AIE Forum on the National Energy Guarantee
Sydney, 26/3/18

Comments: Hugh Outhred

Focus: the NEG reliability objective

How did we let it get to this and what are we going to do about it?
Professor Ian Chubb, former Chief Scientist, ABC AM, 26/3/18

Outline

- Focus of these comments - the NEG reliability objective:
  - *[ensure that] there is a minimum amount of **dispatchable energy** available to **meet consumers' needs** and **keep the system reliable***
    - Why not let consumers decide on their needs?
  - What does *"keep the system reliable"* mean?
    - The SA blackout on 28/9/16, which led to the Finkel inquiry and the ESB was caused by network failure in extreme weather conditions
  - *the closure of Liddell represents exactly "the type of challenge the National Energy Guarantee is intended to solve*" Frydenberg media release 23/3/18 http://www.joshfrydenberg.com.au/guest/mediaReleasesDetails.aspx?id=542
- What do we mean by dispatchable energy, reliability, security & resilience and what does practical experience tell us?
- How does NEG relate to AEMO's Integrated System Plan? http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2017/Integrated-System-Plan-Consultation.pdf
  - AEMO appears to be taking on a more formal planning role:
    - *if so the quality of its work will be crucial – how will that be audited?*
- Could we do better?

AEMO, 22/12/17: Integrated System Plan Consultation

http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2017/Integrated-System-Plan-Consultation.pdf

Figure 4 NEM coal generation fleet operating life to 2050, by 50th year from full operation or announced retirement

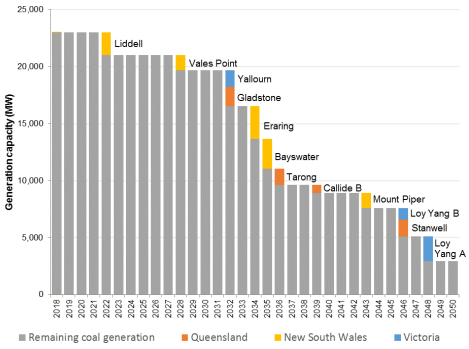
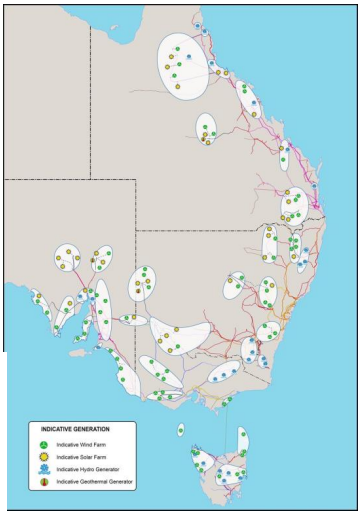


Figure 1 Range of potential REZs



Large-scale PV (solar) and wind generation are now among the cheapest forms of new bulk energy generation. Preliminary modelling indicates up to 25-30 GW of new wind and large-scale PV could be built in the NEM by 2037 (p 28)

NEM planners must prepare for and manage a rapid transformation of the power system, currently projected in the 2030s but which could occur earlier or later, as ~10 GW of coal generation is projected to retire (p 29)

nts by Hugh Outhred

The Health of the National Electricity Market, Energy Security Board, Dec 2017
http://www.coagenergycouncil.gov.au/publications/health-national-electricity-market-report

"The National Electricity Market (NEM) is not in the best of health. The immediate symptoms are a power system where reliability risks are increasing, electricity bills are not affordable, and future carbon emissions policy is uncertain." (ESB Report p3)

"Given the difficulties facing the NEM there is a clear need to improve governance. Between the COAG Energy Council, the market bodies, and now the ESB, the current governance arrangements are in catch-up mode." (ESB Report p38)

Energy Security Board (ESB) members (education):
Kerry Schott AO, Independent Chair: *Arts, Mathematics*
Clare Savage, Independent Deputy Chair: *Commerce, Economics*
Paula Conboy, AER Chair: *Economics*
John Pierce, AEMC Chair: *Commerce*
Audrey Zibelman, AEMO CEO: *Law*

Why is there no electrical engineering expertise on the ESB?

