AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

NEM Virtual Power Plant (VPP) Demonstrations Program

November 2018

Consultation paper

Important notice

PURPOSE

This document outlines the proposed Virtual Power Plant (VPP) Demonstrations framework, including draft objectives and participation requirements. This proposal is published for consultation and AEMO is actively seeking feedback from all stakeholders, including potential participants in the VPP Demonstrations, consumer representatives, network service providers, and state governments.

DISCLAIMER

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VERSION CONTROL

Version	Release date	Changes
#1	23/11/2018	
#2	11/12/2019	Reducing the amount of lower or raise FCAS response capability recognised in the new approach proposed in section 2.3.3 from 8 to 4 MW

Executive summary

A Virtual Power Plant (VPP) broadly refers to an aggregation of resources, coordinated using software and communications technology to deliver services that have traditionally been performed by a conventional power plant. In Australia, grid-connected VPPs are focused on coordinating rooftop photovoltaic (PV) systems and battery storage.

What is the VPP Demonstrations program?

AEMO is collaborating with the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER), and members of the Distributed Energy Integration Program (DEIP), to establish the VPP Demonstrations.

The DEIP is a group of industry bodies which are collaborating to maximise the value of customers' DER to the Australian energy system and all energy users.

These Demonstrations are the first step in a broad program of work designed to inform changes to regulatory frameworks and operational processes so Distributed Energy Resources (DER) can be effectively integrated into the National Electricity Market (NEM), maximising value to consumers while also supporting power system security.

Why is the VPP Demonstrations program needed?

While VPPs in the NEM are currently on a small scale, several large-scale VPP projects, and Government subsidies to support VPP capable systems, have been announced recently, with targets that equate to up to 700 megawatts (MW) of VPPs operating in the NEM by 2022.

VPPs can deliver multiple services to increase the potential 'value stack' delivered to consumers, including by participating in markets for both energy and Frequency Control Ancillary Services (FCAS), as well as entering into network support agreements with network service providers (NSPs). Currently, VPP value stacking in the NEM is in the very early stages of development and there are no VPPs delivering FCAS.

Effective integration of VPPs, providing AEMO with operational visibility, can also help AEMO maintain power system reliability and security. AEMO currently has no visibility of how VPPs operate, however as VPPs reach greater scale in the NEM, continued lack of operational visibility could present system security risks, as VPPs can move from charge to discharge instantaneously.

AEMO intends to establish a framework to allow VPPs to demonstrate their capability to deliver services in energy and FCAS markets. By trialling VPP operations while their aggregated fleets remain of a small scale (less than 5-10 MW per VPP operator), the VPP Demonstrations aim to inform the effective integration of VPPs into the NEM as they reach a larger scale. The VPP Demonstrations will:

- Allow VPPs to demonstrate their capability to deliver the full value stack.
- Provide AEMO with operational visibility to help AEMO consider how to integrate VPPs effectively into the NEM.
- Allow the AEMC and AEMO to make informed changes to the regulatory frameworks, operational systems, and processes required to facilitate the smooth integration of VPPs as they ramp up in size.

Participation and feedback

AEMO is committed to delivering the VPP Demonstrations in collaboration with industry stakeholders. The value of this collective learning exercise increases as more VPPs participate.

AEMO invites all interested parties to provide written feedback on this paper to DERProgram@aemo.com.au by 21 December 2018.

Contents

1. Introduction

1.1 Purpose of this paper

This document outlines the proposed Virtual Power Plant (VPP) Demonstrations framework, including draft objectives and participation requirements. This proposal is published for consultation and AEMO is actively seeking expressions of interest to participate in the VPP Demonstrations and feedback from all stakeholders, including potential participants in the VPP Demonstration, consumer representatives, network service providers (NSPs), and government departments.

1.2 AEMO's Distributed Energy Resources (DER) Program

AEMO has established a DER Program to effectively integrate DER into Australia's power system operations and energy market frameworks. This is a long-term program that is investigating how to facilitate a secure transition to a more decentralised power system, in which consumer investments in DER can play a key role in delivering energy and support services to Australia's energy systems. The DER Program will take an innovative approach to this work, including implementing a number of trials/demonstrations, and AEMO is exploring appropriate funding arrangements to facilitate these demonstrations.

DER can refer to distributed level resources, which produce electricity or actively manage consumer demand

The VPP Demonstrations will facilitate an uplift in AEMO's capability to register, forecast, and monitor VPP operations, and to learn how VPPs can deliver a range of services to the power system in future.

