Electricity

Issues paper

Inquiry into licensing arrangements under the Electricity Act 1996 for inverter-connected generators

December 2016

Request for submissions

The Essential Services Commission (**Commission**) invites written submissions on this Issues Paper by **Monday, 30 January 2017.**

It is the Commission's policy to make all submissions publicly available via its website (www.escosa.sa.gov.au), except where a submission either wholly or partly contains confidential or commercially sensitive information provided on a confidential basis and appropriate prior notice has been given.

The Commission may also exercise its discretion not to publish any submission based on length or content (for example containing material that is defamatory, offensive or in breach of any law).

Responses to this Issues Paper should be directed to:

Inquiry into licensing arrangements under the Electricity Act 1996 for inverter-connected generators

It is preferred that submissions are sent electronically to: **escosa@escosa.sa.gov.au**

Alternatively, submissions can be sent to:
Essential Services Commission
GPO Box 2605
ADELAIDE SA 5001

Telephone: (08) 8463 4444
Freecall: 1800 633 592 (SA and mobiles only)
E-mail: escosa@escosa.sa.gov.au
Website: www.escosa.sa.gov.au

Contact Officer: Con Carellas, Principal Advisor

Table of contents

Glossary of terms

AC	Alternating electric current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CoAG Energy Council	Council of Australian Governments Energy Council
Commission	Essential Services Commission, established under the Essential Services Commission Act 2002
DC	Direct electric current
ESC Act	Essential Services Commission Act 2002
ETSA	Electricity Trust of South Australia
Electricity Act	Electricity Act 1996
GWh	Gigawatt hour
kVA	Kilovolt ampere
MW	Megawatt
NEM	National Electricity Market
NER	National Electricity Rules
PV	Photovoltaic
TR	Technical Regulator
RET	Renewable Energy Target

1 Introduction

In June 2016, the Essential Services Commission (**Commission**) commenced an Inquiry under Part 7 of the Essential Services Commission Act 2002 (**ESC Act**) into the licence conditions which the Commission should apply to grid-scale, inverter-connected wind-powered generators. This is the third review that the Commission has conducted into this matter, following earlier reviews in 2005 and 2010.

Since the 2005 review, the Commission has placed additional conditions on such generators, requiring them to meet higher performance standards under the National Electricity Rules. A key focus for the Inquiry is whether or not those existing conditions should be maintained, enhanced or otherwise altered – and includes a consideration of their application to other inverter-connected electricity generators or other parties.

The technical conditions are in place in the absence of a national framework dealing with the technical and system impacts of inverter-connected electricity generators. Were such a framework in place for existing inverter-connected electricity generators and other emerging generation and storage technologies, specific licence conditions in South Australia may well be unnecessary.

This Issues Paper seeks to facilitate discussion and debate on those matters, through:

- explaining the developments in the electricity generation sector and the Commission's licensing arrangements since the advent of the National Electricity Market (**NEM**) in 1998, and
- providing an initial avenue for response by stakeholders so as to provide the Commission with the widest possible views on matters relevant to this Inquiry.

1.1 Background

The Commission's primary objective under the ESC Act is to protect the long-term interests of South Australian consumers with respect to the price, quality and reliability of essential services. The Commission's role and functions in the electricity sector are set out in the Electricity Act 1996 (**Electricity Act**).

One of those functions is to licence electricity generators. Under the Electricity Act, a person is not permitted to generate electricity (other than for their own use or if the generator is small, with a maximum nameplate output of100 kVA or less) unless they hold a licence issued by the Commission.

In performing that function, the Commission has, since 2005 put in place through licence conditions under the Electricity Act, additional technical requirements for wind-powered electricity generators in South Australia. Those conditions oblige wind-powered electricity generation licensees to provide additional capability and performance to support the network.

The need for these conditions was first identified by the Commission in a review it conducted in 2004, the scope and findings of which were further reviewed and confirmed by the Commission in 2010. Those reviews occurred in the context of the then growing interest in wind-powered electricity generation in this State. They identified that the interest was driven by the development of technologies and national climate change policy responses, with South Australia the focal point of that interest given the availability of high quality wind resources in this State and their proximity to the transmission network.

Through both the 2004 and the 2010 reviews, the Commission identified that, given the different technical characteristics of wind-powered electricity generators and the likely level of investor interest in bringing such technology to market in this State, the then prevailing provisions of the National Electricity Rules (**NER**) did not adequately cater for their integration into a system like South Australia's.

Noting the inevitability of technological change in the market over time and the continuing likelihood of wind-powered and other inverter-connected electricity generators entering the market, the Commission (taking advice from the predecessor body to the Australian Energy Market Operator (AEMO) the Electricity Supply Industry Planning Council (ESIPC)) therefore developed and implemented the licence conditions.

Absent those requirements, wind-powered generators would have been able to enter and operate in South Australia with capabilities at the lower levels which the NER permits through its negotiation framework for network connection. While the NER has provision for higher technical standards, generators are only obliged to meet the minimum standards it contains. The Commission's reviews identified that those lower levels were unlikely to be suitable for the future South Australia power system.

In that context, the conditions require the licensees to have plant and equipment in place which would meet the highest standards permitted, but not required, under the NER for access to the network in terms of their ability to ride through faults and disturbances on the network and the provision of reactive power.