Definition of *dispatchable*

- The NEG consultation paper doesn't define 'dispatchable'
  - However it appears to rely heavily on the AEMO document, *Advice To Commonwealth Government on Dispatchable Capability,* https://www.aemo.com.au/-/media/Files/Media_Centre/2017/Advice-To-Commonwealth-Government-On-Dispatchable-Capability.PDF (Sept 2017)
    - Which uses 'dispatchable' 47 times but also fails to clearly define it
- Dispatchable is used 30 times in the ESB paper, eg (quotes):
  - *dispatchable megawatts or demand response*
  - *dispatchable capacity; dispatchable energy; dispatchable power; dispatchable electricity; dispatchable resources*
  - *dispatchable coal-fired generation*
  - *"dispatchable" (that is, coal, gas and hydro-electric plants)*
  - *non-dispatchable generators like wind and solar*
  - *non-dispatchable renewables*
- *So it appears to mean* ***coal, gas and hydro-electric plants***

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Relevant terminology in the National Electricity Rules V 106

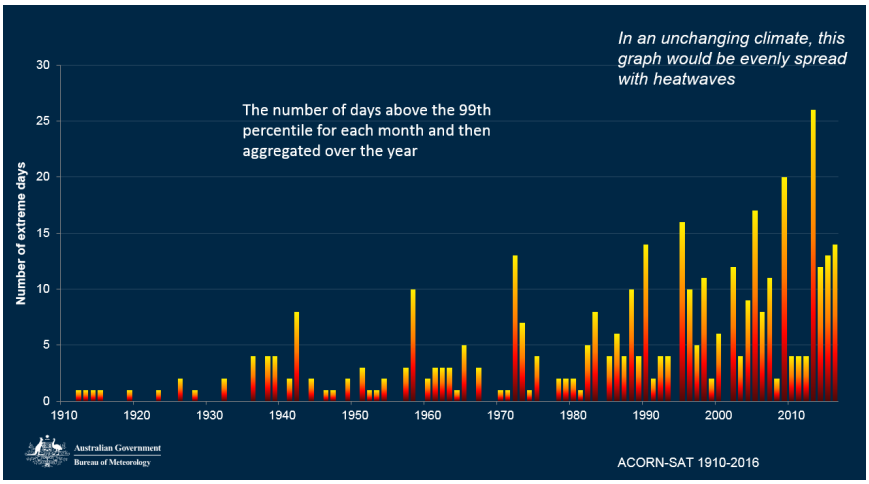
- Dispatchable unit identifier (Chapter 10 glossary):
  - An unique reference label allocated by AEMO for each scheduled generating unit, *semi-scheduled generating unit*, scheduled load, and scheduled network service
- Central dispatch (Chapter 10 glossary):
  - The process managed by AEMO for the dispatch of scheduled generating units, *semi-scheduled generating units*, scheduled loads, scheduled network services and market ancillary services in accordance with rule 3.8
- Semi-scheduled generator (Rule 2.2.7):
  - … must be classified as a semi-scheduled generating unit where the output of the generating unit is *intermittent* unless…
- Intermittent (Chapter 10 glossary):
  - A description of a generating unit whose output is not readily predictable, **including, without limitation, solar generators, wave turbine generators, wind turbine generators and hydro-generators without any material storage capability**

IF *Hence the NER says solar, wave & wind generators are dispatchable*

AEMO, 29/11/17: Summer operations 2017 - 18

https://www.aemo.com.au/-/media/Files/Media_Centre/2017/AEMO_Summer-operations-2017-18-report_FINAL.pdf

Figure 2 Trends in Australian heatwaves



- The rising trend is not only in heatwaves but extreme weather more broadly
- Networks are more exposed to extreme weather than power stations

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SA blackout 28/9/16 AEMO preliminary report, 5/10/16, p 13

http://www.aemo.com.au/Media-Centre/Media-Statement-South-Australia-Interim-Report

3.2 Network damage resulting from the storm (proximate cause)

Following the SA Black System, ElectraNet advised AEMO of network damage resulting from the storm. This included:

- Davenport to Mt Lock and Davenport to Belalie 275 kV line – 5 double circuit towers damaged.
- Brinkworth to Templers West 275 kV line (East circuit) – 2 towers damaged.
- Davenport to Brinkworth 275 kV line (East circuit) – 14 towers damaged.
- Port Lincoln to Yadnarie 132kV line – 1 tower damaged. *(22 towers damaged in total)*

Data currently available to AEMO indicates that the damage to the Davenport – Brinkworth 275 kV or the Port Lincoln – Yadnarie 132 kV lines occurred following the SA Black System.

