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18TH MARCH 2020

Mr John Pierce
Chairman
Australian Energy Market Commission
PO BOX A2449
Sydney South NSW 1235

Dear Mr Pierce

Re: Operating Reserves and Fast Frequency Response Rule Change

Infigen Energy is submitting two Rule Change requests that address growing concerns about uncertainty and volatility in the NEM. This Rule Change request proposes the development an Operating Reserves market, where AEMO will procure Reserves (either from the supply-side or the demand-side) in real-time, co-optimised with the other energy markets.

In our view, this market would be relatively simple to implement and would provide added confidence that sufficient resources to respond to unexpected changes in supply or demand would be available. In particular, it would provide an alternative to RERT procurement and directions (reducing interventions in the market), and assist with bringing demand-side resources into the market (accelerating the transition to a comprehensive two-sided market) – supporting the National Energy Objective.

We look forward to working with the Commission to progress this proposal.

Yours sincerely

Ross Rolfe
Managing Director

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infigen

1. Context for the Rule Change Request

The NEM's plant stock was historically dominated by synchronous generators but in response to falling costs and environmental objectives, the NEM has seen sharply rising levels of asynchronous generation, particularly wind and solar PV (Variable Renewable Energy; VRE). VRE has progressively displaced certain aging synchronous generation units, and AEMO's Draft 2020 Integrated System Plan shows this trend continuing under all scenarios.

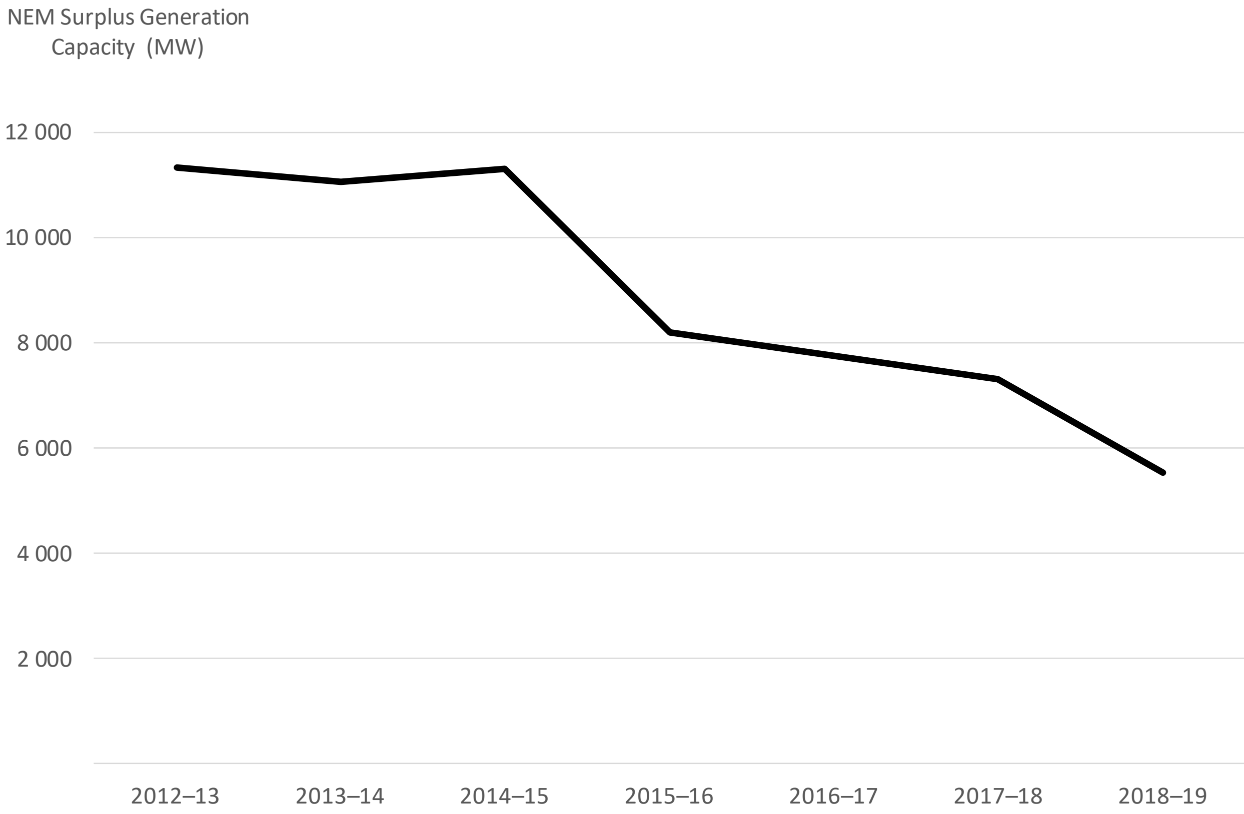
This has led to new operational challenges for the market and for AEMO:

- Increased uncertainty around supply, driven by i). greater variability from VRE resources and ii). rising forced outage rates, consistent with aging of thermal units;
- Increased uncertainty around demand, driven by increased uptake of embedded generation and demand-side response, as well as greater uncertainty around weather-linked demand;
- Increased energy limited resources, including energy storage systems;
- Declining Operating Reserves that were previously provided for free by online spinning generation plant (i.e. coal, gas, hydro);
- A reduction in capacity oversupply, leading to a system operating closer to the Reliability Standard than prior periods (see Figure 1);
- Unanticipated coal plant closures, which led to short-term challenges while AEMO and the market develops a response;
- A reduction in other services that were previously provided for free along-side energy production from synchronous units, including inertia, system strength and tight deadband primary frequency control;
- In certain locations, reduced inertia, leading to an increase in rapid frequency changes on Contingency events; and
- Above all, a dramatically wider range of power system 'modes of failure' – and unlike historical system operation, modes of failure which are unknown.[1]

New and unknown modes of failure, extreme weather conditions and major network events have resulted in greater focus on Contingency events that have traditionally been classified as *non-credible*. The timescale for responding to some events is measured in milliseconds (exacerbated by lower inertia conditions) and AEMO does not currently appear to have the ability to procure fast-acting services on shorter timeframes.

[1] Historically, it was statistically rare to experience two plants tripping at the same time. This is no longer the case. There are now a wide range of new equipment entering the market (e.g. rooftop Solar PV, utility-scale Solar PV, wind generation, Batteries, more active demand, meshed networks) with new and unknown modes of failure. This suggests that n-1 is unlikely to be adequate as the market continues to transition.

