South Australian Government Submission
Inquiry into Modernising Australia's Electricity Grid

1. Introduction

South Australia's electricity network, like those in other Australian states, was originally constructed to deliver electricity generated by centralised, thermal plants to consumers. The role of networks and the markets that support them is necessarily changing as Australia transitions to a carbon constrained future. This is happening in South Australia ahead of other National Electricity Market (NEM) regions.

South Australia's electricity generation mix is changing rapidly. In the last 15 years, renewable generation has grown from a negligible amount to provide 43 per cent of local electricity generation in 2015/16. Since the end of coal-fired generation in South Australia in 2016, supply has increasingly relied on gas, diesel and small non-scheduled generators and on imports across the Heywood and Murraylink interconnectors.

Demand is also changing. Overall electricity consumption and maximum demand are declining, and South Australia faces the prospect of future occasional negative demand. The Australian Energy Market Operator (AEMO) forecasts that operational electricity consumption in South Australia will decline by 0.7 per cent per annum over the 10 years from 2015/16 to 2025/26.

These changes necessitate modernisation of the electricity network, and in the markets and regulatory frameworks that support it. Our submission draws on the South Australian experience to address the Inquiry's terms of reference. It does so in three sections. The first outlines drivers for modernisation of our electricity network, markets and regulatory frameworks. The second outlines the South Australian response. The third outlines relevant national reviews and recommends them to the Committee.

We acknowledge that the Committee considers the appropriate mix of electricity generation and the emissions intensity of the electricity sector to be outside its terms of reference. It is important to note that in recent years, there has been a lack of national leadership on energy policy, particularly over the question of a price on carbon. This uncertainty has led to a lack of investment in new electricity generation while unviable coal-fired power stations have been closing across the country. The South Australian Government has advocated for a national Emissions Intensity Scheme to drive investment in cleaner energy sources, such as gas and renewables. An Emissions Intensity Scheme is supported by businesses, industry groups and energy experts, but not Prime Minister Malcolm Turnbull, despite previous support of the policy. We therefore submit that clear national policy settings that have as their centrepiece an emissions intensity scheme are needed to guide modernisation of the electricity grid.

2. Drivers for modernisation

In this section, we set out features of South Australia's transition to a low carbon future, and explain how they drive the need to modernise the electricity grid.

Changing generation mix
South Australia's electricity generation mix is changing rapidly. The first wind farm in South Australia was built in 2003. By 2015/16, wind accounted for 35 per cent of local electricity generation. Rooftop photovoltaic (PV) generation has grown from a negligible amount in 2008/09, to provide 8 per cent of local electricity generation in 2015/16.

The rise of renewable generation has been accompanied by the closure of South Australia's only coal-fired power stations. The Playford and Northern Power Stations in Port Augusta ceased generation in May 2016. Since the closure, supply has increasingly relied on gas generation and diesel and small non-scheduled generators, particularly during times of low wind. Availability of gas generation has been affected by limited gas supply and high gas prices. Overall, there has been decreased availability of local synchronous power stations. There has also been increased reliance on imports across the Heywood and Murraylink interconnectors. Closure of interstate generators such as Hazelwood Power Station puts further pressure on interconnection supply.

These changes present a challenge to maintenance of adequate system security services. A primary issue with the shift in generation mix is degradation of power system inertia[1]. Other issues are:

- deteriorating system strength[2] at localised points in the network
- reduced capability of emergency frequency protection schemes
- difficulty with more variability and uncertainty of supply.

Declining overall electricity consumption

These changes are occurring in the context of declining overall electricity consumption, and declining maximum demand. AEMO forecasts that operational electricity consumption in South Australia will decline by 0.7 per cent per annum over the 10 years from 2015/16 to 2025/26. Electricity consumption is falling because of flat business sector consumption, energy efficiency improvements, consumer response to electricity price increases, and high rooftop PV uptake.