AEMO has also released a stakeholder paper, *Emerging Generation and Energy Storage in the NEM*, seeking stakeholder feedback on potential rule, procedure, and system changes for better integration of grid-scale energy storage systems (ESS) into the National Electricity Market (NEM), enabling the NEM framework to incorporate new business models[1]. Although this work is separate and is not included in the scope of the VPP Demonstrations, AEMO is considering the relationships between grid-scale ESS and DER for future NEM arrangements.

1.3 Distributed Energy Integration Program (DEIP)

AEMO has collaborated with the Australian Energy Market Commission (AEMC) and Australian Renewable Energy Agency (ARENA) to launch the DEIP. Other members include the Australian Energy Regulator (AER), CSIRO, Energy Consumers Australia, Energy Networks Australia (ENA), the Australian Energy Council, the Clean Energy Regulator, the Clean Energy Finance Corporation, and the Clean Energy Council.

The purpose of the DEIP is for members to collaborate to maximise the value of customers' DER to the Australian energy system and all energy users.

A key element of AEMO's collaboration through the DEIP will be a program of demonstrations that will enable evidence-based learning to inform potential changes to fully integrate DER into Australia's energy market frameworks and operational processes. The demonstrations program aims to map a pathway towards full integration of DER.

The VPP Demonstrations represent the first phase of this program, and have been developed in close collaboration with the AEMC and AER to help shape future regulatory frameworks.

[1] AEMO, 2018. *Emerging generation and energy storage – grid-scale*, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Initiatives/Emerging-Generation-and-Energy-Storage-in-the-NEM---Grid-Scale.

AEMO and ARENA are also exploring complementary small-scale demonstrations and studies to provide input into the AEMC's assessment of the rule change proposals relating to Wholesale Demand Response[2,3,4].

A subsequent phase of demonstrations will be focused on testing operational and regulatory frameworks to facilitate very high amounts of DER participating in Australia's energy markets, and incorporating distribution networks constraints in the DER dispatch process informed by the Open Energy Networks collaboration between AEMO and ENA[5].

Question 1.1: The primary focus of these trials is to demonstrate VPP aggregating battery storage systems. Do intending participants envisage incorporating demand response resources into your aggregated portfolios, and should this be incorporated into the VPP Demonstrations?

1.4 VPPs in Australia

Australia hosts some of the most advanced VPP projects in the world, particularly involving rooftop photovoltaic (PV) systems and battery storage, in both grid-connected and off-grid applications.

Prominent grid-connected examples include:

- South Australian public housing tenants' VPP that, if commercialised, could reach up to 50,000 public and private property installations, which would be one of the biggest VPPs in the world[6].
- Next Generation Energy Storage Program, installing battery storage in more than 5,000 Canberra homes and creating VPP capability of 36 megawatts (MW)[7].
- AGL's VPP in South Australia, which aims to coordinate up to 1,000 residential storage systems[8].
- Simply Energy's 8 MW VPP to be developed in Adelaide, comprising 6 MW of residential battery storage and 2 MW of demand response capacity from commercial businesses[9].
- CONSORT Bruny Island Battery Trial, coordinating 40 systems to alleviate congestion on the undersea power supply cable, reduce reliance on diesel generation, and stabilise local network voltages[10].

State governments are also launching programs to incentivise uptake of smart battery storage systems:

- The South Australian Government's $100 million *Home Battery Scheme* to incentivise 40,000 new battery storage systems[11].
- The Victorian Government's $40 million subsidy to incentivise 10,000 new battery storage systems[12].

[2] Public Interest Advocacy Centre, Total Environment Centre, The Australia Institute, 2018. *Wholesale Demand Response Mechanism* rule change proposal, available at https://www.aemc.gov.au/rule-changes/wholesale-demand-response-mechanism.

[3] Australian Energy Council, 2018. *Wholesale Demand Response register* rule change proposal, available at https://www.aemc.gov.au/rule-changes/wholesale-demand-response-register.

[4] South Australian Government, 2018. *Mechanisms for Wholesale Demand Response* rule change proposal, available at https://www.aemc.gov.au/rule-changes/mechanisms-wholesale-demand-response.

[5] AEMO-ENA, 2018. *Open Energy Networks*, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/DER-program.

[6] South Australian Government. *Public Housing Tenants Virtual Power Plant*, available at https://www.sa.gov.au/topics/housing/public-and-community-housing/tenants/virtual-power-plant.

