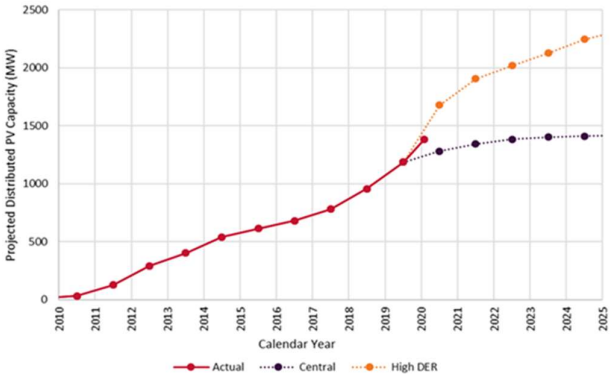
Managing South Australia's energy transition

Australia's energy system is continuing its rapid transition from one built around large-scale centralised synchronous generation to one that is ever more dispersed, weather-dependent and increasingly led by consumers. As a nation, we lead the world in the uptake and utilisation of distributed energy resources (DER), most commonly solar PV, going from 100,000 systems in 2010 to more than 2.2 million at the start of 2020. In the next decades we anticipate continued growth in these resources and increased use of batteries and other storage devices, including electric vehicles.

The changing power system

While this rapid DER uptake allows a new and exciting household-level of energy market participation that can provide substantial economic benefits to consumers, its full economic and environmental value will only be realised when distributed solar PV, including both commercial and household systems, as well as new investments in storage and other smart devices, can be relied on and participate fully as an resource in an integrated power system. Current regulatory and market structures governing DER including solar PV are inefficient both economically and operationally to accomplish this outcome.

Figure 1 Actual/projected capacity of solar PV in SA

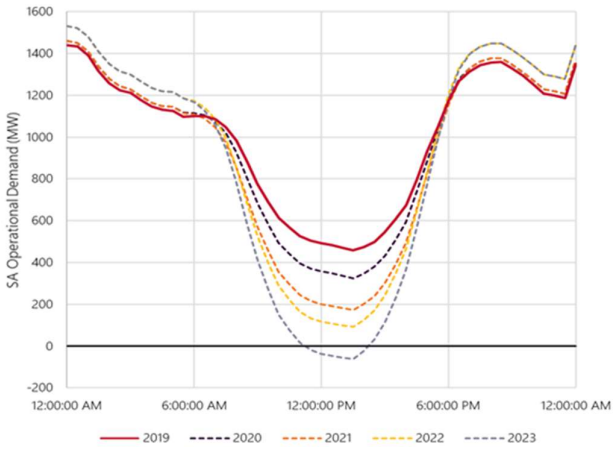


The latest installation data for solar PV, which includes the period up to May 2020, indicates solar PV is growing faster than projected in the Draft 2020 Integrated System Plan's (ISP) Central scenario and at a rate closer to that projected in the High DER scenario. For the 2019 year, 219 MW of solar PV was added to the network.

The need for appropriate regulatory and market instruments is particularly true in Western Australia, where the government has recently published a regulatory and market roadmap for DER integration, and SA, which is at the forefront of the nation's energy transition. Solar PV in SA currently has the capability to provide close to 1 GW of energy under the right conditions (Figure 1), making "consumer" power by far SA's single biggest generator. To put that into perspective, this already world-leading level of solar PV uptake increased by a record 219 MW last year – equivalent to the size of one unit of the state's largest gas-fired power plant.

As levels of solar PV grow across the National Electricity Market (NEM), the demand supplied from large, centralised generators (operational demand) continues to decline, especially during the middle of the day. While this is particularly advanced in SA, where minimum operational demand reached a record low of 458 MW last year (see Figure 2), all Australian states will need to manage this scenario in coming years.

Figure 2 Effect on SA net operational demand from increasing solar PV generation



The 2019-20 (to date) minimum operational demand of 458 MW occurred at 1:30 pm AEST on 10 November 2019. Figure 2 shows this operational demand projected forward with an annual solar PV growth rate of 219 MW (seen in 2019). On this basis, SA operational demand in the middle of the day is projected to continue to decrease as solar PV levels increase, potentially reaching zero in the next two to three years.