Rooftop photovoltaic uptake

South Australia's high penetration of rooftop PV presents some particular challenges to the distribution network. Rooftop PV peak output during daylight hours does not neatly match the peak demand periods which occur late afternoon and early evening. Therefore, while rooftop PV can reduce a site's overall electricity consumption, it does not necessarily reduce the network capacity required to service it. Nor does it reduce the costs of maintaining that capacity, which are ultimately shared amongst all consumers.

A further challenge is managing output of rooftop PV during times when demand is already low. In South Australia, minimum demand generally occurs on a sunny day between 1 November and 31 March, typically on a public holiday. AEMO forecasts show minimum demand declining over time and becoming negative under certain conditions, such as when low demand and high rooftop PV output coincide, by 2026/27. Negative demand has already occurred in South Australia, at the Kadina East transmission connection point, on 25 December 2014.

Very low or negative demand contributes to system security issues, specifically with voltage regulation. Addressing this issue may require network investment in the form of new voltage regulation systems at substations originally designed for one-way flows of electricity.

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[1] System inertia, provided by spinning generators and other devices synchronised to the frequency of the grid, is the ability of the power system to resist changes in frequency arising from unexpected losses of generation, load or transmission lines until such time as the supply-demand balance can be restored.

[2] System strength is a measure of the resilience of the power system in response to a power system short-circuit fault and is typically quantified using fault levels (maximum current in response to a short circuit measured in MVA or kA) and short circuit ratios (ratio of the Fault MVA/Rated MVA at a given point on the network). Reduced system strength in certain areas of the network may mean generators are no longer able to meet technical standards in those areas and may be unable to remain connected to the power system at certain times. Further issues with network protection settings and voltage stability may arise.

Reliance on interconnection
The Heywood (currently 600MW) and 220MW Murraylink interconnectors connect South Australia with the eastern states in the NEM. Through these interconnectors, South Australia imports electricity at times of high demand and low wind, and to a lesser extent, exports renewable generation.

Interconnection contributes to supply diversity, important in systems with high amounts of renewable generation. It also contributes to system strength by allowing system security services, particularly inertia, to be shared across NEM regions. With decreasing availability of local synchronous power stations there is increasing reliance on interconnection to provide inertia. Reliance on limited interconnection for system security services, however, leaves little room for redundancy.

Ongoing change
With the advent and expansion of wind generation, South Australia's networks have had to accommodate new, large-scale generators in new locations. Reporting by AEMO shows continuing wind development and large-scale PV development. At February 2017, AEMO list four large-scale solar projects ranging in capacity from 100MW – 220MW under development in South Australia. At the same time, grid-scale and embedded batteries are on the brink of widespread deployment.

Extreme weather
In 2016 South Australia experienced an unprecedented period of extreme weather and associated power outages. This has drawn attention to costs of repairing weather-related damage to networks, and to how networks might be designed to avoid weather damage. The matter of maintaining reliability in extreme, infrequent events, is one that requires careful consideration due to associated costs.

The state-wide power outage of 28 September 2016 warrants particular mention. On 28 September 2016, extreme weather damaged three major transmission lines. In response to the storm damage, protection systems at nine wind farms activated and their output was reduced. This led to increased flow on the Heywood interconnector to the point that it tripped, islanding South Australia from the NEM.

South Australia's frequency then reduced more quickly than load shedding schemes could respond. Remaining generation was much less than demand and shut down, resulting in a black system event in South Australia. Recommendations from subsequent investigations, including by the AEMO have formed part of the South Australian response.

3. South Australian response

The changes outlined above are driving the need to modernise the electricity network and the markets and regulatory frameworks that support it. In the absence of clear, consistent national policy settings to guide modernisation, South Australia is taking its own action to ensure energy affordability, reliability and security.

South Australian Government action
Action by the South Australian Government to ensure energy affordability, reliability and security is set out in the 14 March 2017 South Australian Energy Plan. It includes:

- Building a government-owned 250MW gas-fired generator to provide inertia for system security at all times, including when the generator is not providing electricity to the market, and to provide electricity at times of emergency for reliability of supply.