Specifically, they require large wind-powered electricity generators connected to the network:

- to have a capability at the highest standard provided under the NER to ride through a fault or event on the power system (referred to as the **fault ride through** capability), and
- to generate and absorb reactive power and to control voltage during and immediately after a fault at the highest standard provided under the NER (referred to as **reactive power** capability). This additional capability is required so that:
  - a contribution to local voltage control is made during, and immediately, after a disturbance, and
  - the impact of further wind-powered electricity generators on the power system would be minimised, thereby deferring the time at which voltage control might become an issue.

The conditions also impose requirements in relation to:

- central dispatch
- wind forecasting
- ancillary services, and
- medium sized wind-powered electricity generators rated at between 5 and 30 MW (which have lesser technical requirements placed on them).

In implementing the conditions, the Commission recognised that a State-based licensing solution is a second-best outcome and that these technical matters ought to be addressed at the national level (through the NER). In that sense, the Commission has always regarded the conditions as transitional.

1.2 Drivers for the current Inquiry

Since 2010, the underlying generation mix in South Australia has changed markedly and rapidly. There has been a shift from large-scale, 'synchronous', centrally-dispatched generation towards distributed and intermittent generation, connected to the power system through solid state inverter systems.[1]

[1] An inverter is an electrical device that converts direct current into alternating current.

These include wind-powered electricity generators, as well as a growing proportion of non-dispatched solar photovoltaic (PV) systems throughout the distribution grid.

This displacement of coal-fired power stations by alternative technologies and generation sources has resulted in the system becoming hybrid in nature – a matter not anticipated or catered for under existing national regulatory rules and arrangements.

The older electricity generation fleet within the power system had inherent properties and qualities that were not separately identified under the national regulatory rules and arrangements, as they were understood to be intrinsic to the way in which electricity was produced. When the NEM was established in 1998, there was little prospect of significant amounts of wind-powered generation, grid-scale (or even small-scale) solar arrays or other inverter-connected generation, nor was the prospect of large-scale battery storage realistically anticipated.

Now the power system is transitioning to a new state — possibly one in which there may be a prevalence of smaller, more widely distributed and embedded electricity generators throughout an 'intelligent' network — one that will see the distinction between electricity generators and consumers blurring, underpinned by other supporting technologies.

Those rapid technological advances, climate change policies and changing customer consumption patterns and behaviour means that the traditional model of energy being produced by large electricity generators, flowing through networks eventually to arrive to passive consumers, is under challenge. Further, the underpinning national regulatory rules and arrangements were not designed to directly address that sort of challenge.

This changing generation mix will ultimately impact on all generation markets – South Australian, Australian and internationally; however, with an abundance of renewable energy sources, South Australia has both the benefit and challenge of being a world leader in that regard. The precise nature of the future is uncertain; it will depend on many factors. From a broader perspective, this transition is more about making the South Australian power system highly adaptable and resilient to whatever changes arise.

Nevertheless, the current hybrid nature of the power system emphasises the need for short-term adjustments to the current framework to allow for both conventional generation and newer technologies to co-exist during transition — hence the need to question the Commission's current licensing arrangements and the reviews being undertaken by national bodies such as the Australian Energy Market Commission (AEMC).

1.3 The scope of the Inquiry

As noted earlier, the Commission is conducting this Inquiry to review the special licence conditions and the technical standards applicable to grid-scale inverter-connected electricity generators.

The Commission regards this matter as sufficiently important to warrant the conduct of a formal Inquiry under Part 7 of the ESC Act. Under that Part, the Commission, following consultation with the Treasurer, can initiate an Inquiry if it considers this is necessary or desirable for the purposes of carrying out its functions The Inquiry will focus on technical licensing requirements for electricity generators, to determine whether or not additional requirements continue to be required for South Australia and, if so, what form they should take and to whom they should apply.

In particular, the Commission will inquire into:

- whether the current licence conditions for the grid connection of wind-powered electricity generators should be removed, retained or varied, and

- whether any additional or amended technical requirements should be imposed on other grid-scale inverter-connected electricity generators (such as solar generation) or other generation technologies and sources.

As a part of this Inquiry, the Commission has sought from AEMO its preliminary advice on the appropriate technical standards for inverter-connected electricity generators, including wind-powered electricity generators. During the course of this Inquiry, AEMO will update its advice to the Commission once submissions are received following the conclusion of the Commission's consultation process on this Issues Paper. A further opportunity for stakeholder engagement and consultation will be available upon the release of the Commission's Draft Report (prior to the publication of the Commission's Final Report in the second half of 2017).

1.4 What the Inquiry will not review

While the Inquiry will be aimed at informing the Commission on its regulatory and licensing functions, it will not be a broader policy review. The Inquiry will not seek to encompass matters relating to national regulatory arrangements (but will take account of those where relevant).

While it is the licensing authority for electricity generators in this State, the Commission does not play an operational role in the generation market. In particular:

- The Commission is not a policy setting body:

  Policy settings for the NEM, including the overall market objective, are established by the Council of Australian Governments Energy Council (CoAG Energy Council). Policy settings for State and Territory-specific arrangements (such as the Electricity Act) which support or supplement the NEM are established by relevant Governments. In both cases, the policy settings are reflected in Acts of Parliament and subordinate legislation.