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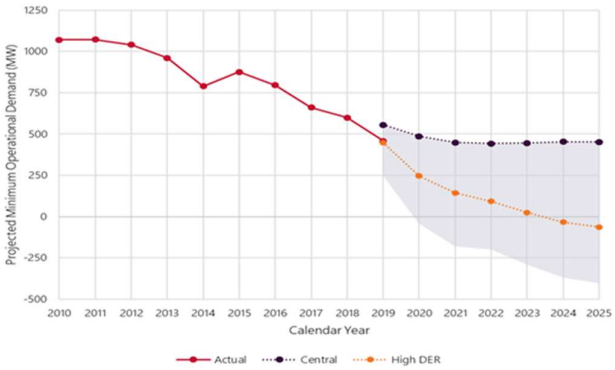
AEMO projections show that visible operational energy demand (net demand) in SA could reach zero and even become negative for some time periods in the next three to four years (see Figure 3).

To AEMO's knowledge, SA is the first large-scale power system in the world to approach zero net operational energy demand – even for very short time periods - due to high proportions of demand being met by solar PV.

Figure 3 Minimum operational demand for SA



It is important to consider the absolute minimum possible demand that could be achieved in each year, so that SA's power system can be prepared. For this purpose, the historic weather and underlying demand conditions of October 2, 2017 were used, with solar PV generation scaled up according to forecast capacity. The conditions on this day typify an extreme low minimum demand day: it was a public holiday with mild temperatures and clear skies. The resulting range of possible minimum demand levels is shown in the shaded grey area which shows that under the most extreme conditions, with ongoing solar PV growth as per the High DER scenario, operational demand in SA could reach zero as soon as later this year.

Changing system security requirements

Under current solar PV uptake projections, a range of novel system security requirements are becoming prevalent across NEM regions and Western Australia's Wholesale Energy Market (WEM), including:

- A progressively larger component of energy generation for which there is limited visibility and control, and which can at times compromise AEMO's ability to keep the power system secure from events that can result in system-wide black outs;
- An erosion of daytime energy system demand that results in that emergency mechanisms that are designed to manage the impact of major disruptions (such as the impact of bushfires on transmission lines) will not be effective and further, AEMO's ability to perform essential energy security functions, such as system restart will be compromised; and
- A need to develop forecasting and advanced decisional tools, including digitalisation, AI and machine learning, to increase situational awareness and manage the volume of data and increasing complexities of relying on weather and climatic conditions, as well as individual human behaviour, as components of forecasting and operating the power system.

AEMO is collaborating across the NEM and WEM with government and industry stakeholders to develop market and regulatory structures that can efficiently and economically manage and resolve the technical and operational implications of Australia's accelerating uptake of solar PV. AEMO's intention is to help ensure affordable and reliable electricity and a market design that supports consumer participation and innovation throughout the value chain.

At the request of the SA Government, AEMO has completed a technical report focusing on the current operational challenges arising from the rapid increase of solar PV in South Australia.

The report focuses on issues arising during high solar PV generation periods which coincide with low demand periods, as well as scenarios such as operating the SA grid when islanded (electrically separated from the NEM).

Given the novel nature of power system operation under these conditions, AEMO's work to explore energy system security will be ongoing and will increasingly include other jurisdictions as these challenges are experienced across all regions of the NEM.The SA Government, along with South Australian Power Networks (SAPN), ElectraNet and AEMO, is already undertaking a number of measures to address these risks. AEMO's technical analysis also shows that many of the security challenges either will be dramatically reduced or removed altogether if the proposed interconnector, EnergyConnect, is constructed and commissioned.

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The economic benefits to consumers from a highly distributed energy system are jeopardised if efficient security measures are not available. In this context, the security benefits associated with Project EnergyConnect are now critical for SA. If Project EnergyConnect and new smart standards for rooftop solar do not proceed, customers will be at an economic disadvantage since the power system will not be able to take full advantage of the benefits obtained through effective integration of DER into the wider power system.