- Building Australia's largest grid-scale battery to provide 100MW of storage to manage dispatchability of intermittent renewable generation and provide system security services. This project, and others, will be supported through the $150 million Battery Storage and Renewable Technology Fund.

- Introducing new Ministerial powers to direct the market to operate in the interests of South Australians. This includes powers to direct generators to operate and direct AEMO to control flows on the Heywood interconnector in the case of an electricity supply shortfall.

- Incentivising increased gas production to ensure more of our State's gas is sourced and used in South Australia. This involves a second $24 million round of the Plan for Accelerating Exploration (PACE) gas fund to unlock gas reserves, and the new PACE Royalties Return Scheme to incentivise landholders to allow exploration.

- Introducing an energy security target to ensure our power system uses additional clean, secure, energy generated in South Australia. The scheme will require electricity retailers to source part of their requirements from generators that are synchronised and scheduled, thereby providing local security services.

- Procuring 75 per cent of the Government's electricity needs from a source that introduces new competition into the energy market, and 25 per cent of the Government's electricity needs from dispatchable renewable energy providers. Tenders for this procurement closed on 6 January 2017. The Government plans to sign contracts with successful parties by mid-2017.

In addition to the South Australian Energy Plan, the South Australian Government:

- Is contributing $500,000 towards a feasibility study conducted by ElectraNet, South Australia's transmission network service provider, to explore options for greater interconnection with eastern states.

- Implemented a new regulation that ensures the power system is operated so that, in the event of a non-credible loss of the Heywood Interconnector, the rate of change of frequency (RoCoF) does not exceed 3 Hertz per second. AEMO has implemented this regulation, as required by the National Electricity Rules (NER), by constraining the dispatch process.

- Proposed a package of NER changes to require AEMO to manage emerging security challenges. On 30 March 2017, the Australian Energy Market Commission (AEMC) made a final determination on these matters in the form of the emergency frequency control scheme rule change. Their determination is broadly consistent with the proposals made by the South Australian Government.

- Changed the National Electricity Law to enable better monitoring of the electricity wholesale market to ensure a competitive environment.

- Committed $31 million to help large South Australian businesses manage their electricity costs through the Energy Productivity Program.

Underpinning this action is the South Australian Government's continued advocacy for a national emissions intensity scheme to promote orderly transition away from emission intensive electricity generation. Lack of clear, consistent national policy in this area will adversely affect timely and efficient modernisation of the electricity grid.

The evidence supporting an emissions intensity scheme is clear. On 9 December 2016 the AEMC released their final report on the integration of energy and emission reduction policy.

It supports a market-based emissions intensity scheme as the policy capable of achieving emissions reductions at the lowest cost and with the lowest impact on prices.

Licence conditions for generators
Since 2005, the Essential Services Commission of South Australia (ESCOSA) has required technical licence conditions for wind-powered electricity generators that are more onerous than those in the NER. In June 2016, ESCOSA commenced an Inquiry into technical licence conditions for inverter-connected electricity generators, which constitutes the third review to look into whether or not technical licence conditions for wind farms should be maintained, enhanced or altered. The 2016 Inquiry includes consideration of application of conditions to other inverter connected electricity generators. A draft report is expected in May 2017 and a final report in August 2017.

In undertaking this Inquiry, ESCOSA has sought advice from AEMO, as the body responsible for maintaining the security of the NEM power system and setting its technical parameters. AEMO advised that it has not identified a case to remove the existing licence conditions, and is seeking to strengthen generator licence conditions. AEMO has provided technical details on additional requirements to be directed at all types of new generators. AEMO is also seeking changes to the NER to improve performance standards.

While the Inquiry is still underway, ESCOSA has implemented interim measures to ensure new generators do not exacerbate existing issues with respect to reduced Frequency Control Ancillary Service[3] (FCAS) availability. ESCOSA's recent generation licence approval for the Hornsdale 2 Wind Farm included two new additional technical conditions relating to frequency disturbances and provision of frequency control ancillary services. In addition, Hornsdale 2 Wind Farm has undertaken to participate in an FCAS trial and has been in discussions with AEMO regarding the parameters and timing of the trial.

