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Volt-face

Changing energy security in the National Electricity Market

Batteries and renewable energy can provide inertia and system strength in the National Electricity Market as coal is retired. The Post-2025 redesign is the opportunity to enable the energy transition with a fit-for-purpose security regime.

Discussion paper

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Executive Summary

In mid-2021 Australian energy ministers will decide on a new 'Post-2025' design for the National Electricity Market (NEM), on advice from the Energy Security Board (ESB). The goal is to maintain reliability and security as coal and gas are increasingly displaced by renewable energy.

The focus of the ESB's Essential System Services work is to design a market to supply more inertia and system strength. Inertia controls frequency and system strength maintains voltage.

The Australia Institute has commissioned a technical study on inertia and system strength from the Victorian Energy Policy Centre to provide input into the ESB process. This current companion report summarises key findings of the technical study, as well as provides context and wider recommendations on energy reform.

The technical study finds that batteries and renewable energy are becoming competitive with conventional sources of inertia and system strength. There is no technical obstacle to them replacing the system security which has been provided by coal and gas generators. Innovative new inverter-based sources are already proving themselves cheaper and better than legacy technologies.

In this period of rapid technological transition, the cost of system security represents around 2% of the cost of wholesale energy. Over the long-term, this cost may decrease. In 2021 synchronous generators were re-regulated to provide inertia and this saw frequency improve.

The rules governing the provision of inertia and system strength are not fit for purpose for the Post-2025 market. They are a brake on the clean energy transition and undermine state-based Renewable Energy Zones.

The ESB 'structured procurement' option would best facilitate coal retirements and the Renewable Energy Zone build-outs. Inertia and system strength should be procured through auctions by the Australian Energy Market Operator (AEMO).

The study highlights deficits in the current regulatory framework. We propose three objectives for Post-2025 redesign of security and other markets: increase competition, promote innovation, be pragmatic by accommodating state policies.

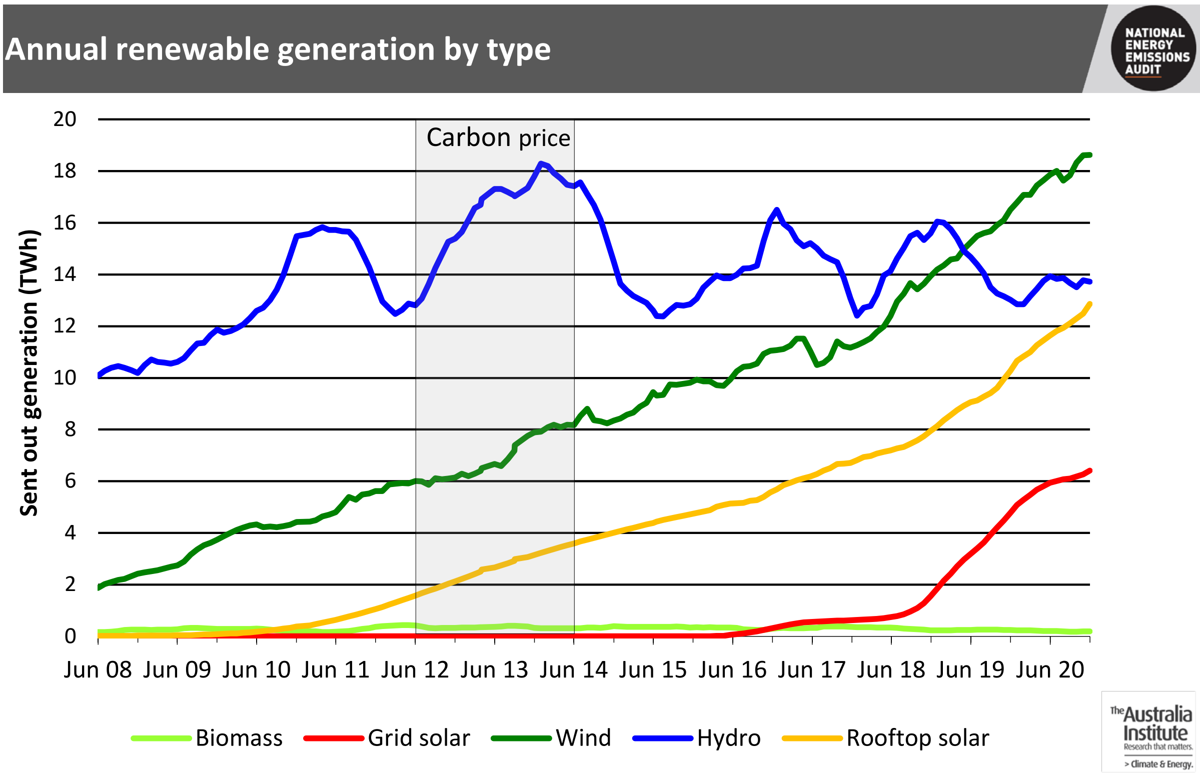
Such reforms are widely popular. Opinion polling shows a majority of Australians support new technologies providing system security.

Contents

Introduction

The amount of renewable energy in the National Electricity Market (NEM) is growing and has been growing steadily for over a decade (Figure 1). This is happening despite a lack of climate policy or electricity policy from the Federal Government. The key drivers of renewable energy investment are state policies and the fact that solar and wind and batteries are increasingly competitive. While there is no federally-led, unified policy for the energy transition, there are processes that are being led by NEM bodies.

Figure 1: Annual renewable energy generation in the NEM 2008-2020



Source: Saddler (2021) *National Energy Emissions Audit Report : January 2021*, p.8

In 2019 COAG Energy Council tasked the Energy Security Board (ESB), which advises governments, to propose options to make the NEM fit-for-purpose and maintain reliability and security as coal-fired generation retires. The ESB is currently concluding this 'Post-2025' review and will publish its *Options Paper* at the end of March 2021.

The Post 2025 review is broad ranging and includes a workstream on Essential System Services, particularly the question of how to maintain system security with large amounts of renewable generation in the NEM. This is not the supply of energy to consumers but the services that keep the frequency and voltage within technical limits.

The ESB's workstream is focused on inertia and system strength services. Inertia refers to the extent to which the power system resists changes to demand and supply, over micro-second time scales. System strength refers to the extent to which a stable voltage waveform is maintained after disturbances to the system, such as from short circuits.

In the past system security was provided by coal-fired and other 'synchronous' generators, mostly gas and hydro. As coal and gas retire, the NEM will need a framework that allows batteries, solar and hydro to supply inertia and system strength.

The Australia Institute commissioned a technical study from Professor Bruce Mountain, director of the Victorian Energy Policy Centre (VEPC) and the Centre's battery economics expert Dr Steven Percy, to contribute to the ESB's reform process.[1]

The technical paper is attached. This report aims to make the key findings of the technical report accessible to a wider audience.

The VEPC report confirms that there is no technical obstacle to maintaining security as the NEM approaches 100% renewable energy. Security services can be, and in many cases are being, provided by renewable energy and batteries.

