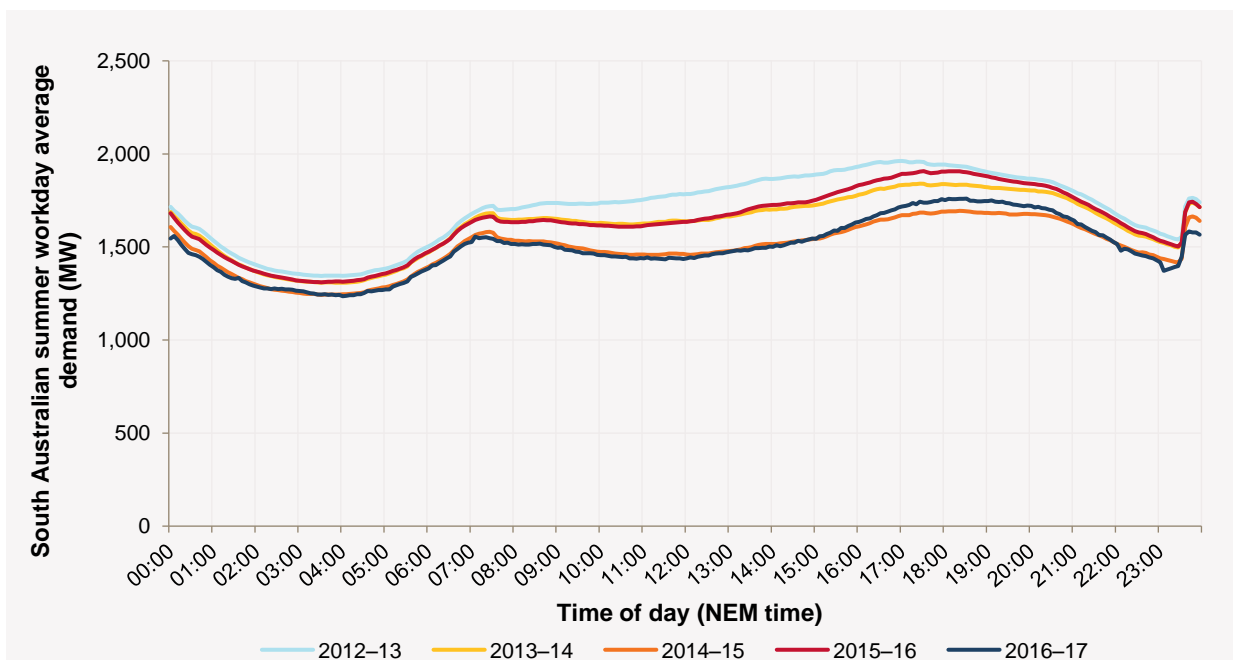
Changes to the average daily demand profile over time can provide insights into the impact of increasing small-scale renewable generation and demand side management.

Only South Australian workdays are included in the analysis. Weekends and gazetted public holidays are excluded.

Summer

Figure 2 shows the South Australian average workday demand profile for summer 2012–13 to 2016–17. Average summer demand year-on-year has been generally declining in daylight hours, due to increasing rooftop PV generation following a continual growth in installations (along with overall energy efficiency gains).

Figure 2 Summer workday average demand profiles



Seasonal hot weather still plays a large role in shaping overall demand. For example, in 2015–16, Adelaide experienced heatwaves and record-breaking daytime temperatures²⁹ which led to a much higher average demand over the summer period than in the adjacent years.

²⁸ The 2017 NEM ESOO and supporting documents are available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities>.

²⁹ Bureau of Meteorology, 1 March 2016. *Seasonal Climate Summary for Adelaide 2015-16*. Available at: <http://www.bom.gov.au/climate/current/season/sa/archive/201602.adelaide.shtml>.

Another noticeable feature in the demand profile is the sharp uptick from 11:30 pm, due to the controlled switching of electric hot water systems.³⁰ SA Power Networks (SAPN) has initiated a project³¹ to re-program up to 90 MW³² of hot water demand to reduce the impacts of the switching on system security in the event of South Australia operating as an islanded network.

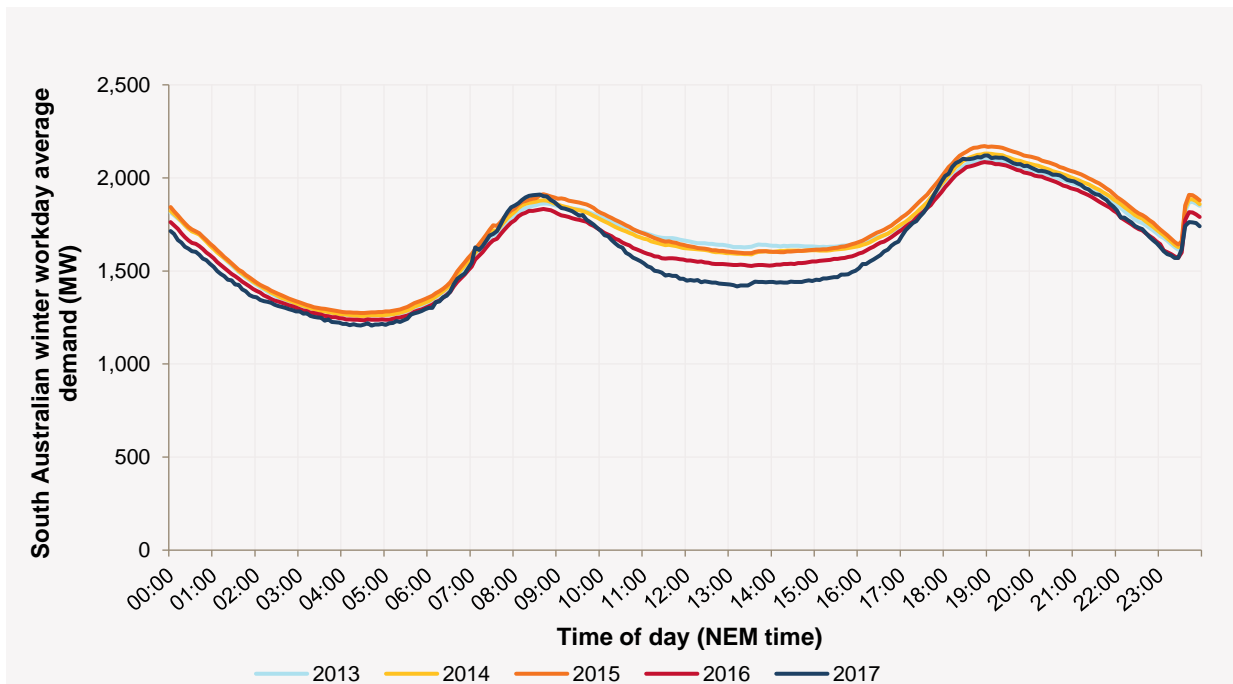
Winter

Figure 3 shows the South Australian average winter workday demand profile for winter 2013 to 2017.³³ Similar to the summer workday profile, there is declining grid demand during sunlight hours from the increase in rooftop PV generation.

A noticeable morning peak is followed by an evening peak in winter, reflecting a combination of demand increases as the workday commences/ends. Reduced grid demand is observed in the daylight hours, due to the increased output of rooftop PV. Evening peaks can be attribute to continual demand from the grid from domestic consumption, mainly heating.

Seasonal weather drives year-to-year consumption patterns, with a milder winter in 2016³⁴ leading to a lower heating load in the evenings, compared to other years with less mild weather.

Figure 3 Winter workday average demand profiles



2.4 Operational consumption

This section presents recent historical observations and long-term forecasts of annual operational consumption in South Australia. Where possible, forecasts from both the 2017 NEM ESOO and 2016 NEFR are shown for comparison across the different sensitivities.

³⁰ South Australian Council for Social Services (SACOSS). *High SA Electricity Prices: A Market Power Play?*, page 10. Available at: https://www.sacoss.org.au/sites/default/files/public/131212_CMU%20SACOSS%20Final%20Report_High%20SA%20Electricity%20Prices_0.pdf.

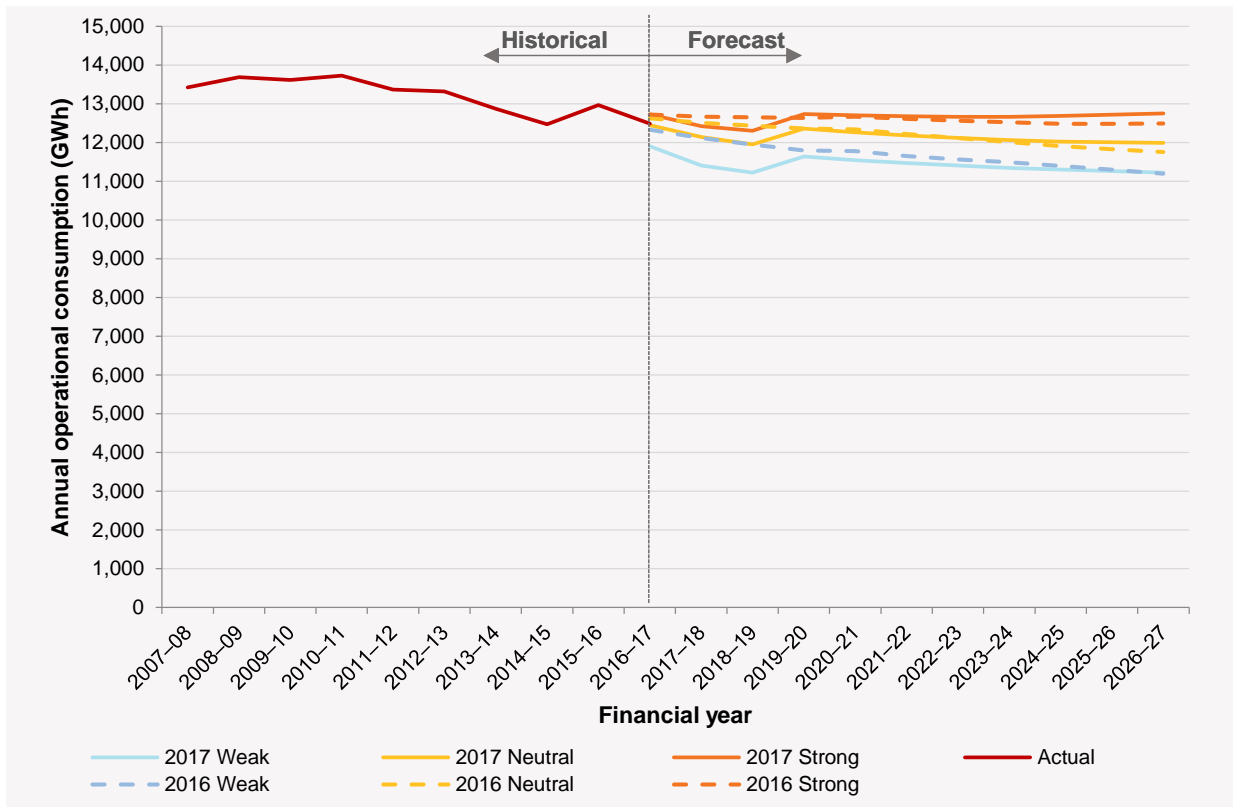
³¹ SA Power Networks. Flexible load strategy, October 2014. <https://www.aer.gov.au/system/files/SAPN%20-%202020.34%20PUBLIC%20-%20SAPN%20Flexible%20Load%20Strategy.pdf>.

³² Refer to Section 6.5.

³³ Winter 2017 includes data for June and July 2017 only.

³⁴ Bureau of Meteorology (BOM). *South Australia in June 2016: above average rainfall and warm nights*. Available at: <http://www.bom.gov.au/climate/current/month/sa/archive/201606.summary.shtml>. Viewed: 3 August 2016.

Figure 4 Annual operational consumption (as sent-out) actual and forecast for South Australia



Recent history

Figure 4 shows the historical trend of operational consumption in South Australia from 2007–08, with a noticeable decline from 2010–11. This has been driven by a fall in residential and commercial consumption as consumers have become more actively engaged in their energy use, with strong uptake of rooftop PV and incorporating more energy efficiency savings. More detail on residential and commercial historical trends is in Sections 2.4.1 and 2.4.2.

In 2016–17, operational consumption was 12,484 gigawatt hours (GWh). This was 3.7% (482 GWh) lower than the 2015–16 consumption of 12,966 GWh. These significant year-on-year differences in consumption were driven by:

- Relatively milder weather conditions over summer 2016–17 compared to 2015–16, resulting in less cooling demand. December consumption in 2016 was 1,012 GWh, significantly lower (by 183 GWh) than December consumption in 2015 of 1,195 GWh.
- Increased rooftop PV generation in 2016–17, with an estimated 108 GWh more PV generation in 2016–17 compared to 2015–16.
- Lost load of approximately 19 GWh during the South Australia black system period (16:18 on 28 September 2016 to 18:25 on 29 September 2016).

Forecast

Figure 4 also shows that, under the 2017 NEM ESOO Neutral sensitivity, operational consumption is forecast to decline in the long-term outlook period (2016–17 to 2026–27) from 12,442 GWh in 2016–17 to 11,989 GWh in 2026–27.

The long-term outlook (to 2026–27) is attributed to:

- In the residential sector, continued high uptake of rooftop PV and energy efficiency savings, as households seek to manage their energy use and costs, being projected to more than offset moderate new connections growth and increasing appliance use by households.
- Flat business sector consumption, as energy-intensive manufacturing is generally not expected to grow, automotive manufacturing is expected to reduce, and projected growth in other business³⁵ demand is forecast to be mostly offset by energy efficiency savings

The Strong scenario projects consumption to follow close to the Neutral scenario in the short term, then start to grow from 2019–20, ending higher by 2026–27 than the Neutral scenario. This growth is driven by assumed stronger growth in population and the economy overall. These drivers are projected to work in the opposite direction in the Weak scenario, where consumption is forecast to continue decreasing, ending below the Neutral scenario by 2026–27.

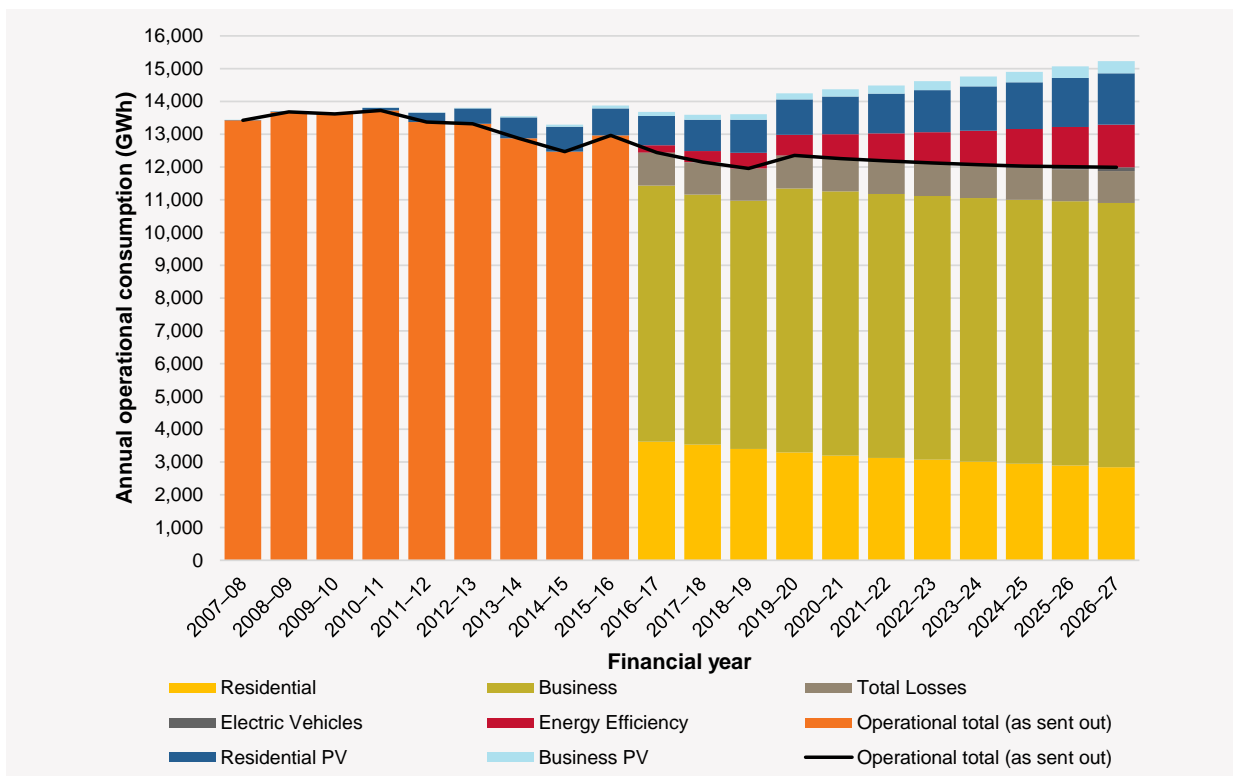
Components of consumption forecast

The different components of the Neutral sensitivity consumption forecast are presented in Figure 5. They highlight the drivers by different components, which affect the overall consumption forecast.

Consumption itself is split into two high-level sectors, residential and business. Network losses and electricity consumption associated with EVs are added to these, which then total to the regional operational consumption.

Figure 5 shows the Neutral forecast, along with stacked bars of components that demonstrate the impacts of energy efficiency and rooftop PV on reducing operational demand.

Figure 5 Forecast annual operational consumption (as sent-out) with stacked components



³⁵ These include domestic businesses servicing industries such as education, financial services, IT, infrastructure, and health and aged care. Growth and consumption trends in this sector are driven by population growth and household disposable income.

In 2016–17, South Australia’s total operational consumption was made up of an estimated 3,620 GWh of residential sector consumption (29% of total), 7,811 GWh of business sector consumption (63%), and 1,011 GWh of total transmission and distribution network losses (8%).³⁶

More information on residential and business sector forecasts is available in Sections 2.4.1 and 2.4.2.

2.4.1 Residential sector

The residential sector, as categorised in the forecast, considers estimated electricity usage by all residential customers in South Australia.

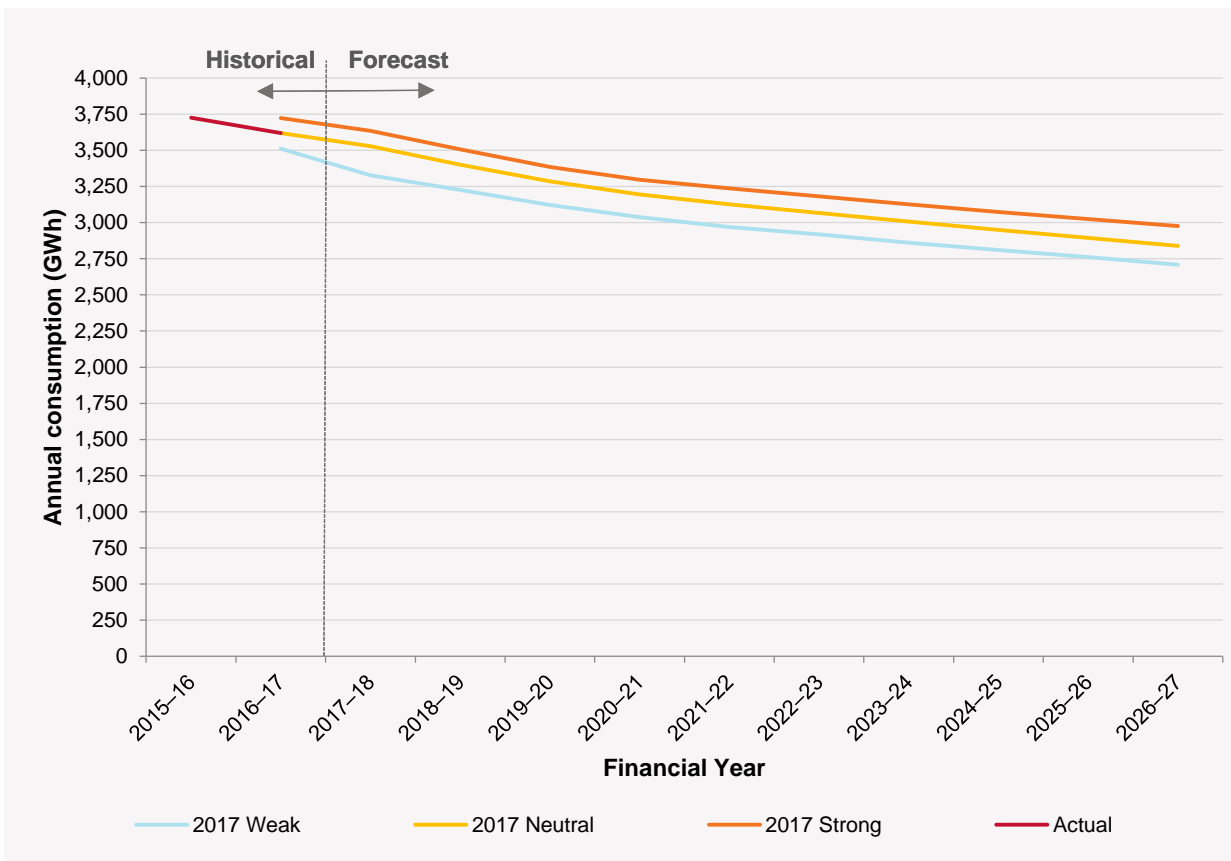
Recent performance and forecast trends

Figure 6 shows that over the long-term outlook period (2016–17 to 2026–27), under the Neutral sensitivity, residential sector annual consumption is forecast to decline at an average annual rate of 2%.