- The Commission does not have the power to set the spot price of electricity:

  Under the NER the spot price of electricity is set every half hour as the simple average of the six dispatch prices bid by the marginal electricity generator to meet electricity demand in each of the six separate five-minute dispatch periods. This element of the market is administered by AEMO.

- The Commission does not have the power to set wholesale pricing (or revenue) outcomes for electricity generators:

  The wholesale pricing outcome for an electricity generator is based on the net position arising from the spot market price set under the NER and any financial arrangements it has entered into (such as hedges or other derivatives it has sold or purchased). It is an outcome of the market.

- The Commission does not have the power to create new primary or secondary energy (or ancillary) markets for NEM participants:

  AEMO is required to operate the power system efficiently and ensure agreed standards of security and reliability are maintained. It does this by establishing and operating markets (or by other means) to deliver services to achieve the above aims — while the AEMC is responsible for setting rules where required.

- The Commission does not monitor compliance with the NER:

  While AEMO conducts the spot market in accordance with the NER, the AER monitors and enforces compliance with those rules by industry participants.

Given the technical focus of this Inquiry and the matters noted above, the Commission, nonetheless, occupies a unique position in the market place as an independent observer of consumers' interests in these matters. Should stakeholders and other interested parties consider that there are related, or associated, matters that the Commission ought to consider, then these should be raised.

1.5 Other contextual matters

On Wednesday, 28 September 2016, there was a complete supply outage on the South Australian power system. Investigations are currently being undertaken by various authorities, including the Commission, AEMO, AER and the Technical Regulator (TR) into all aspects of the event — including its causes, the process for the restoration of the power supply and the performance of all power system elements and entities.

Other – broader – market and technical studies are also being undertaken with respect to power system transition, including AEMO, AEMC and CoAG Energy Council.

The Commission is coordinating with all of those bodies, recognising that each has a defined area of responsibility. The Commission's primary responsibility lies in determining compliance of network and electricity generator licensees with licence conditions under the Electricity Act. To the extent that compliance with those conditions is a matter which itself is conditional on the findings of another body (for example, it is for the AER to determine whether or not the NER have been complied with), then the Commission will await the outcomes of that body's work.

Given the scope of this Inquiry, the Commission will consider the findings of each of those reviews within its scope as they become known.

2 Background

South Australia's electricity generation market has been transitioning from one based on conventional large centrally-located, thermal electricity generators to one that is based on smaller, distributed, renewable generation technologies, with variable (or intermittent) output characteristics. The transition from the old to the new generation technologies has been more rapid than anywhere else in Australia.

2.1 The Commission's licensing function

Under the Electricity Act, a person is not permitted to generate electricity (other than for own use or for small generators with 100 kVA or less output) unless she or he holds a licence issued by the Commission under that Act.

The Electricity Act sets out a scheme for the issuing of licences, which contains various process requirements and establishes the matters of which the Commission must be satisfied before it agrees to the issue of a licence.

One of those matters is that the issue of a licence must be consistent with the Commission's primary statutory objective under section 6 of the ESC Act: the protection of South Australian consumers' long-term interests with respect to the price, quality and reliability of electricity supply.

The Electricity Act also provides for mandatory conditions which must be included within licences issued by the Commission. At the same time, it permits the Commission to include within a licence conditions other than the mandatory conditions.

2.2 The current licence conditions for wind-powered generation licensees

The licence conditions currently imposed on wind-powered generation licensees in relation to fault ride through and reactive power requirements are set out below. As explained below, these conditions have arisen through two reviews conducted by the Commission (in 2004 and in 2010) and are the subject of the current Inquiry.

Fault Ride-Through Capability

1. *Each generating unit which the licensee is authorised to operate under this licence must comply with:*
   - *(a) the automatic access standards for generating system response to disturbances following contingency events specified in clause S5.2.5.5(b)(1) of the NER; and*
   - *(b) subject to clause 2, the automatic access standards for generating system response to disturbances following contingency events specified in clause S5.2.5.5(b)(2) of the NER; and*
   - *(c) subject to clause 3, the automatic access standards for generating system response to voltage disturbances specified in clause S5.2.5.4 of the NER.*
2. *The licensee is not required to comply with clause 1(b) in respect of a generating unit which the Licensee is authorized to operate under this licence where:*
   - *(a) the minimum access standard requirements specified in clause S5.2.5.5(c)(2) of the NER in relation to generating system response to disturbances following contingency events; and*
   - *(b) the requirements of clauses S5.2.5.5(d), (e) and (f) of the NER are satisfied in respect of that generating unit.*

3. *The licensee is not required to comply with clause 1(c) in respect of a generating unit which the licensee is authorized to operate under this licence where:*

   (a) *AEMO and the relevant network service provider have agreed, pursuant to clause 5.2.5.4(c)(3) of the NER, that there would be no material adverse impact on the quality of supply to other network users or of power system security as a result of that non-compliance; and*

   (b) *The requirements of clauses S5.2.5.4(c), (d), (e) and (f) of the NER are otherwise satisfied in respect of that generating unit.*

Reactive Power Capability

1. *The electricity generating plant operated by the licensee must at all times be capable of continuous operation at a power factor of between 0.93 leading and 0.93 lagging at real power outputs exceeding 5 MW at the connection point.*

2. *The electricity generating plant operated by the licensee must at all times be capable of providing:*