H. Brian White, Wind Design Loads, T&D World Magazine, 1/1/08

http://tdworld.com/print/overhead-transmission/wind-design-loads

- *"… every wind-based trigger event evolved from intense thermal actions, including tornados, microbursts and downbursts*
- *… design criteria based on synoptic winds are not appropriately based on wind-based damage to our structures*
- *… suggested increase in design wind speed [to] 250 km/h (70 m/s) … the upper range for F2 (Fujita scale) tornados in the United States*
- *… the penalty associated with reinforcing the structural components to meet higher design wind loads may well be insignificant in comparison to overall maintenance and construction expenditures"*

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Kulkarni & McCormack (2014), "Forensic Engineering for a Transmission Line Failure"
http://www.asec2014.org.nz/Presentations/PDFs/Paper%20089%20Forensic%20engineering%20for%20a%20Transmission%20line%20Failure.pdf

(a well-known risk for South Australia)

- *"...more than 80% of transmission line failures in Australia are attributed to extreme weather conditions - High Intensity Wind phenomenon" (p 3)*
- *"The code of practice for calculating wind effects are evolving. Earlier assets were not designed for some of the phenomenon like oblique winds, High Intensity Winds, Downdraft and Tornado conditions. Even for new assets, the cost involved in making structures safe against such phenomena is great hence more studies are required on framing suitable norms as well as businesses will need to take a pragmatic risk based approach" (p 5)*
- *"Cascading is a common phenomenon observed in transmission line failures i.e. failure of more than one structure in an incident" (p 6)*
- *"Most transmission line failures are due to weather related phenomenon viz Tornados and Downdrafts" (p 9)*

Photograph 1: *Typical failure scenario*

Table 1: *Failure statistics for ElectraNet*

Year	Number of structures lost
1962	8
1963	1
1965	13
1973	32
1975	9
1977	2
1979	156
1991	27
1995	5
1998	4
1999	27
2004	1
2005	1
2011	7
2012	6

ElectraNet has 5,500 km of 275 kV, 132 kV & 66 kV overhead & underground transmission lines (p 2)

Aircraft analogy to clarify *Reliability* & *Security*

- *Reliability:* Design, manufacture, operate & maintain a plane in a manner that ensures its continuing ability to fly safely:
  - Unlike a plane, an electricity industry is geographically dispersed
- *Security:* Ability to fly safely in all plausible conditions:
  - *Observability, predictability & controllability* of a plane under all plausible conditions & pilot skills to fly it safely (people & equipment):
    - These conditions are not met in the NEM for distributed resources
- The plane analogy to the electricity industry is incomplete:
  - A plane is a closed complex system with well-defined & stable scope
  - An electricity industry is an open complex system based on T&D networks & includes end-users & their equipment:
    - Many items of end-use equipment are now flexible and controllable in their electricity demand
    - Nearly 25% of Australian households now have rooftop PV and an increasing number have batteries

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Definition of energy security

- Long-term (decadal):
  - *Energy supply security:* Long-term access to sufficient primary energy resources at acceptable economic, environmental & social cost
  - *Energy service delivery:* Prudent & efficient (e.g. https://2xep.org.au)
- Short-term (intra-year) electricity industry security:
  - *Energy supply security: The safe scheduling, operation and control of the power system on a continuous basis* (NER Ch 10 & Clause 4.2.6)
    - System-level issues, exogenous phenomena
  - *Energy service delivery: Cost-effectiveness*
    (Energy Consumers Australia Survey, December 2017)*:*
    - *Confidence in the energy market is at an all-time low nationally, with falls in every state and territory, and consumer confidence that the overall market is working in their interests averaging 21% nationally*
    - *Across each state and territory, at least 64% and as much as 83% of consumers say that they would be prepared to reduce their energy usage in times of very hot weather (security-cost trade-off)*

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Definition of electricity industry *resilience*

- US Federal Energy Regulatory Commission, 8 January 2018: *https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf, p 18*
  - *The ability to withstand & reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event*
  - *Resilience could encompass a range of attributes, characteristics, and services that allow the grid to withstand, adapt to, and recover from both naturally occurring and man- made disruptive events. At the most basic level, ensuring resilience requires that we both (1) determine which risks to the grid we are going to protect against, and (2) identify the steps, if any, needed to ensure those risks are addressed*
- See also: https://www.greentechmedia.com/articles/read/resilience-in-a-clean-energy-future
- *Reliability, security & resilience all have interpretations at both the system-level and the individual end-user level, where industry value is determined*