We commend the technical report to the ESB and propose the adoption of the 'structured procurement' model for inertia and system strength . We recommend it is designed to maximise competition from new technologies and allow states to have fine control over system security in their NEM regions, to accommodate state policy goals and manage coal retirements and decommitments.

The Energy Security Board can be optimistic and future-focused with its Essential System Services recommendations, to encourage competition and innovation. Over the long term the NEM might not need inertia as conventionally defined at all.

The structured procurement model should give the AEMO the ability to plan the supply of security services well in advance of any shortfalls. Crucially, this procurement model would give states the ability to manage system security in their regions of the NEM as Renewable Energy Zones are built out.

Energy ministers gave the ESB the task of redesigning the NEM. If they engage with system security issues now then the Post-2025 project can deliver a design capable of withstanding coal retirements. The critical test is whether it encourages investors to fund the innovative energy and system security capacity Australia needs as coal exits the stage.

[1] Mountain & Percy (2021) *Inertia and System Strength in the National Energy Market: A report prepared for The Australia Institute*

1. System security

In this paper and the VEPC technical study the focus is on *security* as distinct to *reliability*. *Security* refers to the ability of the power system to stay within safe technical limits. *Reliability* refers to the capacity of generation and demand side resources to supply enough energy to customers to meet their demand. The exit of coal power stations presents challenges to both security and reliability. The VEPC paper, and much of the ESB workstream, focuses on security, particularly inertia and system strength. This discussion is not about providing enough electricity “when the sun does not shine and wind does not blow”, but about ensuring the electricity system keeps working through a range of challenges that new technology is bringing.

The term inertia originally referred to the rotating masses in coal-fired, steam driven generators. The rotating masses of the generators have inertia – they resist changes to their motion. In a power system, with many generators and machines rotating at the same time, inertia refers to the resistance of the system to momentary changes in the system-wide demand and supply. This affects the frequency, how often the system oscillates between positive and negative voltage.

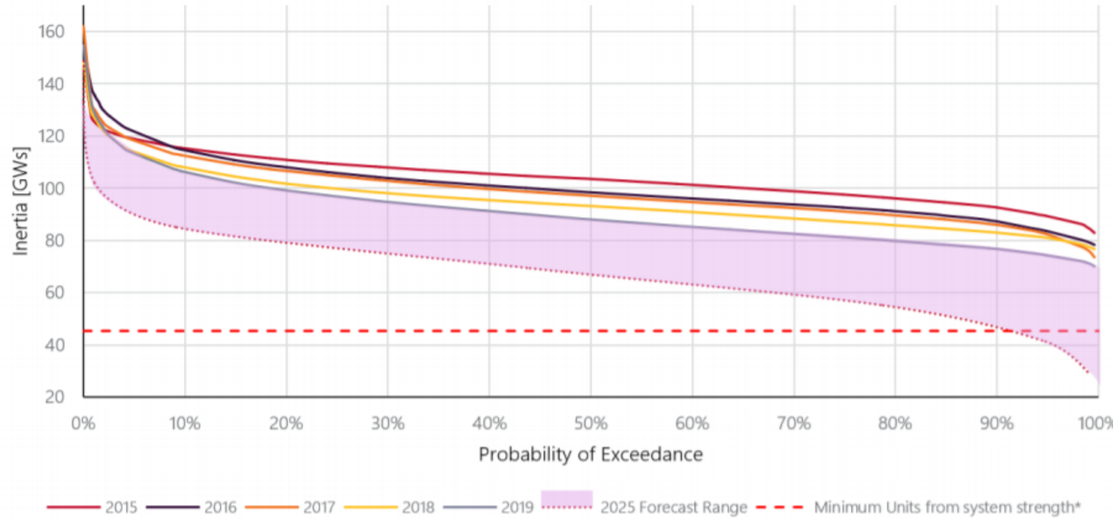
System strength refers to the ability of a power system to maintain stable voltage, or the difference in charge, across the network. This particularly relates to maintaining voltage after a large fault, such as a short circuit. System strength issues are primarily local, while inertia issues are always regional or more extensive, reaching across the interconnectors between states.

Inertia and system strength have ben supplied by the large spinning generators turned by steam, fired by coal or gas, or hydro power. These generators spin at the same rate, or ‘synchronously’. As this synchronous generation is replaced by technology that does not use synchronously spinning generators, like solar panels, batteries and wind turbines, the challenge of how to ensure system security has emerged.

Historically the NEM has had an abundance of inertia provided by synchronous coal, hydro and gas generators. Before 2019 the mainland NEM inertia level was never below 68 GWs.[2] Figure 2 depicts the historical inertia duration curves for the mainland NEM from 2015-2019 and the forecast for 2025. This shows that inertia could be below the ‘initial safety net’ of around 45 GWs for 20% of the time in 2025.

[2] AEMO (2020) *Renewable Integration Study Stage 1 Appendix B: Frequency control*, p.8

Figure 2: Mainland inertia duration curves, 2015-19 and forecast for 2025



Source: AEMO, *Renewable Integration Study: Stage 1 report*, p.45

While a NEM with less synchronous generation does present a system security challenge, the VEPC technical report shows that battery and other inverter-based resources are able to provide inertia and system strength in many regards. For example, one study found that a 50 MW battery does more to improve frequency after a disturbance than a 225 MW synchronous condenser.[3]

Emerging technologies are overtaking conventional technologies

There are a range of technologies capable of providing frequency control and system strength. In the past barriers have excluded clean energy resources from providing system security but this started to change around 2017. The Finkel Review proposed that renewable energy technologies could provide 'synthetic' inertia.[4]

Figure 3 lists key technologies and their inertia and system strength capabilities. Solar, wind and batteries use inverters to convert DC to AC and control power output to the networks and this 'inverter-based' class of technologies will provide most inertia and system strength in the future. In the past the main technologies used were synchronous generators or an allied technology called synchronous condensers and networks (more transmission within states or interconnection between states).

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[3] Spahic, Varma, Beck, Kuhn, & Hild (2016) *Impact of reduced system inertia on stable power system operation and an overview of possible solutions*

[4] Finkel, Chloe Munro, Terry Effeney, & Mary O'Kane (2017) *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future*, p.55

Regulatory barriers continue to be the key limitation on batteries and renewable energy providing system security. For example, renewable energy projects are technically able to contribute to system strength but in the past they were not used this way (see row: 'Tuning inverters at existing renewables'). A project in northern Queensland has retuned the inverters at four large solar farms for a cost that is reported to be around 4% the cost of a conventional synchronous condenser solution.[5]

Batteries can deliver far more system security than a coal generator of the same power capacity. When EnergyAustralia announced that the 1,480 MW Yallourn coal power station would close in 2028 it also announced a new 350 MW battery will be built in 2026. The battery is likely to be able to provide at least three times as much inertia as Yallourn, despite a capacity a quarter as large.[6]

[5] Parkinson (2021) *Inverters are solving grid issues at fraction of cost of spinning machines*, https://reneweconomy.com.au/inverters-are-solving-grid-issues-at-fraction-of-cost-of-spinning-machines/