   (a) *subject to clause 4(b), at least 50% of the reactive power required to meet the power factor referred to in clause 1 on a dynamically variable basis; and*

   (b) *the balance of the reactive power required to meet the power factor referred to in clause 1 on a non-dynamic basis.*

3. *At generation levels below full rated output the electricity generating plant operated by the licensee must be capable of:*

   (a) *absorbing reactive power at a level at least pro-rata to that of full output; and*

   (b) *delivering reactive power at a level at least pro-rata to that of full output.*

4. *For the purposes of clause 2(a):*

   (a) *dynamically variable means continuous modulation of the reactive power output over its range, with an initial response time or dead time < 200 milliseconds and a rise time (as defined in clause S5.2.5.13 of the NER) < 1 second following a voltage disturbance on the network; and*

   (b) *for a period of ≤ 2 seconds on any single occasion, a short-term overload capability may be used to meet the 50% requirement, provided that use of that short-term overload does not cause a breach of any other licence condition.*

5. *The reactive power capability of the electricity generating plant operated by the licensee must be capable of control by a fast-acting, continuously variable, voltage control system which is able to receive a local and remote voltage set point.*

6. *The electricity generating plant operated by the licensee must be able to operate at either a set reactive power, or a set power factor, which is able to be set locally or remotely at any time.*

7. *The power factor or reactive power control mode of the electricity generating plant operated by the licensee must be capable of:*

   (a) *being overridden by voltage support mode during power system voltage disturbances; and*

   (b) *automatically reverting to power factor or reactive power mode when the disturbance has ceased.*

2.3 The generation market up to 2004

Independent regulation of the electricity industry commenced in South Australia in 1999, following the commencement of the NEM in 1998. Since that time, the Commission has been the statutory licensing authority for all new electricity generators.

Prior to 2004, the Commission generally licensed coal, gas and diesel-fired electricity generators — collectively referred to as conventional thermal generation — that had largely been installed under an earlier regime.

Towards the end of 2004, there was increased interest in wind-powered generation in the State due to its sound wind resources which are in close proximity to transmission lines. In addition, the commencement of a Federal Government subsidy scheme (Renewable Energy Target (RET)), along with other Government supports – Federal, State and Local - provided a supportive environment for investors.

This created a keen interest in wind-powered generation and led to the installation of approximately 450 MW of wind-powered electricity generation by November 2004. At that time, the Commission was also aware of proposals for approximately 1,260 MW of new wind-powered generating capacity. This new wind-powered capacity of 1,700 MW (installed and proposed) was in the context of an existing total South Australian market capacity of 3,454 MW at that time.

As the licensing authority, the Commission needed to be satisfied that South Australian consumers' long-term interests would be appropriately protected (with respect to the price, quality and reliability of electricity) when considering whether or not to agree to issue a licence to a new wind-powered electricity generator.

2.4 The 2005 review

Given the significant number of wind-powered generation proposals seeking licences (more than 10 individual projects), during 2005 the Commission took advice from AEMO's South Australian predecessor, the Electricity Supply Industry Planning Council (ESIPC), as to whether or not it could licence those proposed projects while still protecting the long-term interests of consumers. The Commission was concerned that the differing electrical characteristics of wind-powered electricity generators compared to existing conventional electricity generators may create unintended consequences.

ESIPC's advice was that significant levels of wind-powered generation would have major technical implications, given the prevailing NER. It advised that:

- the level of wind could be capped somehow, or
- additional technical licence requirements could be placed on wind-powered electricity generators to make them deliver additional electrical performance to better contribute to system stability, quality and reliability.

ESIPC also advised that it was not possible to predict market pricing impacts from wind-powered generation, given that there was insufficient evidence of practices and behavioural changes (if any) which might arise from the intermittent nature of such generation.

Having noted that these technical issues would best be dealt with by revising the NER (as it considered that non-conventional generation would eventually become a national issue, particularly given Federal Government subsidies for renewables such as the RET), the Commission determined that it would adopt the second option.

It did not want to artificially restrict any technologies nor to introduce the likelihood of any market distortions a cap might bring. It noted that it would look to revise or remove the local requirements once the NER adequately catered for wind and related technologies.

The Commission therefore developed technical licensing principles and conditions, the effect of which were to require wind-powered electricity generators to participate in the dispatch process of the national market (as until then they had been regarded as 'negative demand'), to have additional plant and equipment installed and to provide wind forecasting information.[2]

2.5 The 2010 review

In 2010, the Commission reviewed the above arrangements and found that, while the NER had advanced, they still did not cater for South Australia's unique circumstances with respect to the relative contribution of wind-powered generation to the State's total generating capacity.

Therefore, while it made some adjustments to the terms of its technical licence conditions, the Commission retained special conditions for wind-powered electricity generators.

The Commission also noted that, while the introduction of wind had resulted in an increase in spot price volatility in the wholesale electricity market, the pricing impacts of wind were a matter for the national market rather than technical licence conditions.

Finally, the Commission confirmed its position that the technical principles and special licence conditions were intended to be transitional and that the NER are the most appropriate way to deal with the technical issues raised by non-conventional generation.