[7] ACT Government, 2018. *Next Generation Renewables*, available at https://www.environment.act.gov.au/energy/cleaner-energy/next-generation-renewables.

[8] AGL, 2018, available at https://aglsolar.com.au/power-in-numbers/.

[9] Simply Energy VPP, 2018, available at https://arena.gov.au/news/simply-energy-build-8mw-virtual-power-plant-adelaide/.

[10] CONSORT, 2018.Available: http://brunybatterytrial.org/.

[11] South Australian Government. *Home Battery Scheme*, available at http://www.energymining.sa.gov.au/energy_implementation/home_battery_scheme.

[12] Victorian Government, available at https://www.premier.vic.gov.au/cheaper-electricity-with-solar-batteries-for-10000-homes/.

- The New South Wales Government's $50 million *Smart Energy for Homes and Businesses* program to incentivise 40,000 new battery storage systems[13].

As a result, consumer interest in VPPs is growing, as they see rooftop PV and storage solutions as an effective way to take control of their energy usage and energy costs. VPP proponents from around the world are also seeking to demonstrate their latest technology in Australia, as the combination of high retail electricity prices, high rooftop PV uptake, and highly engaged consumer base means Australia is an attractive jurisdiction to test commercial models for VPPs.

1.5 Why is this important?

Less than a decade ago, there was a negligible amount of consumer-owned energy resources behind the meter (on consumers' premises) in Australia. The power system was built around large, centralised generation assets located remotely from population centres, and electricity flowed in a single direction from the transmission system to consumers in distribution networks.

Australian consumers have now invested in more than 7.6 gigawatts (GW) of rooftop PV capacity[14], and the rate of investment is continuing at over 1 GW per year, driven by the confluence of high prices for grid-delivered electricity and decreasing prices for rooftop PV.

Australia has among the highest per capita rates of rooftop PV adoption in the world (22%), and in Queensland and South Australia this rate is over 30%[15].

Consumers are beginning to take further control of their energy supply by complementing their rooftop PV with battery storage systems, as the global benchmark cost for lithium-ion batteries has reduced by 80% from 2010 to 2017[16].

AEMO's *Integrated System Plan* (ISP) projects that by 2040 the NEM will host up to 21 GW of rooftop PV capacity in a Neutral scenario, and 56 GW if high growth of DER is assumed, making rooftop PV the highest capacity generation technology in the NEM by 2040 under the high DER scenario[17].

This would represent a profound transformation of the power system, from a centralised structure with one-way flows of electricity to a much more decentralised system, where a much higher proportion of total NEM generation is produced and consumed within the distribution networks.

Effectively integrating high penetrations of DER into Australia's power systems and market frameworks will be critical to delivering the most efficient and affordable power system for consumers.

Consumers who combine rooftop PV with battery storage could become over 90% self-sufficient for electricity, and at times have excess PV generation or stored electricity in their battery to export to the power system.

The value of this export can dramatically increase depending on the needs of power system at both the regional and local level, for instance, if the wholesale price of electricity reaches the market cap of $14,500 per megawatt hour (MWh). Wholesale prices rarely peak during the middle of the day, when rooftop PV is generating most, and negative wholesale prices could become more prevalent as more PV generation is connected in the next two decades. As a result, energy storage will be a key technology to capture and deliver new value streams to consumers who have invested in storage, and could make the power system more efficient for the benefit of all consumers.

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[13] New South Wales Government. *Smart energy for homes and businesses*, available at https://energy.nsw.gov.au/renewables/emerging-energy/clean-energy-initiatives#-smart-energy-for-homes-and-businesses-.

[14] Clean Energy Regulator, 2018, available at http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#Summary-of-postcode-data.

[15] Australian PV Institute, 2018. Mapping Australian Photovoltaic Installations (Solar PV status page), available at http://pv-map.apvi.org.au/.

[16] Bloomberg New Energy Finance, 2018.

[17] AEMO, 2018. Integrated System Plan database, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan/ISP-database.

Effective integration of DER will involve enabling:

- Aggregated DER to respond to wholesale energy and Frequency Control Ancillary Services (FCAS) market price signals.
- System operators to have sufficient operational visibility of DER.
- Distribution network limits to be considered when dispatching DER.

The VPP Demonstrations seek to address the first two elements, and AEMO's collaboration with ENA on the Open Energy Networks and the broader DEIP process seeks to tackle the third element.