This trend is attributed to the following factors:

- Continued uptake of and investment in rooftop PV systems.
- Ongoing improvements in appliance and building energy efficiency.
- Changes to consumer behaviours over the forecast 10-year horizon.

Figure 6 South Australian residential sector annual consumption



³⁶ Losses reported in previous SAERs included only transmission losses, with distribution losses being included in the estimated energy use by “residential and commercial” and “large industrial load” sectors.

2.4.2 Business sector

The business sector covers electricity usage by all commercial and industrial customers. The business sector in AEMO’s 2017 NEM ESOO forecasts was further split into:

- Manufacturing (approximately 27% of total business demand), and
- Other business (approximately 73% of total business demand).

Recent performance and forecast trends

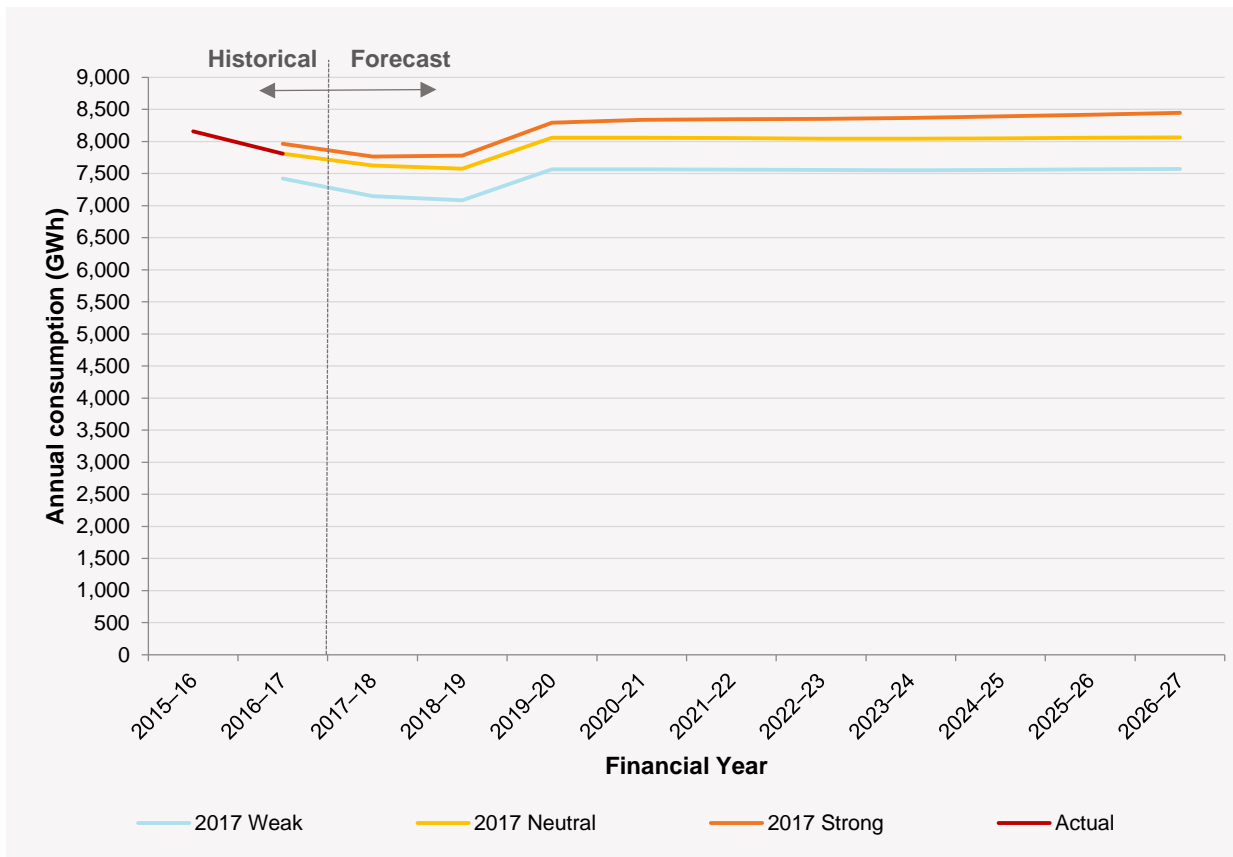
Figure 7 shows the long-term outlook period (2016–17 to 2026–27), under the Neutral sensitivity.

Manufacturing sees an initial forecast drop, driven by automotive industry closures in 2016–17, followed by some expected large industrial load investments over 2018–19 and 2019–20.

In addition to the exit of automotive manufacturing, businesses are forecast to respond to price signals (116 GWh cumulative reduction due to price by 2018–19). Beyond this period, increasing Gross State Product (GSP) drives forecast increased industrial consumption (100 GWh of cumulative growth due to GSP from 2019–20 to 2026–27).

The “other business” sector trend is driven by a slowing population growth rate. Beyond 2019–20, consumption is forecast to slightly decline. The resulting outlook for the total Business sector is flat from a whole of grid perspective, as any increase in consumption (attributable to increased consumer confidence and easing price pressures) is forecast to be either offset by energy efficiency gains or met by increased rooftop PV generation.

Figure 7 South Australian business sector annual consumption



2.4.3 Small non-scheduled generation

Small non-scheduled generation (SNSG) refers to the output from selected non-scheduled generating units that typically have a capacity less than 30 MW. Operational consumption is net of output from these units. In South Australia, the annual generation from SNSG is relatively small compared to the region’s annual operational consumption, resulting in a limited impact overall.

Small non-scheduled generators typically do not have the same NEM registration and metering requirements as scheduled, semi-scheduled, and significant non-scheduled generators. Therefore it is not practical for AEMO to report on SNSG capacity or output to the same granularity as it does for those generators supplying operational consumption. AEMO’s reporting of SNSG output is an estimate based on generators where data is readily available. As visibility, data gathering, and processing techniques for SNSG become available to AEMO, the estimated output may be revised in the future.

Table 5 highlights the estimated contribution³⁷ from SNSG in the region, from the 2017 NEM ESOO. Annual operational consumption is also shown for comparison. The increase in forecast SNSG over the 10-year period is expected to be mostly met by increasing penetration of small-scale solar PV (larger than 100 kilowatts (kW) and smaller than 30 MW).

AEMO has now begun tracking the PV component of SNSG (labelled PVNSG) separately, as this is considered the main growth area. The other non-scheduled generation (ONSG) is now grouped together, with the sum of ONSG and PVNSG equalling the SNSG total.

Table 5 Estimated annual contribution from small non-scheduled generation in South Australia (GWh)

	Source	SNSG (total)	ONSG	PVNSG	Operational consumption
2016–17	Actual	95	78	17	12,484
2017–18	Forecast (Neutral)	106	85	21	12,144
2018–19	Forecast (Neutral)	111	85	27	11,949
2019–20	Forecast (Neutral)	127	93	34	12,355
2020–21	Forecast (Neutral)	134	93	41	12,259
2021–22	Forecast (Neutral)	141	94	48	12,184
2022–23	Forecast (Neutral)	151	96	55	12,120
2023–24	Forecast (Neutral)	159	97	62	12,065
2024–25	Forecast (Neutral)	166	97	69	12,023
2025–26	Forecast (Neutral)	175	98	77	12,005
2026–27	Forecast (Neutral)	183	99	84	11,989

2.5 Operational maximum demand

South Australian operational MD has historically occurred during periods of hot weather over summer. For the last 10 years, South Australia’s load factor has continued to be the lowest of all NEM regions.³⁸ This indicates that South Australia has the greatest difference between average hourly consumption and MD, largely attributed to air-conditioner load.

Figure 8 shows recent historical summer MD actuals, and 10%, 50%, and 90% POE forecasts from the 2017 NEM ESOO (Neutral sensitivity) and 2016 NEFR (Neutral sensitivity).

³⁷ This including loss saving from meeting consumptions from local generation source.

³⁸ Load factor is a measure of MD relative to annual consumption; the lower the load factor, the greater the difference between average hourly energy and MD. Load factors for all NEM regions can be calculated by comparing average hourly consumption to maximum demand. Data is available at: <http://forecasting.aemo.com.au/>. Viewed: 17 June 2016.

Recent history

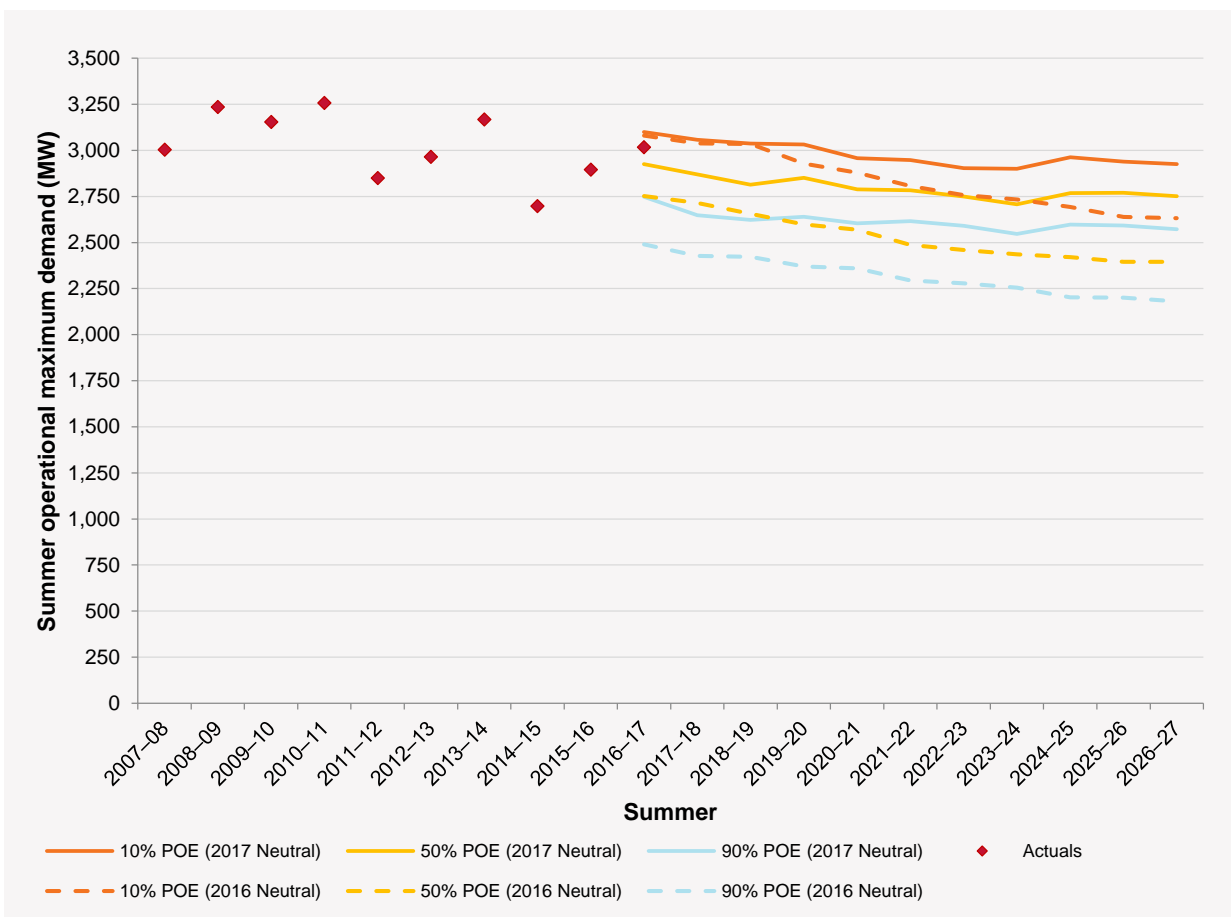
Figure 8 shows that, historically (2007–08 to 2016–17), South Australian MD ranged from approximately 2,697 MW to 3,256 MW. In summer 2016–17, MD was 3,017 MW.³⁹

The 2016–17 actual summer MD was 3.1% (91 MW) higher than the 2017 NEM ESOO’s 50% POE forecast under the Neutral scenario. In terms of the span between the 10% and 90% POE forecasts, this lies relatively close to the middle of the two forecasts. The MD occurred at a point of expected conditions and time, on 8 February 2017 at 6:00 pm where the weekday temperature was above 40°C.

Forecast

As Figure 8 shows, under the 2017 NEM ESOO Neutral sensitivity, forecast 10% and 50% POE summer MD is expected to decrease at an annual average rate of 1% over the long-term outlook period (2016–17 to 2026–27). The forecast decreasing MD plays a key role in the outcome of the supply adequacy modelling discussed in Chapter 5.

Figure 8 Summer operational maximum demand actual and forecast for South Australia (Neutral sensitivity)



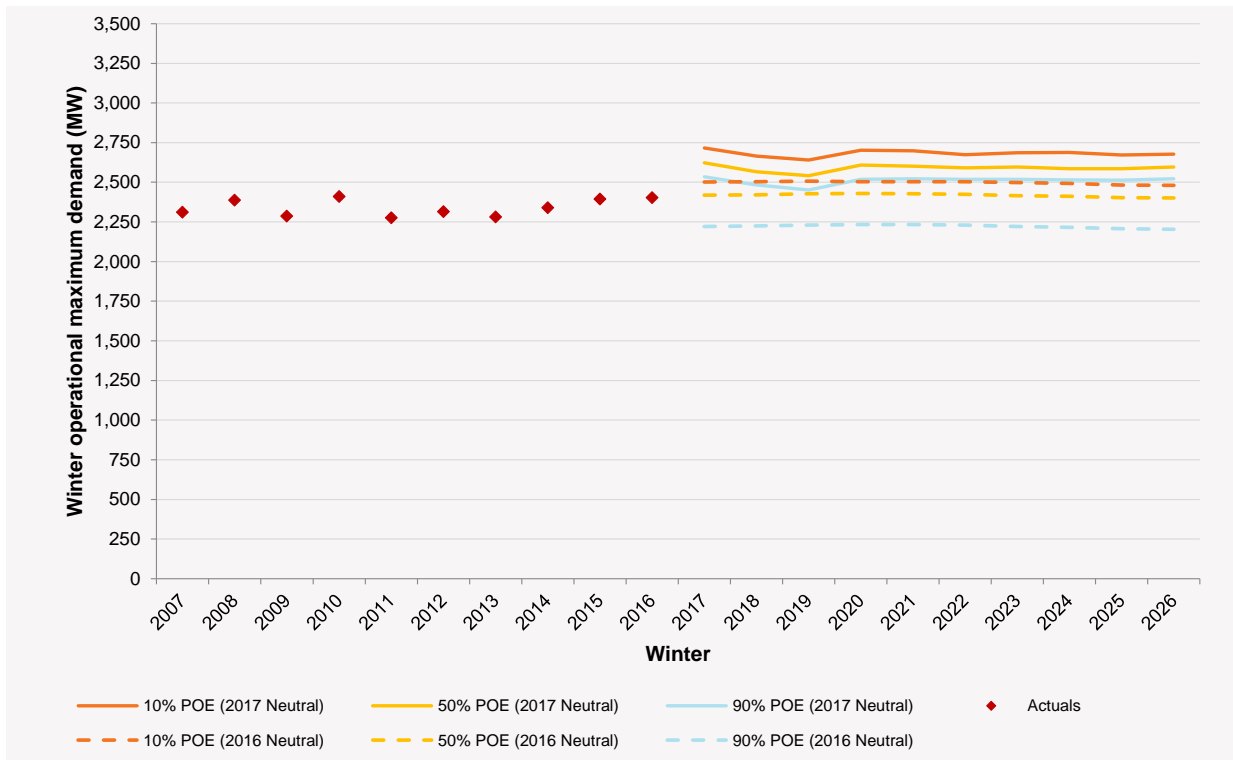
Comparison of the 2016 NEFR Neutral scenario and 2017 NEM ESOO Neutral sensitivity MD forecasts shows that the latest MD forecasts remain above the 2016 NEFR forecasts throughout the 10-year outlook.

³⁹ This number is as sent-out and reflects operational demand that was met. As this demand occurred during a load shedding event, maximum demand would have been higher had supply been available.

The key drivers of regional MD forecasts are similar to those for annual regional consumption. Demand growth is expected to be driven by growth in population, the economy, and increase in appliance ownership, while increasing rooftop PV penetration and energy efficiency measures are projected to have a dampening effect.

Figure 9 shows that, under the ESOO 2017 Neutral forecast, 10% and 50% POE winter MD is expected to remain relatively flat over the forecast period (2016–17 to 2026–27). The replacement of old air-conditioners with new efficient ones is also projected to lower the MD contribution from reverse-cycle air-conditioner heating, but this is offset by forecast fuel switching from gas to electric heating.

Figure 9 Winter operational maximum demand (Neutral sensitivity)



2.5.1 Small non-scheduled generation

Table 6 summarises the 2017 NEM ESOO Neutral estimated output from SNSG in South Australia, at the time of the region’s operational MD, for the past five years and forecast to 2026–27.⁴⁰

It shows that in 2016–17, operational MD was 3,017 MW, and at that time small non-scheduled generation was estimated to be producing 6.5 MW of electricity. There is a forecast increase in SNSG over the next 10 years, the majority of which is contributed to by PV. This component, however, is not expected to materially affect the grid operational demand, because the peak is shifting further into the evening, at the same time as the output from PV is expected to be dropping off.

⁴⁰ The full set of forecast values in each year is available on AEMO’s Forecasting Dynamic Interface. Available at: <http://forecasting.aemo.com.au/>. Viewed: 2 August 2017.

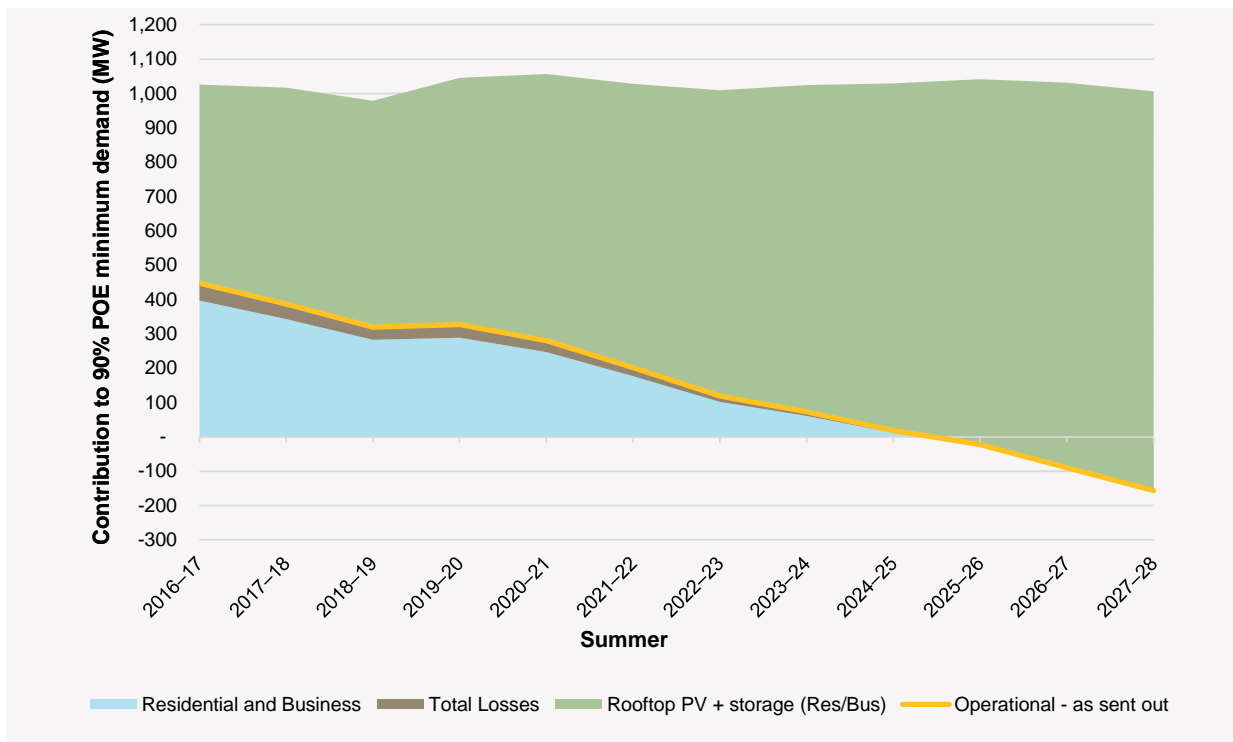
Table 6 Estimated output from other small non-scheduled generation in South Australia, at time of operational MD (MW)

	Source	Small non-scheduled generation output at time of operational MD	Operational MD
2012–13	Actual	10.6	2,965
2013–14	Actual	15.3	3,167
2014–15	Actual	13.4	2,697
2015–16	Actual	14.5	2,895
2016–17	Actual	13.9	3,017
2017–18 to 2026–27	Neutral sensitivity forecast, 10%, 50% and 90% POE, summer	Ranges between 13.9 and 14.7	Ranges between 2,547 and 3,099

2.6 Operational minimum demand

AEMO has forecast minimum demand, to investigate the impact of rooftop PV on the daily load profile. This provides useful information on network usage, which can inform further studies to evaluate operational implications.