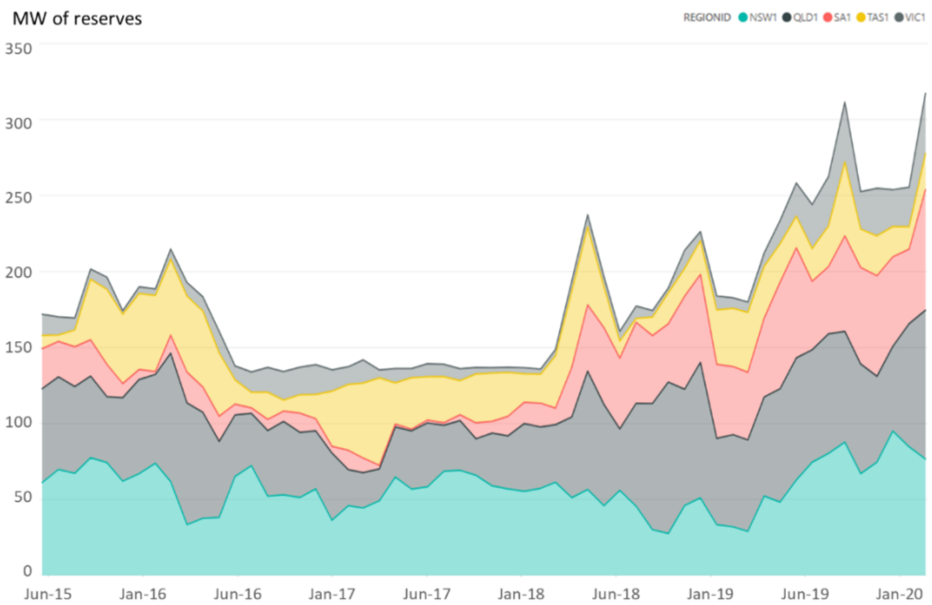
Figure 1 - NEM Surplus Generation Capacity



These challenges have manifested in several ways:

- AEMO has increased the quantity of Regulation FCAS procured (Figure 2) in response to reduced Frequency performance;
- Increased occurrence of Lack of Reserve (LOR) periods, characterised by low Operating Reserves and more frequent procurement and activation of Reliability and Emergency Reserve Trader (RERT) reserves;
- Changed acceptable operating envelope, including reclassifying non-credible Contingencies and a recent rule change request for a Mandatory Primary Frequency Control response from all capable assets with a very tight deadband of +/-15mHz; and
- Increase operational headroom required for prudent management of the power system – including local requirements for Contingency FCAS with AEMO considering regional requirements for Contingency FCAS under normal conditions

Figure 2 - Increase in quantity of procured reserves - Average by Month (Source: AEMO)



Additional context is provided in Appendix A. In our view, it is critical to address these issues now, and before they further impact the reliability of the power system or, alternatively, require greater and more disruptive market changes or interventions. In particular, we consider that:

- Historically, power system 'modes of failure' were well understood, and an N-1 approach to system operations within the current suite of FCAS Regulation & Contingency services was entirely appropriate. But new modes of failure now exist and are not well understood and difficult to predict;
- Greater certainty is therefore required that there will be sufficient Reserves available in the system to respond to possible but unlikely events;
- Understanding the supply and demand of services currently being provided for free is required to enable the market to better quantify the value that more flexible technologies (e.g., batteries, Demand Response) can deliver in response to new modes of failure;
- Ongoing closures of coal generation plant are likely, at faster rates than are currently being projected by AEMO[2], which would have the effect of reducing available Operating Reserves; and
- Potential future shortfalls need to be addressed pre-emptively and 'early' rather than in response to a crisis, and the best approach to do this is via creating transparency through markets for required services.

[2] Infigen's submission to the ISP highlights AEMO's historical conservatism as to the rate of system change. https://www.aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/NEM-Consultations/2019/Planning-and-Forecasting/Submissions/20190319-Infigen-submission---AEMO-2019-Planning-and-Forecasting-Consultation.pdf

2. Problem Statement - Operating Reserves

The availability of near-term Operating Reserves (beyond Contingency FCAS) for security of supply in the NEM, and adequate Capacity 'in aggregate' for reliability of supply have historically been provided without a centrally organised price or market. This is an inherent design aspect of the energy-only NEM – explicit procurement of Operating Reserves were not needed given Regulation & Contingency FCAS, known modes of failure. On Reserve Capacity, the NEM's high Market Price Cap provided a strong signal for participants to invest in, and make available, generation plant capacity.

This market configuration has been entirely appropriate given i) modes of failure were well known, ii) the probability of more than one supply-side Contingency event was statistically remote (vis-à-vis Operating Reserves and security of supply) iii) variability in supply and demand was well characterised and understood, and iv) the NEM's Market Price Cap had a reasonably tight nexus with the Reliability Criteria (vis-à-vis Reserve Capacity and reliability of supply).

However, contemporary system conditions are different. Material changes to the NEM's plant stock, aging plant and falling availability, rising embedded generation and residual demand uncertainty is contributing to an emerging demand for near-term Operating Reserves to assist with security of supply (or alternatively, AEMO interventions will persist). Moreover, changes to the structure of the aggregate supply function – higher and more volatile thermal fuel prices and very low marginal running cost renewables – is also changing the relative pattern of spot market prices and production duties. Consequently, a signal for near-term Operating Reserve to deal with these matters and other considerations (e.g. ramp rates) would be helpful for delivering an orderly market.

Furthermore, fundamental market disruptions facing the NEM (i.e. random and capricious government interventions) appear to be creating frictions vis-à-vis timely investment in new capacity additions.[3] As Figure 1 notes, Reserve Capacity has become noticeably tighter in spite of the NEM's Market Price Cap at $14,700/MWh – albeit we note the market is still achieving the (current) Reliability Standard.

In our view, under 'tight capacity' conditions and tangential risks of random government interventions, a free-rider problem associated with marginal capacity may become pronounced. The marginal value of incremental capacity is by definition very high and delivers considerable benefits to the entire market. It is difficult to exclude non-investors from sharing in such benefits. Non-excludability is a well-known transactions cost problem and a potential source of market failure.

If greater signals for reliability are required, raising the Market Price Cap above $14,700/MWh may not be the most efficient outcome. At these levels, there is a degree of systemic risk to participants inadvertently caught short due to own plant outages, or worse, transmission system outages (e.g. recent Heywood Interconnector outage and consequential impact on generation plant) that impact plant performance and performance against forward contract commitments.

[3] Usual examples cited include i). the Commonwealth Government's Underwriting New Generation Investments Scheme, ii). the so-called Big Stick Legislation, iii). the overhang of Snowy 2.0, iii). retail price-cap regulation and so on. See for example https://www.originenergy.com.au/content/dam/origin/about/investors-media/origin_2019_ibd_final_asx.pdf

Another lever to price near term Operating Reserves, and further telegraph the need for augmenting Reserve Capacity would aide our market, security of supply, reliability of supply, and price stability to consumers without forcing an increase in the Market Price Cap.

2.1.1. Current procurement of Reserves

Operating Reserves are capacity in an energy system that can be called on within a (short) timeframe to balance supply and demand in case there is a material change in market conditions which was otherwise *unforeseen*. This is distinct from the capacity procured through the regular dispatch process to meet *expected* demand.

AEMO currently procures various forms of Operating Reserves to manage both expected and unexpected changes in supply and demand across the NEM. In particular, AEMO co-optimises eight Frequency Control Ancillary Services (FCAS) that deliver reserves on various timeframes:

- AEMO procures Contingency FCAS Reserves which respond to significant system disturbances over 6 second, 60 second and 5 minute timescales through local Frequency sensing (Primary Reserves); and
- AEMO procures Regulation FCAS which manages the expected variability across dispatch intervals on a 4-8 second to minutes timescale and is dispatched centrally through AGC (Secondary Reserves).