System security measures & oversight
AEMO has recently introduced a set of measures to ensure system security in South Australia, as follows:

- As an interim solution for improving system strength, AEMO has put a contingency plan in place to ensure sufficient fault level available for wind generation and dynamic reactive support plant to run by directing two sufficiently large thermal synchronous generating units in South Australia to run at all times. This solution will also help enhance system inertia.
- AEMO, in conjunction with SA Power Networks and ElectraNet, redesigned the under-frequency load shedding (UFLS) scheme to utilise conventional frequency sensitive relays that operate on a frequency pre-set value plus a RoCoF measurement to trip load when a pre-set value of RoCoF is exceeded. The design is now implemented by SA Power Networks.
- AEMO, with ElectraNet, has designed an over-frequency generation shedding (OFGS) scheme to limit the frequency rise in South Australia to 52 Hertz, with the objective to coordinate the tripping of generation in a pre-determined manner by tripping low inertia generators first to maximise the inertia online following an over-frequency event. The OFGS scheme settings have been completed by ElectraNet, which is targeting the end of Q1 2017 for implementation of the scheme.

[3] AEMO procures FCAS from market participants (generally scheduled, synchronous generation) to manage minor and major frequency deviations in line with the frequency operating standards. Frequency control can be divided into *Regulation* and *Contingency* FCAS. *Regulation frequency control* is the correction of the generation / demand balance in response to minor deviations in load or generation. *Contingency frequency control* is the correction of the generation / demand balance following a major contingency event such as the loss of a generating unit/major industrial load, or a large transmission element.

Further, following the extreme weather events of 2016, AEMO has committed to more rigorous monitoring of changing weather forecasts and wind speeds, leading to improved demand forecasting and reclassification decisions.

Interconnection and its alternatives

In its 2016 National Transmission Network Development Plan, AEMO considered that to significantly reduce the risk of having insufficient system security services in South Australia, solutions to ensure that there is more redundancy and strength in the power system must be sought. AEMO modelling has shown total net market benefits from greater interconnection, if competitively priced. Specifically, it has shown net market benefits from a new interconnector between South Australia and Victoria or New South Wales from 2021.

The South Australian Government agrees with the benefits of additional interconnection. To investigate stronger interconnection the South Australian Government has provided $500,000 towards ElectraNet's South Australian Energy Transformation Regulatory Investment Test – Transmission (RIT-T). A RIT-T is required by the NER for new transmission projects with investment of more than $6 million[4].

ElectraNet's South Australian Energy Transformation RIT-T is based on the need to support energy market transition in South Australia. The Project Consultation Specification Report (PCSR), the first step in the RIT-T, identifies that stronger interconnection between South Australia and the eastern states could benefit South Australia by improving wholesale electricity market competition, power system security, and renewable energy goals.

The PCSR identifies four credible network interconnection options, all of which consist of constructing new interconnectors from South Australia to different connection points in neighbouring states. Their capacities range from 300 - 2000 MW, costs range from $500 - $2500 million, and commissioning dates from 2021 - 2022.

ElectraNet is currently seeking submissions from proponents for non-network solutions, and has released criteria that these non-network solutions must fulfil. ElectraNet is seeking proposed non-network solutions that could provide inertia, fast frequency response and/or voltage response capabilities to increase interconnector capacity and reduce risk of supply disruptions.

Potential non-network alternatives include use of batteries, demand response, synchronous condensers, or increased local generation. Each solution provides different benefits, and none materially increase the import or export capability of South Australia, and will therefore not deliver the same range of benefits of an increase in interconnection.

The commercial viability of some of these non-network solutions, particularly grid-scale batteries, is improving quickly. This will change how their benefits compare with greater interconnection. Some open NER changes have the potential to further affect their competitiveness, such as the Five Minute Settlement and the Inertia Ancillary Service Market rule changes.