Figure 10 Summer 90% POE minimum demand forecast segments for South Australia (Neutral sensitivity)



Key insights include:

- The summer minimum demand in 2016–17 was 800 MW on 6 November 2016 (minimum demand generally occurs in summer).
- South Australia is the first NEM region in which high rooftop PV penetration caused minimum demand to shift from overnight to near midday. Since this first occurred in 2012–13, South Australia has experienced relatively warm summers. If South Australia was to experience the cold

summers it did in 2002 or 2005, the mild temperatures coupled with installed PV capacity could produce quite low minimum demand (reflected in AEMO's minimum demand forecasts).

- As Figure 10 shows, AEMO forecasts negative minimum demand for the region under certain conditions by 2025–26. For 90% POE minimum demand days, continued uptake of rooftop PV is forecast to offset 100% of demand in South Australia during the middle of the day. This may introduce operational challenges for balancing the power system. The power system and market will need to evolve to address these challenges, including utilising the opportunities from new technologies. For example, South Australia could store this excess generation, or could export it to the rest of the NEM via the interconnectors, provided they are in service

2.7 Impact of rooftop PV, battery storage, and electric vehicles

Rooftop PV systems installed in South Australian residential and commercial premises have a material impact on the region's electricity demand. This is due to the cumulative effect of their generation output in reducing residential and commercial electricity demand during daylight hours.

The uptake of EVs is expected to have a smaller impact than rooftop PV and battery storage, but is another technology AEMO is tracking.

2.7.1 Rooftop PV

Capacity

Since 2009, South Australia's total installed rooftop PV capacity has grown strongly. This has been primarily due to government incentives in the form of rebates and feed-in tariffs, the Small-scale Technology Certificate (STC) multiplier, falling system costs, and increasing electricity prices. These factors helped reduce payback periods, making rooftop PV generation an attractive option for households, particularly from 2010 to 2012.

More than 30% of dwellings in South Australia now have rooftop PV systems installed.⁴¹

The methodology behind the forecast of rooftop PV is similar to that performed for the production of the 2016 NEFR (and 2016 SAER), with recent updates for the drivers being the main changes. AEMO engaged consultancy Jacobs to complete the forecast.⁴²

To calculate electricity generation from the installed PV capacity, AEMO then used the following steps:

- Based on the average age of panels in each forecast year, AEMO calculated the effective capacity, taking into account the projected degradation of rooftop PV over time.
- AEMO calculated nominal PV generation traces (half-hourly megawatt hour (MWh) generation per MW of effective PV capacity), based on an approach it developed jointly with the University of Melbourne. Two traces were developed, reflecting generation from north-facing panels and west-facing panels. AEMO used these two traces to calculate a blended trace, which captured an assumed westerly shift in rooftop panel orientation. The share allocated to west-facing panels commenced at zero in 2016–17 and increased to 10% by 2036–37, assuming a response to changing consumer incentives.

The rooftop PV installed generation capacity estimated actuals and forecasts for South Australia are shown in Figure 11. The estimates include all residential and business systems⁴³, including those with

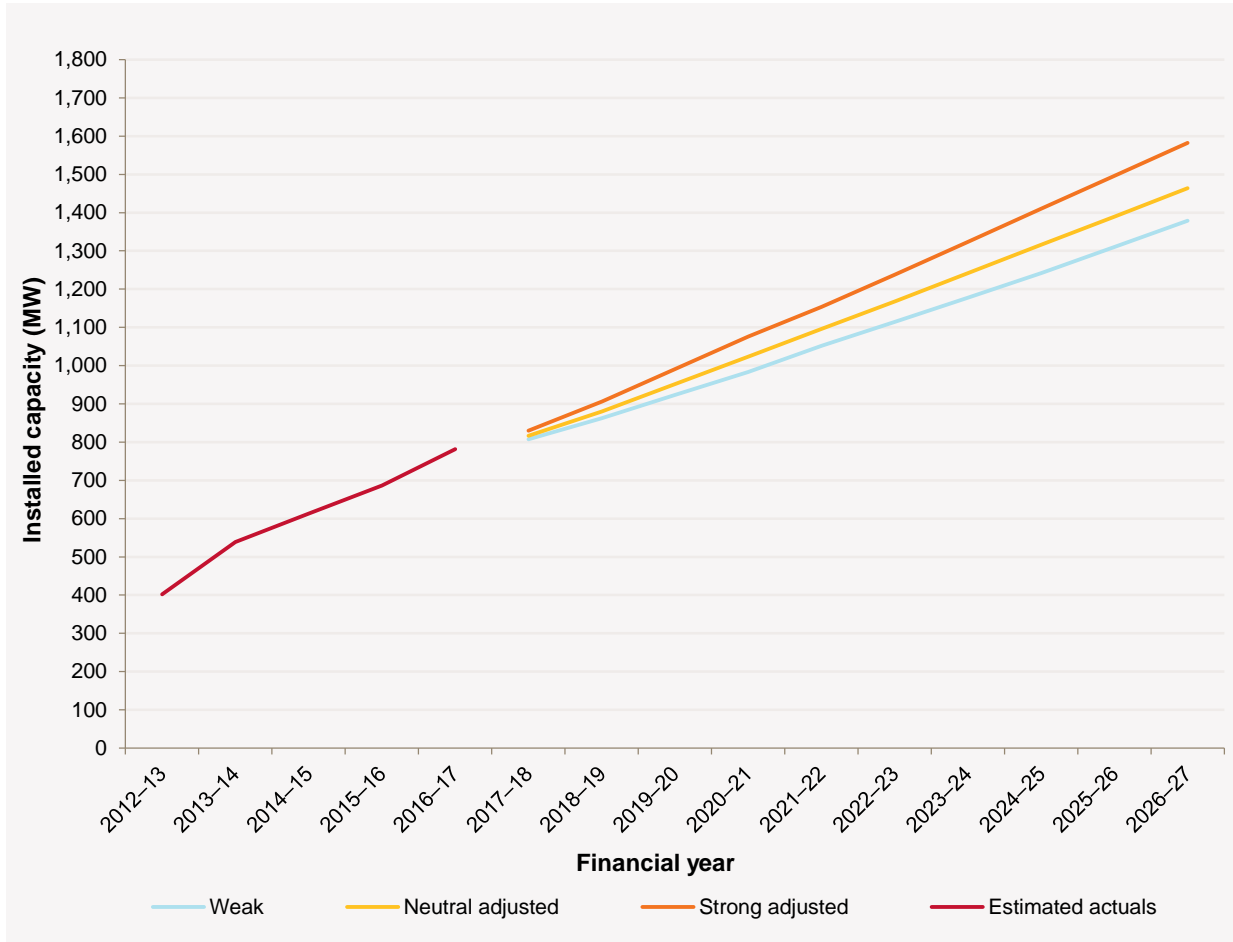
⁴¹ Analysis taken from: Australian PV Institute (APVI) Solar Map, funded by the Australian Renewable Energy Agency, accessed from pv-map.apvi.org.au on 11 Aug 2017.

⁴² Jacobs. *Projections of uptake of small-scale systems*, June 2017. Available at: https://www.aemo.com.au/-/media/Files/Electricity/WEM/Planning_and_Forecasting/ESOO/2017/2017-WEM-ESOO-Methodology-Report---Projections-of-Uptake-of-Small-scale-Systems.pdf.

⁴³ For installations up to 100 kW capacity. Forecasts for installations greater than 100 kW capacity are included in the SNSG forecasts discussed in Section 2.3.3.

battery storage systems. Differences between the forecasts for the Strong, Neutral, and Weak sensitivities are primarily due to differences in population, economic assumptions, and rooftop PV and battery storage systems' capital costs assumed across the scenarios.

Figure 11 South Australian rooftop PV installed capacity forecasts



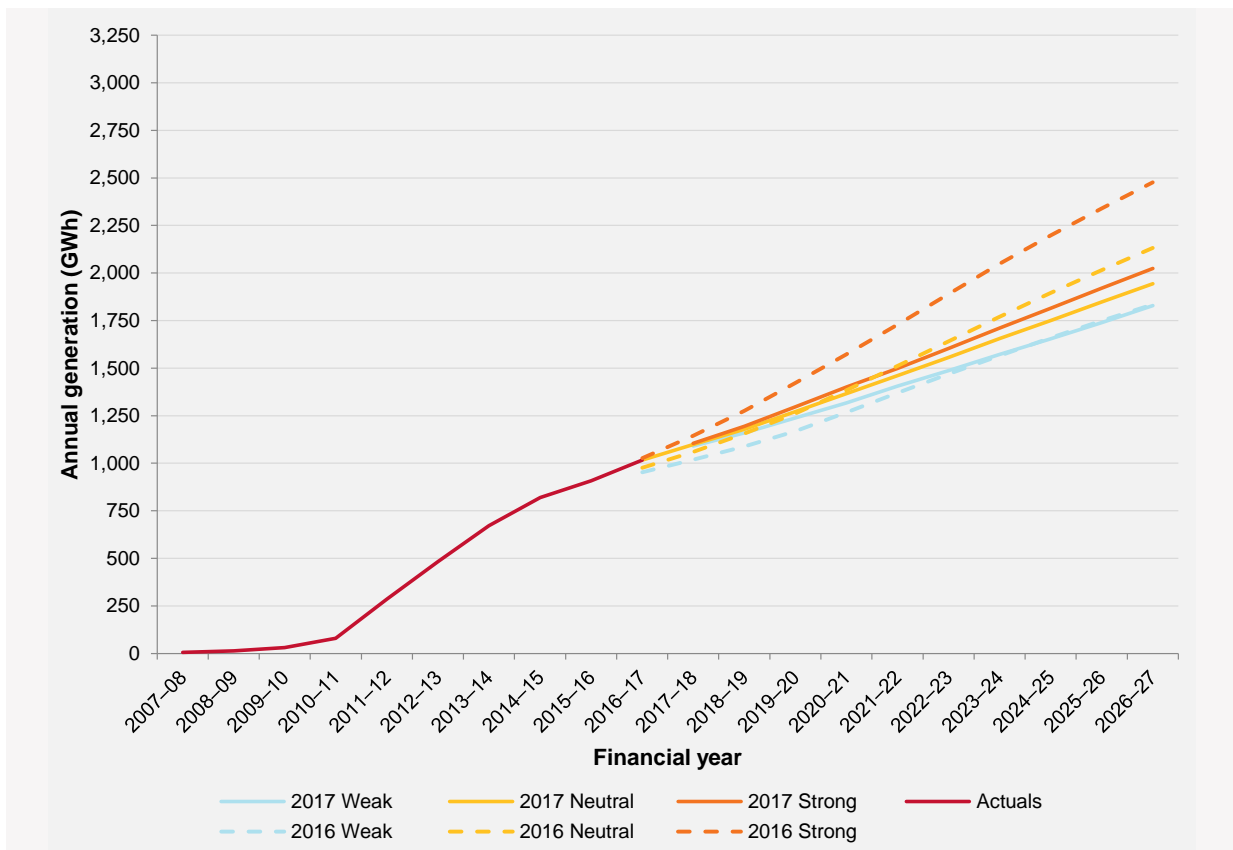
Data for 2012–13 to 2015–16 is different to that presented in the 2016 SAER, due to AEMO’s additional data cleaning of raw Clean Energy Regulator (CER) input data to rooftop PV capacity estimates.

Generation

Over the next 10 years, South Australia is projected to have a higher ratio of rooftop PV generation to operational consumption than any other NEM region and Western Australia’s Wholesale Electricity Market (WEM). This is attributed to the state’s high penetration of rooftop PV installations, good solar resources, and the second-lowest operational consumption of all NEM and WEM regions.

Figure 12 shows rooftop PV estimated generation actuals and forecasts from 2007–08 to 2026–27. This illustrates that rooftop PV generated an estimated total of 1,016 GWh in 2016–17 and is expected to reach 1,943 GWh by 2026–27 (under the Neutral sensitivity).

Analysis of the drivers behind the 2016 NEFR and 2017 NEM ESOO forecasts for rooftop PV in South Australia for the Neutral sensitivity suggests a modest downward revision of forecast growth of installed capacity, for both the residential and business sectors. This is due to revised electricity price assumptions, global economic outlook (including foreign exchange rate movements), and lower capacity saturation limits.

Figure 12 South Australian rooftop PV generation forecasts


2.7.2 Battery storage

Since the 2016 NEFR, AEMO's long-term forecasts have included battery storage uptake projections. Battery systems have been assumed to be installed in conjunction with solar systems in an Integrated PV and Storage System (IPSS). Retrofits of existing PV systems are considered uneconomic under the current assumptions, and have not been considered. The 2017 battery storage forecasts have been prepared by Jacobs.⁴⁴

The 2017 forecast has increased from the 2016 forecast, as the pace of the reduction in the costs of storage has accelerated. Uptake of battery storage is forecast to start slowly and pick up especially after 2020, in both the residential and business sectors, reaching 591 MWh installed in 2026–27.

AEMO expects a proportion of new storage to be aggregated and used for price hedging by retailers and provision of ancillary services, further increasing the value streams for batteries and accelerating the rate of uptake.

As in the 2016 SAER, a specific charge/discharge pattern was assumed. Under the assumptions, the impact of battery storage in shedding peak demand is estimated to be negligible in the short-term forecast and to reach approximately 2% of peak demand in 2026–27.

More information on battery storage can be found in AEMO's 2017 *South Australian Renewable Energy Report* (SARER), which will be published in Q4 2017.

⁴⁴ Jacobs' consultancy report, *Projections of uptake of small-scale systems*, June 2017. Available at: https://www.aemo.com.au/-/media/Files/Electricity/WEM/Planning_and_Forecasting/ESOO/2017/2017-WEM-ESOO-Methodology-Report---Projections-of-Uptake-of-Small-scale-Systems.pdf.

2.7.3 Electric vehicles

In 2016, AEMO commissioned Energeia to produce a forecast for EV uptake and the impacts on regional annual consumption and maximum/minimum demand for each of the three sensitivities presented in the 2016 NEFR.⁴⁵

Table 7 shows the annual consumption impact is forecast to be limited to 112 GWh by 2026–27 in the Neutral sensitivity. The impact on the daily demand shape is larger, but as charging is mostly assumed to happen at night, it is assumed to have no impact on forecast regional MD. EVs could potentially have some impact on the MD experienced for distribution feeders, depending on both EV uptake and whether changing tariffs incentivise charging outside local peak demand.

Table 7 Forecast consumption from EVs in South Australia (GWh)

	2016–17	2021–22	2026–27
Strong sensitivity	3	60	288
Neutral sensitivity	1	17	112
Weak sensitivity	0	6	29

AEMO notes major uncertainties affecting the emergence of EVs, which need to be investigated to better forecast their likely impact on the energy system. These include:

- The design, technology, and commercialisation of future public charging infrastructure.
- Potential development of government policies affecting transport, such as transportation fleet energy efficiency standards or local policy measures which further support EV uptake.
- Price and tariff structures to accommodate electric vehicles.
- Heavy transport options.
- The role of EVs in the future power grid, in particular their contribution of energy storage to households and the grid, and contribution of network support services to address the management of frequency, energy, and voltage.

⁴⁵ *AEMO Insights, August 2016, Electric Vehicles*. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Electricity-Forecasting-Report>.



3. SUPPLY

This chapter summarises South Australia's electricity supply in recent years. The information is sourced from the 2017 SAHMIR⁴⁶ and the 5 June 2017 South Australia update to the AEMO Generation Information web page.⁴⁷ The information on this web page is provided to AEMO by generators.

Summary

The supply capacity and generation mix in South Australia have continued to evolve in recent years. There have been increases in wind farm, rooftop PV, and gas-powered generation of electricity (GPG) capacity, and the ongoing upgrade to the Heywood Interconnector import and export capability.

Potential supply developments are focused mostly on wind farms, several upcoming large-scale solar projects, utility-level battery, and one GPG proposal.

3.1 Generation

3.1.1 Historical summary

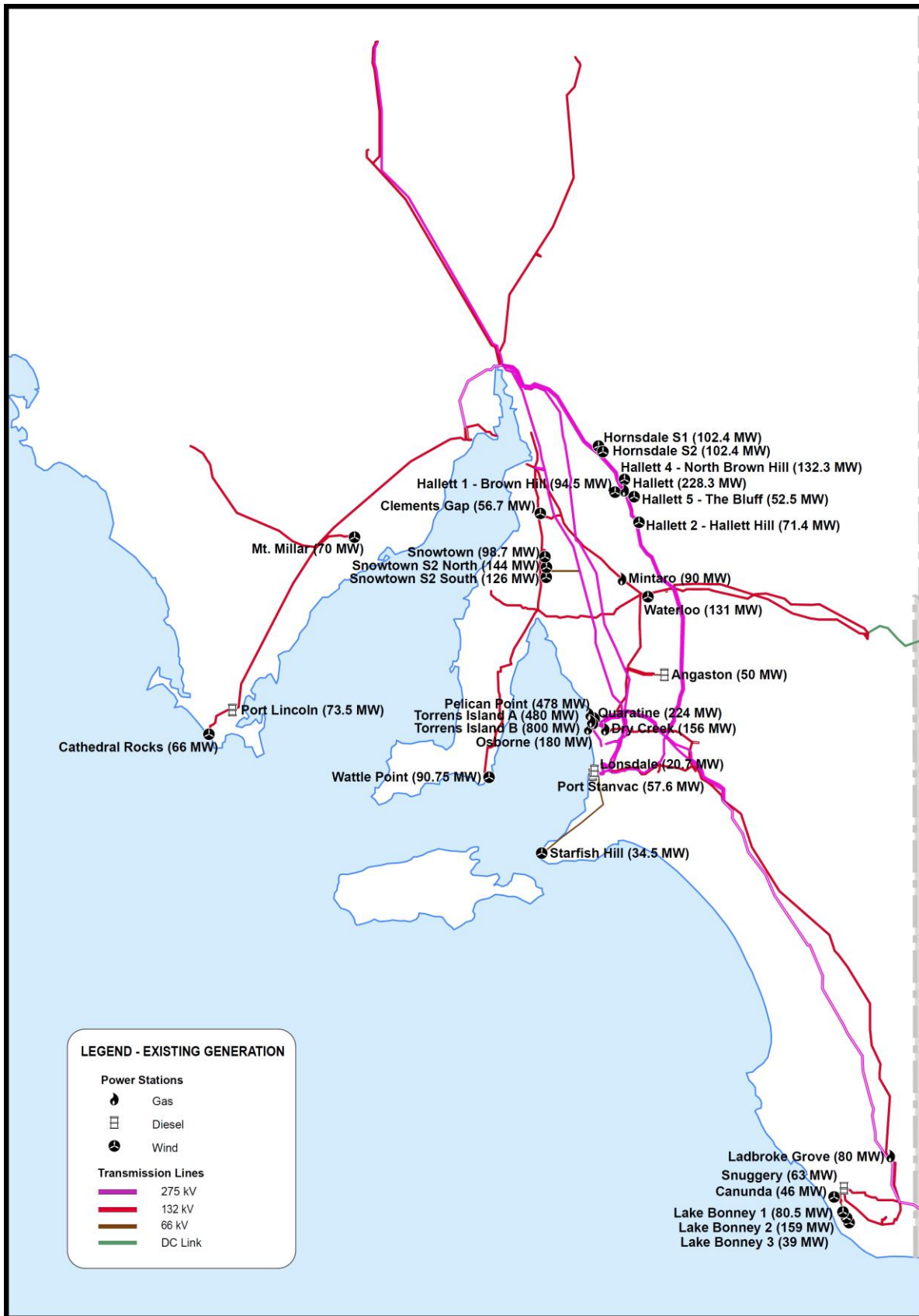
Generators – location, capacity and energy source

Figure 13 shows the location, nameplate capacity, and energy source of registered operational generators in South Australia (all scheduled, semi-scheduled, and significant non-scheduled generators used in operational reporting). More details of existing generators can be found in Appendix B.

⁴⁶ AEMO. 2017 SAHMIR. Available at <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions>.

⁴⁷ AEMO. Generation Information (5 June 2017, South Australia). Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>.

Figure 13 Location and capacity of South Australian generators



Local generation capacity and output

Table 8 summarises the local electricity supply breakdown for 2016–17.

In South Australia, in 2016–17, local GPG was the largest proportion of:

- Registered capacity, at approximately 49.1% of total registered capacity.
- Energy generation, at approximately 50.5% of total generation.

Wind generation was the second largest proportion of:

- Registered capacity, at approximately 31.2% of total registered capacity.
- Energy generation, at approximately 39.2% of total generation.

In the previous financial year, total GPG increased by 1,058 GWh to 5,596 GWh, the first increase in four years.

Table 8 South Australian registered capacity and local generation by energy source in 2016–17

Energy source	Registered capacity		Electricity generated	
	MW	% of total	GWh	% of total
Gas	2,668	49.1%	5,596	50.5%
Wind	1,698	31.2%	4,343	39.2%
Coal	0	0.0%	0	0.0%
Diesel + SNSG*	289	5.3%	122	1.1%
Rooftop PV**	781	14.4%	1,016	9.2%
Total	5,436	100%	11,077	100%

* Diesel + SNSG includes small and large diesel, small landfill methane, hydro generating systems, and PVNSG.