On longer timeframes supply is managed through a suite of tools including:

- The NEM's liquid forward market and high Market Price Cap (MPC), which together ensure market participants have strong incentives to make capacity available;
- Pre-dispatch and PASA, which informs AEMO and the market of potential shortages and/or high prices, published up to 40-hours ahead of real-time and updated continuously;
- The Lack of Reserve (LOR) framework, where AEMO issues Market Notices when reserves fall below specified levels;
- RERT, which allows for out-of-market Reserves to be procured and held over longer timeframes (up to nine months ahead); and
- Directions, whereby AEMO can direct market participants to ensure system reliability and security.

Together, these frameworks have (historically) allowed market participants to manage unit commitment, fuel procurement and maintenance decisions - preserving the flexibility to deliver the most efficient outcomes in real-time while still allowing AEMO to intervene in extreme situations. This framework has been successful at helping the NEM achieve the Reliability Standard by managing unit commitment and dispatch in the short-run, and principal market participants are bound by strong incentives to ensure coverage of forward derivative & physically contracted positions.

Infigen is not aware of any instances where the de-centralised NEM unit commitment process has delivered an inefficient outcome compared to what a "centralised" dispatcher would have achieved[4], and the risk of the Market Price Cap has provided an effective incentive for Reserves given our (existing) stated Reliability Criteria.

2.1.2. Managing reserves may be more challenging in the future

The NEM has proved entirely sufficient to date. However, with rising levels of VRE, embedded generation and extreme weather events, modes of failure are becoming harder to predict (by comparison to historical failure modes) and the extent of unit price variation (dispersion & volatility) is likely to rise, which will have impacts on dispatchable plant scheduling. AEMO has articulated there is increased uncertainty in market operations due to increased variability in supply and demand, and increased uncertainty of forecasts[5,6,7,8]. Van Stiphout, de Vos and Deconinck (2017)[9] found that with increased share of renewable energy generation, Operating Reserves are needed and neglecting or misrepresenting operational challenges can lead to underestimation of operating costs. AEMO[10] and Bialek (2019)[11] consider that with this increasing variability, the amount of 'operational headroom' required to prudently manage the power system will increase. This is consistent with other studies which have found current mechanisms may need to be expanded and enhanced in the future[12,13,14].

Prof Janusz Bialek of Newcastle University & Skoltech explains of power systems globally, with rising levels of new sources of supply and net demand, inadequate operational experience exists given the wide array of potential 'unknown unknowns' (i.e. new and unknown modes of failure), and consequently, N-1 appears no longer appropriate.[15]

For example, the market has historically responded to AEMO Lack of Reserve notices (or informal requests, with limited transparency) by making additional generation capacity available.

However, there have been a number of recent incidences where LOR conditions were not projected by AEMO (or by other participants) in advance due to unexpected changes in demand or supply. Given expected increases in supply (and residual demand) variability and uncertainty, it may become more problematic for participants to make Operating Reserves

4 Infigen is only aware of one instance (the February SA load shedding event) where load shedding occurred and a unit that could otherwise have been available was not available real-time. However, this was driven by inaccurate forecasts that did not identify a reserve shortfall until after unit commitment was (apparently) not possible.

5 Maintaining Power System Security with High Penetrations of Wind and Solar Generation, AEMO October 2019

6 Power system requirements AEMO March 2018

7 Proposal for an enhanced Reliability and Reserve Trader (RERT), AEMO March 2018

8 Options for NEM market designs Flexibility and firming markets for security and reliability AEMO September 2019

9 Stiphout, Arne van, Kristof De Vos and Geert Deconinck. "The Impact of Operating Reserves on Investment Planning of Renewable Power Systems." IEEE Transactions on Power Systems 32 (2017): 378-388.

10 Power system requirements AEMO March 2018

11 See https://www.eprg.group.cam.ac.uk/wp-content/uploads/2019/12/J.-Bialek_winter-2019.pdf

12 Electricity Sector Transition in the National Electricity Market of Australia Managing Reliability and Security in an Energy Only Market, Farhad Billimoria, Rahmatallah Poudineh, November 2018

13 van Stiphout, de Vos and Deconinck, 2017

14 Riesz, et al, 2015.

15 We should add that while Prof Bialek makes the case that n-1 is no longer adequate given 'known unknowns', he suggests that n-2 may be excess to requirement.

available – not due to participant intent, but due to sharply rising supply-demand variability, uncertainty and their consequences.

Clearly, Retailers and customers would be worried about the price impacts of unhedged load and generators would see an investment opportunity – however, as noted further below, there may be an operational risk *in the future* that Operating Reserves are not available in real-time for *unforecastable* events. This is distinct from allowing the market to most efficiently deliver supply to meet the *expected* range of supply-demand outcomes (e.g. as informed through pre-dispatch and sensitivities).

While an increased Market Price Cap could incentivise greater procurement, this increases the overall risk profile of operating in the NEM. Creating a market for Operating Reserves should provide a reinforcing signal for operationalising capacity without the need to raise the Market Price Cap. This concept is entirely consistent with Hogan's (2005[16], 2013[17]) Operating Reserve Demand Curve, which is developed from first principles to improve reliability and scarcity pricing while being compatible with economic dispatch (i.e. in economics it is generally accepted that mis-priced goods will be over-consumed and undersupplied).

The recent increase in procurement, enablement, and activation of out-of-market RERT capacity risks fundamentally distorting the market, and will be exacerbated if Reserve Capacity is withdrawn from the market over multiple years (e.g. through a "standing reserve"). By way of example, high value Demand Response providers may be attracted to a risk-free multi-year contract with AEMO, meaning their response is not available to retailers to efficiently hedge risk and increase the supply of (and reduce the cost of) retail contracts to market participants. Conversely, procuring Reserves through an Operating Reserve market would allow current out-of-market resources to be used in-market when appropriate.

2.1.3. Investment in Reserve Capacity

A closely linked issue is ensuring sufficient resources are made available in the market in real-time. One potential risk to resource adequacy in energy markets (and particularly energy-only markets) is 'missing money', where price signals are insufficient to fully incentivise *timely* investment commitment. Of course, not every generator that fails to recover costs can trace the cause to an episode of missing money or market failure[18]. In the NEM, missing money is managed through maintaining a tight nexus between the Market Price Cap and the Reliability Criteria (and is delivered through liquid forward markets). However, an efficient market necessarily relies on price signals to deliver appropriate investment in reserves, and constant interventions in the market are making investment cases in capacity more challenging. A mechanism that explicitly prices Operating Reserves in real-time will provide a price signal for investment in reserves *before* actual shortfalls in the market. (We note again that this will require co-optimising reserve quantity and pricing with the Market Price Cap.)