2.6 The South Australian generation market in 2016

By September 2016, the Commission had issued 40 electricity generation licences authorising the operation of 4,718 MW of generation plant throughout South Australia. Of those, 20 are licensed wind-powered electricity generators (19 national electricity market participants and one non-market), with a total capacity of 1,596 MW – approximately one-third of the State's total generation capacity. As a result, South Australia has the highest penetration of wind generation compared to total generating capacity in Australia and, also, ranks among the highest penetration levels to be found in the world.

South Australia's fleet of wind-powered electricity generators are currently subject to three slightly differing sets of licence conditions (as described above):

- The first set of licence conditions reflected the general licensing conditions for all electricity generators prior to the Commission undertaking studies on this matter and were applied to the very first wind-powered generator farm (Starfish Hill) and which was licensed on 29 January 2002.
- The second set of licence conditions were introduced on 30 September 2005 and incorporated a set of special licensing conditions and wind licensing principles following the Commission's review.
- The third set of licence conditions were introduced on 3 May 2010 following the Commission's subsequent review of the applicability of national regulatory frameworks within the South Australian context.

[2] Applicants for a wind generation licence must familiarise themselves with the Commission's Statement of Principles for Wind Licensing which can be found at: http://www.escosa.sa.gov.au/library/100430-LicenceConditionsWindGenerators-FinalDecision.pdf.

Table 1 identifies the capacity of the wind-powered electricity generation plant currently installed in South Australia and the relevant version of the licence conditions applicable to each plant.

Table 1: South Australian wind-powered generation plant installed as at 8 November 2016

Generating system	Licenced capacity (MW)	Date licence issued	Special licence conditions	Year and version of applicable special licence conditions
Semi-scheduled market generators				
Clements Gap Wind Farm	57.8	3/06/2005	N	-
Hallett 1 (Brown Hill) Wind Farm	94.5	10/03/2006	Y	2005 v1
Hallett 2 (Hallett Hill) Wind Farm	71.4	13/03/2008	Y	2005 v1
Hallett 4 (North Brown Hill) Wind Farm	132.3	9/12/2009	Y	2005 v1
Hallett 5 (The Bluff) Wind Farm	52.5	25/09/2012	Y	2010 v2
Hornsdale Stage 1 Wind Farm	100	12/05/2016	Y	2010 v2
Lake Bonney Stage 2 Wind Farm	159.5	22/03/2006	Y	2005 v1
Lake Bonney Stage 3 Wind Farm	39	23/12/2009	Y	2005 v1
Snowtown Wind Farm	98.7	9/01/2007	Y	2005 v1
Snowtown Stage 2 South Wind Farm	126	23/07/2013	Y	2010 v2
Snowtown Stage 2 North Wind Farm	144	10/07/2012	Y	2010 v2
Waterloo Wind Farm Stage 1	111	16/10/2009	Y	20'05 v1
Waterloo Wind Farm Stage 2	19.8	17/12/2015	Y	2010 v2

Generating system	Licenced capacity (MW)	Date licence issued	Special licence conditions	Year and version of applicable special licence conditions
Non-scheduled market generators				
Canunda Wind Farm	46	1/10/2004	N	-
Cathedral Rocks Wind Farm	66	22/10/2004	N	-
Lake Bonney Wind Farm	80.5	22/07/2002	N	-
Mount Millar Wind Farm	70	23/09/2004	N	-
Starfish Hill Wind Farm	34.5	29/01/2002	N	-
Wattle Point Wind Farm	90.75	14/04/2004	N	-
Non-market generator				
Barunga Range	2.1	09/02/2011	N	-

In summary, the number and size of wind farms subject to the three different sets of licence conditions, at 8 November 2016, include:

- Eight wind farms representing approximately 448 MW of installed capacity that are subject to the requirements of the NER that were applicable at the time (and are not subject to special licence conditions)
- Seven wind farms representing approximately 706 MW of installed capacity that are subject to the special licence conditions introduced in September 2005, and
- Five wind farms representing approximately 442 MW of installed capacity that are subject to the updated special licence conditions introduced in May 2010.

2.6.1 The changing supply mix

Over the last 12 months, further changes have continued to occur in the South Australian electricity generation market, including:

- the withdrawal of coal-fired plant, which has changed the generation mix fundamentally (as it proportionally increases the penetration of wind generation and other non-synchronous forms of generation)

- continuing interest in new investment in wind, solar and other generation sources following recent policy announcements (such as the COP21[3] agreement dealing with greenhouse gases emissions mitigation, adaptation and finance)
- the growing commercial and technical viability of battery storage and related technologies
- the increasing interest in micro-grid technologies (whether stand-alone or connected to the NEM)
- risks which arise if the high voltage interconnectors with Victoria are out of service, and
- the availability and pricing of gas for electricity generation.

This transformation of the energy industry was not envisaged when the NEM was established. The NEM assumes large, conventional generation sources, connected to end-users by transmission and then distribution networks, with retailers selling that energy to the end-users. This model is under significant challenge and nowhere more so than in South Australia. Indeed, the proliferation of renewable generation technologies, together with the withdrawal of coal-fired generation locally, may be unprecedented in the world and it is changing the technical and operational characteristics for the management of the local power system.

Under normal operating conditions of the power system, this transition is unremarkable; however, under certain rare situations (referred to in the NER as non-credible contingency events) — such as the total loss of transfer capacity on the Heywood interconnector and the resulting electrical separation of South Australia's network from Victoria — problems can arise; particularly so, if there is also a lack of 'inertia' which is currently provided by conventional synchronous generation (and discussed in further detail in Section 2.6.3). This very unlikely set of circumstances may result in the power system becoming unstable, leading to issues with the quality and reliability of electricity supply.