** Rooftop PV installations are not registered with AEMO, but are included here given their material contribution to generation. Rooftop PV capacity and generation estimates as listed build on those presented in the 2017 NEM ESOO forecasts.

Capacity factors

Figure 14 (scheduled generation) and Figure 15 (semi-scheduled and non-scheduled wind farms) show the capacity factors for South Australian generation based on registered capacity. Generating systems that respond to peak demand generally have lower capacity factors, as they operate for short time periods and are idle most of the year. Baseload generating systems typically have higher capacity factors, as they tend to run continuously unless shut down for maintenance.

The capacity factor analysis excludes periods when a generating system was seasonally or permanently withdrawn from service.⁴⁸ Consideration was given to newly-constructed or discontinued generators. If a generator was not operating for 90% of the analysis period, it was not considered for analysis, as data would be skewed. Hornsdale Stage 1 Wind Farm is featured in this analysis from 2016–17, as it began generating in the last few days of the 2015–16 financial year.

Changes of note between 2015–16 and 2016–17 are:

- Northern Power Station's capacity factor reduced from 65.2% in 2015–16 to 0% in 2016–17, due to its closure.
- The capacity factor of Pelican Point Power Station, Quarantine Power Station, and Torrens Island B increased from 14%, 7%, and 28% in 2015–16 to 56.5%, 13.5% and 32.5% in 2016–17, respectively. This was due to market responses to higher market prices and improved gas supply to Pelican Point Power Station.⁴⁹

⁴⁸ This change in methodology for 2016 analysis means historical capacity factors for Northern and Playford B are materially different to the capacity factors published in the 2015 SAER.

⁴⁹ Origin. Media release, "Origin works with ENGIE to help boost energy security in South Australia, 29 March 2017. Available at: <https://www.originenergy.com.au/about/investors-media/media-centre/origin-works-with-engie-to-help-boost-energy-security-in-south-australia.html>.

Figure 14 Financial year capacity factors for scheduled generators

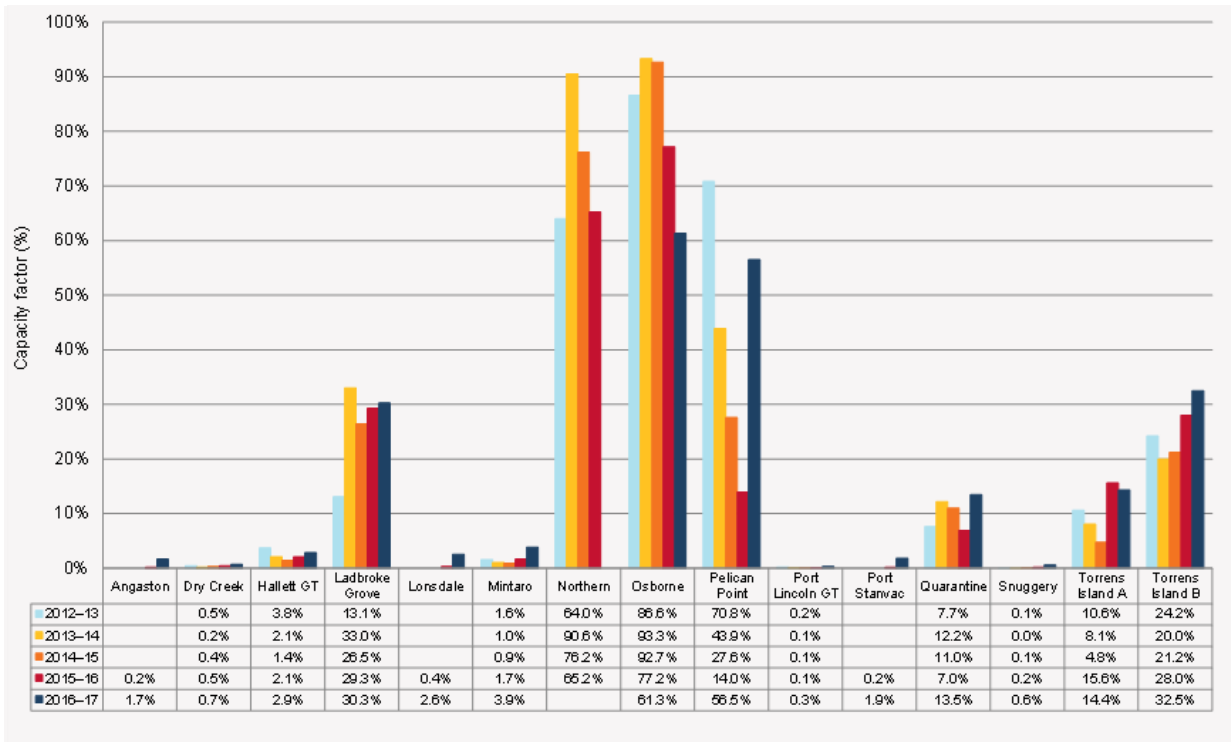
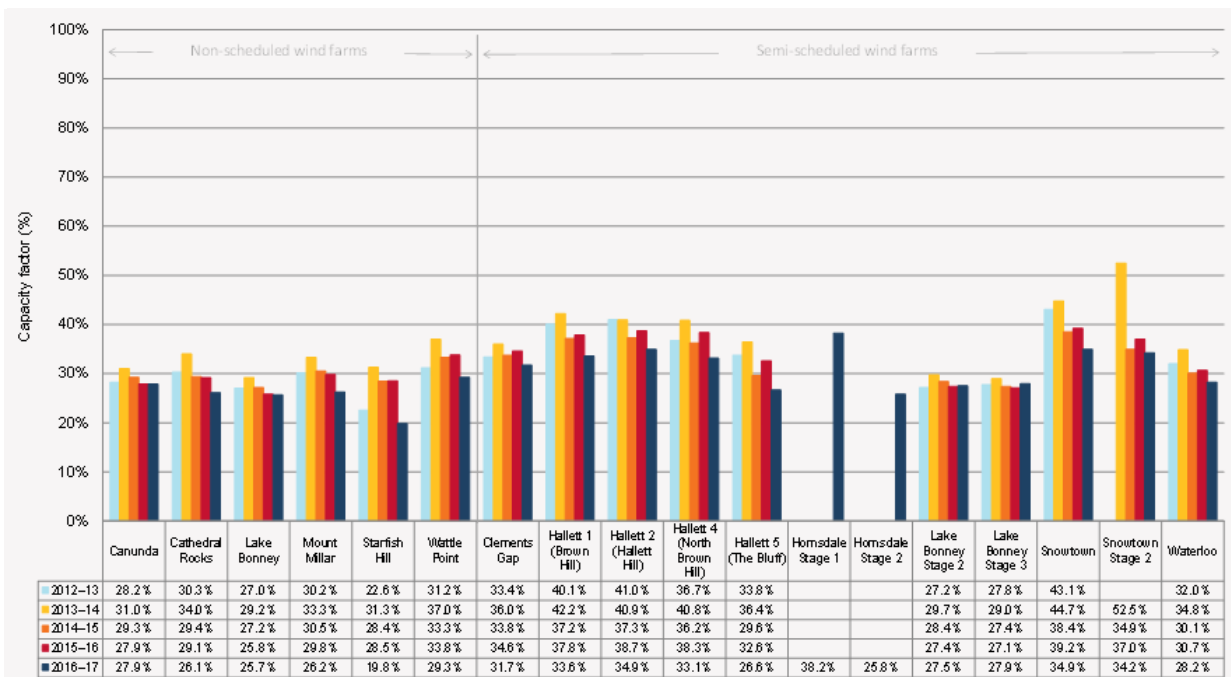


Figure 15 Financial year capacity factors for non-scheduled and semi-scheduled wind farms



Snowtown Stage 2 capacity factor is calculated for Snowtown Stage 2 North and Snowtown Stage 2 South wind farms combined.

Wind generation summary

South Australia has the highest registered wind generation capacity of any NEM region. Table 9 shows the total capacity for all South Australian semi-scheduled and non-scheduled wind farms registered with AEMO, with the maximum 5-minute generation output, from 2012–13 to 2016–17.

Hornsedale Wind Farm Stage 2 (102.4 MW) was registered in 2017, and Waterloo Wind Farm increased in registered capacity as a result of an expansion (19.8 MW). Changes in registered wind farm capacity do not always match changes in maximum 5-minute generation. Maximum generation can change each year because geographic diversity means not all wind farms contribute their maximum generation in the same 5-minute period. Further details of these new project developments can be found in Section 3.1.2.

Table 9 Registered wind generation capacity and maximum 5-minute wind generation

	Registered capacity (MW)*	Reason for increase in capacity	Maximum 5-minute generation (MW)*
2012–13	1,203	NA	1,067
2013–14	1,473	Snowtown Stage 2 (270 MW)	1,325
2014–15	1,473	NA	1,365
2015–16	1,576	Hornsedale Stage 1 (102.4 MW)	1,384
2016–17	1,698	Hornsedale Stage 2 (102.4 MW) Waterloo (19.8 MW)	1,546

* Data is captured from when each wind farm was entered into AEMO systems, and includes the commissioning period.

Table 10 summarises wind generation and its annual change from 2012–13 to 2016–17.

Key observations are:

- Annual wind generation in South Australia increased in line with installed capacity increases from 2012–13 to 2016–17.
- In 2013–14, Snowtown Stage 2 Wind Farm was brought online, and first reached 90% of its registered capacity in June 2014. Growth in wind generation in 2014–15 was largely driven by Snowtown Stage 2 Wind Farm’s availability for the full financial year.
- Annual capacity factors for individual wind farms can vary by up to 9% year on year, though in aggregate the variation is no more than 4% (as seen in Figure 15).

Table 10 Total South Australian wind generation

	Annual South Australian wind generation (GWh)	Annual change in wind generation	Annual capacity factor*
2012–13	3,475		33%
2013–14	4,088	18%	32%
2014–15	4,223	3%	33%
2015–16	4,322	2%	31%
2016–17	4,343	0%	29%

* Capacity factor is based on the annual generation in this table compared to theoretical maximum possible, assuming the annual capacity reported in Table 9.

Average daily supply profile 2016–17

The average daily supply profile for South Australia, seen in Figure 16, represents the supply (in MW) for each 30-minute trading⁵⁰ interval of a day, averaged over the 2016–17 financial year. The figure

⁵⁰ 5-minute dispatch intervals for scheduled generation, wind generation, and interconnector flows have been averaged to a 30-minute dispatch interval to better correlate with 30-minute rooftop PV.

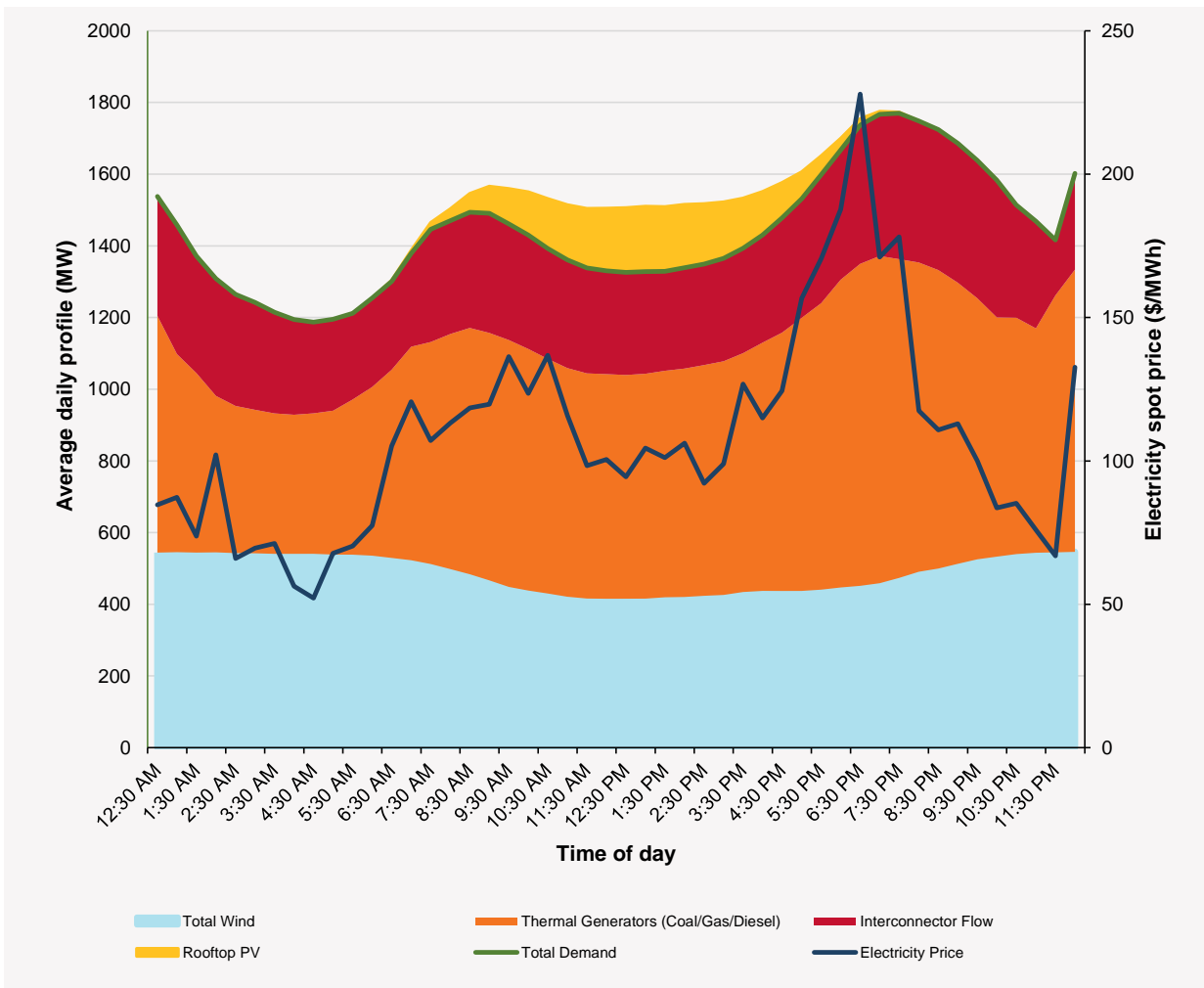
displays the average mix of generation dispatched on an average day, split between wind, thermal (coal, gas, and diesel), and combined interconnector flows for both interconnectors.

Rooftop PV is displayed above the demand curve, and shows the amount of underlying energy that is consumed at the household level and provided by these systems (reducing the need for consumption from large-scale generators).

Figure 16 shows that:

- Average wind output was slightly higher during the evening and early morning periods, complementing average rooftop PV generation, which produced most of its output between 8.00 am and 6.00 pm.
- Scheduled generation contributed the most to the daily profile. On average, at least 388 MW of thermal generation was dispatched in every period (trading interval).
- The average price correlated closely with average demand, particularly in the early morning hours. Price peaks at 6.30 pm were in line with increases in demand from residential loads.
- Interconnectors were often relied on throughout the day to provide additional generation, reducing the need for local generation.

Figure 16 Average daily supply profile



3.1.2 Proposed changes to supply

This section describes:

- South Australia’s scheduled, semi-scheduled, and significant non-scheduled generation capacity.
- Generation changes that AEMO considers in its planning.
- Other more speculative developments that might occur over the 10-year outlook period (2017–18 to 2026–27).

Summary of existing and proposed generation

The capacity of existing or withdrawn generation, and committed or proposed projects, in South Australia is shown by energy source in Figure 17 and Table 11.

This includes scheduled, semi-scheduled, and non-scheduled generation information, based on AEMO’s latest generator survey results for South Australia.⁵¹

As of 1 July 2017, 1,515 MW of solar generation and 3,178 MW of new wind generation projects are either committed or proposed in South Australia.

Figure 17 Capacity of existing or withdrawn generation, and committed or proposed projects (MW) at 5 June 2017

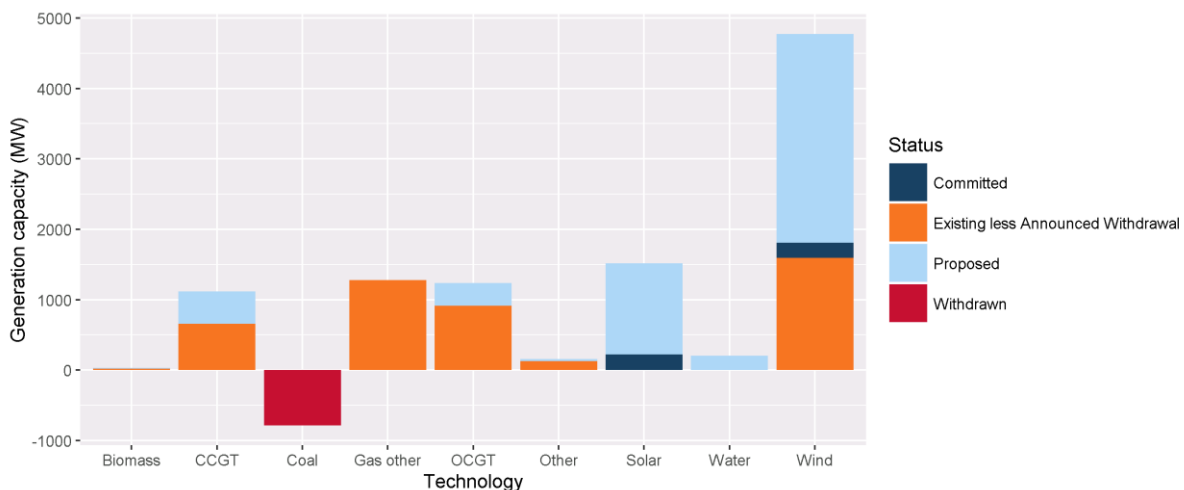


Table 11 Capacity of existing or withdrawn generation, and committed or proposed projects (MW) at 5 June 2017

Status	Coal	CCGT **	OCGT ***	Gas other	Solar	Wind	Water	Biomass	Other	Total
Existing*	0.0	658.0	914.8	1,280.0	0.0	1,595.0	2.5	18.2	129.3	4,597.8
Announced withdrawal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Committed	0.0	0.0	0.0	0.0	220.0	211.4	0.0	0.0	0.0	431.4
Proposed	0.0	460.0	320.0	0.0	1,295.0	2,966.4	200.0	15.0	28.8	5,285.2
Withdrawn	-786.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-786.0

* Existing includes any announced withdrawal at 5 June 2017. The recently constructed Hornsdale Stage 2 is included under the committed category.

** CCGT: Combined-cycle gas turbine.

*** OCGT: Open-cycle gas turbine.

⁵¹ AEMO. Generation Information (5 June 2017, South Australia). Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>.

Generation capacity for the year ahead

Table 12 shows scheduled, semi-scheduled, and significant non-scheduled generation available capacity and estimated firm capacity for summer 2017–18 and winter 2018. The figures are provided by market participants.⁵²

Differences in scheduled and semi-scheduled generation available capacity between seasons arise from seasonal temperature variations.⁵³ In general, summer available capacity for thermal generators is lower than winter, due to higher thermal generation efficiencies at cooler ambient temperatures.

Table 12 Scheduled, semi-scheduled, and significant non-scheduled generation available capacity

Energy source*	Summer 2017–18 available capacity (MW)	Winter 2018 available capacity (MW)
Diesel	238	265
Gas	2,517	2,695
Wind (semi-scheduled)	1,359	1,417
Wind (significant non-scheduled)**	388	388
Total	4,502	4,765

* Coal generation is permanently withdrawn from the market, and is therefore excluded from this table.

** Significant non-scheduled wind farms do not provide 10-year availability forecasts to AEMO, therefore available capacities are based on nameplate rating.

Committed and potential supply developments

Generation investment in South Australia continues to focus on renewable developments, the largest projects being:

- Ceres Project (up to 636 MW).
- Woakwine Wind Farm (400 MW).
- Leigh Creek Energy Project (460 MW).

As at 5 June 2017⁵⁴, AEMO was aware of 29 publicly announced electricity generation developments in South Australia, totalling 5,717 MW. Table 13 aggregates the new developments by energy source.

Several large proposals have also been announced since the 2016 SAER:

- Solar:
 - Riverland Solar, PV tracking flat panel (330 MW).
 - Taillem Bend Solar, PV panels (100 MW).
 - Whyalla Solar, PV panels (140 MW).
 - Whyalla Solar Farm, PV tracking flat panel (100 MW).
- Pumped storage:
 - Spencer Gulf Pumped Storage Hydro (150 MW).
- Diesel:
 - Taillem Bend Diesel, Compression Reciprocating Engine (29 MW).

⁵² Additional data for the entire 10-year outlook period is available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>.

⁵³ These figures are based on the regional reference for South Australian temperatures of 43°C for summer and 11°C for winter.

⁵⁴ AEMO Generation Information (5 June 2017, South Australia). Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>.