[6] Mountain & Percy, p.3

Figure 3: Capabilities of inertia and system strength technologies

Source: VEPC technical study

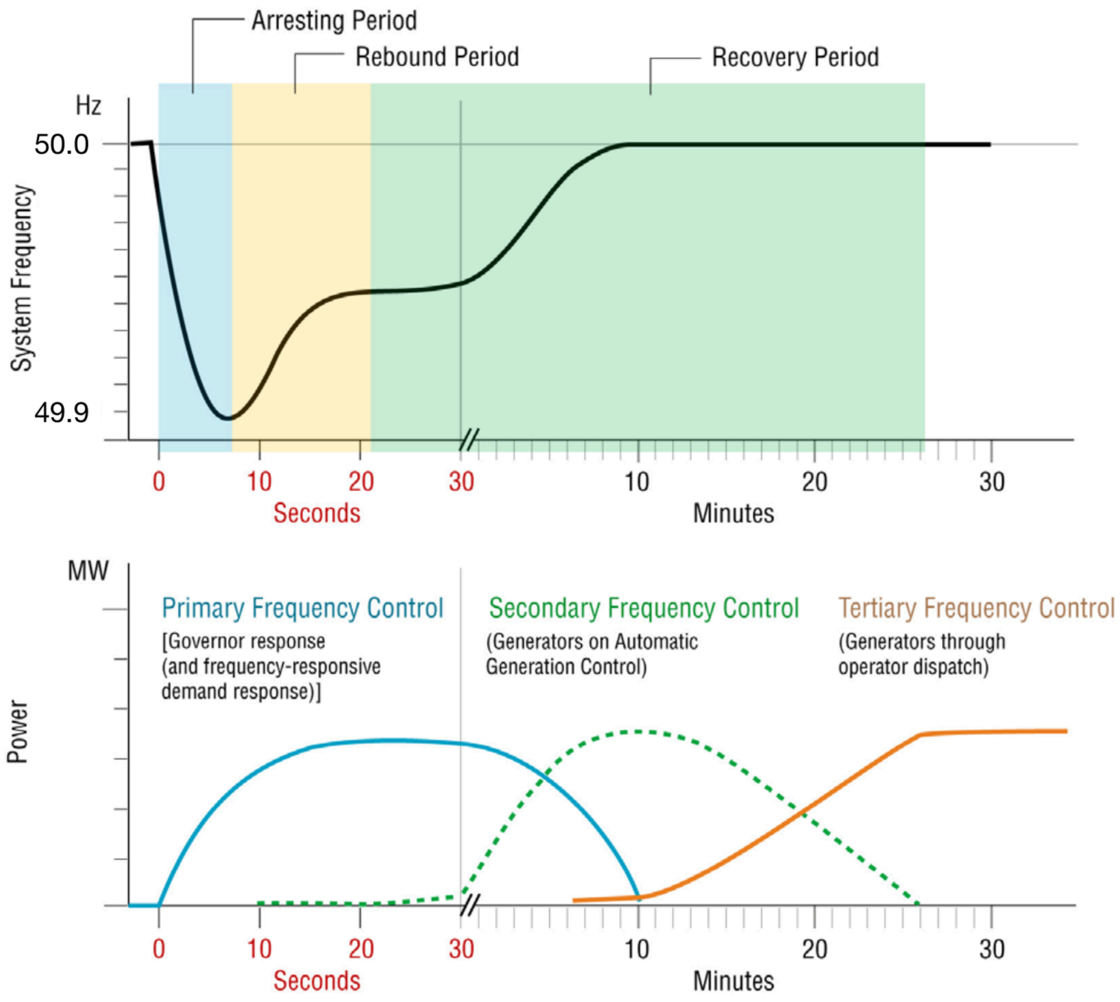
Technology	Inertia capabilities	System strength capabilities	Energy role
Synchronous generation	Coal, gas and hydro generators. The turbine and generator sets resists system frequency change, supplying or absorbing active power.	When synchronized with grid frequency generators resists voltage change, even if not providing real power. System strength diminishes with electrical distance from generator.	Primary purpose is energy production.
Synchronous condensers	Large spinning machine like a synchronous generator but spinning freely. It resists frequency change. The mass may be augmented with a flywheel to increase inertia.	Support network voltage by strength by supplying or absorbing reactive power.	None
Synchronous condenser clutches	Synchronous generator retrofitted with device so it can be decoupled from turbine. Turbine provides inertia while generator stationary.	As above	None
Network augmentations	New or stronger interconnections in a network increase inertia.	Distribution network augmentations can improve network voltage during low inertia conditions.	Primary purpose is energy production.
Reactive power supply	None	Devices added to the transmission (or distribution??) network that provide fast-acting reactive power and support network voltage.	None
New batteries & renewables	Batteries can be 'grid forming' – setting frequency not simply following it. Inverter-based systems can resist system frequency change, like a synchronous generator. Software determines the shape of the frequency response. Batteries have inertia in proportion to energy stored. Solar can only increase reactive power if curtailed and wind can only draw on kinetic energy in the turbine. Inverter based systems can also provide fast frequency or active power response, which does not mimic a synchronous generator and may be as fast as 70 milliseconds.		Primary purpose is energy production or storage. Batteries (including when paired with renewables) can import energy, providing additional load-shifting benefits, arbitrage revenue and network support compared with synchronous generators.
Tuning inverters on renewables generation	The settings on grid-following inverters can be tuned so that instead of creating cascading system strength and inertia problems they can support system strength.		Primary purpose of generators is energy production.

How frequency response is managed in the NEM

In this section we will focus on how generators and batteries are used to provide frequency control after a disturbance.

After a frequency disturbance, there may be up to three overlapping waves of frequency control used to restore frequency (Figure 4).

Figure 4: Overview of the phases of frequency control



Source: Miller & el.al. (2017) *Technology Capabilities for Fast Frequency Response*, p.16

For small events requiring a 'regulation' response, a control signal is sent out centrally by AEMO. For large events a local control signal triggered by the frequency deviation causes a 'contingency' response.

The instant, inertial resistance provided by rotating generators (and induction motors) is part of the primary frequency control phase. This first set of response lasts up to around 10 seconds. The purpose of primary frequency response is to stop the deviation from getting worse and keep frequency within safe limits.

Conventional inertia is not enough to arrest a significant deviation caused by a major or 'contingency' event. This is because inertia is a physical characteristic of the synchronised devices not a control action. It does not target the restoration of frequency. It also runs out within a few seconds and may not have enough power to bring frequency back to normal.

Small frequency deviations that can not be instantly corrected by physical inertia are corrected within seconds by Automatic Generation Control systems on synchronous generators. They act in response to a central control signal sent by AEMO every 4 seconds and this service is paid for in the regulation Frequency Control Ancillary Service markets (raise and lower).[7] The regulation control is always on and works within the narrow, 'normal operating frequency band'.