National solutions, which are based on a much lower penetration of new and inverter-connected generation technologies, may not necessarily apply in South Australia.

The earlier reviews undertaken and special licence conditions imposed by the Commission allowed for the integration of wind-powered electricity generators into the South Australian market provided they met additional technical requirements over and above those required of conventional electricity generators. Under those licence conditions, the Commission requires wind farms to deliver technical performance outcomes over and above those required of conventional electricity generators so as to mitigate the potential technical risks they pose.

The growth in new and inverter-connected generation technologies in this State, both in large-scale wind-powered and small-scale solar PV generation, is shown in Figure 1. It highlights the changing generation mix in South Australia and the speed of that transition since 2003-04, when the first wind-powered electricity generators were installed. Electricity generation from coal and gas-fired plants has reduced over that period and culminated in the withdrawal of coal-fired generation in May 2016.

Similar changes are occurring in Victoria, with the announcement of the closure of the 1,542 MW coal-fired Hazelwood Power Station in early 2017[4] and approval for approximately 2,600 MW of wind-powered generation in the west of the State.[5]

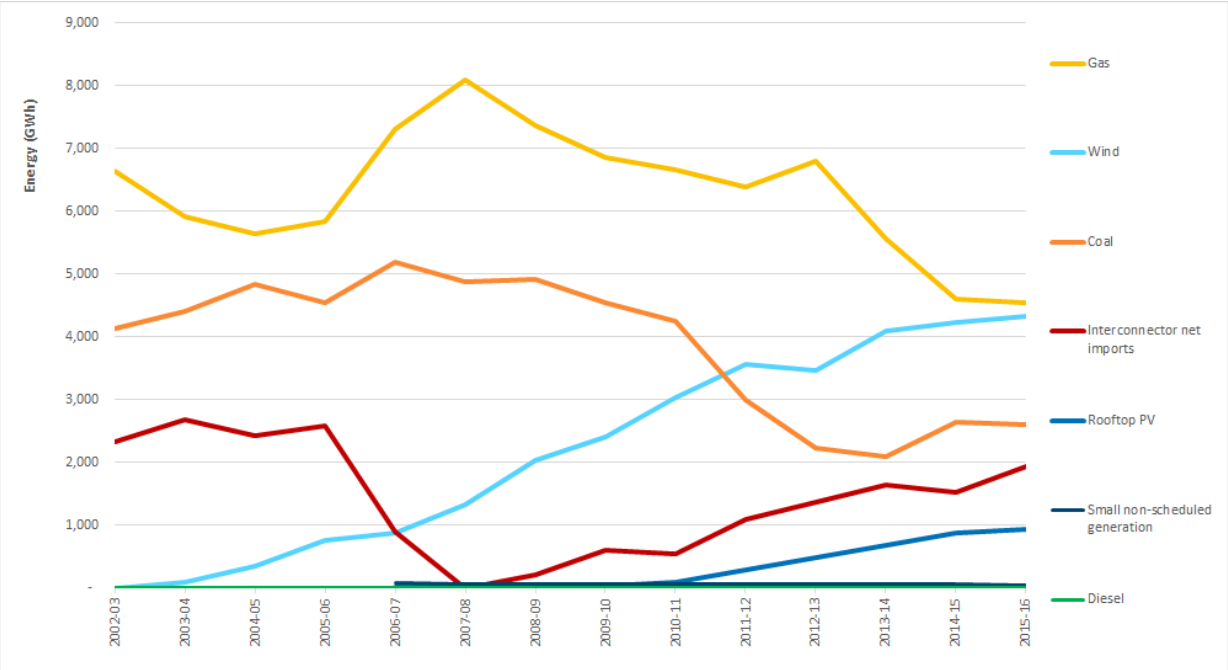
---

[3] COP21 refers to the Paris Climate Conference which is officially known as the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change.

[4] A press release from ENGIE is available at: http://www.gdfsuezau.com/media/newsitem/Hazelwood-to-close-in-March-2017 and was viewed on 4 November 2016.

[5] The Victorian Government's 'Wind Projects in Victoria' website was viewed on 4 November 2016 and is available at: http://earthresources.vic.gov.au/energy/sustainable-energy/wind-energy/wind-projects.

Figure 1: South Australian energy generation by fuel type/source, 2002-03 to 2015-16 (GWh)



Source: ESCOSA from AEMO data
Note: Data not available for PV and small non-scheduled generation prior to 2006-07.

2.6.2 Changing system characteristics

This transition has altered the technical and operational characteristics of the local power system. AEMO is responsible for maintaining the security of the NEM power system. To do so, it manages and operates the power system in a secure operating state. In a technical sense, this requires the AEMC's Reliability Panel (of which AEMO is a member) and AEMO to set and monitor, respectively, the technical parameters of the power system such as voltage, frequency, and the rate at which these both may change, as well as other parameters so that the system is better able to withstand faults, disturbances or other disruptive events.