The consumer benefit of effective DER integration should be experienced by all consumers, not just those consumers with direct access to the DER. DER integration will aim to:

- Provide new sources of energy and system support services that improve reliability and increase market competition, reducing wholesale energy and ancillary services costs.
- Delay, reduce, or negate the need for certain network investments, reducing network costs for all consumers.

1.5.1 Delivering the full 'value stack' to consumers

Large portfolios of batteries operated in unison have the potential to deliver a range of services, such as dispatchable energy, peak capacity, flexibility or ramping services, network congestion relief, and ancillary services such as FCAS.

VPPs will benefit consumers most if the VPPs can earn returns from each of the services they are able to deliver. VPPs were not contemplated when the current energy regulatory framework was developed, and it is difficult under current regulatory and operational settings for VPPs to deliver the full "value stack" without registering as a Market Customer.

Currently, a VPP operator could seek registration as a Market Ancillary Services Provider (MASP) to participate in FCAS markets. Alternatively, the VPP operator could seek to register as a Small Generation Aggregator (SGA), and ensure that each generating unit has a connection, to participate in the wholesale energy market. Under the current rules, a MASP cannot participate in the wholesale energy market, and an SGA cannot participate in FCAS markets[18]. Accordingly, under the current regulatory framework, a VPP operator needs to enter into a commercial arrangement with a retailer, who, as the registered market customer at the connection point, can participate in both FCAS and energy markets.

The AEMC's Reliability Frameworks Review final report recommended changes to the regulatory framework to introduce a new market participant category for demand response aggregators, and to better enable consumers to access multiple service providers at a single connection point[19]. Since the conclusion of its review, the AEMC has received three rule change requests relating to the introduction of a wholesale demand response mechanism.

If such changes were to be made, it may provide a framework for VPPs to be able to participate in the wholesale market directly to deliver a range of services in their value stack. This first phase of VPP Demonstrations will not seek to test new participant categories or multiple relationships at a single connection point, but will focus on separate objectives that are discussed further in Section 2.1.

These trials will allow VPPs to demonstrate as many services as possible by delivering both energy services and FCAS from both positive and negative electricity flows.

1.5.2 System security risk of not integrating VPPs into market frameworks

AEMO currently has no visibility of how a VPP is operating in real time, as VPPs do not participate in the market dispatch process.

[18] The AEMC intends to consider streamlining some of the market participant categories through the Wholesale Demand Response rule change process.

[19] AEMC, 2018. *Reliability Frameworks Review final report*, available at https://www.aemc.gov.au/markets-reviews-advice/reliability-frameworks-review.

Under the National Electricity Rules (NER), a generating unit with a nameplate rating of 30 MW, or which is part of a group of generating units connected at a common connection point with a combined nameplate rating of 30 MW or more, is classified as a scheduled generating unit, unless AEMO approves a different classification. The NER consider generating units behind a common connection point collectively for these purposes.

However, where generating units behind different connection points are operated in a single fashion as a coordinated fleet, the rules do not require the scheduling of that fleet – regardless of the total aggregated fleet size. This is important, as a 20 MW VPP could conceivably ramp up to 40 MW instantaneously if moving from charging to discharging (or vice versa).

While VPPs are small, rapid changes in how they are operating should not materially impact the broader market. Continued growth of "unscheduled" VPPs could have the following implications:

- AEMO would have little information on the expected operation of the VPP, particularly relating to active responses to changing power system prices. AEMO may have some ability to forecast this behaviour, but the limited information available would manifest as escalating demand forecast errors as VPPs grow.
- Escalating forecast errors would need to be managed by increasing enablement and use of Regulation FCAS. The costs of this service are borne by consumers and market participants.
- Large, sudden VPP movements could exceed the capability of Regulation FCAS reserves to respond, and would trigger the use of Contingency FCAS to quickly rebalance the system. This means growth in active VPPs may cause increasing triggering of Contingency FCAS, increasing costs for consumers.
- Very large VPP movements could exceed the capabilities of FCAS reserves to respond, and may threaten system security.
  - For example, a sudden VPP movement in South Australia could cause a large and sudden increase in flows on the Heywood interconnector. If the Heywood interconnector was operating near its nominal limits, a 500 MW movement could be sufficient to increase flows beyond the stable limits of the interconnector. In the absence of emergency protection schemes, this may lead to a loss of synchronism, and trip of the interconnector. Even with emergency schemes, this would lead to involuntary load or generation shedding when the scheme operates.