Additional proposed generation developments since the 5 June 2017 update, which do not contribute to the total generation analysis in this chapter, are:

- South Australia Energy Plan’s 276 MW diesel generation.⁵⁵
- South Australia Energy Plan’s 100 MW (129 MWh) battery⁵⁶ at the Hornsdale Wind Farm.
- ElectraNet’s 30 MW battery.⁵⁷
- The South Australian Government’s power purchase agreement for 150 MW of solar thermal generation.⁵⁸

There have been two significant project developments in 2016–17:

- Hornsdale Stage 2 Wind Farm (102.4 MW) was reported as committed in August 2016 and is now under construction, with commercial operation expected by December 2017.
- An additional 19.8 MW of capacity for the existing 111 MW Waterloo Wind Farm was reported as committed in August 2016 and was completed in November 2016.

Table 13 Publicly announced and committed generation projects by energy source at 5 June 2017

Energy source	Number of projects	Capacity (MW)	Capacity (%)
Solar*	9	1,515	26.5
Wind	15	3,178	55.6
Gas**	2	780	13.6
Water	1	200	3.5
Diesel + other***	2	44	0.8
Total	29	5,717	100.0

* This does not include the new announced 150 MW solar thermal power plant for Port Augusta.

** Gas includes fuel type with natural gas and syngas.

*** Other includes small non-scheduled generation. The 276 MW diesel generation included in the South Australia Energy Plan is not included in this table.

Figure 18 shows the location and capacity of the publicly announced generation projects discussed above.

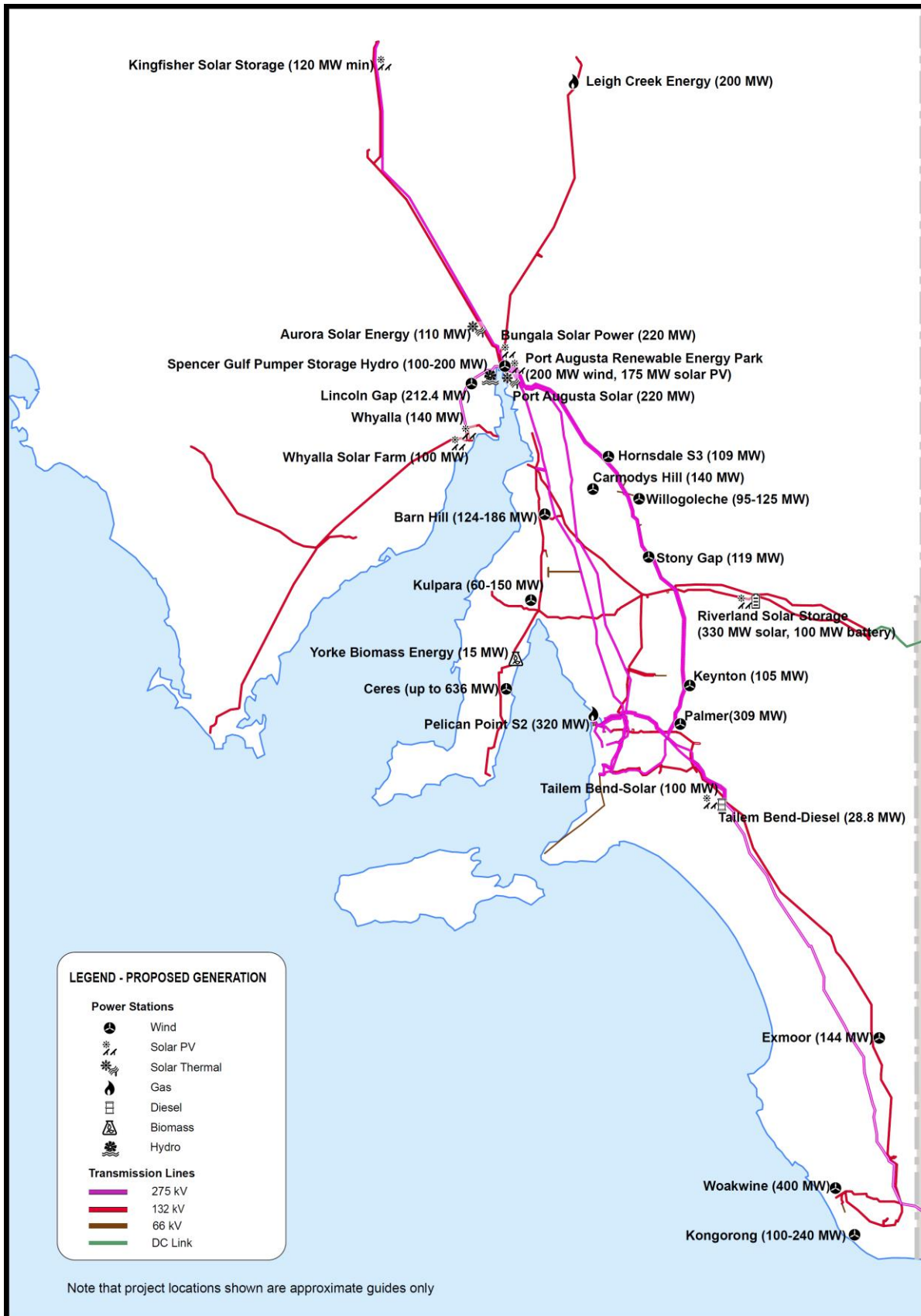
⁵⁵ South Australian Government Energy Plan for Gas Power Plant. Available at: <http://ourenergyplan.sa.gov.au/gas-power-plant.html>.

⁵⁶ South Australian Government Energy Plan for Battery. Available at <http://ourenergyplan.sa.gov.au/battery.html>.

⁵⁷ ElectraNet’s Battery Storage Project: Available at: <https://arena.gov.au/blog/southaustraliabattery/>.

⁵⁸ Clean Energy Council. Media release, “South Australia invests in the future with Port Augusta solar thermal project”, 14 August 2017. Available at: <https://www.cleanenergycouncil.org.au/news/2017/august/solar-thermal-south-australia.html>.

Figure 18 Location and capacity of South Australian proposed generation projects



Generation withdrawals since 2016 SAER

The 2016 SAER reported the announced withdrawal of one unit of the Pelican Point Power Station. Recently, Pelican Point has been made available again to the market, reversing the previous mothballing of one unit (239 MW).⁵⁹ Table 14 summarises this development.

Table 14 Publicly announced generation withdrawal changes since the 2016 SAER

Station name	Energy source	2016–17 proposed capacity change (MW)	Update
Pelican Point	Gas	-239	Pelican Point Power Station was available at half capacity (one unit, 239 MW) from 1 April 2015. ENGIE has advised that the full power station capacity has been made available to market as of July 2017.

3.2 Interconnection

South Australia’s transmission network is connected to the rest of the NEM via the Murraylink and Heywood interconnectors, which allow electricity to flow between South Australia and Victoria. Electricity typically flows from South Australia to Victoria during periods of high generation in South Australia, and vice versa.

The Murraylink Interconnector connects South Australia to north-west Victoria via the Riverland region. It has a nominal rating of 220 MW, although its actual limit depends on flow direction and local conditions. Murraylink is a direct-current (DC) transmission link, and cannot currently transfer frequency control capability.

The Heywood Interconnector is an alternating-current (AC) link connecting South Australia to south-west Victoria. A project to increase the capacity of the existing Heywood Interconnector between Victoria and South Australia, from a nominal 460 MW to 650 MW in both directions, is nearing completion, and its capability is being progressively increased (currently operating with a nominal capacity of 600 MW) as testing and commissioning activities continue.⁶⁰ A separate report on the performance of the interconnector during the upgrade will be published once the upgrade project has been completed.⁶¹

Many factors can limit interconnector flow to less than its capacity, including:

- Thermal limitations and voltage stability in the south-east South Australian transmission network.
- Thermal limitations and transient stability around South Morang in the Victorian transmission network.
- Oscillatory stability limits between Victoria and South Australia.

More detailed information about constraints affecting power transfer capability between South Australia and Victoria is available in AEMO’s *NEM Constraint Report*.⁶²

3.2.1 Historical summary

Figure 19 shows total interconnector imports and exports for South Australia from 2007–08 to 2016–17. Energy imported into South Australia from Victoria during the year is plotted in the orange column bars

⁵⁹ AEMO, Generation Information. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>

⁶⁰ Refer to information available on AEMO’s website at: <http://www.aemo.com.au/Stakeholder-Consultation/Consultations/Heywood-interconnector-upgrade-program-for-inter-network-tests>.

⁶¹ The report will be available on AEMO’s website at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions>.

⁶² AEMO. *NEM Constraint Report* 2016, Sections 5.5 and 5.6. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information/Statistical-Reporting-Streams>.

above the 0 GWh line (x-axis), and energy exported from South Australia to Victoria is shown below this line.

Over the last decade, South Australia has predominantly been a net importer from Victoria. From 2007–08, there has been a steady increase in annual imports from Victoria to South Australia, due to the reduction of local GPG and coal-fired generation (offset by increased renewable generation).

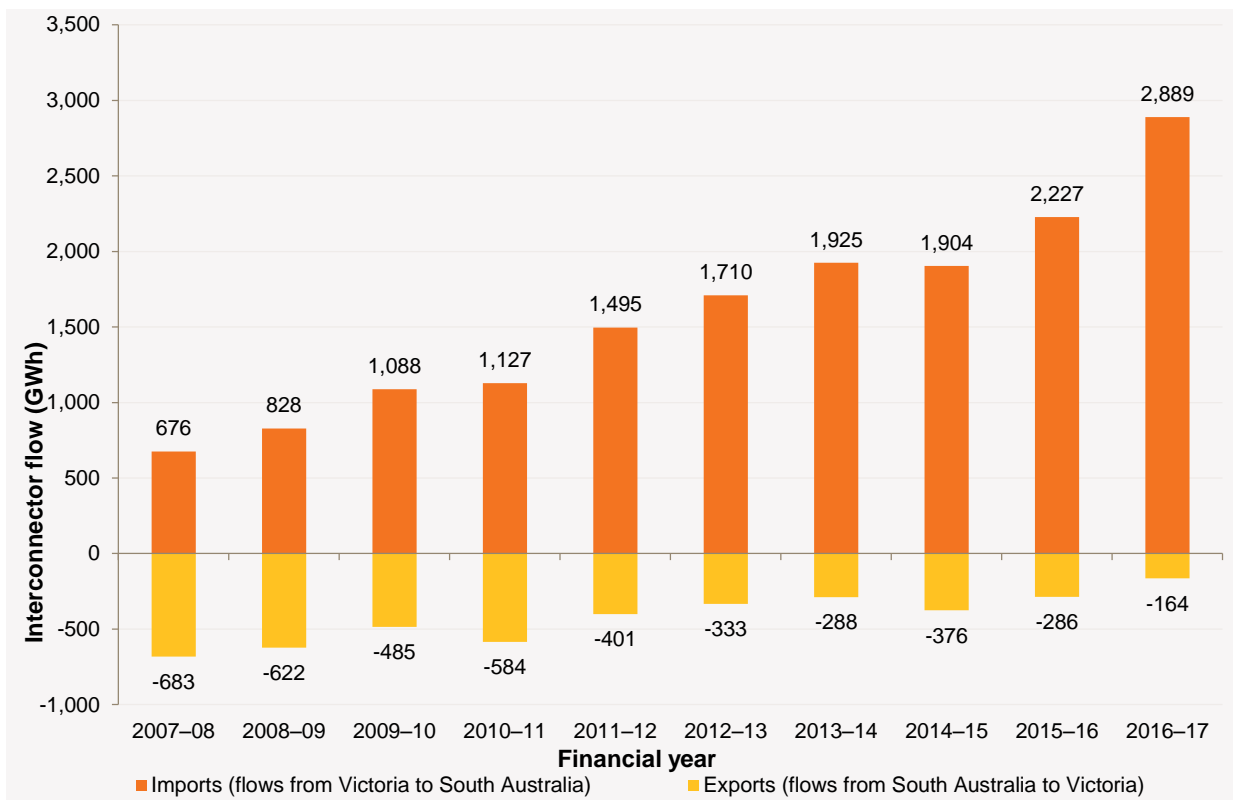
In 2016–17, South Australia imported 2,889 GWh, mainly via the Heywood Interconnector. This was the highest import in 10 years. The average annual import increase through Victoria to South Australia since 2007–08 is 246 GWh, or 18%.

A variety of factors have led to greater imports, including:

- Reduced local installed baseload capacity in South Australia due to generating plant withdrawals.
- Increased interconnector capacity.

In 2016–17, total imports from Victoria represented approximately 21% of South Australian operational consumption, while net imports (total imports less total exports) accounted for around 20%.

Figure 19 Total interconnector imports and exports



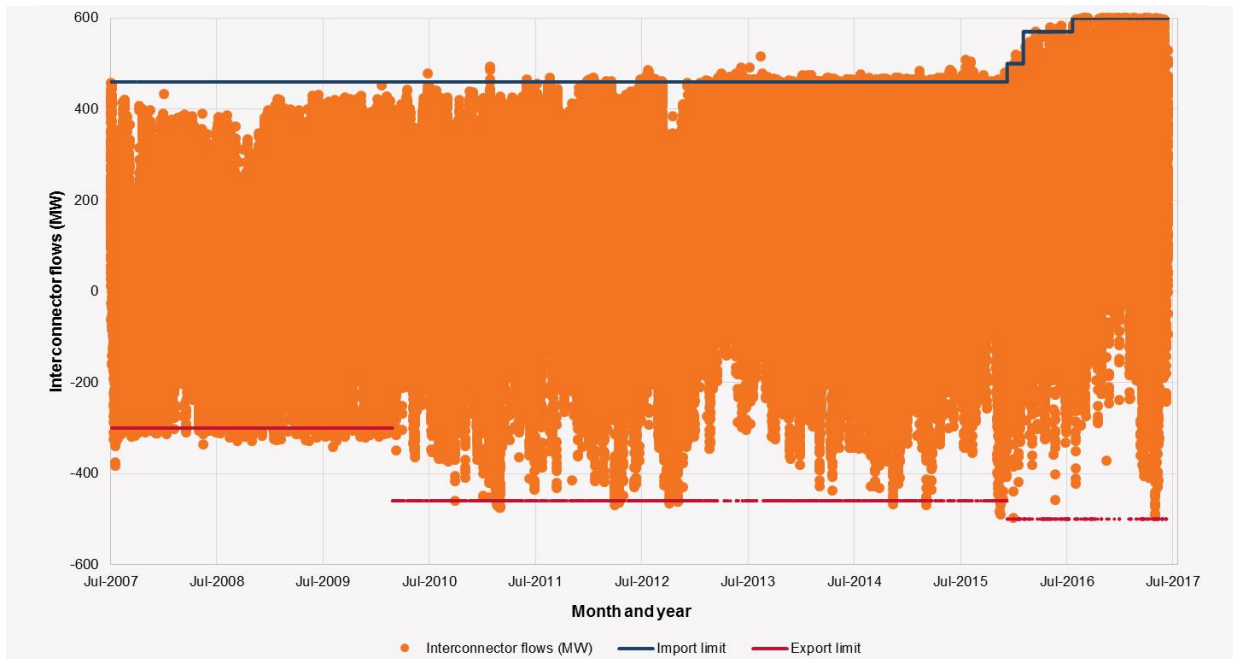
3.2.2 Current and proposed capacity increases

Average flows following capacity increases

Heywood Interconnector import maximum flows are higher since commissioning of the third Heywood transformer, which progressively increased nominal flow capability by 140 MW between December 2015 and August 2016. As yet, market conditions have not allowed for final testing to be completed, therefore the nominal Heywood export limit has not yet increased beyond the 600 MW capacity set in August 2016.

Figure 20 illustrates Heywood’s nominal capacities and 30-minute average flow values in MW for the last 10 years.

Figure 20 Heywood Interconnector flows



New interconnection

ElectraNet has commenced a Regulatory Investment Test for Transmission (RIT-T) in consultation⁶³ with other NEM transmission network service providers (TNSPs) to explore potential new high-voltage interconnector options between South Australia and the eastern states, which may facilitate integration of more renewable generation in the region and improve system security.

ElectraNet has identified four credible network options⁶⁴, which will be analysed further in the RIT-T process. The analysis will take into account the South Australian Government’s Energy Plan. ElectraNet is engaging with non-network option proponents so an initial assessment of feasibility and likely benefits of non-network solution options can be progressed.

⁶³ ElectraNet. *South Australian Energy Transformation, RIT-T: Project Specification Consultation Report*, 7 November 2016. Available at: <https://www.electranet.com.au/wp-content/uploads/resource/2016/11/20161107-Report-SouthAustralianEnergyTransformationPSCR-1.pdf>.

⁶⁴ ElectraNet, 2017 Transmission Annual Planning Report. Available at: <https://www.electranet.com.au/wp-content/uploads/2017/06/2017-Transmission-Annual-Planning-Report.pdf>.

4. ELECTRICITY SPOT PRICE

4.1 Average electricity prices

South Australia had the highest time-weighted average wholesale electricity price⁶⁵ in the NEM for 2016–17, at \$108.66 per MWh (nominal). This was approximately 76% higher than the time-weighted average price for 2015–16.

Table 15 lists the time-weighted average price for all NEM regions in 2016–17.

Table 15 2016–17 Time-weighted average prices for the NEM (nominal)

	Queensland	New South Wales	Victoria	South Australia	Tasmania
Time-weighted average	93.12	81.22	66.58	108.66	75.40

Table 16 presents 10 years of:

- Time-weighted average prices for South Australia, with prices adjusted for quarterly CPI changes, using June 2016 as the reference.⁶⁶
- Volume-weighted average prices, which take into account the amount and price of electricity for a given interval.

Table 16 Average prices for South Australia (real June 2017 \$/MWh)

Financial year	Time-weighted average	Volume-weighted average
2007–08	89.41	112.18
2008–09	60.23	76.54
2009–10	63.92	87.81
2010–11	36.40	42.60
2011–12	33.02	33.28
2012–13	74.55	75.84
2013–14	64.36	69.99
2014–15	40.32	41.45
2015–16	62.73	66.05
2016–17	108.92	124.44

AEMO's analysis suggests the higher prices in South Australia in 2016–17, compared to 2015–16, were mainly due to:

- Reduced firm capacity – in particular, the closure of Northern Power Station changed the region's generation mix, increasing the dependence on higher-cost GPG.
- High prices across the NEM, due to tightening of supply (exacerbated by the retirement of Hazelwood Power Station in Victoria in early 2017).
- Exposure of GPG to higher gas prices. Adelaide spot gas prices increased in the past year from an average ex-ante price of \$5.74/GJ in 2016 to \$8.83/GJ in 2017.

⁶⁵ Time-weighted average price is a simple average of 30-minute spot market prices over a period of time, and does not take into account the different volumes of energy sold within the interval. It represents the average price a generator would have received if it generated at full capacity for the financial year.

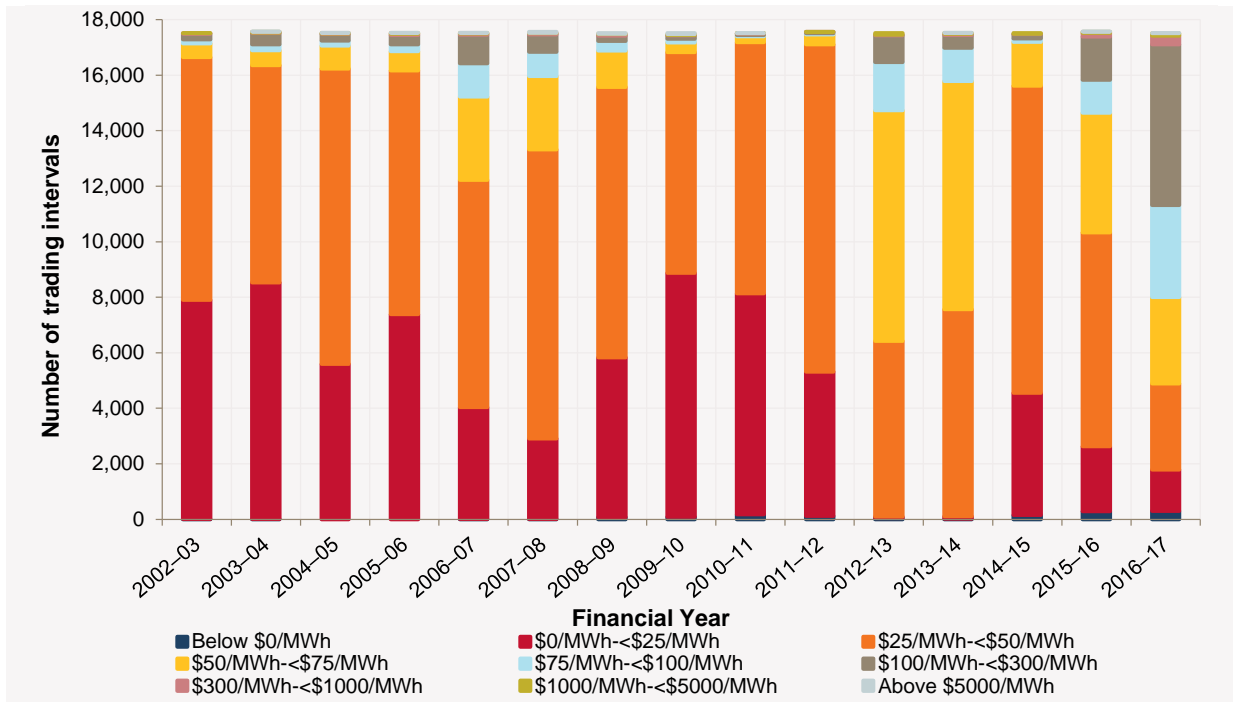
⁶⁶ CPI values taken from Australian Bureau of Statistics Series ID A2325821J (Adelaide).