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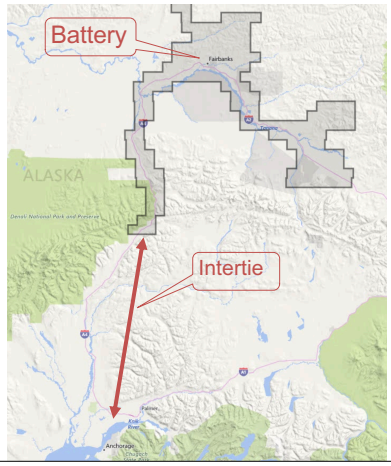
A battery near load can reduce the impact of network outages:

Golden Valley Electric Association, http://www.gvea.com/energy/bess?tmpl=component&print=1

27MW for 15min, max 46MW for 5min, NiCAD, 1500ton, 20-30 year life, cradle-to-grave

Video at https://youtu.be/kL_2rLyNPsI

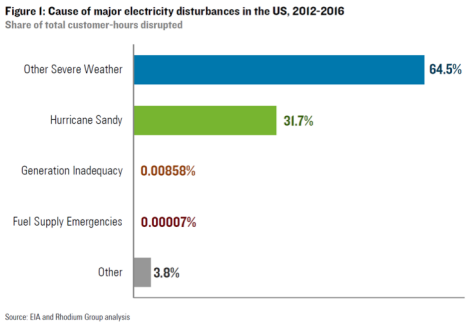
Year	No. of outages prevented, OP	Average OP per customer meter
2003	3	<1
2004	56	7
2005	34	5.6
2006	82	7.5
2007	65	9
2008	25	2.3
2009	28	2.6
2010	40	3.9
2011	18	1.7
2012	43	2.6
2013	60	6.9
2014	78	6.1
2015	52	7.1
2016	69	6.3

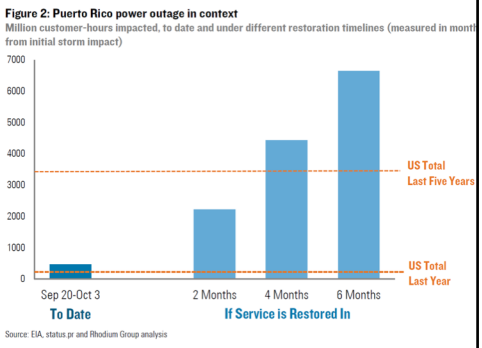


Outages prevented include those due to local generation & transmission outages & those due to loss of power from Anchorage via the Intertie.

Value of battery depends on context

The Real Electricity Reliability Crisis (USA), Houser et al, The Rhodium Group, 3/10/17, http://rhg.com/notes/the-real-electricity-reliability-crisis





"Of all the major power disruptions, nation-wide over the past five years, only 0.00007% were due to fuel supply problems. The vast majority were the result of severe weather knocking down power lines, like in Puerto Rico where Hurricane Maria caused more customer-hours of electricity delivery to be lost over the past 12 days than in last year in the rest of the country combined"

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AEMO Power System Incident Reports, 2017

https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/Power-System-Operating-Incident-Reports

'These events are known as "reviewable operating incidents" and are generally not considered as "credible contingency events". As such, these events are not normally taken into account in the operation of the NEM'

Note: Distribution system events aren't included

24/10/2017	Trip of Mudgeeraba 2/4 110kV busbars	Network
01/09/2017	Offloading of ROTS-SMTS-KTS 500kV lines	Network
31/07/2017	Simultaneous trip of South East No.1 and No.2 ±75 kV SVCs	Network
27/07/2017	Trip of 330kV Main busbar at Vales Point	Network
28/06/2017	Capital A & C 330kV busbar tripped on 3 May 2017 and 28 June 2017	Network
06/06/2017	Trip of Brunswick No2 220kV busbar	Network
03/06/2017	Trip of Vales Point 330kV GEN busbar	Generation
31/05/2017	Loy Yang 1/3 500kV busbar tripped	Generation
18/05/2017	Keilor No3 220kV busbar tripped	Network
08/05/2017	Trip of Loy Yang A1 & A2 generating units within 30 minutes	Generation
07/05/2017	Trip of both Colongra-Munmorah 330kV lines	Network
30/03/2017	Outage of Lismore SVC on 30 March 2017	Network
29/03/2017	Trip of Mudgeeraba 110kV busbar	Network
12/03/2017	Trip of Baslink and UFLS in Tasmania	Network
03/03/2017	Fault at Torrens Island switchyard	Generation
19/02/2017	Trip of Eildon 220kV busbar in Victoria	Network
13/02/2017	Multiple line outages in the Mt England-Tarong area	Network
13/02/2017	Multiple 275kV transmission line trips at Mt England in QLD	Network
11/02/2017	Trip of multiple transmission elements in the southern NSW area	Network
10/02/2017	System event report NSW	Heatwave
08/02/2017	System event report SA	Heatwave