The power system impact of VPPs will depend on the total VPP capacity that moves. A single moderately sized VPP may not prove problematic, but the synchronised movement of many smaller VPPs (perhaps in response to the same price signals, weather events, or other stimuli) could exceed the ability of the power system to respond efficiently and remain secure.

It is, therefore, vital that AEMO obtains appropriate operational visibility of VPPs. Allowing AEMO to observe VPPs in these Demonstrations while they are small will enable AEMO to put in place measures to obtain the appropriate level of visibility for when VPPs scale up.

2. Objectives and approach

The VPP Demonstrations aim to provide an evidence base to support development of a fit-for-purpose regulatory environment for VPPs, and are expected to inform changes to the NER and AEMO's operational processes. The objectives of the VPP Demonstrations are set out in more detail below.

2.1 VPP Demonstrations objectives

1. Allow participants to demonstrate basic control and coordination capability for VPPs providing market services in the NEM relating to both energy and FCAS.
   - VPP cloud-to-cloud communication and control technology, used to orchestrate fleets of DER, is at the cutting edge of technology development globally. The VPP Demonstrations aim to facilitate collective learning on how reliably VPPs can orchestrate fleets of batteries to the delivery of energy and FCAS in real-time markets. Although VPPs will continue to operate unscheduled during the trials, observing VPP operations is expected to assist AEMO to determine what systems and capabilities are needed to support VPP market participation, potentially as a scheduled resource in future, while maintaining system security.
2. Develop basic systems and capability to provide AEMO with operational visibility of VPPs to understand their impact on power system security and how they interact with the market.
   - As VPP participants will operate unscheduled in the market, AEMO will establish an application programming interface (API) that will enable participants to submit operational forecasts and actual performance data from their VPPs to AEMO. This data will provide sufficient operational visibility for the duration of the trials, and the opportunity to learn about potential data challenges and opportunities relating to VPP operation that can inform the best approach to integrate them into market frameworks after the trial is complete. For example, the data will inform AEMO's consideration of whether VPPs should be required to schedule their aggregated fleet and at what aggregated capacity threshold.
3. Assess current regulatory arrangements affecting participation of VPPs in energy and FCAS markets, and inform new or amended arrangements where appropriate.
   - The Demonstrations will operate under the current regulatory framework, and AEMO will implement some new approaches for the trials to enable VPPs to demonstrate energy and FCAS delivery, including the draft specification for DER to provide contingency FCAS[20]. The trials aim to assess the suitability of these approaches, and inform consideration of any required changes to regulatory frameworks and operational processes to ensure VPPs are better integrated into the NEM.

Question 2.1: Are these objectives logical and achievable? Should any other objectives be considered for these VPP Demonstrations?

[20] AEMO, 2018. *Distributed Energy Resources FCAS Specification – Draft*, available at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Distributed-Energy-Resources-FCAS-Specification.pdf.

2.2 Roles and responsibilities

The VPP Demonstrations are a collaboration between NEM statutory organisations and market participants, intended to establish a shared evidence base of VPP operation and how VPPs should be integrated into energy market frameworks and policies. The expected contributions from each of the key stakeholders are highlighted below.

2.2.1 AEMO

As the market operator, AEMO is responsible for ensuring power system security is maintained in accordance with principles set out in Chapter 4 of the NER. AEMO also plays a role in processing registration applications from current and intending market participants, including undertaking technical due diligence of each party's ability to deliver services for which they are seeking to register.

On this basis, AEMO has a central role in conceiving and implementing the VPP Demonstrations frameworks such that system security is maintained and trial activities do not result in unacceptable operational risks.

AEMO's role in designing and implementing the demonstration framework will involve:

- Managing the consultation process for the demonstration design and finalising the terms and conditions to apply to participants engaging in the demonstration.
- Testing proposed changes to AEMO requirements to better integrate VPPs into energy and FCAS market frameworks, discussed further below.
- Considering and processing registration applications in connection with the demonstration, including undertaking due diligence on the ability of trial participants to provide FCAS.
- Leading the data analysis to identify trial learnings that can inform changes to operational processes or the NER.
- Developing and implementing a variety of new IT systems to facilitate the trials, including:
  - A new web-based portal to receive:
    - Operational forecasts from VPP operators, enabling AEMO to monitor the regional supply/demand balance, adjusting regional forecasts to account for anticipated VPP activity.
    - Operational performance data from VPP operators. This dataset will allow the AEMC, AER, and AEMO to assess the relevance of existing NER frameworks to VPPs across a range of areas, including, but not limited to, the suitability of existing network regulations for enabling DER capability, metering requirements, and the registration thresholds, criteria, and processes.
  - New automated systems for FCAS measurement and verification for DER.
  - New VPP Registration support tool. This will allow basic standing data (for example, National Meter Identifiers [NMIs]) for each connection point in a VPP portfolio to be easily provided, amended as VPPs scale up in size, and integrated with other AEMO systems.

