How South Australia can function reliably while moving to 100% renewable power

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Peak energy demand sometimes occurs when there's no wind. Credit: Shutterstock

Despite the criticism levelled at South Australia over its renewable energy ambitions, the state is nevertheless aiming to be carbon neutral by mid-century, which will mean moving to 100% renewable electricity over the next 15-20 years.

The biggest challenge will be meeting the 2-3 hours of peak demand during the evenings, when wind generation happens to be low. This will require a mix of different technologies and strategies, including solar, wind, storage, and possibly a new interconnector to New South Wales.

The issue is the variable nature of some renewable energy technologies – wind turbines only generate electricity when there's sufficient wind, solar panels when the sun shines. But peaks in demand occasionally coincide with periods of low renewable generation, as was the case during the heatwave a few weeks ago. Although sufficient gas-fired generated capacity existed to pick up the slack, it was not all available at the time and short, localised blackouts were implemented.

Without strategic preparation, these events are going to be more difficult to handle in future as wind and solar farms grow, especially if the interconnector between SA and Victoria fails at a critical time.

But here are some of the things we can do in the short term (the next 2-3 years) and medium term (the coming decade) to create a reliable system on the path to 100% renewable electricity.

The short-term

The key point is that the challenging periods will be infrequent and only last for a few hours. Coal or nuclear power stations, which operate best when run continuously at full power, are too inflexible in operation to pick up the slack at peak demand. They would also be too expensive, hazardous and slow to construct.

In the short term, then, we need to install options that are flexible and dispatchable (i.e. able to generate when required). The options include open-cycle gas turbines (OCGTs), preferably each with a dedicated gas storage; concentrated solar thermal power with thermal storage (CST); and batteries. With the right policies these technologies could make significant contributions to peak supply within 2-3 years.

Currently 320 megawatts of OCGT capacity have been proposed for SA. These generators have the advantage of low capital cost and, as they would be operated infrequently, low annual operating cost. They can be started from cold in about 10 minutes, compared with up to a day for coal power. OCGT owners would be compensated for keeping their units on standby, ready to go when we need it. OCGTs are also sustainable when they operate on renewable fuels – biofuels, hydrogen and ammonia.

There are already several proposals for CST power stations near Port Augusta. Initially about 100MW could be installed. Subsequently, as the global CST market expands and the cost declines, more modules could be added. To use CST for evening peak demand periods, we would need to pay a time-variable feed-in tariff or a contracted price that is highest for supply during those periods.

Battery prices are declining rapidly as mass production takes off, so they could also make a significant short-term contribution. Together with solar panels on both residential and commercial rooftops, batteries could help reduce the overall demand on the grid. Residential and commercial solar owners should be given incentives to install batteries by raising electricity prices during peaks in demand, thus increasing the economic savings from self-consumption and the benefit of feeding-in any excess power generated.

While extra solar and wind farms should be constructed, they should also be balanced by flexible, dispatchable renewable electricity generation. To drive the implementation of CST and large batteries in the absence of federal government support, SA could hold reverse auctions, as Canberra does.

To offset, at least partially, increased peak electricity prices and to help electricity users reduce unnecessary demand, state and federal governments should also expand their energy-efficiency programs.

The medium term

Globally, we are at the beginning of a transition to "smart" grids, in which demand for electricity can be modified almost instantaneously by both the customer and the utility. For the utility to do this, a contract is needed to reward customers for being occasionally and partially "offloaded" (that is, having your air conditioning, refrigerator, or hot water turned off for a short period of time). Currently, only some huge electricity consumers such as aluminium smelters are subject to offloading.

For this to be expanded to residential and smaller commercial customers, we need some kind of "smart" switch. These would be operated remotely, turning off supply to electricity-hungry appliances. While the technologies already exist for smart demand reduction, it could take 5-10 years to mass-produce and roll them out on a large scale.

The cheapest form of electricity storage for the grid is pumped hydro. This is where excess electricity generated during off-peak periods – for instance by wind and solar in the middle of the day – is used to pump water from a low to a high reservoir. During peak periods, the water is then released from the upper reservoir and flows through a turbine, generating electricity.

Pumped storage is well established and can even be found on the Tumut River as part of the Snowy Mountains hydroelectric scheme. Although SA has negligible potential for hydro based on rivers, it appears to have considerable potential for pumping seawater up into many small reservoirs in coastal hills. A research group, led by Andrew Blakers at ANU and funded by ARENA, is investigating this.

Another option is to build a new transmission line to join SA directly to eastern New South Wales via Broken Hill. Although such a line could take a decade to plan and build, and would be expensive, it would make the National Electricity Market grid more resilient and controllable, and would link up renewable energy generation in South Australia (wind and possibly future geothermal) and western NSW (solar and wind) with demand centres in the east. Since it would be valuable national infrastructure, the cost could be shared between the federal and state governments.

A 100% renewable future

Over the next 20 years it is entirely feasible for SA to aim for 100% continuous renewable electricity. The important requirements for reliability and stability are a diverse set of renewable energy sources, especially a balanced mix between variable and flexible-dispatchable technologies, storage, geographic dispersion of wind and solar farms, smart demand management, energy efficiency and possibly a new interconnector joining SA and NSW.

Furthermore, CST, OCGTs, batteries with appropriate inverters, and synchronous condensers can all contribute to a stable and 100% renewable SA.

As a driver of long-term investment, a national carbon price that steadily increases to a high level would compensate for the environmental costs of burning fossil fuels. Furthermore, the Renewable Energy Target (RET) should be extended from 2020 to 2030 and increased in scale. We should also create separate targets for CST with thermal storage and large-scale storage. Finally, the NEM Objective and several of its rules will have to be changed.

However, even without national drivers, SA could transform its grid to one that is renewable, reliable and affordable – in the process showing other states how it can be done.

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