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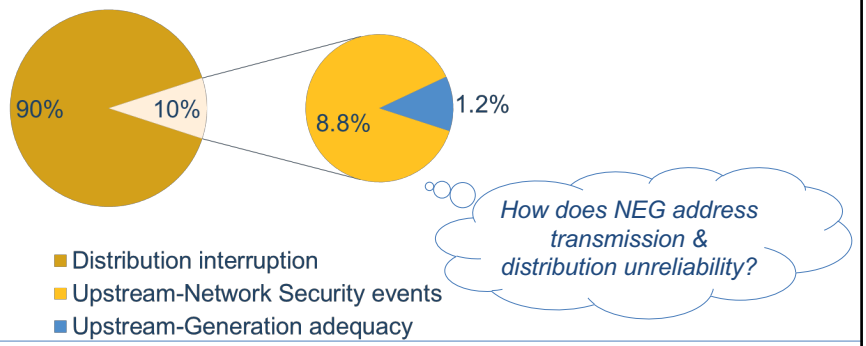
AEMO (27/2/17), *Submission to the Independent Review into the Future Security of the National Electricity Market*, p 25

https://www.aemo.com.au/Media-Centre/Submission-to-Independent-Review-into-the-Future-Security-of-the-National-Electricity-Market

Sources of Customer Interruption 2005-10 (AEMC)



Notes:
1. Distribution networks are more extensive than transmission networks and, if above ground, more exposed to external risks (weather, vegetation, lightning, vehicles, etc.)
2. NEM governance & design still focused on transmission-level issues & NEG reinforces that

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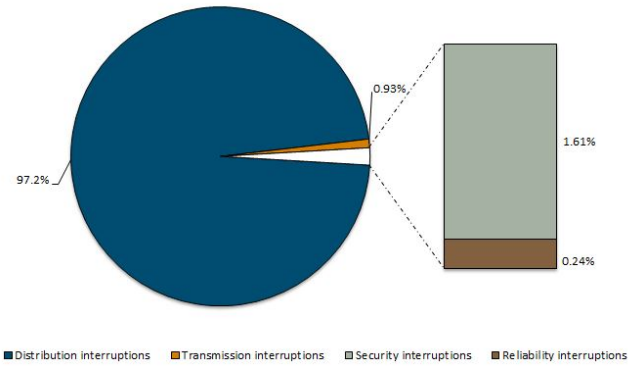
AEMC, Reliability Frameworks Review, Interim Report, 19/12/17
https://www.aemc.gov.au/sites/default/files/content/888511f5-9f89-4af2-8803-6302b53636f4/EPR0060-Interim-report-For-publication.pdf

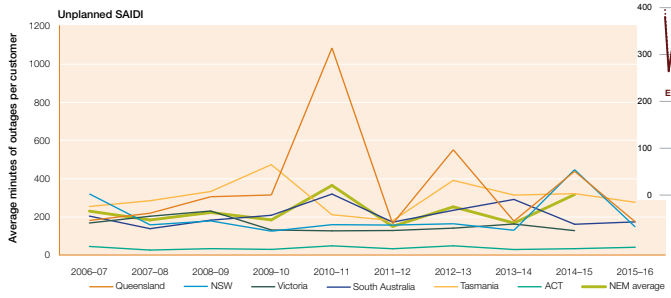
Figure 3.1 Sources of supply interruptions in the NEM: 2007-08 to 2015-16



Distribution unreliability dominates supply interruptions even more than before despite increasing network charges (See Grattan Institute, Down to the Wire, https://grattan.edu.au/wp-content/uploads/2018/03/903-Down-to-the-wire.pdf)