For large, contingency events, the main supply of primary frequency control in the NEM is provided by the six second contingency Frequency Control Ancillary Services.[8] This response also uses Automatic Generation Control but unlike regulation it is triggered locally.

For a fast generating plant such as a gas peaker, the continency response can trigger it to turn on. For slower coal plants, the governor on the steam turbine opens or closes a valve. Once the thermal inertia in the boiler is used, the initial raise response of a coal plant literally runs out of steam.

Inverter-based technologies are able to replace both inertia and the six second frequency response with a new kind of programmed, 'fast frequency response'. This response to deviations very quickly: around 70 milliseconds including external detection and signalling for lithium and flow batteries, flywheels and super capacitors, 160-280 milliseconds for solar PV and 120-580 milliseconds for wind.[9] These times are so rapid it would be hard to depict them on Figure 2, at the base of the blue line on the bottom chart that represents the frequency correction of synchronous generators. Inverter response must be triggered by a detection system.

The AEMC is currently considering rule changes to enable inverter-based technologies to provide fast frequency response as part of the Post-2025 redesign.

The secondary frequency control phase starts later and lasts longer. Coal and gas generators have to be fired up to increase output and this control response take tens of seconds to reach full power. There is paid through the 30 second contingency Frequency Control Ancillary Service market.

[7] AEMO (2020) *Market Ancillary Service Specification*, p.10

[8] Miller & el.al. (2017) *Technology Capabilities for Fast Frequency Response*, p.6

[9] Ibid, p.5

The tertiary frequency control phase is longer again and brings the frequency within the normal operating band, which is the system operator's target for 99% of the time. There is paid through the five minute contingency Frequency Control Ancillary Service market.

System security costs at historical high but may be coming back down

The total cost for system security in the NEM rose from around $317 million in 2019 to around $522 million in 2020.[10] $229 million of this increase fell in Q1 of 2020 and was caused by a major storm on 31 January 2020 and two other separation events.[11] Average system costs for the last three quarters of 2020 were lower than the average quarterly cost in 2019.[12]

Frequency control is more than two thirds of the total so the re-regulation of synchronous generators to provide more inertia over late 2020 and early 2021 may see system costs lower than in 2019.

If we assume an annual system cost around $320 million this is around 2% of the total cost of electricity traded in the NEM for financial year 2019-20[13].

Figure 5 charts the value of all Frequency Control Ancillary Services payments in the NEM from 2012 to 2020.[14] It shows that raise (the darkest bands) account for about two thirds of the cost. This is because the most common frequency problem is a drop in energy. The total cost of the wholesale frequency control markets in the NEM in 2020 was $363 million.

The frequency control markets were only opened up to competition from batteries and demand response in 2017 and they have competed successfully against the incumbents. Demand response captured about 12% of the frequency control markets in Q4 of 2020 and batteries were at about 26%.[15]

Figure 6 charts the technology shares in one of these markets, for 6 second raise Frequency Control Ancillary Services, since 2012. This is the main primary frequency response service in the NEM. Batteries went from zero to at least 30% of the market in just 3 years.

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[10] AEMO (2021) *Quarterly Energy Dynamics - Q4 2020*, p.23

[11] Ibid, p.3

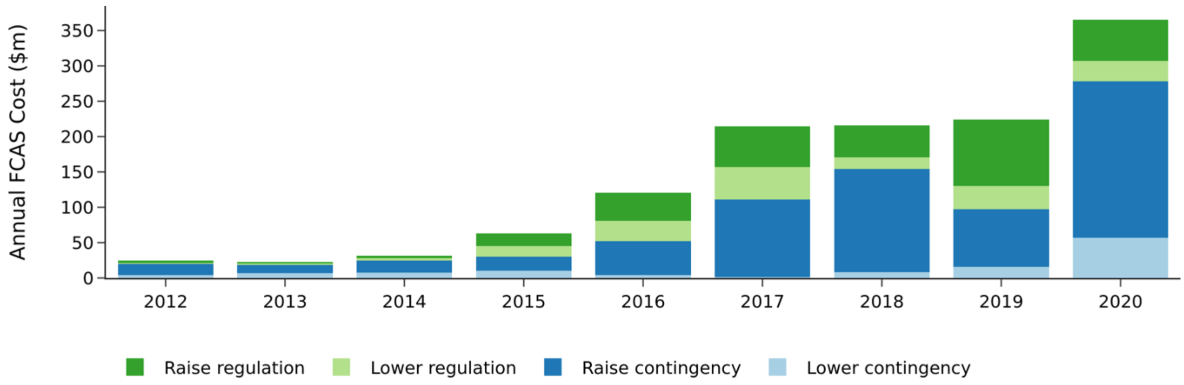
[12] Ibid, p.24

[13] AEMO (2020) *The National Electricity Market*

[14] There are six contingency markets (raise and lower over 6 and 30 seconds and 5 minutes) and this chart combines all the raise and all the lower markets for simplicity.

[15] AEMO (2020) *Quarterly Energy Dynamics - Q1 2020*, p.24

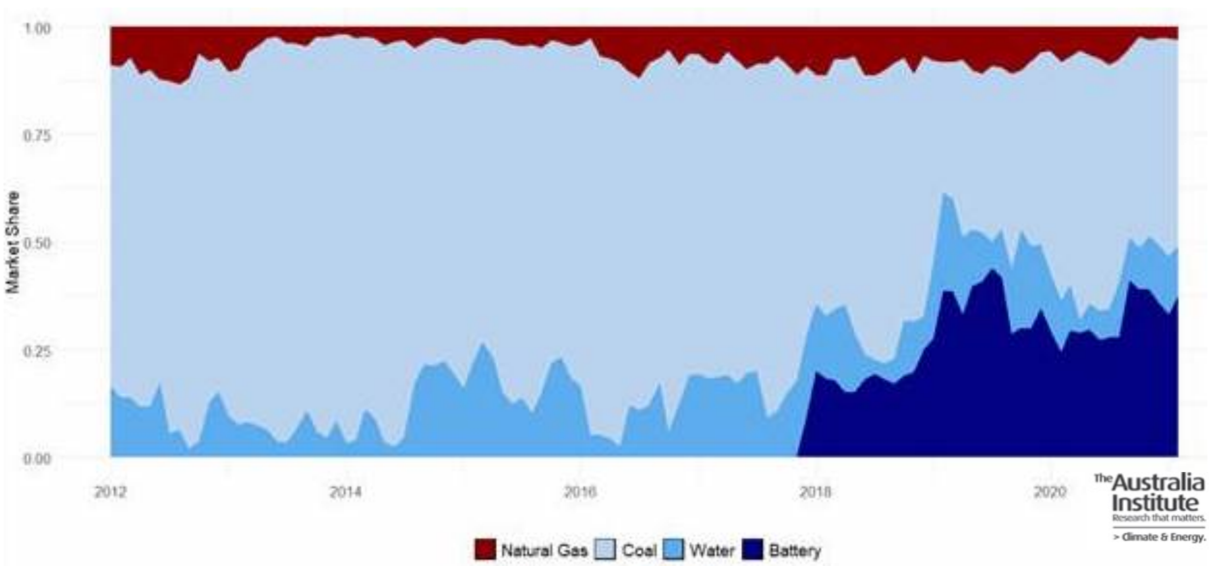
Figure 5: Regulation and contingency frequency payments in the NEM 2012-2020