2.2.2 AEMC

The AEMC is responsible for assessing changes to the NER and National Energy Retail Rules. These rules are the general statutory framework under the National Electricity Law and National Energy Retail Law which regulate the operation of the NEM. The AEMC is also responsible for market development and design and provides advice to the Council of Australian Governments (COAG) Energy Council.

The AEMC has highlighted, in its *Reliability frameworks review, Frequency control frameworks review*, and *Electricity network economic regulatory framework review*, the need to consider how to best integrate VPPs, and DER more broadly, into the NEM in a manner that will enable the most efficient outcomes in both operational and on investment timeframes.

The VPP Demonstrations will provide useful input and learnings to the AEMC and inform its considerations of proposed rule changes and market design changes.

2.2.3 AER

The AER is responsible for monitoring and enforcing the NER, the retail customer protection, and the achievement of the National Electricity Objective. The increasing number of new participants, in conjunction with the rapid evolution of new sources of supply, is already affecting energy markets and warrants significant attention. Promoting activity on the demand side is consistent with the conclusions of recent reviews and poses a range of potential challenges. Through its involvement in this project, the AER provides information regarding practical compliance and enforcement of the existing rules and can consider, with AEMO and the AEMC, where and how new rules may need be required to support the National Electricity Objective and consumers.

2.2.4 VPP consortia participating in the Demonstrations

Demonstration participants are expected to include parties with VPP capability looking to test basic commercial models for VPPs providing energy market services – namely energy and FCAS.

Participants will be responsible for ensuring compliance with relevant laws and regulations, including energy market rules and policies (except where these policies may be varied as a part of the trial program) and health and safety laws. Network connection and consumer protections requirements relevant to each NEM region must also be observed, such as having a valid connection agreement from the relevant NSP and using suitably accredited installation staff for individual DER comprising a VPP.

In addition, trial participants will be required to submit operational forecasts and actual performance data of their VPP to AEMO. These obligations are explained further in Chapter 4 below.

2.2.5 Distribution Network Service Providers (DNSPs)

AEMO recognises that DNSPs will play a key role in effectively integrating DER into Australia's energy systems. Their role will cover setting DER connection standards (that are aligned as much as possible across Australia[21]), as well as understanding, monitoring, and communicating the dynamic limits of their local networks to DER aggregators such as VPPs.

As the amount of grid-connected DER grows over the next two decades, up to five-fold from current levels, considering local network limits will become a key element of the dispatch process to ensure DER aggregators are able to securely dispatch the resources they want to when responding to price signals.

AEMO is keen to collaborate with DNSPs in a number of areas, such as:

- The specification of web-based interfaces to communicate with VPPs.
  - Both AEMO and DNSPs are seeking to establish APIs to receive information (such as operational forecasts) and send information (such as dynamic networks limits or instruction notices). AEMO is keen to minimise duplication of data requirements for VPP operators, and to align API designs where possible to make it as easy as possible for VPPs to integrate with their systems.
- Identifying new data sources.
  - To maximise the utilisation and efficiency of their network, DNSPs need to obtain power quality data across their networks (including at the low voltage level). VPPs could represent new sources of this data, as an alternative to installing separate monitoring equipment at consumers' expense. Data from the VPP Demonstrations could show that VPPs represent a viable source of power quality data for DNSPs, potentially delivering a new revenue stream for VPPs and representing a cost saving for DNSPs and consumers in their network.

[21] Energy Networks Australia, 2018. *DER National Connection Guidelines*, available at https://www.energynetworks.com.au/distributed-energy-resources-national-connection-guidelines.

2.2.6 Federal and state governments

AEMO is keeping governments informed of how the VPP Demonstrations framework is developing and, where requested, is providing technical assistance in the development of state programs relating to DER.