4.2 Price volatility

All NEM regions experience price volatility to varying degrees, and South Australia has experienced varying levels of electricity spot price volatility throughout its participation in the NEM. This can be shown by the frequency of spot price occurrence in different pricing bands, summarised in Figure 21.

In the past year, spot price volatility has been greater than was observed in the previous four years, due to the effect of closures of coal generation (in South Australia and Victoria) placing greater reliance on GPG (in an environment of higher gas prices) and intermittent generation sources.

Figure 21 South Australian spot prices frequency by price bands 2002–03 to 2016–17 (nominal \$/MWh)



AEMO monitors and reports on “significant pricing events” in the NEM.⁶⁷ These are trading intervals where either:

- The wholesale electricity spot price is above the threshold of \$2,000/MWh.
- The wholesale electricity spot price is below -\$100/MWh.
- The FCAS half-hourly averaged price exceeds \$300/MWh.⁶⁸

The major factors which influenced South Australian pricing events in 2016–17 were:

- Planned and unplanned network outages and generator outages.
- Low wind generation.
- Changes in generation offers.
- High regional demand.
- Daily changes in hot water load, as some 300,000⁶⁹ hot water systems are set to switch on at 11:30 pm in South Australia when the off-peak tariff starts.

⁶⁷ Significant price event reporting criteria were last updated in January 2017. These criteria and all reports are published on the AEMO website at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notice-and-events/Pricing-event-reports>.

⁶⁸ In Tasmania, the FCAS threshold is \$3,000/MWh.

⁶⁹ SAPN Flexible Load Strategy, October 2014, Section 3.4. Available at: <https://www.aer.gov.au/system/files/SAPN%20-%202020.34%20PUBLIC%20-%20SAPN%20Flexible%20Load%20Strategy.pdf>. Viewed 3 August 2016.

Negative prices

There were 298 negative priced 30-minute trading intervals during 2016–17. This was higher than the previous five years, and compares to 288 such intervals during 2015–16.

In general, negative prices may occur due to generating unit commitment decisions to maintain generation at minimum levels, rather than shutting down, during lower operational demand and high wind generation conditions.

As wind farms can gain revenue from large-scale generation certificates (LGCs) in addition to the spot market, it is not unusual for wind farms to continue operating during negative pricing events, provided LGC revenue exceeds the cost of continuing to generate.

4.3 South Australian FCAS price trends

During 2016–17, South Australian (and NEM-wide) FCAS prices increased substantially in the regulation services (averaging about \$125/MWh in each service, representing a 74-fold increase on historical levels) and to a lesser extent in the contingency raise services.⁷⁰

Historically, FCAS prices across all services have typically been very low (about \$1–2/MWh for each service). This pricing dynamic changed in 2015–16 and 2016–17, influenced by two key factors⁷¹:

- AEMO pre-emptively procured 35 MW of regulation FCAS in South Australia at times when the separation of the region at the Heywood Interconnector was a credible contingency. During these times of local requirements, FCAS prices have been very high, due to the limited number of suppliers of these services in the region.
- Generators offering these services to the NEM have reduced their quantity of low-priced bids in regulation and contingency raise services.⁷² For example, in Q2 2017, meeting the NEM-wide average raise regulation requirement (135 MW) cost around \$25/MWh, up from around \$4/MWh in Q2 2017.

Higher FCAS prices led to record FCAS costs in South Australia in 2016–17 of \$34 million, 81% higher than the next highest year (2015–16) in the past five years.

⁷⁰ Regulation FCAS is enabled to continually correct the generation/demand balance in response to minor deviations in load or generation. Contingency FCAS is enabled to correct the generation/demand balance following a major contingency event, such as the loss of a generating unit or major industrial load, or a large transmission element. Contingency services are enabled in all periods to cover contingency events, but are only occasionally used (if the contingency event actually occurs). There are two types of regulation FCAS and six types of contingency FCAS. See Chapter 6 for more information.

⁷¹ AEMO's FCAS requirements have remained broadly flat over the past two years, so this has not materially contributed to the cost increases.

⁷² FCAS is generally procured NEM-wide rather than in particular regions.

5. SUPPLY ADEQUACY OUTLOOK

This chapter compares the current and future generation capacity outlook announced by industry against forecast operational consumption and MD to identify low reserve condition (LRC) points. LRC points indicate when a region's reserves fall short of what is required to meet the NEM reliability standard.⁷³ The current reliability standard requires that a maximum of 0.002% of energy demanded can go unserved for any region in any financial year.

The 2017 SAER supply adequacy results are taken from AEMO's 2017 NEM ESOO.

5.1 Overview

For the 2017–18 summer in South Australia:

- Planned actions via the South Australian Energy Plan⁷⁴ and Reliability and Emergency Reserve Trader (RERT)⁷⁵ provisions will be necessary to reduce risks of supply interruptions.
- Without these actions, depending on variation in supply and demand:
 - There would be a 26% to 33% likelihood of unserved energy (USE) occurring in South Australia, resulting an expected USE in the range between 0.0015% and 0.0025%.
 - USE in South Australia could reach levels close to or exceeding the 0.002% reliability standard. The risk may be greater if actual supply or demand were to vary from the forecast. If the largest thermal generating unit in either South Australia or Victoria was unavailable over the summer, expected USE would be above the reliability standard in both regions.

The risk of USE is forecast to reduce substantially from 2018–19, as peak demand is moderated by increasing rooftop PV uptake and energy efficiency, and additional large-scale renewable generation enters the NEM.

Renewable generation can help meet peak demand, even without significant firm capacity (which can supply electricity at specific times), and continued development of renewable generators can lower the risk of USE. However, if this renewable development was to lead to earlier retirement of existing thermal generation, the risk of USE would increase without additional firm capacity.

5.2 Scenarios modelled

The 2017 NEM ESOO increased the number of scenarios modelled to capture a broad range of possibilities that could occur in the NEM in the next 10 years. The 2017 NEM ESOO scenarios considered three distinct factors, summarised below.

Demand forecast assumptions

The 2017 NEM ESOO builds on the traditional Neutral, Strong, and Weak demand forecast scenarios. The demand forecasts in the 2017 NEM ESOO are updated from the *2017 Electricity Forecasting Insights*⁷⁶ forecasts published in June 2017.

The demand side participation (DSP) forecasts used in the 2017 NEM ESOO are sourced from AEMO's *2017 Electricity Forecasting Insights*.

⁷³ Australian Energy Market Commission (AEMC). NEM Reliability Standard – Generation and Bulk Supply. Available at: [http://www.aemc.gov.au/getattachment/f93100d9-72d2-46fb-9c25-ac274a04ae58/Reliability-Standards-\(to-apply-from-1-July-2012\).aspx](http://www.aemc.gov.au/getattachment/f93100d9-72d2-46fb-9c25-ac274a04ae58/Reliability-Standards-(to-apply-from-1-July-2012).aspx). Viewed: 21 August 2016.

⁷⁴ Refer footnote 3. Government of South Australia. Our Energy Plan. See: <http://ourenergyplan.sa.gov.au/>.

⁷⁵ For more information about the RERT and actions for summer 2017–18, see: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Emergency-Management/RERT-panel-expressions-of-interest>.

⁷⁶ AEMO. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Electricity-Forecasting-Insights>.

Generation assumptions

Project development lead times are now sufficiently short for some renewable generation technologies that it may be possible for generators that are not yet ‘committed’ according to AEMO’s commitment criteria⁷⁷ to be operational within short timeframes. AEMO’s traditional approach, to consider only generators that meet AEMO’s current commitment criteria in the ESOO, may therefore need to be revised in the future.

Three paths for renewable generation builds in the NEM have been used in the 2017 NEM ESOO:

- **Committed and existing generation** – including existing generation in the NEM in accordance with current industry advice that meet AEMO’s current commitment criteria.
- **Concentrated renewables** – assumes additional development after 2020 is geographically concentrated, particularly in Victoria, driven by the Victorian Renewable Energy Target (VRET).
- **Dispersed renewables** – assumes developments are driven by national targets that deliver a more even geographic spread of renewable generation across the NEM, leading to a greater penetration of renewables than is achieved if they are geographically concentrated.

Extended outage and early retirement contingency events

In the 2017 NEM ESOO, AEMO has focused on potential supply disruptions to existing dispatchable generation (which can adjust its output or be switched on or off to order), and the adequacy of the system to deliver electricity reliably to consumers under these unlikely but possible events.

Additional detail about each of the 2017 NEM ESOO scenarios and methodology is available on the NEM ESOO page on AEMO’s website.⁷⁸

5.2.1 Supply and demand changes in South Australia since the 2016 supply adequacy assessment

Table 17 summarises the changes to forecast supply and demand since last year’s supply adequacy assessment was reported in the 2016 NEM ESOO.

These differences help explain the changes seen in this year’s supply adequacy projections, discussed in Section 5.3.

Table 17 Supply and demand changes in South Australia since the 2016 assessment (all projected to 2026–27)

Quantity	Change
Summer maximum demand (10% POE)*	293 MW higher
Committed plant capacity announced**	329 MW higher
Announced return to service***	239 MW
Changes to withdrawal announcements****	240 MW deferred
Government energy projects*****	30 MW

* Difference between 2016 NEFR and 2017 NEM ESOO 10% POE MD forecasts in 2026–27. This includes the risk adjustment identified in section 2.7, which added 92 MW.

** This includes 220 MW of new solar generation and 109 MW of new wind generation which has met AEMO’s commitment criteria.

***In AEMO’s 2 June 2017 Generation Information update, ENGIE published their intention to return Pelican Point Power Station to full service in July 2017. As at August 2017, the full station capacity of Pelican Point is available to the market.

**** AGL has announced that the mothballing of two 120 MW units in Torrens Island A has been deferred to July 2019.

***** AEMO has modelled the market-operated component of the announced 100 MW/129 MWh battery project in South Australia.

⁷⁷ AEMO’s commitment criteria for generation are published in each regional spreadsheet on its Generation Information web page, <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>.

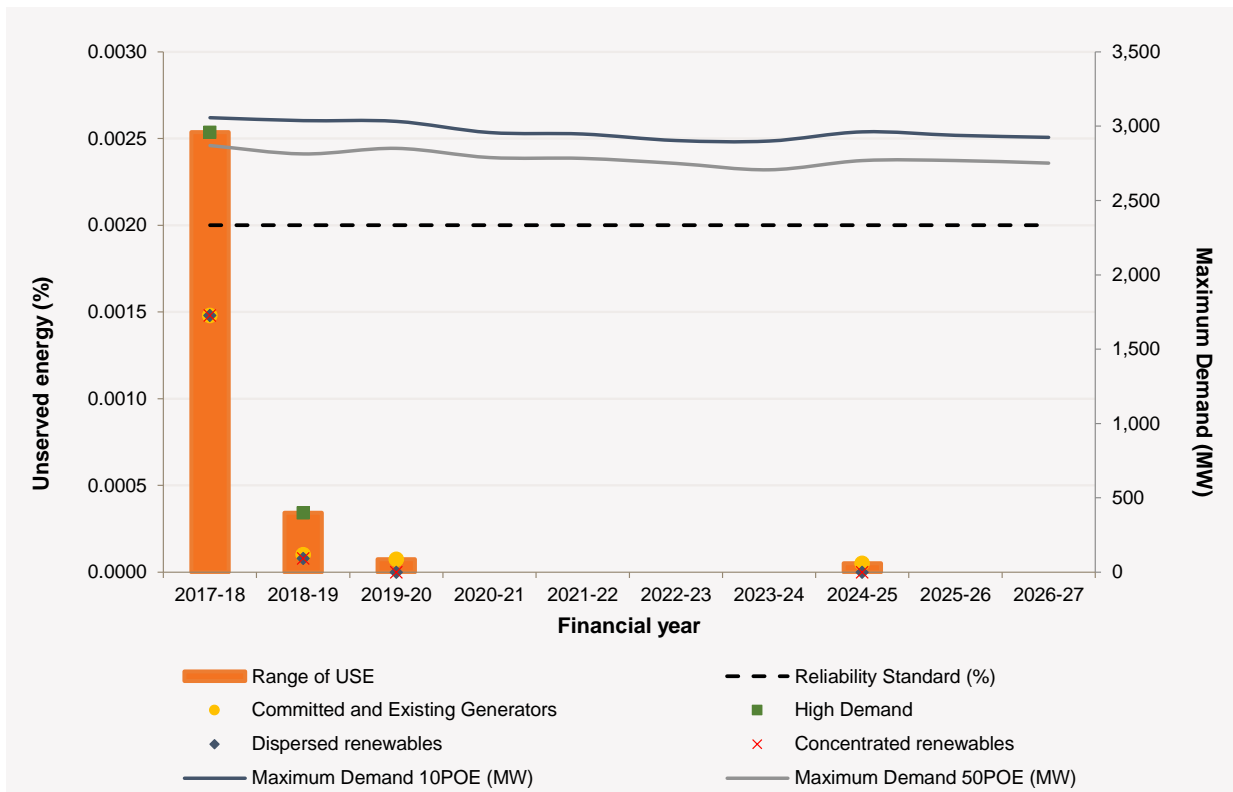
⁷⁸ The 2017 NEM ESOO and all supporting documents are available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities>.

5.3 Supply adequacy assessment

Low Reserve Conditions

Figure 22 shows levels of projected USE as a percentage of total demand, and compares them with the current reliability standard of 0.002% USE and the 2017 NEM ESOO 10% POE and 50% POE operational MD forecasts.

Figure 22 South Australia supply adequacy



Note:

- **Committed and Existing Generators** includes all existing generators and committed projects that meet AEMO’s commitment criteria. Not all potential renewables required to meet State and Federal renewable energy targets and the Paris COP21 commitments are developed.
- **Dispersed Renewables** shows USE if, as well as all existing generators and projects meeting AEMO’s commitment criteria, additional renewable generation was to be developed to deliver a national renewable generation outcome, leading to greater penetration than can be achieved if geographically concentrated.
- **Concentrated Renewables** shows USE if, as well as all existing generators and projects meeting AEMO’s commitment criteria, additional development after 2020 was geographically concentrated particularly in Victoria, driven by the VRET.
- **High Demand** shows the impact on USE if demand growth was in the upper range of expectations, assuming generation was developed according to the Dispersed Renewables pathway. The effect of higher demand on USE would be even greater if modelling assumed only Committed and Existing Generators.

AEMO’s analysis shows:

- In the 2017–18 summer, without planned actions via the South Australian Energy Plan and RERT:
 - There would be heightened risk of USE in South Australia and an increased potential for the current reliability standard not to be met.
 - The likelihood of a shortfall is between 26% and 33%, with expected USE in the range between 0.0015% and 0.0025%. The average shortfall projected is likely to be between 81 MW and 97 MW, but could reach 243 MW. If USE occurs, it is likely to be for two to four hours.
- From 2018–19, the risk of USE in South Australia drops substantially compared to next summer, as peak demand is moderated by increasing rooftop PV uptake and energy efficiency, and

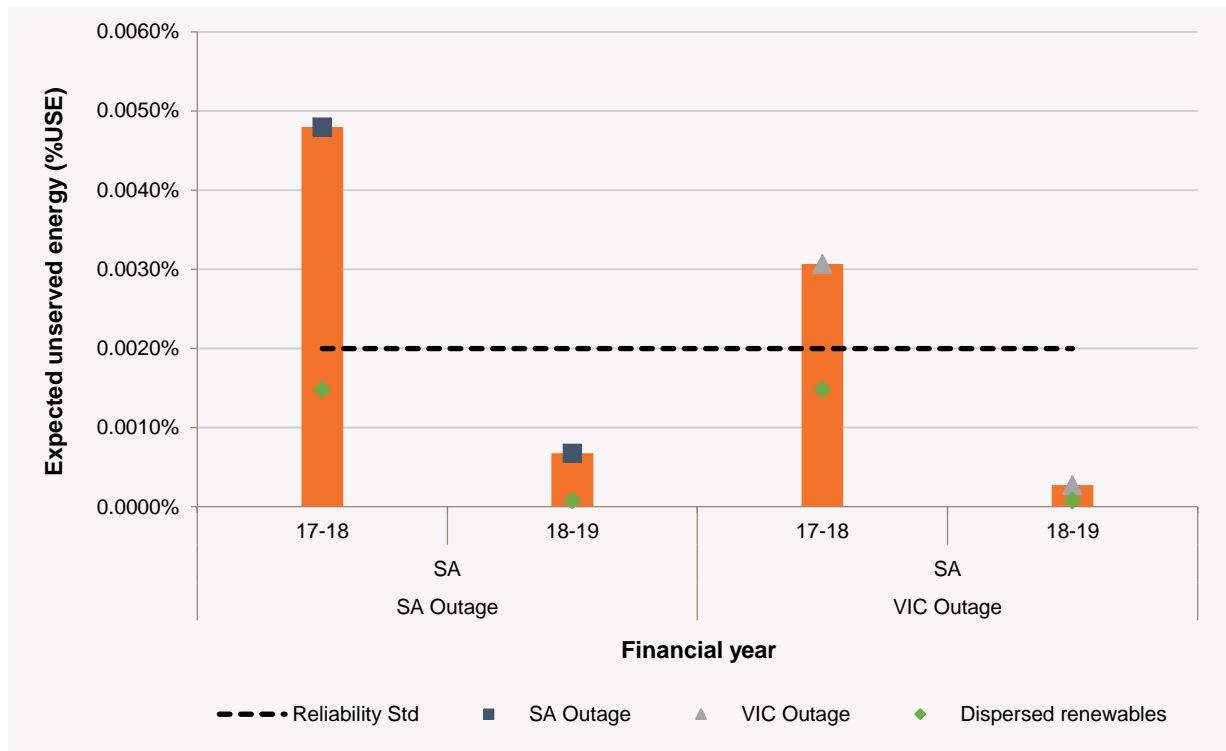
additional large-scale renewable generation enters the NEM. South Australia can also capitalise on an improved supply-demand balance in Victoria through improved interconnector support.

Currently, the Medium Term PASA (MT PASA) is projecting that key large thermal units in South Australia will be unavailable during the coming 2017–18 summer, reducing the generator availability in South Australia which was assumed in 2017 NEM ESOO modelling by about 240 MW.⁷⁹

The balance of supply and demand in Victoria and South Australia is sufficiently tight that the extended unavailability of any further capacity, delays in connection of renewable generation, or failures in generator fuel supplies over the peak summer months would likely lead to further supply shortfalls, well above the reliability standard.

Figure 23 shows the impact to South Australia in 2017–18 and 2018–19 if the largest generating unit in Victoria or South Australia was unavailable in this period, and without planned actions via the South Australian Energy Plan and RERT provisions. The extended unavailability of the largest unit in Victoria or South Australia would increase the range of USE in South Australia in 2017–18 from 0.0015% to 0.0031% or 0.0048%, respectively.

Figure 23 Risk of USE after extended unavailability of largest generator in South Australia or Victoria (Dispersed renewables scenario)



In this figure:

- **Dispersed Renewables** shows USE if, as well as all existing generators and projects meeting AEMO’s commitment criteria, additional renewable generation was to be developed to deliver a national renewable generation outcome, leading to greater penetration than can be achieved if geographically concentrated.
- **SA Outage** case refers to the impact of an extended outage of the largest unit (240 MW) in Victoria on top of the Dispersed Renewables development. The effect of an outage on USE with only committed and existing generators or higher demand would be even greater.
- **VIC Outage** case refers to the impact of an extended outage of the largest unit (560 MW) in Victoria on top of the Dispersed Renewables developments. The effect of an extended outage on USE with only committed and existing generators or higher demand would be even greater.

⁷⁹ Capacity of 240 MW in South Australia is roughly equivalent to one of the following: one Pelican Point unit, two Torrens Island A units, one Torrens Island B unit, the entire Hallett GT Power Station, or the entire Quarantine Power Station. The modelling reasonably depicts outcomes associated with the withdrawal or unavailability of any of these units/power stations.

6. SYSTEM SECURITY IN A CHANGING GENERATION MIX

6.1 Reliability and security with a changing generation mix

In a secure and reliable power system, supply and demand of electricity must constantly be in balance. Security and reliability are distinct but related concepts:

- **Security** means the power system can continue operating within defined technical limits even when a disruptive event occurs, such as a generator trip. System security relates to the technical parameters of the power system such as voltage, frequency, network loading, and how the system responds to a disruption.
- **Reliability** means there is enough supply capacity (including generation, transmission, and distribution infrastructure) available to meet customer demands at any point in time.

The South Australian generation mix now includes increased amounts of non-synchronous and inverter-connected plant, such as wind and PV generation. This changing generation mix introduces a different set of challenges to those associated with predominantly synchronous generation (including coal, gas, and hydro).

For example, synchronous generation has inherent attributes which support the fundamental design and operation of a power system. One of these attributes is the inertia provided by the large synchronous rotating masses of generator turbines.