The next stage of the RIT-T involves ElectraNet undertaking full economic modelling of credible network and non-network options. The results, together with the project assessment draft report (PADR), are expected to be published by June 2017.

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[4] The test is a financial cost benefit analysis for regulated electricity transmission investments seeking the most economic investment. The types of benefits included in the assessment include fuel savings, reductions in load shedding, reduced network losses and ancillary services, changes in timing of capital expenditure for participants, competition benefits (changed market behaviour) as well as benefits from providing optionality for future investment.

The RIT-T is now better able to reflect the full range of benefits interconnection offers. On 14 December 2016 the COAG Energy Council agreed to a number of improvements to the RIT-T, including

- to ensure that system security and emission reduction goals are adequately considered;
- low probability but high impact events like the South Australian system black event in September 2016 are appropriately taken into account; and
- information about transmission networks supports more effective engagement by non-network providers.

Ministers agreed the AEMC will further explore the merits of increasing AER oversight of the RIT-T.

Distributed energy resources

SA Power Networks are exploring the potential of combining rooftop PV with battery storage to manage network capacity requirements through their residential battery storage trial. The trial has involved installation of 100 residential batteries in the northern Adelaide suburb of Salisbury, and the use of energy management software. It is funded by SA Power Networks Demand Management Incentive Scheme (DMIS)[5]. Salisbury is an area with increasing demand, which SA Power Networks had expected would require $3 million of network upgrades. The purpose of the trial is to test how battery/rooftop PV combinations can be used to defer network infrastructure spending. It will run until 2019.

The South Australian Government is actively investigating the role of battery storage in embedded in the distribution network. The Government has awarded Zen Energy a $1.1 million contract to install 448.6 kWh of battery storage at three state government buildings with existing solar PV, due to be commissioned by late 2017. These installations will investigate load shifting, demand tariff reductions, and energy cost savings. The Government will share learnings with households and businesses throughout the project for the broader benefit of the South Australian energy market.

AEMO has noted its ambition to improve visibility of distributed energy resources in its Future Power System Security (FPSS) program. With the proliferation of behind-the-meter energy sources, AEMO is seeking a formal mechanism to obtain data on distributed energy resources, revised models of physical plant and modelling tools to provide accurate system information and appropriate methods of representation and aggregation (including forecasts) of distributed energy resources generation output. The objective of all such efforts is for AEMO to be able to quantify and manage the operational impacts of distributed energy resources on the power system.

3. National reviews

Jurisdictional, regulatory and operational bodies across Australia have been active in finding the necessary technical, market and regulatory frameworks to ensure that all interconnected regions of the electricity grid are in a secure operating state now and in the future. This section recommends the following national reviews to the Committee:

- The Finkel Review (Independent review of the National Electricity Market); COAG Energy Council. The COAG Energy Council has commissioned Australia's Chief Scientist, Dr Alan Finkel AO, to lead an independent review into the future security of the national electricity market. The review will develop a national reform blueprint to

[5] The DMIS is established under the NER. It incentivises DNSPs to consider infrastructure augmentation.

maintain energy security and reliability in the NEM. In December 2016, the review published its Preliminary Report as an issues paper to identify key themes and questions for open consultation to aid the design of the blueprint. A Final Report is expected in mid-2017.

- Future Power System Security Program (FPSS); AEMO. Established in December 2015, the FPSS) aims to adapt current processes to address immediate risks, and promote solutions to maintain power system security over the next 10 years.

  The FPSS focuses on four broad areas of high priority: *frequency control* (RoCoF and FCAS); *managing extreme power system conditions* (UFLS and OFGS, both especially applicable to the non-credible[6] event of the separation of the South Australian system from the rest of the NEM); *visibility of the power system* (especially of distributed energy resources); and, *system strength*.

- System Security Market Frameworks Review; AEMC. As the rule maker and market developer of the national energy markets, the AEMC has initiated the System Security Market Frameworks Review to consider required changes to the wholesale energy market frameworks to address the changing generation mix.