Source: VEPC technical study

A recent survey suggests there may be around 7 GW of battery projects already at proposal stage or more advanced stages of development.[16]

Figure 6: Market share of 6 second raise Frequency Control Ancillary Service market since 2012



Source: Australia Institute chart from VEPC analysis of AEMO data

The VEPC technical report states that 'the aggregate cost of inertia, system strength and frequency response ancillary services will continue to be an almost inconsequentially small part of customers' bills.'[17]

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[16] Matich (2020) *Australia's battery energy storage pipeline at 7 GW*, https://www.pv-magazine.com/2020/12/17/australias-battery-energy-storage-pipeline-at-7-gw/

[17] Mountain & Percy, p.11

2. Energy transition requires new security regime

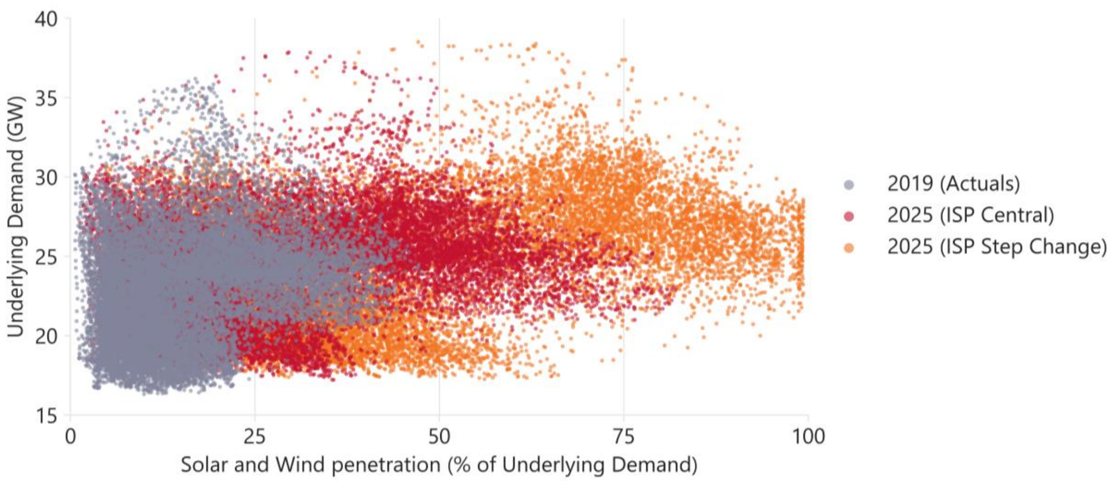
In this section we look at the challenges facing the power system. The growth of renewables is just one factor. One of the emerging difficulties is that coal generators are starting to lose money and make financial decisions that harm system security. They will reduce maintenance, generate at a lower level and mothball or 'decommit' units, which makes them unavailable even when required for system security.

The quantity of inertia and system strength required at any point in time is not just a function of the amount of renewable energy capacity. The relative levels of synchronous and asynchronous generation and also the level of demand are critical.

When solar and wind generation is very high levels, the instantaneous balance of synchronous and renewable generation may degrade security. While the average annual renewable energy generation is sitting at 27% of sent-out supply, the level of renewable energy at any point it time can be much higher.[18]

AEMO has projected the maximum proportion of supply from solar and wind in 2025. Figure 7 charts the instantaneous penetration of solar and wind on the X- axis. Black represents 2019 and orange represents 2025 if renewable energy growth is rapid.[19]

Figure 7: Instantaneous penetration of wind and solar generation, actual in 2019 and forecast for 2025 under ISP Central and Step Change generation builds



Source: AEMO (2020) *Renewable Integration Study: Stage 1 report*, p.6

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[18] Saddler (2021) *National Energy Emissions Audit Report : January 2021*, p.8

[19] The Step Change scenario in the 2020 Integrated System Plan.

This shows that there are likely to be many periods when solar and wind produce 100% of the supply in the NEM - indicated by the dots along the right hand axis. If the security regime has not been updated to allow clean energy and batteries to supply the services required, then the system will become insecure.

If should be noted that a single state can have 100% renewable energy for short periods if it remains connected to another state with sufficient inertia to maintain frequency in both. AEMO reports that power systems that are interconnected synchronously (so that inertia is constant) have remained secure when 'wind and solar energy was larger than demand – including Denmark (157%) and South Australia (142%)'.[20]

Renewable energy is steadily decreasing the minimum 'operational' demand. This is the level of energy demand on the grid for 'sent-out' supply. The problem is that when minimum demand is less than the minimum safe output of a synchronous unit[21] then it will shut down. When it removes its energy production capacity this removes both inertia and system strength supply. In 2020 new records were set for minimum operational demand, of 270 MW in South Australia, 3,712 MW in Queensland and 3,073 MW in Victoria.[22]

How regulation is improving frequency in 2021

In recent years the frequency in the NEM departed from the normal operating band more often. This and other security challenges are often blamed on renewable energy, but the story is more complex. The regulatory requirements that forced coal and other synchronous generators to provide inertia were relaxed. These decisions led to a reduction in mainland inertia that was only restored this year, after generators were required to reinstate this vital security service.

Figure 8 charts the system frequency in the mainland NEM from 2012 to 2020. The target frequency is 50 Hz so the taller and narrower curves indicate better frequency control. What is notable is the degree to which frequency control was restored after reregulation of inertia settings on synchronous generators in late 2020 and early 2021 (the *Mandatory primary frequency response* rule change).[23]

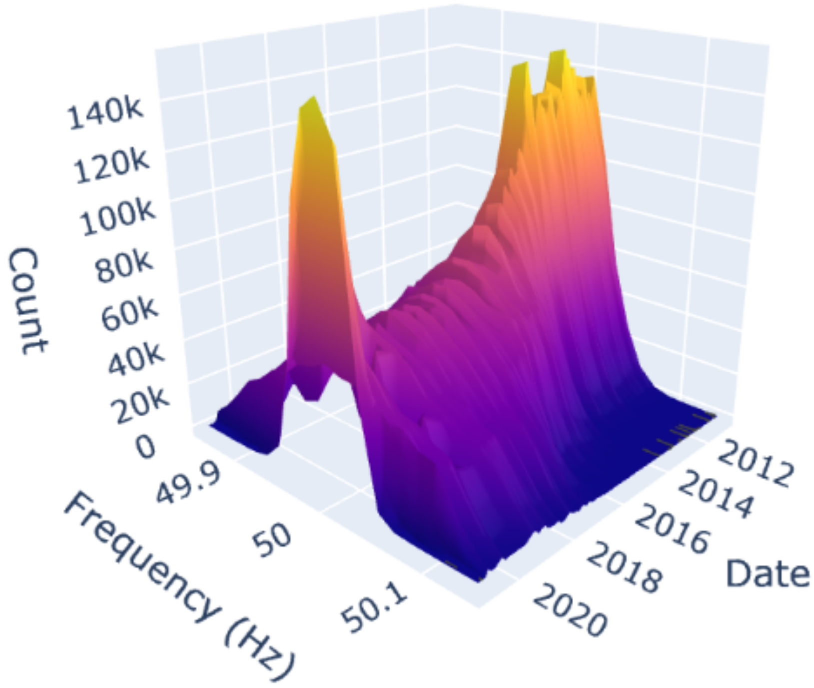
[20] AEMO (2019) *Maintaining Power System Security with High Penetrations of Wind and Solar Generation*, p.3