Inverter-connected non-synchronous generation does not provide inertia as a by-product of generation. It also does not rely on inertia to the same extent as synchronous generators. Because non-synchronous machines are connected to the network via power electronic converters, they are able to withstand a much broader range of operating frequencies than a traditional synchronous generator.

As the generation mix continues to change across the NEM, and particularly in South Australia, it is no longer appropriate to rely solely on synchronous generators to provide essential non-energy system services (such as voltage control, frequency control, inertia, and system strength). Instead, additional means of procuring these services must be considered, either from:

- Non-synchronous generators (where it is technically feasible), or
- Network or non-network services (such as demand response and synchronous condensers).

6.2 Frequency control, inertia, and ramping

Frequency control is critical to the security of the power system. It measures the instantaneous balance of supply and demand – if supply exceeds demand, frequency will increase, and vice versa. The NEM operates at the nominal frequency of 50 Hertz (Hz).

There are a number of different frequency control mechanisms that act over different timescales and play different, collaborative roles in managing power system frequency. Table 18 summarises the types of frequency services used in the NEM, and their current providers. Although each service acts in different ways across different timescales, they are intrinsically linked, and solutions to challenges in any one cannot be considered in isolation.

Table 18 Overview of current frequency control mechanisms in the NEM

Service	When it is relevant	What it does	What it can't do	Current providers	Key challenges emerging or anticipated from the changing generation mix
Inertia	After a contingency event	Slows frequency changes	<ul style="list-style-type: none"> Halt/arrest frequency changes Restore frequency to 50 Hz 	Automatic physical property of synchronous rotating machines	<ul style="list-style-type: none"> Level of inertia reduces Potential exposure to high rate of change of frequency (RoCoF) in South Australia after a contingency event.
Primary frequency control	Normal operating conditions	Halts/arrests frequency changes	<ul style="list-style-type: none"> Slow frequency changes instantly after the disturbance Fully restore frequency to 50 Hz 	Governor response of synchronous units providing a controlled response to local frequency measurement	<ul style="list-style-type: none"> Quality of frequency control has declined over the last couple of years Frequency performance still exceeds the minimum standard required by frequency operating standards (FOS) Number of excursions outside the normal operating band increased significantly in 2016
Regulation FCAS	Normal operating conditions	Restores frequency to close to 50 Hz	Act quickly, as total response times are limited by minimum Automatic Generation Control (AGC) cycle time of 5–10 seconds.	Synchronous generation via autonomous changes to unit set points	<ul style="list-style-type: none"> Historically, regulation and contingency FCAS is provided by synchronous generation – if this generation is displaced, the level of FCAS it provided will have to be procured from other sources, which the market has not attracted to date If the FCAS market does not encourage new participants to provide the service, FCAS will become increasingly scarce and costly If utility-scale intermittent generation is also a large proportion of the generation mix, as in South Australia, there will be more uncertainty overall in the dispatch process, and more balancing might be required to maintain frequency within the FOS.
Contingency FCAS	After a credible contingency	6 and 60 second contingency FCAS halts/arrests frequency changes	<ul style="list-style-type: none"> Slow frequency changes instantly after the disturbance Fully restore frequency to 50 Hz 	Controlled response locally	
		5 minute contingency FCAS restores frequency to close to 50 Hz	Act quickly, as total response times are limited by minimum AGC cycle time of 5–10 seconds	Synchronous generation via autonomous changes to unit set points	
Emergency frequency control schemes	Triggered by detection of a specific event, such as loss of an interconnector	Rapidly corrects imbalance for specific event	Respond to general frequency disturbances	<p>Under frequency load shed (UFLS) schemes, for loads with peak demands in excess of 10 MW.*</p> <p>Over Frequency Generation Shed (OFGS) scheme if available.**</p>	UFLS schemes are currently the most commonly used emergency frequency control schemes in the NEM. Their effectiveness may be reduced with increased distributed energy resources (DER). In the case of a non-credible loss of the Heywood interconnector, UFLS schemes might not react fast enough to arrest the fall in frequency and prevent cascading generation failure. This is being managed through the development of a special protection scheme (SPS) in South Australia, to manage sudden excessive flows on the Heywood Interconnector.***

* NER S5.3.10 Load Shedding facilities.

** The OFGS scheme was developed in 2016 between AEMO and ElectraNet, and is due to be completed by summer 2017–18. For further information on ElectraNet's OFGS, refer to section 8.9.1 of the South Australia Annual Planning Report, available at: <https://www.electranet.com.au/wp-content/uploads/2017/06/2017-Transmission-Annual-Planning-Report.pdf>.

*** For further information on ElectraNet's SPS, refer to section 8.9.2 of ElectraNet's South Australia Annual Planning Report, available at: <https://www.electranet.com.au/wp-content/uploads/2017/06/2017-Transmission-Annual-Planning-Report.pdf>.

6.2.1 Inertia

Declining levels of inertia is particularly relevant in the context of the South Australian power system. Inertia is a characteristic of synchronous machines, which provides an inherent inertial response to the frequency deviations, slowing the rate of change of frequency (RoCoF) following power system disturbances. Since inertia has to date been provided by the rotating mass inherent in synchronous machines, a power system with less synchronous generation online (lower inertia) leads to a higher RoCoF than one with more synchronous generation (higher inertia).

As the level of inertia in the power system reduces, supply-demand imbalances due to any disturbance will cause larger and more rapid frequency deviations that will be increasingly hard to manage. This could result in the loss of additional generation or load to arrest the frequency deviation when it occurs.

The risk of high RoCoF resulting from the non-credible separation of South Australia was identified by AEMO in August 2016.

AEMO has acted to mitigate the risks of high RoCoF by:

- Constraining the flow on the Heywood Interconnector, such that RoCoF would not exceed 3 Hz/s if it disconnected.
- Working with the Australian Energy Market Commission (AEMC) to establish a new protected events category in the NER to provide AEMO with the ability to pre-emptively plan for certain non-credible contingency events.
- Working with the AEMC to establish clear accountabilities and capabilities with respect to emergency frequency control schemes (EFCS).
- Working with ElectraNet to redesign the existing under-frequency control load shedding scheme in South Australia and the implementation of an over-frequency generation shedding scheme.
- Working with the AEMC to establish procurement mechanisms for minimum inertia.

AEMO's power system studies have made it clear that while inertia and system strength are separate requirements for power system security, solutions to address high RoCoF (that is, lower inertia) are closely inter-related with solutions to address low system strength (see section 6.3). For instance, AEMO's current operational constraint to maintain a certain level of synchronous plant online in South Australia to address system strength concerns also assists in managing high RoCoF.

6.2.2 Ramping

Ramping refers to services required to match demand with supply due to variation in demand or supply, over specific timeframes longer than those covered by existing frequency control services.

Historically, the daily load profile could be predicted with satisfactory accuracy, based on specific parameters such as time of day, day of week, and day of year. This was possible because of the underlying diversity of demand.

However, the increase in rooftop PV over recent years is changing the daily load profile in ways that can create new operational challenges. Similarly, the anticipated increase in installation of utility-scale PV in the near term will add to operational challenges from changes in other intermittent generation, such as wind.

AEMO is undertaking further analysis to better understand the impacts of ramping from utility-scale PV, and at what scale this becomes a security challenge as traditional frequency control services will either become insufficient or inefficient.

In its advice to Essential Services Commission of South Australia (ESCOSA) on South Australian generator licence conditions, AEMO recommended that new entrant generators have the capability to

limit the rate of increase and decrease of active power output from plant.⁸⁰ Applications of this capability could include:

- Limiting active power ramps on start-up or planned shutdown of plant, or when a constraint on active power output is engaged or released.
- Management of electrical islands, or potential islands, with high instantaneous penetration of variable renewable generation.
- Managing the impact of rapid short-term changes in active power output on the local power network.

ESCOSA adopted AEMO’s recommendation and the new conditions came into effect in August 2017.⁸¹

6.3 System strength

System strength reflects the sensitivity of power system variables to disturbances. It provides an indication of inherent local system robustness, with respect to properties other than inertia. It affects the stability and dynamics of generating systems’ control systems, and the ability of the power system to both remain stable under normal conditions, and to return to steady-state conditions following a disturbance, as set out in Table 19.

Table 19 Summary of main issues associated with low system strength

Issue	Description
Non-synchronous plant stability	<p>Non-synchronous generation that is connected to the network using power electronic converters (PEC’s) requires a minimum system strength to remain stable and maintain continuous uninterrupted operation. Different types of converters use different strategies to match their output to the frequency of the system while maintaining voltage levels and power flows. In a weak AC system, this can lead to</p> <ul style="list-style-type: none"> • Disconnections of plant following credible faults, in particular in remote parts of the network. • Adverse interactions with other non-synchronous plant (instabilities/oscillations have been observed in practice in the NEM). • Failure to provide sufficient active and reactive power support following fault clearance.
Synchronous plant stability	<p>Low system strength can affect the ability of generators to operate correctly, resulting in disconnections of synchronous machines during credible contingencies.</p>
Operation of protection equipment.	<p>Protection equipment within power systems work to clear faults on only the effected equipment, prevent damage to network assets and mitigate risk to public safety. In weak systems:</p> <ul style="list-style-type: none"> • Protection mechanisms have a higher likelihood of mal-operation. • Protection mechanisms may fail to operate, resulting in uncleared faults and/or cascaded tripping of transmission elements due to eventual clearance of the fault by an out-of-zone protection resulting in excessive disconnection of transmission lines and associated generation.
Voltage management.	<p>Strong power systems exhibit better voltage control in response to small and large system disturbances. Weak systems are more susceptible to voltage instability or collapse.</p>

6.3.1 System strength in South Australia

The South Australian region of the NEM is in many ways unique in the world. Its key features include:

⁸⁰ https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/2017-ESCOSA-Review--Addendum-to-Final-Report.pdf
⁸¹ <http://www.escosa.sa.gov.au/projects-and-publications/projects/inquiries/inquiry-into-licensing-arrangements-under-the-electricity-act-1996-for-inverter-connected-generators/inquiry-into-licensing-arrangements-under-the-electricity-act-1996-for-inverter-connected-generators>

- It has only one AC interconnector to the rest of the NEM power system that is capable of transferring system security services, such as frequency control and inertia (the Heywood Interconnector).
- Most demand and synchronous generation is concentrated in the Adelaide metropolitan area. The next closest group of major synchronous generating units likely to be in service is in Victoria's Latrobe Valley, over 800 km away.
- Being relatively weakly connected to the rest of the NEM, South Australia has only marginal benefit from the "strength in numbers" of the synchronous generation along the east coast of Australia.

South Australia's power system has a very high ratio of wind generation compared to the demand in the state. Instantaneously, South Australia is capable of meeting, and historically has met, over 120% of its demand from wind generation alone. Periods of such high penetration of non-synchronous generation present challenges for managing power system security, particularly in relation to maintaining adequate system strength. The strength of the power system can be low during these periods, due to reduced levels of online conventional synchronous generation.

AEMO has published a detailed assessment of system strength requirements in South Australia.⁸² We have also worked with the AEMC to implement a new regulatory framework from managing system strength and applied the new framework to issue an updated NSCAS gap for South Australia. As an interim measure, we have put in place constraints that are designed to maintain system strength. Where these constraints are insufficient to meet system strength requirements, AEMO directs on synchronous generators.

System strength rule change

In its final determination on the 'Managing power system fault levels' rule change,⁸³ the AEMC has established new frameworks to address weak system issues, including:

- Obligations on TNSPs to maintain minimum fault levels (for example, if synchronous machines retire).
- Obligations on new non-synchronous units connecting to "do no harm" to the security of the power system in relation to any adverse impact on the ability to maintain system stability, or on a nearby generating system to maintain stable operation.
- Clarifying obligations to manage system strength in real time.

As part of its decision, the AEMC put in place transitional arrangements to ensure solutions can be implemented as quickly as possible. AEMO has made use of these transitional arrangements in order to apply the new framework to the previously issued NSCAS gap for South Australia.

NSCAS gap for South Australia

In December 2016, AEMO published its 2016 *National Transmission Network Development Plan* (NTNDP).⁸⁴ This report included an assessment of whether further Network Support and Control Ancillary Services (NSCAS) are required in the next five years.

In this assessment, AEMO identified an NSCAS gap to provide system strength in South Australia. The gap was confirmed in an update to the 2016 NTNDP, published 13 September 2017.⁸⁵ Following

⁸² AEMO, *South Australian System Strength Assessment*, September 2017, https://www.aemo.com.au/-/media/Files/Media_Centre/2017/South_Australia_System_Strength_Assessment.pdf

⁸³ AEMC, *Managing power system fault levels rule change*. Available at: <http://www.aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels>

⁸⁴ AEMO, *2016 National Transmission Network Development Plan*, December 2016. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Transmission-Network-Development-Plan>.

⁸⁵ AEMO, *Update to the 2016 National Transmission Network Development Plan*, September 2017. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2017/2016-NATIONAL-TRANSMISSION-NETWORK-DEVELOPMENT-PLAN.pdf.

changes to the NER for managing system strength (see section 6.3.2), AEMO now considers that South Australia's system strength needs will be better managed under the new system strength framework. AEMO withdrew the NSCAS gap for system strength in South Australia declared on 13 September 2017, and declared a new system strength NSCAS gap on 13 October 2017,⁸⁶ enabling the new system strength framework to be utilised in accordance with clause 11.101.6 of the NER.

AEMO has identified a system strength NSCAS gap for 620 MVA at the Davenport 275 kV transmission connection point (to be provided by synchronous machines within South Australia). This NSCAS gap:

- Requires the provision of system strength services, including fault current, for areas of South Australia with high non-synchronous penetration levels.
- Is required for maintaining power system security.
- Exists today, and is required for the remainder of the current five-year NSCAS planning horizon (until 1 July 2021) and beyond.

AEMO is collaborating with ElectraNet to validate the technical capability of any proposed solutions to ensure power system security.

Revised operating advice for South Australia

Until other viable solutions for managing system strength are available through regulatory frameworks, AEMO has established a requirement for a minimum level of synchronous generation to remain online in South Australia at all times.⁸⁷ This minimum level of synchronous generation required to be online increases as the output of non-synchronous generation rises.

AEMO set an initial minimum requirement equivalent to having the two largest synchronous machines remaining online at all times. Further detailed power system studies have identified that a more complex arrangement of synchronous machines must remain online to maintain sufficient system strength for various levels of non-synchronous generation dispatch.⁸⁸ AEMO has recently issued an updated transfer limits advice that summarises the combinations of synchronous generators that would provide sufficient system strength to withstand a credible fault and loss of a synchronous generator, at different non-synchronous generation levels.⁸⁹

6.4 Black system event

On 28 September 2016, all electricity supply to the South Australia region was lost in an event called a black system. The first customers had power restored by 7.00 pm on 28 September, the majority had been restored by midnight, and, as fallen transmission lines were bypassed, all customers had supply restored by 11 October 2016. AEMO has summarised what happened before, during and after this event, contributing factors, and recommendations in its final report.⁹⁰

AEMO has acted, with industry and government, to implement the recommendations set out in this report. These actions aim to reduce risk in five key areas:

- Reduce the risk of the South Australia region islanding (separating from the rest of the NEM).
- Improve forecasting of events that could cause islanding.

⁸⁶ AEMO, *Second Update to the 2016 National Transmission Network Development Plan* for the NEM, October 2017. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2017/Second_Update_to_the_2016_NTNDP.pdf.

⁸⁷ AEMO, *Update to the 2016 National Transmission Network Development Plan* for the NEM, September 2017. http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2017/2016-NATIONAL-TRANSMISSION-NETWORK-DEVELOPMENT-PLAN.pdf.

⁸⁸ AEMO, *South Australia System Strength Assessment*, September 2017. Available at: <http://www.aemo.com.au/Media-Centre/South-Australia-System-Strength-Assessment>.

⁸⁹ AEMO, *Transfer Limits Advice, South Australian System Strength* October 2017. Available at: http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/2017/Transfer-Limit-Advice---South-Australian-System-Strength-v3.pdf

⁹⁰ AEMO, *Black System South Australia 28 September 2016*, March 2017. Available at: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notice-and-events/Power-System-Operating-Incident-Reports>.

- Increase the likelihood, in the event of islanding, that a stable electrical island in South Australia can be sustained.
- Improve the system restart process, so supply to customers can resume as quickly as safely possible.
- Improve market and system operations processes during periods of market suspension.

To reduce the energy supply risk to South Australian consumers:

- For this summer, AEMO will have completed its recommended actions to support measures needed to identify, minimise, and manage islanding risks for South Australia.
- Critical improvements to operational tools and processes have been implemented.
- AEMO is working with ElectraNet to complete a range of actions to expand available capacity (including necessary upgrades to hardware and secondary systems).

6.5 Actions underway to support system security

AEMO supports the position of the Finkel review⁹¹ that the design of the grid of the future must be fit-for-purpose to deliver the key outcomes of increased security, future reliability, rewarding consumers, and a lower emissions trajectory.

AEMO is working collaboratively with the energy industry and governments to:

- Prepare for next summer.⁹²
- Strengthen transmission network.
 - AEMO is working with ElectraNet to implement a special protection scheme to operate in response to sudden excessive flows on the Heywood Interconnector, and to initiate load shedding with a response time fast enough to prevent separation.⁹³
 - In November 2016, ElectraNet commenced a RIT-T to explore the technical and economic feasibility of a new interconnector and alternative non-network solution options.
- Increase South Australia's power system security by traditional means.
 - Sufficient FCAS needs to be enabled so the system can respond effectively to frequency deviations.⁹⁴ FCAS can be sourced from any NEM region, or sourced within South Australia when a credible risk of South Australia islanding exists (an islanded region is limited to its own available internal FCAS resources to manage events). In this situation, all registered FCAS providers need to be online and operating to supply regulation FCAS. The withdrawal of any registered FCAS providers, or any of their registered FCAS facilities being offline during this event, would increase the risk of widespread load shedding.
 - AEMO is reviewing the system restart process and implementation of System Restart Standard recommendations made by the Reliability Panel.
 - New procedures are being implemented to ensure the minimum number of synchronous generating units are online in South Australia (as discussed in Section 6.3.4).

⁹¹ *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future*, June 2017. Available at: <http://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf>.

⁹² AEMO's preparations for summer 2017–18 focus on generation and the availability of generation fuel (coal, gas, and water), completion of generation and transmission maintenance before summer, facilitating new generation and storage, seeking offers of additional reserves through the Reliability and Reserve Trader (RERT) provisions, and encouraging greater utilisation of consumer-owned energy resources through demand response initiatives.

⁹³ For further information on ElectraNet's SPS, refer to section 8.9.2 of the South Australia Annual Planning Report, available at: <https://www.electranet.com.au/wp-content/uploads/2017/06/2017-Transmission-Annual-Planning-Report.pdf>.

⁹⁴ The minimum timeframe for FCAS delivery is over six seconds, that is, much longer than the quarter of a second the South Australia frequency took to collapse.

- Restrictions have been placed on Heywood Interconnector flow to ensure the RoCoF in South Australia for the unexpected loss of the Heywood Interconnector alone does not exceed 3 hertz per second (Hz/s).⁹⁵

AEMO, the energy industry, and the South Australian Government are also working together to increase South Australia's power system security by additional means of procuring essential non-energy system services:

- From all generators (where it is technically feasible).
 - ESCOSA has reviewed licensing arrangements for generators in South Australia and found there is a need for it to continue to apply transitional technical conditions within licences for new electricity generators which are to be connected to the NEM.⁹⁶
- Requiring applicants for new electricity-generation projects to demonstrate how they add to local energy system security.⁹⁷
- From network or non-network services (such as demand response and synchronous condensers). AEMO is:
 - Seeking demand-based resources, as well as supply, through the Reliability and Emergency Reserve Trader (RERT) provisions.⁹⁸
 - Working with the Australian Renewable Energy Agency (ARENA) to procure 100 MW of new demand side participation from industry.⁹⁹

The technical challenges of the changing generation mix must be managed with the support of efficient and effective regulatory and market mechanisms, to ensure the most cost-effective measures are used in the long-term interest of consumers.

Other regulatory and strategic initiatives in progress include:

- Exploring options to procure inertia and system strength in South Australia.
 - The AEMC System Security Market Frameworks review has explored NEM-wide options for procuring inertia and system strength from synchronous machines.¹⁰⁰ On 27 June 2017, AEMC published its final report, making nine recommendations for changes to market and regulatory frameworks.
- AEMC made a final rule determination on the South Australian Minister for Mineral Resources and Energy's Emergency Frequency Control Scheme rule change request. The resulting rule includes:
 - A framework to regularly review current and emerging power system frequency risks, and then identify and implement the most efficient means of managing relevant contingency events.
 - An enhanced process to develop emergency frequency control schemes that allow for the efficient use of all available technological solutions to limit the consequences of major frequency deviations, recognising that both under-frequency and over-frequency control schemes may be required.
 - Provision for the declaration of 'protected events', as a sub-category of non-credible contingency events. Once declared by the Reliability Panel, AEMO will manage power system

⁹⁵ ElectraNet. South Australian Energy Transformation, 13 February 2017, Section 2.6.1. Available at: <https://www.electranet.com.au/wp-content/uploads/resource/2017/02/SAET-Supplementary-Information-Paper-Final-13-Feb-2017.pdf>.