  The AEMC identify technical solutions in their December 2016 Interim Report and the rule change packages proposed their March 2017 Directions Paper. On 30 March 2017, the Australian Energy Market Commission (AEMC) made the emergency frequency control scheme rule change final determination. Their determination is broadly consistent with the proposals made by the South Australian Government.

- Electricity Network Economic Regulatory Framework Review; AEMC. Vital to the modernisation of the electricity grid is a regulatory framework that can deliver the National Electricity Objective (NEO)[7] as the energy market evolves.

  This review follows a 2015 stress test of the electricity network economic framework undertaken by officials at the direction of the COAG Energy Council. The stress test identified the potential for increased uptake of decentralised electricity supply options to lead to asset under-utilisation and/or stranding if network businesses do not take appropriate action to respond to these changes.

  In August 2016 the COAG Energy Council initiated this review by tasking the AEMC to monitor developments in the energy market, including the increased uptake of decentralised energy, and provide advice on whether the economic regulatory framework for electricity transmission and distribution networks is sufficiently robust and flexible to "continue to achieve" the NEO in light of these developments.

  The AEMC is required to publish its findings annually from 1 July 2017. They released an approach paper in December 2016 noting three focus areas for the 2017 report:
  - a review of the current state of the market
  - an overview of the economic regulatory framework and assessment of whether it is sufficiently flexible and robust in light of recent market changes
  - priority areas for future reforms.

In addition to these national reviews, we note rule changes underway to further promote efficient investment in network expenditure. These include the upcoming introduction of cost-reflective distribution network tariffs, and the open rule change to extend the RIT-T to

[6] Non-credible contingency events are defined in the NER, and broadly refer to events that are very rare and unexpected, such as the loss of multiple generating systems/units or multiple lines.

[7] The National Electricity Objective is to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to price, quality, safety, reliability, and security of supply of electricity; and the reliability, safety and security of the national electricity system.

relatively major network replacements on key transmission flow paths (currently an open rule change). Further, industry bodies such as the Energy Networks Association, through initiatives such as the Electricity Network Transformation Roadmap, are proactively exploring options on how electricity networks can transform to respond to the changes.

5. Conclusion

Transition to a carbon constrained future is occurring in South Australia ahead of other NEM regions. South Australia's electricity generation mix has changed quickly. The rise of renewables has been accompanied by the closure of South Australia's only coal-fired power stations. Limited gas supply and high gas prices have contributed to decreased availability of local synchronous power stations. Changes in the generation mix are set to continue, with several large-scale PV projects under development and embedded and grid-scale batteries on the brink of deployment.

These changes are driving the need to modernise the electricity network and the markets and regulatory frameworks that support it. In the absence of clear, consistent national policy settings to guide modernisation, South Australia is taking its own action to ensure energy affordability, reliability and security.

Action by the South Australian Government is set out in the 14 March 2017 South Australian Energy Plan. It includes a suite of measures to manage system security, increase competition in the wholesale electricity market to put downward pressure on prices, and improve gas supply. It also restates the South Australian Government's commitment to continued advocacy for a national emissions intensity scheme, which has widespread industry and scientific support.

Continued rapid development and commercialisation of technology presents a challenge to modernisation of the electricity network. Our submission has pointed to developments in technologies that offer partial solutions, including grid-scale batteries, synchronous condensers, and sophisticated demand response. It has also discussed managing increasing penetration of distributed energy resources.

Jurisdictional, regulatory and operational bodies across Australia have been active in investigating the necessary technical, market and regulatory frameworks to ensure that all interconnected regions of the electricity grid are in a secure operating state now and in the future. These investigations have all paid regard to the South Australian experience and we recommend them to the Committee.

Modernisation of the electricity network is needed to support Australia's transition to a carbon-constrained future. Clear national policy settings that have as their centrepiece an emissions intensity scheme are essential to this task.