AER (2017), *State of the Energy Market* & Grattan (2018), *Down to the Wire*

Figure 3.15
System reliability—unplanned SAIDI



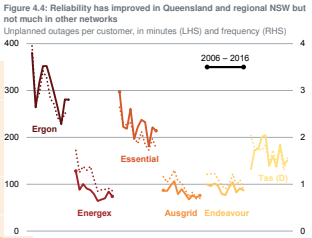
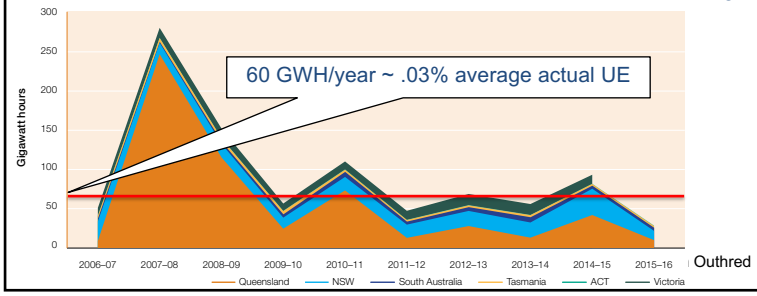


Figure 3.17
Total energy unsupplied

NEM wholesale-level target EUE ≤0.002% x ~200 TWH ~ 4 GWH
NEM retail level actual UE far exceeds wholesale level target EUE



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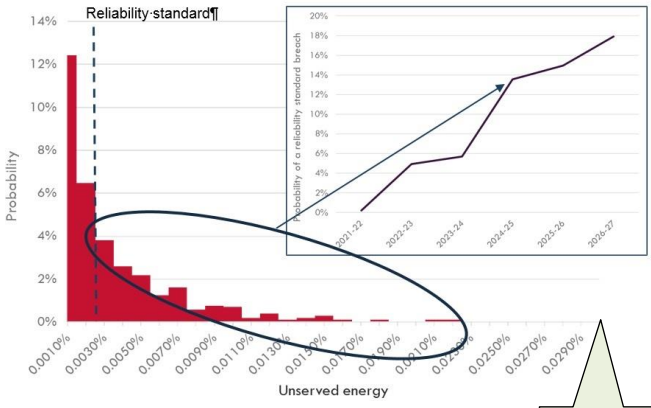
AEMO, 16/3/18, Advice to the Commonwealth relating to AGL's proposal to replace Liddell
http://www.aemo.com.au/-/media/Files/Media_Centre/2018/Liddell-Advice_Final_.pdf

Note: Fig 2 only applies if AGL fails to implement the investment program it has publicly committed to

Figure 2: Distribution of annual unserved energy showing probability that standard will be breached, 2024-25[4]



Why should consumers pay to increase EUE at generation level?

Actual end-user average actual UE

AEMO, 16/3/18, Advice to the Commonwealth relating to AGL's proposal to replace Liddell
http://www.aemo.com.au/-/media/Files/Media_Centre/2018/Liddell-Advice_Final_.pdf

- For *Scenario 1*, there is a risk of load shedding every 4 years, resulting in approximately 174,000 households without power for 3.6 hours:
  - On average, 174,000 households without power for 0.9 hours/yr
  - On average for 2.77 m households, without power for 0.06 hours/yr
    (https://profile.id.com.au/australia/household-size?WebID=100)
- For *Scenario 2*, this risk of load shedding reduces to 1-in-20 years, resulting in approximately 172,000 households without power for 2.2 hours:
  - On average, 172,000 households without power for 0.22 hours/yr
  - On average for 2.77 m households, without power for 0.01 hours/yr
- For comparison, NEM average SAIDI for distribution networks is about 250 minutes/yr or ~4 hours/yr

Conclusions & recommendations

- Long-term energy supply security & energy service delivery:
  - NEG emissions requirement*: poor design & inadequate scope*
    - A cruel hoax in terms of making a reasonable contribution to avoiding dangerous climate change, we must do better
  - NEG reliability requirement*:*
    - Should be deferred until AEMO Integrated System 1st Plan is completed because it is a more coherent approach:
      - However, AEMO ISP scope should be extended to distribution networks & end-users & it should be rigorously externally audited
- Short-term (intra-year) electricity industry security:
  - NEG reliability requirement: *poor design & inadequate scope*
    - End-users should be assisted to assess their own needs & manage their procurement:
      - Energy Service Companies have never been more important

IPEN AIE Forum on the National Energy Guarantee: Comments by Hugh Outhred

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Hugh Outhred is Managing Director of Ipen Pty Ltd, established in 1998 to provide advisory and educational services on energy, society and the environment.