[21] A large power station may comprise multiple units each with a turbine and generator

[22] AEMO (2020) *2020 System Strength and Inertia Report*, p.4

[23] AEMC (2020) *Mandatory primary frequency response, Rule determination*

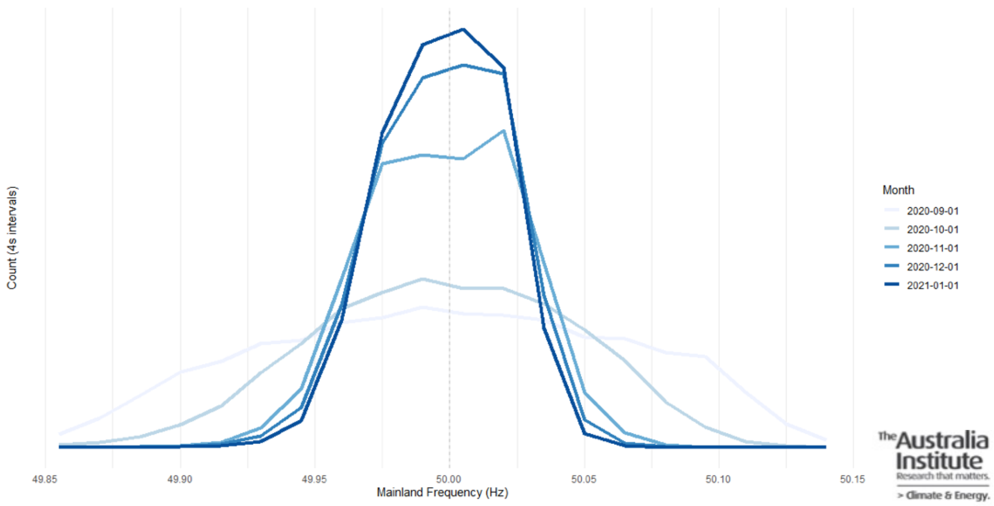
Figure 8: Mainland frequency in the NEM 2012-2020



Source: VEPC technical study

The impact of re-regulating the coal, gas and hydro generators to provide frequency control is more clearly seen in Figure 9.

Figure 9: Mainland NEM system frequency in before and after re-regulation of synchronous generator frequency control services



Source: Australia Institute chart from VEPC analysis of AEMO data

Inertia and system strength projections

Figure 10 summarises inertia and system strength current status and projections to 2025 and remediation undertaken. All the current issues have been previously identified by AEMO and some are already being remediated.

The key new risk identified by AEMO is that coal generators will 'decommit' units when prices are low. The issue is that as renewable energy capacity supply rises this reduces wholesale energy prices. Coal generators will increasingly respond by withdrawing functioning units from dispatch.

AEMO warns about the impact this will have on system security;

> Depending on the timing, number and location of these decommitments, AEMO may be required to declare shortfalls in system strength …. An inertia shortfall for the Queensland region may also arise due to these same decommitments.[24]

Figure 10: Inertia and system strength requirements in state regions 2020-2025

State	Inertia and system strength status and remediation
Queensland	System strength shortfall at Ross currently in remediation. Potential inertia shortfall in 2025 and system strength at Gin Gin.
NSW	No shortfalls currently. Potential system strength shortfalls at Newcastle and Sydney West in 2025 particularly if low wholesale prices cause coal generators to withdraw capacity (whilst not retiring).
Victoria	No inertia shortfalls. Red Cliffs services in place to address system strength shortfall until 2022.
South Australia	4 synchronous condensers with flywheels being installed to remedy system strength shortfalls. Inertia shortfall until 2023 (how fixed?)
Tasmania	In 2019 AEMO declared inertia and system strength shortfalls when low demand and high imports over Basslink mean insufficient hydro units online. Basslink imports are increasing as more solar and wind installed in Victoria. TasNetworks contracts with Hydro Tasmania to run hydro units as synchronous condensers until 2024. In 2020 AEMO declared additional shortfalls from 2024.

Sources: VEPC technical study, AEMO (2020) *2020 System Strength and Inertia Report*

Australian innovations

Australia is doing world-leading RD&D of inverter-based technologies to maintain system security. The Australian Renewable Energy Agency provided $12 million to ElectraNet to build a 30 MW / 8 MWh properly 'grid forming' battery at Dalrymple on the lower Yorke Peninsula in South Australia.[25] It supports fast frequency response, which increases flows on

[24] AEMO (2020) *2020 System Strength and Inertia Report*, p.4

[25] ElectraNet (n.d.) *About the Battery*, https://www.escri-sa.com.au/

the Heywood interconnector between South Australia and in that sense it competes with network augmentation as a solution for energy, inertia and system strength.

The Dalrymple battery can also 'island', or form a self-sufficient mini-grid, along with the Wattle Point Wind Farm, local energy users including rooftop PV.

TransGrid is building a 50MW/75MWh battery at the Wallgrove substation in New South Wales. This will provide inertia, fast frequency response and effectively system strength services. TransGrid claims the battery will provide inertia 'at a small fraction of the cost of traditional technologies such as synchronous condensers.'[26] It cites analysis by HoustonKemp that benefits to NSW consumers will be in the range of $93m to $135m.

AEMO is optimistic about the capabilities of new technologies. It notes that new sources of supply of inertia and system strength 'may provide further efficiencies in the future power system design'.[27]

Technology has outpaced the rules and in the next section we look at problems caused by outdated regulatory frameworks for system security in the NEM.

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[26] TransGrid (2020) *First large-scale grid battery in NSW coming to Western Sydney*, https://www.transgrid.com.au/news-views/news/2020/Pages/First-large-scale-grid-battery-in-NSW-coming-to-Western-Sydney.aspx

[27] AEMO (2020) *2020 System Strength and Inertia Report*, p.4

3. Problems with system security regulation in the NEM

The existing regulatory framework for security services was designed around coal. The purpose of the Post-2025 project is to rewrite the rules to promote investment in batteries and other new resources to maintain reliability and security as coal-fired generation retires. Innovators and AEMO will solve the technological challenges, the issues for the ESB is how to solve the institutional and regulatory challenges.