Similarly, holding the reliability criteria constant (or alternatively, if the criteria is changed), the introduction of more VRE may lead to a need for a higher Market Price Cap[19] in order to maintain a tight nexus. An alternate to raising the Market Price Cap is the incorporation of

[16] Hogan, William W., (2005). "On an 'energy only' electricity market design for resource adequacy". Tech. rep., Center for Business and Government, JFK School of Government, Harvard University
[17] Hogan, William W., (2013), Electricity Scarcity Pricing Through Operating Reserves, Economics of Energy & Environmental Policy, Volume 2, issue Number 2
[18] The issue here is to distinguish between economic losses caused by missing money, and economic losses caused by an episode of structural oversupply.
[19] See for example Riesz, Gilmore & MacGill (2016) "Assessing the viability of Energy-Only Markets with 100% Renewables", *Economics of Energy & Environmental Policy*, 5(1): 105-130.

markets for Operating Reserves (and an Operating Reserve Demand Curve) and expansion of the FCAS market services as Hogan (2005, 2013) explains.

We note internationally some markets include capacity markets to procure capacity. Apart from noting this would represent a radical shift from our current market design, these markets have typically resulted in an over-procurement of capacity with the costs borne by consumers (see Leautier, 2016). Furthermore, organised capacity markets have increasingly sought to impose performance payments on participants that are not available in real-time. But as Hogan (2013) explains, there is no simple way to observe and measure the 'delivery' of capacity. Hogan made this observation well before the current supply-side transition – where observing, measuring and even defining 'capacity' has become dramatically more complex. In contrast, principal participants in the NEM sign long-term forward commitments (i.e. contracts) and the Market Price Cap provides a particularly strong signal for real-time performance.

3. Proposed Market for Operating Reserves

Infigen proposes expanding the number of co-optimised real-time markets to allow for the procurement of the additional services to manage supply and demand. A new Dynamic Operating Reserve Market (DORM) comprising a dispatchable, raise-only service, would be established whereby AEMO would procure additional Operating Reserves in a similar fashion to the current Contingency FCAS markets. Whereas the Contingency FCAS markets require a response in 6s/60/5min, additional Operating Reserves do not necessarily need to respond in such tight timeframes – imposing unnecessarily fast response times on Operating Reserves would reduce the available supply stock.

Resources enabled in the Operating Reserve market would ideally be withdrawn from the energy market until called upon by AEMO in response to certain reliability criteria, but conversely, productive capacity needs to be co-optimised with the spot market so as to ensure no adverse incentives exist with respect to forward contract commitment levels.

Once co-optimised it effectively delivers a dynamically procured "Standing Reserve" subject to spot market conditions (i.e. ensure that capacity is always directed to maximise welfare). All things being equal, this should provide AEMO with more confidence that if demand or supply deviates materially from pre-dispatch forecasts, there will be Operating Reserves available without further intervention. However, it differs from an out-of-market Standing Reserve because both the suppliers of this Reserve and the quantity to procure can (and should) vary dynamically.

When system Reserves are high, there will likely be sufficient competition such that the service will be priced at, or close to, zero. Conversely, when reserves are low, the price of Reserves will typically be high.

This dynamic approach provides an explicit price signal to dispatchable plant and has the effect of substantially reducing the probability of binding LOR2 conditions. The design brings forward the opportunity value of capacity in the form of the Operating Reserve price for future or "ahead" periods, thereby providing a distinct signal to dispatchable plant (Reserves) once the system approaches Reserve shortage conditions. Its purpose therefore is for participants provide such capacity in advance, rather than in response to a crisis.

Infigen has considered various design options and our recommended approach is below.

3.1.1. Trigger of procurement

Operating Reserves could always be procured, or only be procured during times of sufficiently tight supply-demand balance. Infigen considers that procuring Reserves at all times is likely to be most efficient:

- new modes of failure exist, and these are not well understood;
- some level of Operating Reserves may be required at all times including, increasingly, in off-peak times given rising Forecast Uncertainty during that period; and
- when there is sufficiently large volumes of Operating Reserves, clearing prices should be at, or close to, zero as is currently the case in Contingency FCAS markets.

3.1.2. Volume to procure

The level of Operating Reserves to be procured needs to provide AEMO with sufficient flexibility to respond to real-time variability while still being consistent with the Reliability Standard. Given that all sources of uncertainty and modes of plant failure have not yet been quantified, it would be appropriate for the volume to be procured to be set by the Reliability Panel, based on advice from AEMO (or, alternatively, through Guidelines and Procedures, similar to RERT procurement).

Infigen proposes that the existing Forecast Uncertainty Measure (FUM) which analyses the risk of variable generation, outages and demand variations (and is already incorporated into the LOR framework) should be considered as the starting point for the volume of Operating Reserve procurement. This is consistent with Billimoria and Poudineh (2019) who suggested enhancements to the energy-only design, including dynamic reserves.

In our view, Total Reserves (i.e. Existing FCAS + proposed Operating Reserves) should be equal to the Largest Credible Contingency (N-1) *plus* either the real-time FUM forecast or the second largest contingency (N-2).

Regional requirements would need to be determined, and could be considered through AEMO's current PASA review.

The volume of Regulation Reserves, Contingency Reserves and the new Operating Reserves should be co-optimised across all relevant services such that the volume of Total Reserves is met, with Operating Reserves being the final "floating" component[20].

3.1.3. Procurement timeframe

As with Contingency FCAS, a price would be defined in each 5 minute period. Unlike Contingency FCAS, Operating Reserves would be procured "ahead" (albeit with real-time resolution). Payment for enablement would be subject to compliance and co-optimisation with the spot electricity market.

The timeframe for procurement will necessarily depend on the type of service that is required. Infigen suggests that procuring Reserves for 30 minutes ahead of time (with a 15

[20] AEMO currently allows Regulation FCAS to offset 5 Minute Contingency FCAS procurement (but not the reverse). This reduces the total volume procured (and hence cost), but creates the possibility that insufficient reserves will be available if a (generation) contingency event occurs when all Raise regulation FCAS is utilised *and* insufficient replacement capacity is available through the regular dispatch process. The appropriate "overlap" of all reserves should be considered by the Reliability Panel.

minute call-time) would align with current system security requirements, viz. returning the system to a secure operating state within 30 minutes while providing flexibility around notification and unit-start time, or Demand Response time. Fast-start Inflexibility Profiles or similar could be applied.

Similar to the 5 minute call-time of the Delayed Raise service, Infigen expects that Operating Reserves would have a call-time that reflects physical characteristics of the resources. This should be as short as possible, but 15 minutes reasonably reflects the start-time of a wide array of competitors spanning very fast starting equipment (Batteries) through to conventional fast start plant (hydro and gas turbine plant) along with all other generators operating below rated capacity.

3.1.4. Eligibility of Operating Reserves

Under Infigen's proposal, Operating Reserves would not technically be dispatched for production duties unless called under what would previously have been an LOR2 condition. Because Operating Reserves apply to the dispatch interval T+30 minutes, any plant capable of producing in that timeframe could offer to be available in that future period – similar to the existing Contingency FCAS markets.