Some major elements of the South Australian power system were designed and built in the 1950s, 1960s and 1970s. During that era, the entire value chain, including coal mining, generation, transmission, distribution and retailing of electricity, was provided by the Electricity Trust of South Australia (ETSA)

ETSA was a government-owned vertically integrated monopoly business. It designed and constructed all of the elements of a power system to meet its objectives at the time. The power system was designed around very large centralised conventional thermal power stations (including base load, intermediate and peaking plant) injecting power into specific connection points to service a large centralised load centre.

By way of contrast, a possible future power system might include a multitude of small variable (intermittent) micro-generators based on (but not limited to) a range of new energy sources supplemented by energy storage technologies. Those forms of generation may be widely distributed throughout a network and do not have the operational capabilities that were intrinsic to traditional conventional electricity generators that ensured the smooth functioning of the power system. This may blur the distinction between consumers and electricity generators and permit trading amongst all participants (including consumers). In such a world, the stability and security of the system would become a shared responsibility.

Today's power system sits somewhere between these two situations — and is very much a hybrid.

Under normal operating conditions, this is manageable; however, under certain (infrequent) conditions this may not be possible and the power system may be compromised (as the events of 28 September 2016 demonstrated — with the highly unusual circumstance of a multiple number of faults (six) over a very short timeframe of 88 seconds, the loss of a heavily loaded interconnector between South Australia and Victoria and an associated lack of availability of large conventional electricity generators).

As the power system continues to evolve in South Australia, there is a need to ensure that those intrinsic operational capabilities of conventional electricity generators, necessary to support the power system's capacity to provide supply to end use customers, are still available.

However, national solutions, which may assume lower levels of penetration of new generation technologies, may not necessarily apply to South Australia's circumstances. Absent national solutions which cater for those circumstances, additional requirements may be needed (as has been the case since 2004).

2.6.3 Synchronous generation and system inertia

Modern wind-powered and solar photovoltaic electricity generators convert a direct electric current (DC) into an alternating electric current (AC) to meet the specific requirements of the power system (or grid). These electricity generators incorporate extensive solid state electronic inverter systems to make the conversion from DC to AC at the specified power system voltage and frequency.[6]

These electronic inverter systems, to date, tended to have their manufacturers' operating ranges set conservatively, making them sensitive to changes in both system voltage and frequency, If the system voltage and frequency deviate from the inverter's settings, then there is a risk that the inverter may cause the electricity generator to trip and disconnect from the grid. This may create consequential or cascading effects on the network.

Conventional electricity generators, such as those fired by coal, gas and hydro, are large, rotating machines that are 'magnetically' coupled to the operational frequency of the power system. Once 'coupled' to the system in this way, they are able to resist, to a certain extent, large and rapid changes[7] in frequency in a way that is not necessarily possible for inverter-connected electricity generators to date.[8] For this and other reasons, large conventional generators, also referred to as 'synchronous' generators, have the ability to dampen the effects of changes in power system frequency, exhibiting a quality referred to as 'electrical inertia'. This feature of conventional generation assists in managing the power system in a secure manner and in this context is known as 'system inertia'.

6 Power system frequencies vary around the world but here, in Australia, the power system frequency is set at 50 Hertz (or cycles per second).

7 Frequency can speed-up or slow-down in response to generation or customer loads changing to meet changes in the supply or demand for electricity.

8 Although there may be some limited ability for inverter-connected electricity generators to do so.

2.6.4 System strength

Another notable feature of conventional, large synchronous electricity generators in traditional power systems is 'system strength'. Strong systems are characterised by the resilience of the power system to withstand fluctuations in voltage as a result of changes in generation (or customer load). In a power system with weak system strength, the same changes in generation (or load) would result in large fluctuations in voltage. Inverter-connected, non-synchronous (or asynchronous) electricity generators generally contribute little system strength under current arrangements.

In the AEMC and AEMO joint work on System Security Market Frameworks Review,[9] the AEMC notes that the NER:

> *'…do not provide mechanisms to manage a reduction in the strength of the system. In particular, no entity is responsible for maintaining the system strength at a connection point and there are no system standards for system strength because it varies significantly throughout the power system and under different conditions. Also, the rules are not explicit as to whether a generator is required to modify its generating units if they no longer comply with the technical standards at the reduced system strength.'*

Further, as noted in the South Australian Government's rule change requests to the AEMC,[10] and in the AEMC's subsequent consultation paper on its System Security Market Frameworks Review,[11] the potential consequences of low system strength are a reduction in the safe operation and effectiveness of protection systems, large fluctuations in voltages on the network and a compromised ability of inverter-connected electricity generators to operate continuously following a disturbance or to meet their agreed performance standards.

---

9 AEMC, System Security Market Frameworks Review: Consultation Paper, 8 September 2016, p. 21.

10 Further detail on each of the South Australian Government's four rule change requests may be accessed from:
- 'Managing the rate of change of power system frequency/ may be found at: http://aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque.
- 'Managing power system fault levels', may be found at: http://aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels.
- 'Emergency overfrequency control schemes', may be found at: http://aemc.gov.au/Rule-Changes/Emergency-frequency-control-schemes-for-generation.
- 'Emergency underfrequency control schemes', may be found at: http://aemc.gov.au/Rule-Changes/Emergency-frequency-control-schemes-for-excess-gen.

11 AEMC, System Security Market Frameworks Review: Consultation Paper, 8 September 2016 may be accessed at: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review.