Hugh retired in 2007 after a 35-year career at the University of New South Wales (UNSW) with research contributions in power system dynamics, electricity industry design & renewable energy integration, most recently as Presiding Director, Centre for Energy and Environmental Markets and Head, Electrical Energy Research Group, School of Electrical Engineering and Telecommunications. He is a fellow of the Australian Institute of Energy and a Life Member of the Institute of Electrical and Electronic Engineers.

During his career, Hugh has been a Fulbright Senior Fellow at the University of California Berkeley, a Member of the National Electricity Tribunal, a Member of the New South Wales Licence Compliance Advisory Board, a Board Member of the Australian Cooperative Research Centre for Renewable Energy, an Associate Director of UNSW's Centre for Photovoltaic Devices and Systems, a Member of CSIRO's Energy Flagship Advisory Committee and a Lead Author for the IPCC Special Report on Renewable Energy Sources & Climate Change Mitigation, 2011.

Since 1989, Hugh has taught 130 short courses in 15 countries on electricity industry design & renewable energy integration.

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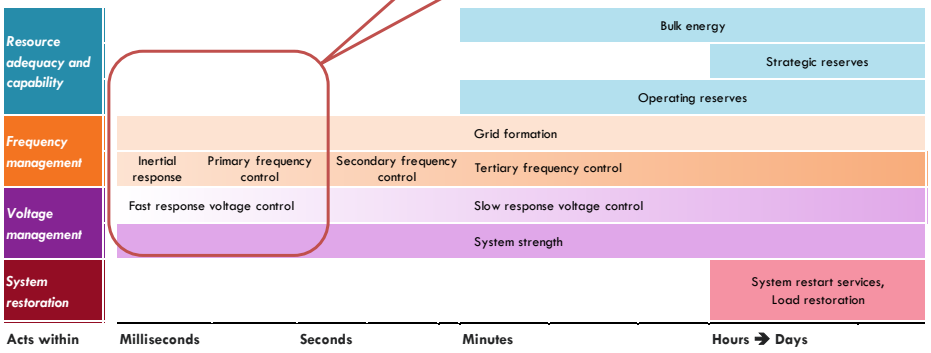
Power system requirements, AEMO, 6/3/18

https://www.aemo.com.au/Media-Centre/AEMO-publishes-Power-System-Requirements-paper

Replace with:
Management of short-term dynamic behaviour

Figure 1 Operation timescales for services needed



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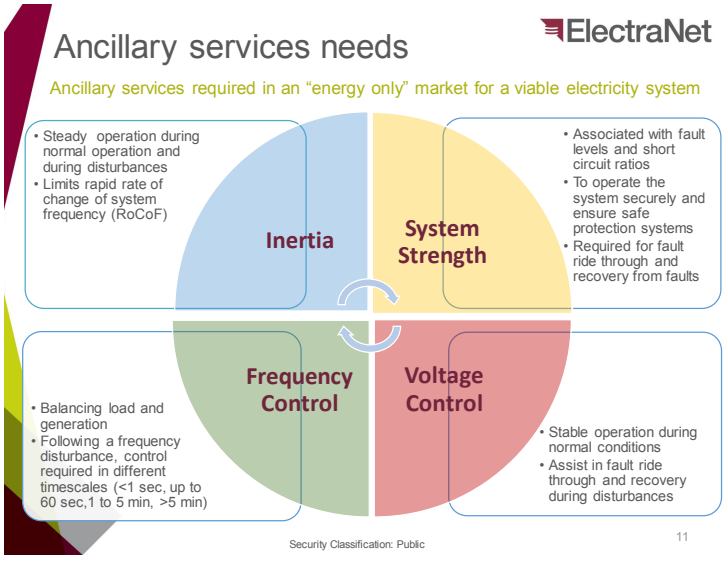
What is a grid-scale battery energy storage system (BESS) best used for in SA?, presentation for the EESA 16/8/17



Unfortunately, these four Ancillary Service "needs" aren't well specified and cannot be decoupled during periods of large, rapid change. They become subsumed within consideration of short-term dynamic behaviour, which may place more complex requirements on individual resources.

https://www.roymorgan.com/findings/7262-solar-energy-electric-panels-march-2017-201707061419

Household PV ownership in March 2017

It appears likely that battery ownership will now also grow