Dispatchable plant capacity would therefore be co-optimised vis-à-vis participating in the energy market, FCAS markets, *and* Operating Reserves market.

3.1.5. Pricing of Operating Reserves

A plant scheduled to provide Operating Reserves should be paid the marginal 'availability' price when called. Infigen considers applying the Market Price Cap across all services is appropriate.

The Operating Reserve market effectively shifts the demand curve to the right and this should be balanced by an increase in resources, particularly from Demand Response resources that currently participate in the RERT.

Of central importance is the fact that a market for Operating Reserves formally draws resources into the market. This capacity will therefore be made available to the demand-side for contracting and market balancing. We expect Operating Reserves will be low priced except when avoiding the credible risk of Unserved Energy, where recent consultation on the RERT has raised the discrepancy between the Market Price Cap and the Value of Customer Reliability.

Under ERCOT's Operating Reserve Demand Curve, Operating Reserves could be paid the same regardless of the *probability* of Unserved Energy occurring. We would envisage similar outcomes are plausible, and this in and of itself should drive incremental capacity to better manage system security and system reliability.

Other markets (e.g. the original England & Wales gross pool) market have paid Reserves at the Market Price Cap times the Loss of Load Probability (i.e. probability of Unserved Energy). The Reliability Panel will need to review the market settings to ensure that the Market Price Cap is still set at the appropriate level.

A plant scheduled to provide Operating Reserves also needs to be able to co-optimise (and re-organise) its total position so that the incentives of offering Operating Reserves do not adversely impact the spot market, the forward contract market and their associated activities and commitments. From a consumer welfare perspective, conditions in the spot and forward electricity markets are of greater importance than FCAS and Operating Reserve markets due to the relative turnover involved. This may subsequently create shortages in the Operating Reserve market, but the quantities applying are limited to the differential between N-1 and N-2/the Forecast Uncertainty Measure (see Section 3.1.2). Further consideration will be required by the AEMC as to the appropriate trade-off between operating incentives, investment incentives, and quantity of Reserves procured, including the risk of triggering scarcity pricing (i.e. the MPC).

3.2. How this rule change will address the problem

3.2.1. Contribution to the NEO

The proposed market for Operating Reserves market will contribute to the NEO through:

- Providing a market price signal for Operating Reserves, and therefore being more efficient than AEMO interventions and reducing the quantity of out-of-market RERT that would be required to be purchased achieve the same reserve levels;
- Tuning of the quantity of Total Reserves to be procured in real-time, provide additional tools for the Reliability Panel to adjust market settings to meet the Reliability Standard (e.g. can now vary Market Price Cap and/or the quantity of Operating Reserves procured because the latter notionally shifts the aggregate demand function);
- Providing further opportunities for Demand Response;
- Strengthening investment signals for new flexible dispatchable capacity by valuing Reserves before the supply-demand balance becomes critical, and therefore reducing any “missing money” problem that may arise from timing of investment commitment (acknowledging that care must be taken not to “gold plate” the system); and
- All else being equal, reducing cyclical spot market outcomes that breach consumer (and therefore political) tolerances.

Further investigation will be required to determine the near-term cost of Operating Reserve provision.

3.2.2. Costs and benefits

This market proposes to price a service that was previously provided for free – i.e., the provision of sufficient market Operating Reserves. On face value, this represents a new cost to consumers. However, we expect that this cost will be negligible most of the time (when Operating Reserves are in good supply). Furthermore, procuring Operating Reserves will remove the need for RERT procurement and activation, which has cost $35-52m per year. To the extent it increases overall demand for flexible and dispatchable resources, there may also be flow-on effects to energy prices; this would be balanced by drawing additional resources into the market (including new investment, new demand-side response and moving previously out of market resource (i.e., RERT) into the market).

Customers will benefit from reduced variability in underlying energy prices from year to year, and reduced out of market interventions that lack transparency. Previously out of market resources (e.g., RERT) should be drawn into the market, providing additional hedging products for the benefit of retailers and customers, and this may make additional lower-cost contracting available to consumers. As noted in this Rule Change, consideration of the appropriateness of the existing Market Price Cap to meet the Reliability Standard will also be required.

AEMO will benefit from greater flexibility around procuring Operating Reserves, and greater certainty that sufficient Operating Reserves will be available to respond to possible but unexpected events. The rule change will require changes to AEMO's dispatch and settlement systems, including NEMDE. In particular, AEMO will need to develop systems that, in the current dispatch interval, price capacity for a future dispatch interval. AEMO is best placed to develop a cost estimate for these changes. AEMO and the Reliability Panel will also need to develop procedures and frameworks for the volume of reserves to procure and how dispatch of those reserves are triggered.

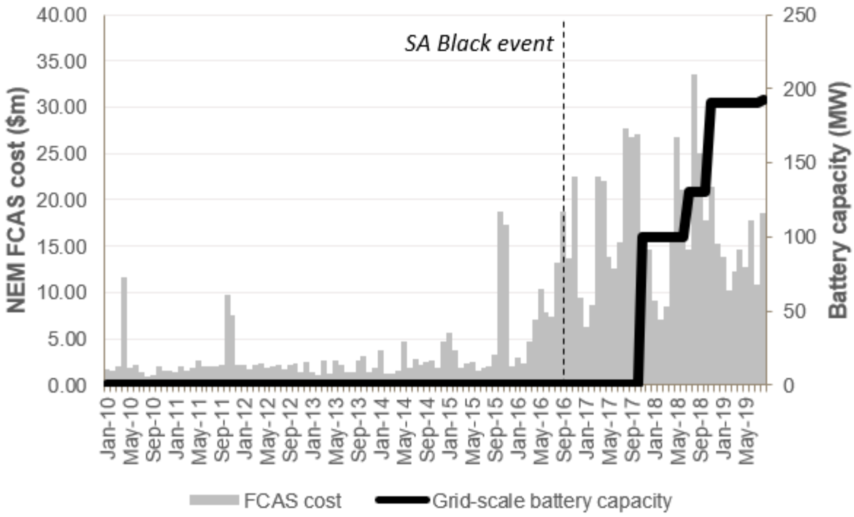
Flexible, dispatchable resources including demand response will have their value recognised through an alternative source of market revenue, reducing the statistical variability in revenues in the current market. Participants in the new market will need to develop appropriate procedures to respond to the Reserve signals, and updated settlement procedures.

3.2.3. Addresses issues in advance, rather than during a crisis

With the benefit of hindsight, a lack of an explicit requirement for system strength, inertia, and Primary Frequency Control has resulted in significant system disruption when unvalued resources exit the market. In our view, it is therefore prudent to establish certain services and associated markets ahead of time, even if the service is priced at or close to zero. We should highlight that not all services need organised spot markets – in some instances sealed-bid auctions and tenders may be more appropriate. Organised spot markets are costly to establish and administer, and without adequate competition can produce adverse consumer outcomes.

By way of specific example, the lack of price signals for inertia and system strength in South Australia resulted in the need for interventions, and the optimal market response was not to establish an organised spot market but to resolve supply by way of tenders and economic regulation. Conversely, while existing FCAS services were historically low priced, once a shortfall appeared a very clear spot market signal was delivered. The market response (supported by governments) was rapid and without the need for intervention by the market operator, as Figure 3 illustrates.