3 Issues

Under the Terms of Reference for this Inquiry the Commission will:

- Inquire into appropriate regulatory arrangements administered by the Commission under the Electricity Act (including subsidiary regulatory instruments made by the Commission such as industry codes) to apply in relation to grid-scale wind and inverter-connected electricity generating plant and equipment.
- In undertaking those inquiries, the Commission will:
    - Analyse the regulatory issues associated with the quality and reliability of electricity supplied by grid-scale wind and inverter-connected electricity generating plant and equipment, with a view to ensuring that any regulatory arrangements it administers are targeted, efficient and appropriate.
    - Identify an appropriate regulatory framework that:
        - has relevance for customers and for licensees and exempted entities currently providing grid-scale wind and inverter-connected electricity generation, and
        - will be relevant in the context of new participants, business models and/or technologies which could deliver more effective and innovative outcomes for customers in the future.
- Have regard to:
    - other relevant contextual matters, including (without limitation), the legal and regulatory regime which applies to the operations of the NEM, and
    - other matters which may arise in connection with or through its Inquiry (particularly issues raised by stakeholders) into the matters relevant to the foregoing.

3.1 AEMO's preliminary advice

AEMO is assisting the Commission in its Inquiry and provided its preliminary advice in early September 2016. Its report, 'The Technical Standards for Grid Connected Wind Farms and Inverter-Connected Generators in South Australia' (Report), may be accessed from the Commission's website.

In its covering letter to the Commission, AEMO summarised its preliminary advice to the Commission:

- AEMO has not identified a case to remove the existing licence conditions (for fault ride through and reactive power capability) at this time, although some amendments may be considered.
- AEMO is of the preliminary view that there may be value in including additional requirements relating to:
    - frequency control
    - the rate of change of frequency, and
    - system strength.
- AEMO is also of the preliminary view there may be a case for extending the licence conditions to other technologies such as photovoltaic, battery storage and synchronous generation.

AEMO further noted that wind and other inverter-connected (or non-synchronous) electricity generators be required to provide active power control similar to the requirement in international jurisdictions.

3.2 Specific matters on which stakeholders' views are sought

Stakeholders are invited to provide information, comment, views and submissions on matters they think relevant to the Terms of Reference and in response to the preliminary advice provided by AEMO. The following specific questions may assist respondents in formulating their submissions.

Q1 Should the Commission continue to require the existing special conditions?

Should licence conditions for fault ride through and reactive power capabilities continue to be applied?

If so, to which classes of entities? For example, all inverter-connected generation plant? If not, please provide justification.

Q2 Should those licence conditions be varied?

Should those licence conditions for fault ride through and reactive power capabilities be varied or should other, new, conditions be required?

If so, how and why? If not, please provide justification.

Q3 Should licence conditions be made to apply both to prospective and existing licensees?

Should any changes to licence conditions arising from this Inquiry apply only to those seeking a new electricity generation licence or should existing generation licensees also be compelled to meet new or changed standards?

In either case, why?

Q4 Should generation licence holders be required to upgrade or refurbish plant and equipment to meet the licence conditions of the day?

Should existing (or future) licensees be required to upgrade or refurbish plant and equipment to meet the licence conditions prevailing at the time at either the end of the plant's notional economic or engineering design life or the period over which the project was originally financed?

Q5 Do you have any comments or views on AEMO's preliminary report?

AEMO's preliminary advice notes that in addition to possibly making amendments to the existing licence conditions for fault ride though and reactive power capability there may be value in including additional requirements in relation to: frequency control, the rate of change of frequency, and system strength. It also notes that there may be a case for extending licence conditions to other technologies.

Do you have any comment on those matters?

Q6 Are there any other matters relevant to the Inquiry that the Commission should consider?

Notwithstanding the technical focus of this Inquiry and the matters noted above, are there related, or associated, matters that the Commission ought to consider in this Inquiry?

4 Next steps

The Commission seeks and welcomes all views on matters relevant to this Inquiry. Written submissions on this Issues Paper are invited by Monday, 30 January 2017. Information on how to make a submission to the Inquiry is set out on the inside front cover of this Issues Paper.

However, the Commission's consultation is not limited to the receipt of stakeholders' written submissions: it is seeking to engage directly with a broad range of stakeholders and will also continue to work closely with AEMO in relation to technical matters. [12]

Following a consideration of the issues raised through consultation, and taking into account any further advice from AEMO, the Commission will release a Draft Report, which will also be the subject of public consultation, prior to a Final Report being released.

Under the Inquiry provisions of the ESC Act, a copy of the Inquiry's Final Report will be tabled in Parliament.

4.1 Timetable for this review

The intended timeframes for the upcoming stages of this Inquiry are provided below.

Stage	Timing
Release of this Issues Paper	December 2016
Public consultation	December 2016/January 2017
Submissions due	30 January 2017
Draft Report released	May 2017
Public consultation	June 2017
Final Report released	August 2017

[12] The Commission's approach to consultation is detailed in its Charter of Consultation and Regulatory Practice which may be accessed at: http://www.escosa.sa.gov.au/consultation/charter-of-consultation-and-regulatory-practice.

The Essential Services Commission
Level 1, 151 Pirie Street Adelaide SA 5000
GPO Box 2605 Adelaide SA 5001
T 08 8463 4444
E escosa@escosa.sa.gov.au | W www.escosa.sa.gov.au