Perhaps even more concerning is the adverse impact of the absence of sufficient power system security measures for consumers. If these measures are not in place and the ability for AEMO to maintain secure operations is in jeopardy, we will be compelled to ask governments to consider a moratorium on new rooftop solar installations as well as other more expensive interventions to maintain power system security. Measures such as these would of course be averse to our objectives of supporting competitive markets and innovation to support the economic and environmental interests of Australian energy consumers.

AEMO' technical report details two current issues in SA that need to be addressed:

- **The disconnection of solar PV inverters when there are severe faults on the transmission network** – analysis shows that a fault near the Adelaide metropolitan area could cause disconnection of up to half the solar PV in the SA region. For instance, if a large generator tripped off, there is significant risk of large amounts of solar PV "shaking off," significantly exacerbating the initial event. This creates numerous challenges for AEMO in planning for and dealing with faults. Managing this risk would become increasingly costly for consumers as more solar PV connects. Eventually, the impact could become unmanageable and potentially lead to cascading failure in the electricity system that cannot be arrested resulting in a major outage or 'black system'.
- **The reduced ability to retain a minimum level of operational demand during the day** – the lowest operational demand periods in SA now occur in the middle of the day on mild-temperature, sunny days and particularly on weekends and public holidays. Maintaining a certain level of operational demand is particularly important if SA is to operate while separated from the NEM. Without the ability to curtail solar PV generation, AEMO has very few tools available to manage the supply-demand balance. Faults under these circumstances could lead to a 'black system'.

It is important to note that that the above situations will only appear when there is a rare combination of circumstances, including a separation event such that requires SA to be operated as an electrical island at a period with very low operational demand and a severe fault occurring in or close to the Adelaide area.

While these circumstances may only occur extremely rarely, it should be noted that recent extreme weather events and unforeseen technical incidents have resulted in South Australia being electrically islanded five times in the past three years, and for an extended period in January 2020.

AEMO's technical report is an extensive and detailed consideration of the capability of SA's network to operate under these challenging (and extreme) scenarios.

Immediate measures to address system security

In collaboration with local distribution and transmission utilities, AEMO recommends the following measures be delivered and/or agreed to prior to spring 2020:

- Improve DER performance standards, so solar PV can "ride-through" disturbances, better support grid security and provide enhanced technical capability;
- Implement increased capabilities for solar PV – including enhanced voltage management to enable emergency controls for new solar PV installed in SA. These controls would only be used as a last-resort measure under extreme conditions to prevent system collapse and avoid a 'black system';
- Adapt operational practices such as network constraints, interconnector limits and network outage planning to incorporate new insights on successful DER integration;

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- Expand and continue to invest in the network – greater interconnection between regions helps make the grid more robust to disturbances. The proposed EnergyConnect project will dramatically increase SA's grid resilience by significantly reducing the risk of islanding;
- Improve frequency control arrangements - fully integrating available technologies such as battery storage;
- Improve network emergency mechanisms and tools - ensuring they are robust and function properly during any high solar PV or low demand condition; and
- Coordinated stakeholder engagement with customers, industry participants and the community - to transparently share identified system security risks and consider proposed mitigation approaches. Consistent and transparent information from AEMO, the SA Government, SAPN, ElectraNet, the ECA, the Energy Security Board, the AER, the AEMC and other key decision makers is required.

AEMO considers each of these actions to be required for DER to support full consumer choice and economic benefit. Further, not making any changes is not a realistic option. If we fail to make the changes required for DER integration, the requisite alternative measures will be to limit new solar installations and costly retrofits of existing installations. Further, protective and more costly measures of this kind will become increasingly likely if Energy Connect is not constructed and commissioned consistent with current project timelines.

National frameworks

Beyond the near-term measures outlined above, holistic NEM-wide policy frameworks for successful integration of DER are required. These will include various reforms underway as part of the Energy Security Board's 2025 market design and the development of ahead and two-way energy markets.

Next steps

AEMO is continuing to collaborate with the SA Government, SAPN and ElectraNet in developing and executing a detailed plan to deliver these actions. AEMO will continue working with these and other stakeholders to maintain a secure, reliable and affordable power system for all SA consumers and market participants.

AEMO will also be publishing a technical guide to inform the capabilities and technical standards needed to successfully integrate DER, including solar PV, across the entire network and is extending this analysis to other jurisdictions.