Figure 3 - NEM FCAS costs over time and growth of grid-scale battery capacity



3.2.4. Operating Reserves outside of peak times

The demand for Operating Reserves may occur outside of high demand periods, including unforecasted events. Over time, as incumbent thermal plant is forced to change its mode of operation (daily, weekly, seasonal), it may create the conditions for low Operating Reserves during off-peak periods. Compounding matters are forecast errors, which occur at any time.

We expect a mechanism that *explicitly* recognises the value that Operating Reserves provide, even if not explicitly exercised, will improve Operational and Investment decisions by market participants. In particular, maintaining some level of Operating Reserves beyond existing FCAS services is already an *implicit* part of the NEM (viz. AEMO's Market Notices for Lack of Reserve conditions). An explicit price signal will assist Operational and Investment decisions by market participants and improve overall efficiency. It will have a negligible value in oversupply conditions, and may approach the Market Price Cap under scarcity conditions.

3.2.5. A flexible option for Reserve procurement

Currently, AEMO only has two options for real-time reserves: Regulation FCAS and Contingency FCAS. While AEMO could procure additional Reserves through Contingency FCAS, Operating Reserves for (say) 30 minutes into the future can also include non-spinning reserves which can be brought on quickly[21].

3.2.6. Links procurement to need

While some global markets use static Operating Reserve requirements, newer studies have suggested that the inputs that cause variability and uncertainty should be used to determine a dynamic reserve requirement[22]. The use of dynamic, rather than static, Operating Reserve quantities and using probabilistic forecasts can contribute to improved system performance and reduced cost.

Better scarcity pricing would also contribute to long term resource adequacy. Hogan (2013) compares this to a high offer cap, and notes that while a high offer cap may help any missing money problem that may exist, it fails to deal with the treatment of Operating Reserves or the real-time reliability problems that arise with uncertainty.

3.2.7. Should result in fewer market interventions

The proposed framework should strengthen the market signals for delivering Reserves and should therefore (to the extent physically possible in the market) reduce the incidence of LOR events. We expect that Operating Reserves will be called instead of RERT resources and thereby avoid both the procurement of RERT and intervention in the market.

This will not preclude AEMO intervening if a market response is not delivered, but this framework should reduce the incidence of events. It will be important, however, for the Reliability Panel to determine the framework for the quantity of reserves to be procured.

3.2.8. Provides additional flexibility for meeting the Reliability Standard

This submission should not be seen as altering or somehow superseding the Reliability Standard. Eliminating Unserved Energy is neither possible nor efficient. However, a market for Operating Reserves may provide another "lever" to ensure the Reliability Standard is met

[21] Delayed Raise services can also be non-spinning, but has a faster call time than is perhaps necessary to respond to slower changes in supply and demand.
[22] Operating Reserves and variable generation, Ela, Milligan and Kirby August 2011

(*cf.* rather than simply increasing the Market Price Cap). The current Market Price Cap is known to be less than the true Value of Lost Load, representing a trade-off between spot market efficiency and cost risk to consumers.

3.2.9. Why a real-time market?

A real-time approach to procurement of Operating Reserves is not new. AEMO procures FCAS Reserves through a real-time market, and this has been highly successful at delivering low-cost resources to meet the specified service. The procurement of additional Operating Reserves, including reserves with slower call times, is not fundamentally different, and the flexibility to adjust physical positions closer to real-time (subject to commitment and decommitment notification periods in the NER, e.g., Section 3.8.4) will help to deliver the maximum efficiency from the power station fleet.

We consider that market participants are best placed to manage their assets and the risks of unit commitment decisions. Furthermore, the best information is available close to real-time and is consistent with recent decisions (5MS, etc.). In particular, participants that are required to make “ahead” decisions (e.g., coal unit commitment, gas purchases, reserving stored energy for later use, etc.) are already doing so in the NEM. The proposed market for Operating Reserves will further de-risk these commitment decisions.

Given ‘forward to physical’ market liquidity ratios of c.350%, market participants in the NEM are generally heavily contracted and therefore have strong incentives to make capacity physically available when there is a risk of high spot prices. The Retailer Reliability Obligation has further reduced the risk of loads not contracting during forecastable times of scarcity. As such, participants continually monitor forecasts in pre-dispatch and ST-PASA to ensure they are available. That is, in the most simplistic interpretation, participants are considering their expected profit or loss under credible scenarios over minutes to days.

Slow-start generation participants are currently required to submit unit commitment and decommitment plans to AEMO two days before a trading day (section 3.8.4 of the NER), and variations are subject to bidding in good faith rules. Therefore, under the proposed rule change, as with current pre-dispatch energy prices the market will have sufficient information to deliver on the desired level of Reserves. For example, if a participant seeks to decommit a unit and this materially affects the level of Operating Reserves likely to be available, there will be a corresponding increase in the Operating Reserve (and potentially energy) price, and therefore provide an incentive for other participants to make capacity available, or invest in more flexible capacity. In real-time, participants will be compensated for maintaining headroom above their energy limit.

Most significantly, real-time markets avoid the need to forecast and (re)contract the entire projected demand and supply. This contracting exposes consumers to errors in AEMO supply and demand forecasts, and a *financial* day-ahead market still does not provide greater certainty over the level of Reserves in real-time (given that most generation is already contracted).

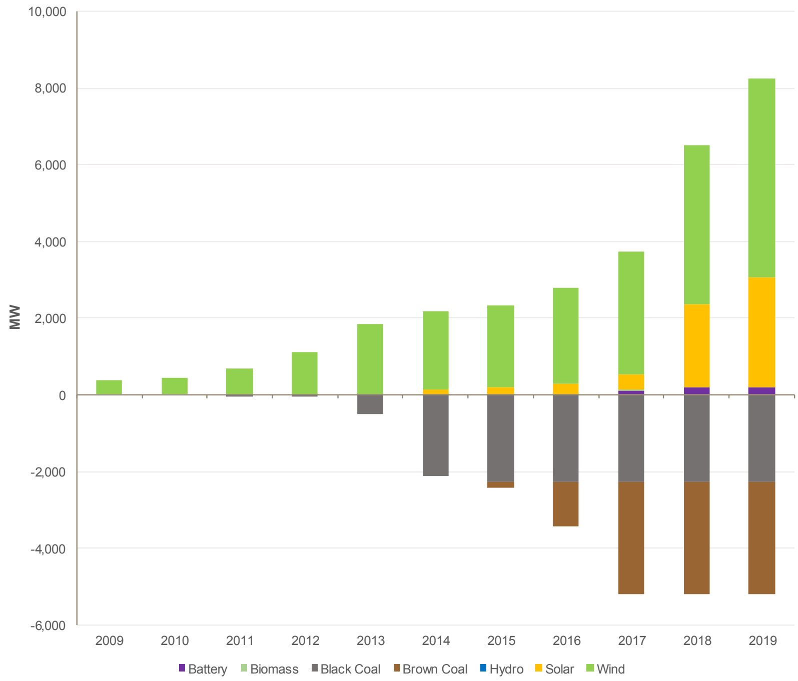
Alternatively, a *physical* day-ahead market (including where the market operator regularly intervenes in the market, such as through “Reliability Unit Commitment” frameworks) forces units to physically dispatch. This is counter to recent improvements to market design to strengthen real-time market signals, including 5MS and AEMC’s progress towards a two-sided market. Furthermore, to the extent that it results in different dispatch decisions, there is a risk that such strategies will simply incentivise inflexible coal generation – reducing incentives for flexible capacity and creating additional pain when those units eventually close - again counter to AEMO’s recognition that statistical models are required. It may also mute signals for new technologies to deliver other key services, including grid forming battery plus inverter combinations and synchronous condensers.