⁹⁶ ESCOSA Inquiry into the licensing arrangements for generators in South Australia. Available at: <http://www.escosa.sa.gov.au/projects-and-publications/projects/inquiries/inquiry-into-licensing-arrangements-for-inverter-connected-generators>.

⁹⁷ South Australian Government, *Our Energy Plan*, 21 June 2017. Available at: <http://ourenergyplan.sa.gov.au/>.

⁹⁸ Information about Reliability and Emergency Reserve Trader (RERT) provisions is available at: <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Emergency-Management/RERT-panel-expressions-of-interest>.

⁹⁹ AEMO. Media release, "ARENA and AEMO join forces to pilot demand response to manage extreme peaks this summer", 19 May 2017. Available at: <https://www.aemo.com.au/Media-Centre/ARENA-and-AEMO-join-forces-to-pilot-demand-response-to-manage-extreme-peaks-this-summer>.

¹⁰⁰ A short overview of system strength can be found in the following fact sheet: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-Fact-Sheet-System-Strength-Final-20.pdf. Following a system event in November 2016, new arrangements to maintain power system security during periods of anticipated low fault levels (low system strength) were implemented, and more information is available at: http://www.aemo.com.au/-/media/Files/Media_Centre/2016/SA-System-Strength.pdf.

security to provide for the occurrence of protected events, as well as credible contingency events, within the applicable frequency operating standards.

This integrated framework for emergency frequency control schemes and protected events will support security of supply for consumers.

In addition to the South Australian Government's Energy Plan to source, generate, and control more of South Australia's power system in South Australia, AEMO, ARENA, and industry are also progressing work to address the challenges resulting from decreasing levels of synchronous generation in the region, including:

- Changes by several wind farms in South Australia to the settings for the protective feature for multiple voltage disturbances.
- Proof-of-concept trials of promising new technologies, starting with use of the new Hornsdale Stage 2 Wind Farm¹⁰¹ to provide grid stabilisation services. These projects can deliver engineering solutions to make the grid more resilient and protect customer supply as the transformation of Australia's energy system continues.

¹⁰¹ AEMO media release, "AEMO and ARENA looking to evolve traditional electricity market", 10 August 2017. Available at: <https://www.aemo.com.au/Media-Centre/AEMO-and-ARENA-looking-to-evolve-traditional-electricity-market>.

7. LINKS TO SUPPORTING INFORMATION

Table 20 provides links to additional information provided either as part of the 2017 SAER accompanying information suite, or related AEMO planning information.

Table 20 SAER topics and source publications

Information source	Website address
2017 SAER – tables and figures	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions
2017 South Australian Demand Forecasts	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions
2017 Electricity Statement of Opportunities for the NEM	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities
Retail electricity price history and projections	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Electricity-Forecasting-Report
Projections of uptake of small-scale systems	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Electricity-Forecasting-Report
2017 South Australian Historical Market Information Report	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions
Generation Information page	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information
South Australian Planning Requirements for New Electricity Generation	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/South-Australian-Advisory-Functions
Maps and network diagrams	http://www.aemo.com.au/aemo/apps/nem_map/index.php
AEMO's Future Power System Security program	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability
AEMO Insights, August 2017, <i>Electric Vehicles</i>	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Electricity-Forecasting-Report
AEMO's Guide to Ancillary Services in the National Electricity Market	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services
Fact sheets – frequency control, system strength, visibility of the power system	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis

APPENDIX A. DATA REPORTING DEFINITIONS

A.1 Operational consumption and operational maximum demand definitions

A.1.1 Consumption and demand

Consumption refers to electrical energy needed over a period of time and is measured in GWh, whereas demand refers to electrical power needed at a particular point in time (or the average over a short period of time like five or 30 minutes) and is measured in MW.

This report generally considers consumption or demand over particular reporting periods such as a financial year, summer, winter or calendar month.

A.1.2 Operational reporting

This report presents AEMO's operational data for historical results, estimates, and forecasts. Operational data comprises the electricity consumed by the NEM's transmission and distribution networks to supply residential and business customers, as well as the inherent electrical losses in the networks.

Furthermore, operational reporting is defined as that electricity supplied by scheduled, semi-scheduled, and significant non-scheduled generating units, and includes net interconnector imports when reporting on a particular NEM region. It excludes electricity supplied by SNSG, which is discussed in Sections 2.3.3 and 2.4.1, and rooftop PV, which is discussed in Section 2.6.1.

Underlying consumption and demand refers to electricity consumed by customers at their premises, supplied from both the grid and rooftop PV combined, but it does not include contribution from SNSG.

A.1.3 "Sent-out" versus "as-generated" data

Sent-out data is measured at each generating system's connection point. This represents the electricity supplied to the market, and excludes its auxiliary loads. As-generated data, measured at each generating unit terminal, represents its entire output, including the energy supplied to its auxiliary loads.

Usage in this report

Chapter 2 (excluding Section 2.2) of the SAER reports sent-out data for both operational consumption and operational minimum and maximum demand.

Chapter 3 (and Section 2.2) of the SAER reports on findings in the SAHMIR and uses as-generated data for both generator electrical output and operational demand.

A.1.4 Probability of demand exceedance

A probability of exceedance (POE) refers to the likelihood that a maximum demand (MD) or minimum demand forecast will be met or exceeded.

For a given reporting period, a 10% POE MD projection is expected to be exceeded, on average, one year in 10, and a 50% POE MD projection is expected to be exceeded, on average, five years in 10 (or one year in two). In the case of minimum demand however, 90% POE means demand is expected to exceed the forecast nine years out of 10, or to only be under the forecast minimum one year in 10.

A.2 Inputs to operational consumption forecasts

AEMO's forecasts are based on a wide range of inputs.

The key inputs into the residential forecast are:

- Historical consumption data.
- Historical and forecast weather data.
- Forecast population growth and building construction.
- Forecast appliance ownership.
- Forecast retail price projections.
- Forecast rooftop PV and storage uptake and generation.
- Forecast energy efficiency savings.
- Forecast gas to electric appliance switching.

The business sector forecast uses:

- Historical consumption data.
- Historical and forecast weather data.
- Forecast developments of macroeconomic variables, including:
 - Household disposable income forecasts.
 - Gross state product forecasts.
- Forecast retail price projections.
- Forecast rooftop PV and storage uptake and generation.
- Forecast energy efficiency savings.

Part of the business forecast is informed by surveying large customers directly.

A.3 Differences between 2017 and 2016 historical data and forecasts

A.3.1 Analysis of consumption sectors

In SAERs before 2016, annual consumption was split into the residential and commercial sector, and the large industrial sector. Due to changes in the consumption analysis in the 2016 NEFR, the 2016 and 2017 SAER now report on the residential sector and the business sector. Because the sector splits are not directly comparable, the sector forecasts this year are not comparable to those presented in 2015.

As explained in Section 2.2.2, for South Australia the business sector forecast is split into manufacturing (which includes the large industrial loads from previous years) and 'other business'. This breakdown allows AEMO to make better forecasting models.

A.3.2 Generators included in small non-scheduled generation estimates

Table 21 and Table 22 shows the ONSG and PVNSG included in this year's reporting (2017 NEM ESOO and 2017 SAER).

Table 21 South Australian small non-scheduled generating systems for 2017

Generating system	Generation type	Energy source	Capacity (MW)
Blue Lake Milling Power Plant	Compression reciprocating engine	Diesel	1
Coopers Brewery Cogeneration	Thermal co-gen	Natural gas	4.4
KCA Millicent	Thermal co-gen	Natural gas	21
SA Water Bolivar Waste Water Treatment Plant	Waste water	Sewage gas	9.9
SA Water Seacliff Park Mini Hydro	Hydro – gravity	Water	1.155
Tatiara Bordertown Plant	Compression reciprocating engine	Diesel	0.5
Terminal Storage Mini Hydro Power Station	Hydro – gravity	Water	2.5
Vibe Bordertown	Compression reciprocating engine	Diesel	4
Wingfield 1 Landfill Gas Power Station	Spark ignition reciprocating engine	Biogas	4.12
Wingfield 2 Landfill Gas Power Station	Spark ignition reciprocating engine	Biogas	4.12

Amcor Glass, Gawler Plant became de-registered from the NEM effective 1 January 2016. Highbury Landfill Gas Power Station and Tea Tree Gully Landfill Gas Power Station became de-registered from the NEM effective 19 June 2016.

Table 22 South Australian small rooftop PV non-scheduled generating systems for 2017

Name of project	Capacity (MW)
Adelaide Zoo Solar System	0.15
Bianco Construction Supplies Solar System	0.2
Bianco Precast Solar System	0.2
KJM Contractors Solar	0.5
Living Choice Fullarton Solar	0.2
Redmud Green Energy 1	0.19
Redmud Green Energy 2	0.19
Redmud Green Energy 3	0.19
Redmud Green Energy 4	0.6
Redmud Green Energy 5	0.21
Renmark Self Storage	0.18
S.G.U. Deemed Solar	4.38

APPENDIX B. GENERATION INCLUDED IN REPORTING

Table 23 presents the name, dispatchable unit identifier (DUID), energy source, and nameplate and registered capacity of the scheduled, semi-scheduled, and significant non-scheduled generating systems used in this report's analysis. They make up the generation used in operational¹⁰² generation, consumption, and demand analysis in this report. SNSG and embedded generation are discussed in Appendix A.3.2.

A generating system's registered capacity is the nominal MW capacity registered with AEMO. The registered capacity is often the same as a generating system's nameplate capacity. Nameplate capacity represents the maximum continuous output or consumption in MW, as specified by the manufacturer, or as subsequently modified. Nameplate capacity can change for a number of reasons, such as upgrade projects, age, or a review of performance.

Table 23 South Australian generating systems and capacities included in reporting

Generating system	Current DUID(s)*	Energy source	Nameplate capacity (MW)	Registered capacity (MW)
Scheduled generating systems				
Angaston**	ANGAST1	Diesel	50	50
Dry Creek	DRYCGT1, DRYCGT2, DRYCGT3	Gas	156	156
Hallett GT	AGLHAL	Gas	228.3	205.6
Ladbroke Grove	LADBROK1, LADBROK2	Gas	80	80
Lonsdale***	LONSDALE	Diesel	20.7	20
Mintaro	MINTARO	Gas	90	90
Osborne	OSB-AG	Gas	180	180
Pelican Point	PPCCGT	Gas	478	478
Port Lincoln GT	POR01, POR03	Diesel	73.5	73.5
Port Stanvac***	PTSTAN1	Diesel	57.6	57.6
Quarantine	QPS1, QPS2, QPS3, QPS4, QPS5	Gas	224	224
Snuggery	SNUG1	Diesel	63	63
Torrens Island A	TORRA1, TORRA2, TORRA3, TORRA4	Gas	480	480
Torrens Island B	TORRB1, TORRB2, TORRB3, TORRB4	Gas	800	800

¹⁰² Operational reporting includes the electrical energy supplied by scheduled, semi-scheduled, and significant non-scheduled generating units. It does not include the electrical energy supplied by small non-scheduled generating units or rooftop PV. On a regional basis, as in this South Australian report, it also includes net interconnector imports for the state.

Generating system	Current DUID(s)*	Energy source	Nameplate capacity (MW)	Registered capacity (MW)
Semi-scheduled generating systems				
Clements Gap Wind Farm	CLEMGPWF	Wind	56.7	57
Hallett 1 (Brown Hill) Wind Farm	HALLWF1	Wind	94.5	94.5
Hallett 2 (Hallett Hill) Wind Farm	HALLWF2	Wind	71.4	71.4
Hallett 4 (North Brown Hill) Wind Farm	NBHWF1	Wind	132.3	132.3
Hallett 5 (The Bluff) Wind Farm	BLUFF1	Wind	52.5	52.5
Hornsedale Stage 1 Wind Farm	HDWF1	Wind	102.4	102.4
Hornsedale Stage 2 Wind Farm	HDWF2	Wind	102.4	102.4
Lake Bonney Stage 2 Wind Farm	LKBONNY2	Wind	159	159
Lake Bonney Stage 3 Wind Farm	LKBONNY3	Wind	39	39
Snowtown Wind Farm	SNOWTWN1	Wind	98.7	99
Snowtown Stage 2 Wind Farm	SNOWNTH1, SNOWSTH1	Wind	270	270
Waterloo Wind Farm	WATERLWF	Wind	131	131
Significant non-scheduled generating systems				
Canunda Wind Farm	CNUNDAWF	Wind	46	46
Cathedral Rocks Wind Farm	CATHROCK	Wind	66	66
Lake Bonney Wind Farm	LKBONNY1	Wind	80.5	80.5
Mount Millar Wind Farm	MTMILLAR	Wind	70	70
Starfish Hill Wind Farm	STARHLWF	Wind	34.5	34.5
Wattle Point Wind Farm	WPWF	Wind	90.8	90.75

* Some generators have used different DUIDs historically.

** Angaston was scheduled from 2004 to 2012, was then non-scheduled but still reportable, and became a scheduled generator again on 27 May 2016.

*** Lonsdale and Port Stanvac became scheduled generators on 12 January 2016.

MEASURES AND ABBREVIATIONS

Units of measure

Abbreviation	Unit of measure
GW	Gigawatt
GWh	Gigawatt hour
Hz	Hertz
Hz/s	Hertz/second
kW	Kilowatt
MW	Megawatt
MWh	Megawatt hour

Abbreviations

Abbreviation	Expanded name
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AGC	Automatic Generation Control
ARENA	Australian Renewable Energy Agency
CER	Clean Energy Regulator
COP21	21 st Conference of Parties
CPI	Consumer Price Index
DER	Distributed energy resources
DSP	Demand side participation
DUID	Dispatchable unit identifier
ESCOSA	Essential Services Commission of South Australia
ESOO	Electricity Statement of Opportunities
EV	Electric vehicle
FCAS	Frequency control ancillary services
FOS	Frequency operating standards
GPG	Gas-powered generation
GSP	Gross state product
LGC	Large-scale generation certificate
LRC	Low Reserve Condition
LRET	Large-scale renewable energy target
MD	Maximum demand
NEFR	National Electricity Forecasting Report
NEM	National Electricity Market
NER	National Electricity Rules
NSCAS	Network support and control ancillary services
NTNDP	National Transmission Network Development Plan
OFGS	Over-frequency generation shedding
OSNSG	Other small non-scheduled generation
POE	Probability of exceedance



Abbreviation	Expanded name
PV	Photovoltaic
PVNSNG	Photovoltaic small non-scheduled generation
RIT-T	Regulatory Investment Test – Transmission
ROCOF	Rate of change of frequency
SA	South Australia
SAER	South Australian Electricity Report
SAHMIR	South Australian Historical Market Information Report
SAPN	SA Power Networks
SARER	South Australian Renewable Energy Report
SNSG	Small non-scheduled generation
SPS	Special protection scheme
STC	Small-scale Technology Certificates
TNSP	Transmission Network Service Provider
UFLS	Under-frequency load shedding
USE	Unserved energy
VIC	Victoria
VRET	Victorian Renewable Energy Target
WEM	Wholesale Electricity Market (in Western Australia)

GLOSSARY

The 2017 SAER uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified. Other key terms used in the 2017 SAER are listed below.

Term	Definition
as-generated	A measure of demand or energy (in megawatts (MW) and megawatt hours (MWh), respectively) at the terminals of a generating system. This measure includes consumer load, transmission and distribution losses, and generating system auxiliary loads.
black system	The absence of voltage on all or a significant part of the transmission system or within a region during a major supply disruption affecting a significant number of customers.
capacity factor	The output of generating units or systems, averaged over time, expressed as a percentage of rated or maximum output.
contingency FCAS	Contingency FCAS is enabled to correct the generation/demand balance following a major contingency event, such as the loss of a generating unit or major industrial load, or a large transmission element.
COP21	Paris 21 st Conference of Parties, 2015, where countries including Australia committed to emissions reduction targets. Australia set a target to reduce carbon emissions by 26% to 28% below 2005 levels by 2030. The Council of Australian Governments (COAG) Energy Council has stated that a 28% reduction from 2005 levels by 2030 is an appropriate constraint for AEMO to use in its ongoing forecasting and planning processes. AEMO analysis suggests that meeting the COP21 commitment is likely to require both generation withdrawals and investment in low-emission generation capacity.
feed-in tariff	A tariff paid to consumers for electrical energy they export to the network, such as rooftop PV output that exceeds the consumers' load.
frequency control ancillary services (FCAS)	Used by AEMO to maintain the frequency on the electrical system, at any point in time, close to fifty cycles per second as required by the NEM frequency standards.
generating capacity	Amount of capacity (in megawatts (MW)) available for generation.
generating unit	Power stations may be broken down into separate components known as generating units, and may be considered separately in terms (for example) of dispatch, withdrawal, and maintenance.
Heywood Interconnector	The Heywood Interconnector is a connection between the Victorian and South Australian power systems. It consists of two 275 kV AC electricity transmission lines, between Heywood Terminal Station in Victoria and South East Switching Station in South Australia. Following the completion of upgrade works currently underway, it will have a rated capacity of 650 MW power transfer in either direction.
installed capacity	The generating capacity (in megawatts (MW)) of the following (for example): <ul style="list-style-type: none"> • A single generating unit. • A number of generating units of a particular type or in a particular area. • All of the generating units in a region. Rooftop PV installed capacity is the total amount of cumulative rooftop PV capacity installed at any given time.
interconnector power transfer capability	The power transfer capability (in megawatts (MW)) of a transmission network connecting two regions to transfer electricity between those regions.
large-scale generation certificates (LGCs)	Under the LRET target, generators are awarded large-scale generation certificates (LGCs) by the Clean Energy Regulator for every MWh of renewable energy they produce, and sell these LGCs in a market to RET-liable entities, who must meet a yearly target for certificates to cover their electricity purchases.
large-scale renewable energy target (LRET)	The LRET, as amended in 2015, is set as 33,000 GWh of utility-scale renewable generation in Australia by 2020, compared with 1997 levels.
load factor	This is a measure of MD relative to annual consumption; the lower the load factor, the greater the difference between average hourly energy and MD.
Low Reserve Condition (LRC)	When AEMO considers that a region's reserve margin (calculated under 10% Probability of Exceedance (POE) scheduled and semi-scheduled maximum demand (MD) conditions) for the period being assessed is below the reliability standard.

Term	Definition
nominal dollars	The actual price in dollars at the time a cost was incurred, without any CPI adjustment. See real dollars.
non-scheduled generation	Generation by a generating unit that is not scheduled by AEMO as part of the central dispatch process, and which has been classified as a non-scheduled generating unit in accordance with Chapter 2 of the NER.
operational consumption	This includes all residential, commercial, and large industrial consumption, and transmission losses (as supplied by scheduled, semi-scheduled and significant non-scheduled generating units). Significant non-scheduled generation means: <ul style="list-style-type: none"> • Wind generators greater than 30 MW, • Generators treated as scheduled generators in dispatch, • Generators that are required to model network constraints, and • Generators previously classified as scheduled.
payback period	The time required for the return on an investment to equal the original investment amount.
probability of exceedance (POE) maximum demand	The probability, as a percentage, that a maximum demand (MD) level will be met or exceeded (for example, due to weather conditions) in a particular period of time. For example, for a 10% POE MD for any given season, there is a 10% probability that the corresponding 10% POE projected MD level will be met or exceeded. This means that 10% POE projected MD levels for a given season are expected to be met or exceeded, on average, 1 year in 10.
real dollars	An adjusted price in dollars, as referenced from a particular period in time. In this report, CPI is the basis for adjustment. See nominal dollars.
reliability standard	The power system reliability benchmark set by the Reliability Panel. The current reliability standard for generation and inter-regional transmission elements in the national electricity market is a maximum expected unserved energy (USE) in a region of 0.002% of the total energy demanded in that region for a given financial year.
regulation FCAS	Regulation FCAS is enabled to continually correct the generation/demand balance in response to minor deviations in load or generation. There are two types of regulation FCAS: <ul style="list-style-type: none"> • Raise (used to correct a minor drop in frequency). • Lower (used to correct a minor rise in frequency).
scenario	A consistent set of assumptions used to develop forecasts of demand, transmission, and supply.
scheduled generation	Generation by any generating unit that is classified as a scheduled generating unit in accordance with Chapter 2 of the NER.
semi-scheduled generation	Generation by any generating unit that is classified as a semi-scheduled generating unit in accordance with Chapter 2 of the NER.
sent-out	A measure of demand or energy (in megawatts (MW) or megawatt hours (MWh), respectively) at the connection point between the generating system and the network. This measure includes consumer load and transmission and distribution losses.
small non-scheduled generation	This represents non-scheduled generating units that typically have a capacity less than 30 MW.
summer	Unless otherwise specified, refers to the period 1 November – 31 March.
synchronous generation	The output from a synchronous generating unit, which is an alternating current generator typical of most thermal and hydro (water) driven power turbines which operate at the equivalent speed of the frequency of the power system in its satisfactory operating state.
transmission losses	Electrical energy losses incurred in transporting electrical energy through a transmission network.
winter	Unless otherwise specified, refers to the period 1 June – 31 August.