In March 2020 the AEMC made a rule change that required all generators that can be instructed to run (coal, gas and hydro) and also semi-scheduled generators (large wind farms that can adjust output to a degree in response to instructions) to provide inertia. AEMO is currently coordinating the implementation of this obligation and it should be complete by mid-2021. Figures 7 and 8 above show this rule has already improved frequency control substantially.

This highlights a governance and design challenge for the ESB. Critical issues within the scope of the Post-2025 redesign are not entirely within the control of the ESB. The AEMC has commenced several rule changes about system services and these are underway at the same time as the Post-2025 redesign. AEMO leads the technical development of security frameworks, particularly through its Renewable Integration Study and frequency control work plan.

This splitting of both decision making and consultation makes the reform process unwieldy for stakeholders. There is a risk it could result in a lack of unity of design. It is encouraging that the AEMC has stated that its frequency rule change work 'is consistent with and builds on' the work undertaken by the ESB and will 'dovetail' with its Post-2025 recommendations.[28]

Security and reliability frameworks in the NEM have failed to keep up with the clean energy transition, so States have had to move into security markets for the same reason that they have moved to organise energy supply. States have organised procurements which are at the cutting edge of innovation. South Australia has a contract with the Hornsdale Power Reserve (the 'Tesla battery') for sophisticated frequency control services. The development of this technology was partially funded by the Australian Renewable Energy Agency.[29]

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[28] AEMC (2020) *Frequency control rule changes*, pp.i, ii

[29] ARENA (2017) *What is Frequency Control Ancillary Services?*, https://arena.gov.au/blog/what-is-frequency-control-ancillary-services/

In 2016 the South Australian Minister for Mineral Resources and Energy sought to fix the national framework. The Minister proposed a rule change request to the AEMC which would allow AEMO to contract for inertia and system strength. In 2017 the AEMC made a 'preferable' rule which passed this responsibility for procurement to network providers.

The new arrangement is that the procurement of new resources for inertia and system strength is managed by network operators, under direction from AEMO (except in Victoria where AEMO is the jurisdictional planning body). The transmission operator is the Inertia Service Provider for that region and when AEMO identifies a shortfall, the transmission operator has an obligation to fix it, on behalf of all consumers and generators.

This framework is not optimal. It leads to inefficient investment as sources of system strength can be expensive assets that cannot be shared and built in scale proportional to the wind and solar projects. Coordinating and allocating costs across multiple projects to pay for synchronous condensers is complex and inefficient.[30]

The VEPC technical study identified serious market distortions created by the current regime with regard to generator investments. The regime obliges new generators to 'do no harm' to system strength. The marginal project that tips system strength below a safe level is deemed to be responsible for what is a complex function of the total system of supply and demand in that area.

Inertia and system strength are public goods and this should inform how they are procured. All users benefit from them and it would not be possible to withdraw these goods from certain users if they refused to pay for them (they are non-excludable). They should be procured by a single buyer on behalf of all users. The cost could be recovered from both users and generators (who require these goods in order to earn revenue).

Renewable energy generators are also required to pay for regulation Frequency Control Ancillary Services. In 2001 the historical requirements on synchronous generators to provide security services were first relaxed and markets introduced for frequency control. A 'causer pays' methodology was designed for synchronous generators to ensure they ramped up and down according to dispatch instructions from AEMO – their 'schedule' of production. This would reduce the number of small frequency deviations and reduce the cost of regulation services.

When very large scale renewable projects entered the market, these were classed as 'semi-scheduled'. They were required to hit a schedule of production even though they are powered by variable wind and solar. AEMO predicts solar and wind output for each unit and

[30] GHD Advisory (2020) *Managing system strength during the transition to renewables*

imposes this as a dispatch target then penalises them if they fail to meet it. The AEMC has described this as 'complex and opaque'.[31]

These penalties on renewable energy projects are counterproductive. They are an impediment to the very renewable energy growth that is required in order to deliver new capacity to keep the system secure and reliable as coal retires.

The VEPC technical study identified a number of other weaknesses in the security services regime. These are three of the key ones:

- Network operators have an incentive to 'gold plate' system security investments. Large investments will add to the regulated asset base and give networks a guaranteed, high return over the long-term (up to 40 years).
- The long-term nature of regulated network investments will mean locking in today's technologies for decades.
- Batteries can deliver a stack of many service including energy arbitrage. If the networks own the assets and use them for these services then they are moving into contestable markets they are not supposed to be in.

One of the key trade offs being debated in the Post-2025 process is whether to prioritise the optimal dispatch of existing capacity or whether to seek efficient investment in new capacity. Given the concerns around disorderly coal retirements, investment is clearly the priority.

In the next section we provide a broad set of recommendations for a new inertia and system strength framework, based on the VEPC report findings and recommendations.

[31] AEMC (2020) *Frequency control rule changes*, p.96

4. Procurement and related recommendations

Our primary recommendation is that we endorse the ESB's 'structured procurement' option for both inertia and system strength. This is the model proposed by the South Australian Minister for Mineral Resources and Energy in 2016. We also make related recommendations about other parts of the Essential System Services framework for the Post-2025 redesign.

The goals for these reforms should be to increase competition, promote innovation and be pragmatic policy-wise (accommodate state energy plans and policies).

AEMO operates the system and should be the buyer, to best manage security challenges through the energy transition

AEMO is the appropriate buyer of system security as a public good. As the system operator it is best placed to coordinate system security. It has the best visibility of inertia across regions. AEMO manages the Integrated System Plan and tracks the progress of interconnector and REZ projects, which are key factors affecting security and reliability.

AEMO should work closely with network service providers to assess and procure remedies for system strength on their networks. It would be worth having oversight of the procurement process by a panel, to assist AEMO control costs and develop the market.[32]

As the South Australian Minister's system services rule change proposal stated, this approach would provide 'AEMO with the flexibility to manage emerging security challenges'.[33]

Prioritise simplicity and investment certainty now and consider a real time market later

There have been proposals for new, co-optimised real time and various forward markets in Essential System Services. In our submission to the *Consultation Paper* the Australia Institute voiced support in theory for a real-time market but we pointed out that the risks make such a model impractical in the short term.[34]

We have consulted with AEMO and appreciate the reasons why the system operator would value a co-optimised real time market. AEMO is right to insist on better visibility over and control of energy resources. Our contention is that a fine-grained market signal for security service dispatch is not necessary for visibility and control.

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[32] FTI (2020) *Essential System Services In The National Electricity Market*, pp.203-207

[33] Koutsantonis (n.d.) *Proposed Rule Change- System Security*, p.2

[34] Cass (2020) *Post 2025 Market Design Consultation Paper Submission*, p.12

The purpose of the Essential System Services framework is to get new resources built. This will only happen if investors are happy to invest. In a trade-off between simplicity and investment impact versus market efficiency, it would be advisable to emphasise simplicity.

The benefit of achieving a perfect market for system services would be marginal to the overall consumer cost of energy.