APPENDICES

4. Appendix A – The changing NEM

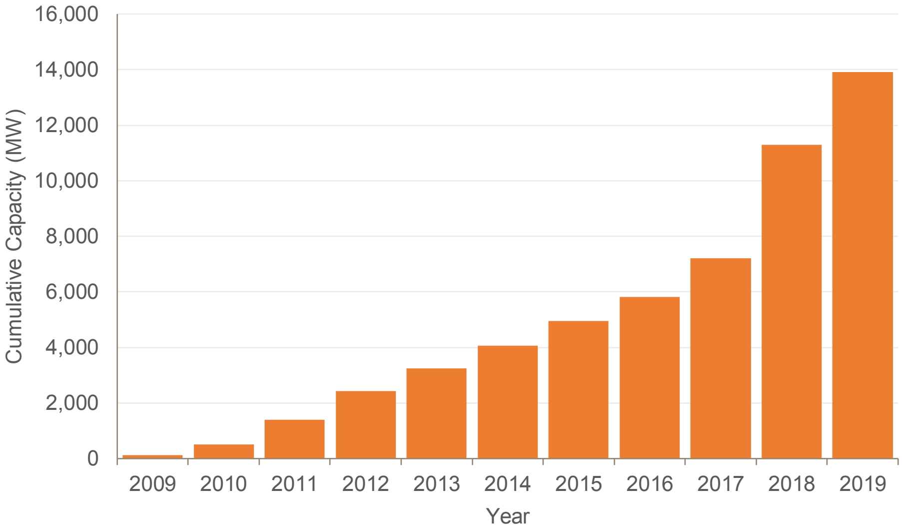
The NEM's plant stock has historically been dominated by 'synchronous generators' but as Figure 6 notes, there is sharply rising levels of asynchronous generation, particularly wind and solar PV (Variable Renewable Energy; VRE). AEMO's Draft 2020 ISP shows this trending continuing under all scenarios.

Figure 4 - Increase in quantity of procured reserves (Source: AEMO)



Consumers are also engaging with electricity in new ways. Australia has had almost 14GW of rooftop solar enter the market since 2009, with 7GW installed in the last two years.

Figure 5 - Growth of rooftop PV[23]



The change in power systems dynamics has highlighted the need to change operational assumptions of the NEM. From a physical system perspective, closures at-scale exposed gaps in services procured vis-à-vis system strength, system security, and the integration of distributed energy resources (DER). Policy uncertainty, random government interventions and unanticipated changes in plant entry and exit dynamics has resulted in a more challenging power system.

While the NEM's fundamental wholesale market design (spot and forward derivatives market) remains strong, it is *incomplete* and characterised by 'missing markets'.

These missing markets include services relating to Frequency management, inertia and system strength. The demand for these services has always existed, and an abundance of supply meant that (beyond Frequency management) they have been provided free of charge from synchronous generators. However, as the system changes, the demand for these services is rising while supply is falling. New services, we would suggest, are also required including Fast Frequency Response to improve Frequency performance and deliver simulated inertia that can relax Rate of Change of Frequency (RoCoF) constraints. New services, such as the provision of Operating Reserves and Ramping Duties, may be required to deal with rising uncertainty over demand and (intermittent) supply forecasts.

4.1. Impact on Operating Reserve requirements

The trends identified above increase the variability and uncertainty of supply and demand. The NEM has:

- changing Frequency Control capabilities – decreasing inertial response
- increased variability in supply and demand – more Frequency deviations

Traditional reserve procurement has been to manage the loss of the largest credible contingency based on an N-1 criteria. This concept was largely adopted globally when power systems, the equipment and the modes of failure were well understood. It was statistically rare to experience two plant tripping at the same time. This is no longer the case. There are

[23] APVI data as at 11th December 2019

now a wide range of new equipment entering the market (e.g. rooftop Solar PV, utility-scale Solar PV, wind generation, Batteries, more active demand, meshed networks) with new and unknown modes of failure. This suggests that N-1 is unlikely to be adequate as the market continues to transition. That is, the prospect of a conventional mode of failure combining with alternate and unknown (new) modes of failure, and the potential for cascading failures, has a much higher probability of occurrence.

In short, while deterministic criterion such as the instantaneous loss of the largest generating unit or network element on the power system remains important, these are increasingly inadequate for forecasting real risk. Instead, greater consideration of forecasting errors in short-term supply and demand are likely to be required. These variations occur due to:

- Increased variability around demand – forecasting errors in extreme hot weather and DER;
- Variability and uncertainty in VRE;
- thermal de-rating of all plant types during stressful ambient conditions; and
- Variations in network constraints.

AEMO has recently increased the quantity of Regulation FCAS procured to manage reduced Frequency performance (Figure 8). While driven partially by reduced levels of inertia and a reduced quantity of (freely provided) narrow-band Primary Frequency Response, it is also consistent with AEMO's modelling which indicates higher variability within dispatch intervals given increased quantities of VRE (Figure 9).

Figure 6 - Increase in quantity of procured Regulation reserves (Source: AEMO)

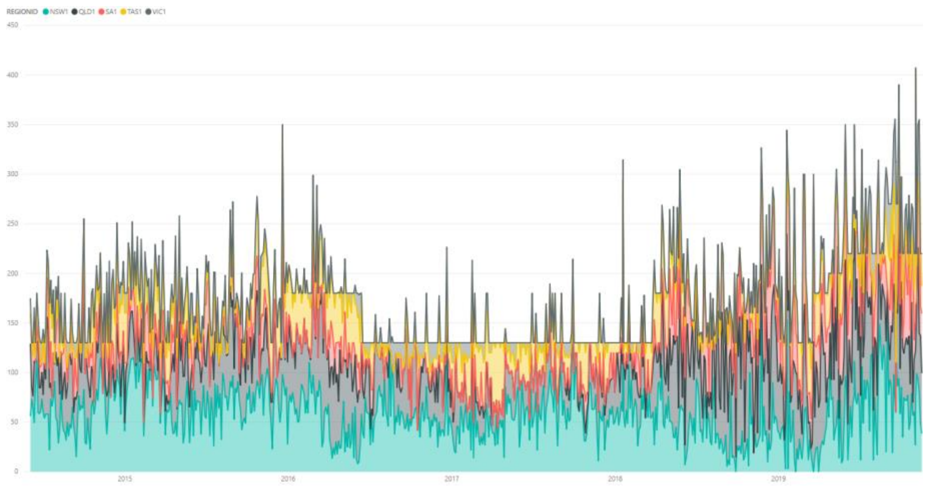
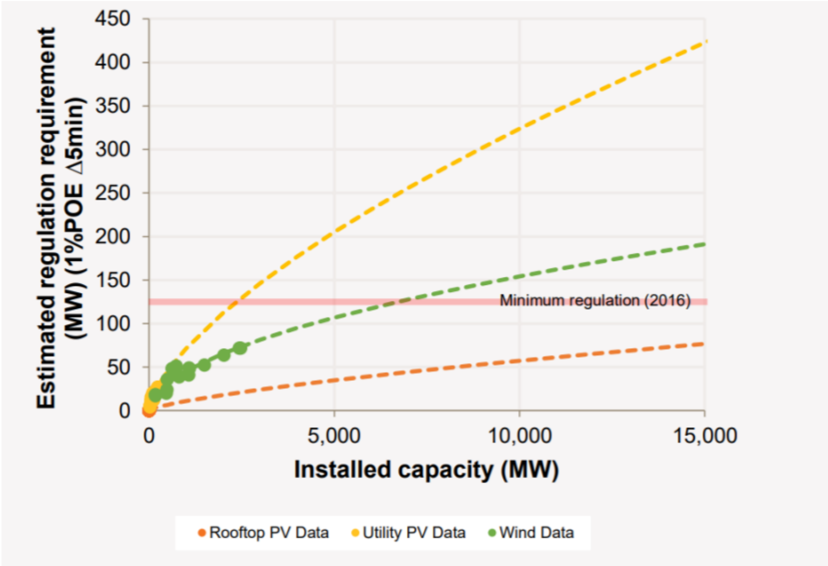
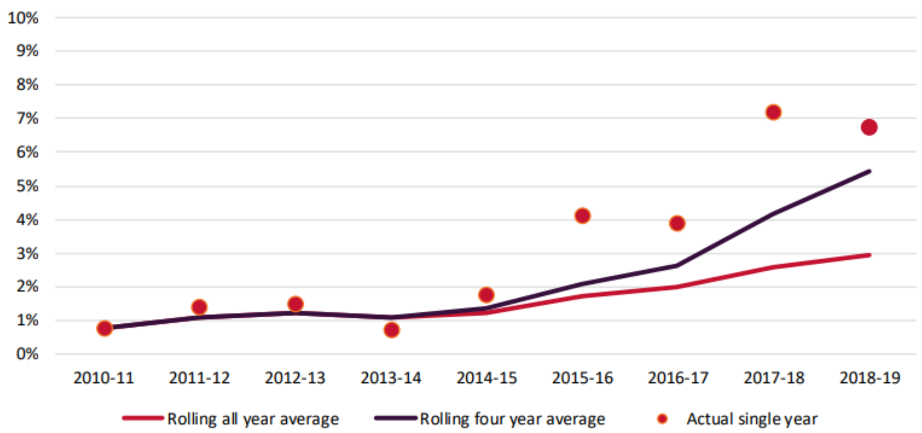


Figure 7 - Increase in regulation requirement with increased VRE (Source: AEMO[24])



AEMO has also demonstrated increased outage rates for thermal generators, particularly brown coal plant (Figure 10).

Figure 8 - Historical brown coal forced outage rates (Source: AEMO 2019 ESOO)



As AEMO notes *"Managing variability and uncertainty is increasingly challenging at higher levels of wind and solar generation."*[25] By definition forecast errors (as measured by AEMO's Forecast Uncertainty Measure) and simultaneously a significant uptake of DER and Demand Response has reduced AEMO's visibility of price responsive supply and demand. This lack of visibility also extends to the technical behaviour and response of embedded/behind the meter generation.

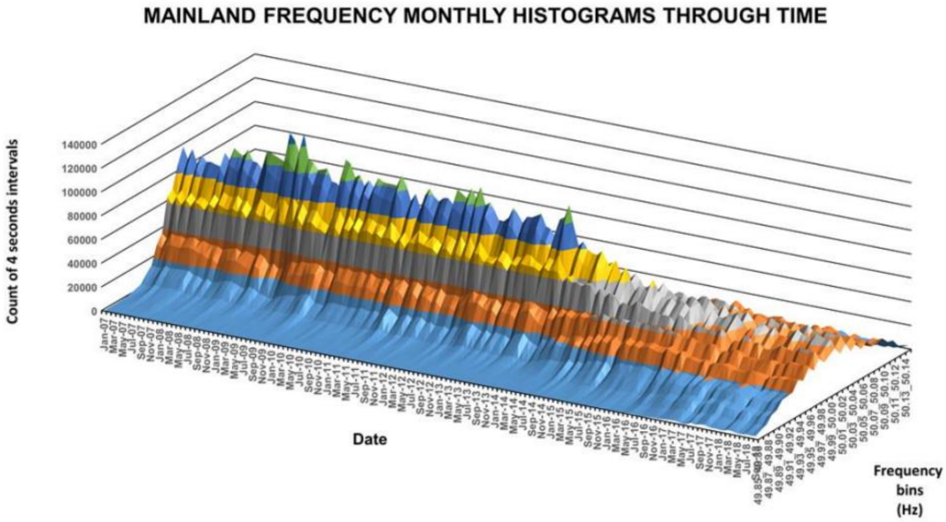
24 Figure 9, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2016/Database/2016-NTNDP-Methodology-and-Input-Assumptions.pdf

25 AEMO actions Item 4, p31, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Future-Energy-Systems/2019/AEMO-RIS-International-Review-Oct-19.pdf

Frequency performance during normal operation has deteriorated in recent years. Frequency historically operated very close to 50Hz for most of the time, but in recent years has spread within the NOFB and operates further away from 50Hz more of the time, this change can be seen in Figure 11. This figure shows that frequency spends less time close to 50Hz and instead has begun to spread across the NOFB. This spread of frequency can be attributed to:

- Loss of synchronous generation and increased asynchronous generation (which has led to a higher RoCoF resulting in easier excursion away form 50Hz); and
- Withdrawal of active governor response within the NOFB. When Frequency moves within the NOFB there no response to arrest system Frequency until it moves outside the NOFB

Figure 9 - Mainland frequency month histograms through time (Source: AEMO)



The NEM has a relatively high market shares of renewable generation by world standards, with South Australia being amongst the highest in the world. AEMO is therefore operating a system that is at the cutting edge of power system operations. As shown in Figure 12, all regions in the NEM have a ‘maximum’ VRE output greater than 25% of native demand. Reductions in synchronous generation plant capacity changes the acceptable operating envelope of the system, and increases the complexity of system operators. While AEMO (and international operators) gain experience, providing explicit confidence that Operating Reserves with appropriate response times exist should reduce the risk and consequence of “unknown unknowns”.

Figure 10 - Penetration of renewable generation in Australia vs international markets