'Do no harm' and 'causer pays' is counterproductive because it undermines renewable energy investment

If the 'do no harm' obligation for system strength is left in place it will add unfair costs to new renewable energy projects and create investment uncertainty.[35] Renewable energy generators should not be treated like scheduled generators for the purpose of 'causer pays' charges for regulation of frequency control. The new Essential System Services framework and AEMC rule changes should remove these disincentives for renewable energy investment.

Shorter and medium-term contract terms to encourage innovation and efficiency

The UK National Grid's 'Pathfinder' procurement for inertia services was contracted to mostly legacy technologies with 6 year terms. These short terms mean that in only 6 years a future round will be able to incorporate emerging battery and other inverter-based technologies. The network-led procurement used in South Australia procured synchronous condensers for 40 years. This has locked in last century technology until the second half of this century.

There is a benefit is using some legacy technologies at the same time as pushing innovation. As coal and gas power stations become increasingly unprofitable as energy generators there may be a business case for using them more for inertia, such as retrofitting them with synchronous condensing clutches.

We recommend terms around 5-10 years. Longer contracts could be used to attract innovative solutions and shorter term contracts used to repurpose existing plant to provide more predictable services immediately.[36]

Maximise information sharing, involve CEFC and ARENA

Australia's clean energy innovation agencies, ARENA and the CEFC, should continue to play a major role in system security innovation and commercialisation. The procurement framework should be designed in collaboration with both agencies.

[35] This point has also been made by the Clean Energy Council and Reach in ESB (2021) *Post-2025 Market Design Directions Paper*, p.41.

[36] FTI, p.158

ARENA requires projects to share knowledge and this is an important benefit from having grant-based funding. There may be other ways for AEMO procurement to maximise knowledge sharing in order to promote innovation and increase public accountability.

Realise the full value stack from batteries

In order to deliver competition and innovation, a procurement mechanism must allow projects to capture the full value stack that their technologies are capable of providing. Conventional inertia and system strength technologies such as synchronous condensers tend to deliver fewer services than new inverter-based technologies. Batteries, for example, are able to deliver everything from fast to 'slow' inertia (primary, secondary and tertiary frequency response), as well as system strength, system restart services and energy.

If Australia is to drive innovation, the ESS markets must be truly agnostic and enable multi-service technologies to provide maximum market value and public goods.

Facilitate state energy policies

The ESB has successfully resisted calls to criticise the states for moving forward with their own regulatory solutions and policies. In the Post-2025 *Discussion Paper* the ESB said it is 'working hard' so the new designs 'work alongside government policy targets and aspirations at state or federal level.'[37]

States have regained much of the planning and coordination role they had before the NEM. This is not about to change and there is not going to be a return to any idealised national, top-down system of governance.

The Post-2025 design options should go beyond being merely pragmatic and actively support the leadership of states in implementing REZs and interconnectors. The Essential System Services design should give states significant control over decisions around system security. States are the ones that will be negotiating with generators around future closures, as they have done with Yallourn and to a lesser extend Liddell.

If a state learns that a coal power station is becoming unprofitable or unreliable, through closure negotiations or in its role licencing a generator (or its mining operations) then the state should be able to work with AEMO to manage system security risks.

Seek holistic solutions from Renewable Energy Zones

State governments are increasingly going to procure and manage 'firm' energy capacity to provide reliability of energy supply and security services. NSW and Victoria have legislated to give themselves considerable control over reliability and security, as they build out their Renewable Energy Zones to replace retiring coal power stations.

The procurement process should be designed to make the most of the opportunity presented by REZs. Each REZ is a potential supply of inertia and system strength. Before

[37] ESB, p.15

going to the structured procurement of inertia and system strength, there would be value in AEMO working with network service provider, ARENA, the CEFC and the state REZ coordination agencies to consider holistic solutions to REZ and state-wide security needs.

A broad request for proposals could see big-picture and innovative models for delivery of security as an integrated part of projects that would otherwise be designed primarily for energy supply.

Well-resourced and experienced developers and technology companies might well be able to offer sophisticated systems that would deliver multiple services cheaper than separate procurements for energy, firming,[38] inertia, system strength and perhaps even other services that have been entirely the domain of synchronous generators such as system restart.

Fast frequency response markets would support structured procurement

We support the concept of extending existing frequency markets to include fast frequency response. AEMO has found this will reduce the demand for inertia. It is a service definition that is perfectly suited to batteries and other emerging technologies. This extension of Frequency Control Ancillary Services would work well in conjunction with structured procurement. It would mean there is a good mix of real time allocative efficiency and a solid investment signal to give developers the revenue certainty they need to develop large or innovative projects.

Maintain and strengthen primary frequency response and other standards

Standards and primary frequency response are vital parts of the security framework. They should not be watered down. During the period when a Post-2025 design is being implemented, it is important not to create new risks. The new obligations sunset on 4 June 2023, two years before the ESB redesign in scheduled to commence. It is necessary to maintain this re-regulation of synchronous generators while new security frameworks can be built.

[38] For example the Long Term Energy Services Agreements for firming projects in the NSW Transmission Infrastructure Strategy see DPIE (2020) *NSW Electricity Infrastructure Roadmap - Detailed Report*, p.31.

Conclusion

The critical and urgent challenge for the NEM is to replace the system security provided by coal power stations. Renewable Energy Zones and the Integrated System Plan are designed to stimulate investment in new generation sufficient to replace the energy produced by coal. There is no integrated plan to replace security services provided by synchronous generators.

The VEPC technical study confirms that new inverter-based technologies are rapidly becoming commercially viable and even superior sources of both inertia and system strength. ARENA, state governments, technology companies and electricity networks are delivering innovative batteries and renewable energy solutions more cheaply than conventional sources of security.

In March 2021 the Australia Institute conducted a national opinion poll of 1040 people which reveals 51% of Australians would prefer to pay for new batteries to keep the grid secure and 26% prefer to continue to pay coal generators.[39]

Renewable energy growth is reducing wholesale electricity prices. Coal generators will make financial decisions that put security and reliability under pressure. In addition to disorderly retirements, AEMO is concerned that unit decommitments will reduce inertia and system strength.

Even at this time of transition, system security is around 3% of the annual cost of energy in the NEM. The VEPC study advises that inertia and system strength are likely to remain a relatively small cost as coal retires.

We support the Energy Security Board's structured procurement option model. AEMO is the best buyer because it is the system operator and can best coordinate procurement of this public. The model should promote competition and innovation and allow states to continue to remake the NEM in the absence of leadership from the federal government.

[39] The question was 'Part of your power bill is paid to coal generators to make electricity secure by keeping voltage and frequency stable. This can now be done by large-scale batteries, without any greenhouse gas emissions. Would you prefer to pay coal generators to keep the grid secure or pay for new batteries to be built to provide the same service?' The results were Coal 26%, Batteries 51% and Don't know/Not sure 23%. The Australia Institute conducted a national survey of 1,000 people between 11 and 12 March 2021, online through Dynata with nationally representative samples by gender,age and state and territory. The margin of error (95% confidence level) for the national results is 2.6%.