AEMO encourages stakeholders to engage with all consultative processes relating to VPPs, by responding to this consultation process, and any similar processes for state or federal government programs.

2.2.7 Consumer representative bodies

AEMO, the AEMC, and the AER are keen to use the VPP Demonstrations to improve the consumer experience when engaging with VPP consortia to learn about potential benefits, costs, and operating models associated with VPP participation.

Question 2.2: How can projects involved in the VPP Demonstrations better capture consumer insights and improve customer experience and outcomes?

2.3 AEMO's approach for the VPP Demonstrations

This section outlines AEMO's proposed approach for the VPP Demonstrations. It is important to note that the arrangements facilitating the VPP Demonstrations do not necessarily set a precedent for how VPPs will interact with the NEM going forward. The VPP Demonstrations will provide valuable insights for the AEMC, AEMO, and the AER to develop ongoing arrangements for VPP participation in the NEM, in consultation with the industry.

2.3.1 Limited duration

The VPP Demonstrations will be open for a limited period of 12 months. Because the effectiveness of the program will depend on observing a critical mass of operating projects, the duration of the trial may be extended so sufficient operational data can be gathered to fulfil the objectives, or until ongoing arrangements for market participation can be implemented.

2.3.2 How will VPPs operate in the energy market?

If a trial participant is registered as a Market Customer (that is, as a retailer), it will participate in the energy market according to the general provisions applying to energy markets.

The retailer would pay the spot price for the customer loads for which it is the Financially Responsible Market Participant (FRMP) at each connection point. Periods of net generation from households participating in the VPP Demonstrations are considered 'negative load', and the retailer would be paid at the spot price for this generation, which would reduce the retailer's settlement bill for energy consumed by customers in its portfolio.

It is expected that the DER employed as part of the trial will meet the requirements of the standing exemption for generating units under 5 MW as set out in *AEMO's Generation Classification and Exemption Guidelines*[22]. The Guidelines were recently revised, effective 17 August 2018.

Participants in the VPP Demonstrations will operate as a non-scheduled, price-taking resource. AEMO intends to use the VPP Demonstrations to inform whether VPPs should be required to schedule their aggregated fleet and, if so, at what aggregated capacity threshold.

[22] AEMO, 2018. *AEMO's Generation Classification and Exemption Guidelines*, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Exemption-and-classification-guides.

2.3.3 Classification of ancillary service loads

For the purposes of the VPP Demonstrations, AEMO will adopt a new approach to the classification of ancillary services load. Trial participants will be permitted to seek classification of both negative and positive flows from the connection point as part of their ancillary services load. Generally, under the Market Ancillary Services Specification (MASS)[23] and AEMO's registration requirements, AEMO registers an ancillary services load with respect to the load-side of a battery only. That is, where a MASP or Market Customer registers a load or market load (as applicable) as an ancillary services load, the export potential of a battery is not recognised.

To illustrate the difference in approach to be adopted in the VPP Demonstration, consider a 4 MW battery which is at a Market Customer's connection point.

- Under the traditional approach, the load could be classified as an ancillary services load capable of providing up to 4 MW of lower or raise response (from -4 to 0).
- Under the approach to be adopted in the trial, this connection point could be classified as an ancillary services load capable of providing up to 4 MW of lower or raise response (between -4 to +4). Trial participants will be required to satisfy AEMO that, as a technical matter, the VPP is capable of providing that FCAS up to the MW amount to be registered.

2.3.4 Measurement and monitoring of FCAS

The VPP Demonstrations will test verification for fast FCAS by assessing measurements from both high-speed meters at a sample of sites and lower granularity measurements from each battery device. These requirements, and others, are set out in the draft DER FCAS specification[24].

Currently, AEMO generally requires fast FCAS services to be measured using high-speed meters at every participating site. The expense of installing high-speed meters at every site is not considered commercially viable for DER participation in FCAS, and AEMO intends to test whether sufficient information about the delivery of a response can be obtained through data from a sample of sites, rather than from every site.

2.3.5 Metering and settlement of energy

Energy provided by VPPs in the Demonstrations will be settled via the wholesale market and will be metered according to current NER requirements. This will require a single FRMP for each connection point and suitable NEM standard metering in place.

2.3.6 Cyber security requirements

AEMO intends to utilise the VPP Demonstrations to explore what level of cyber security obligations AEMO may seek to impose on VPPs that participate in the energy and FCAS markets in future. AEMO intends to consult with intending participants to the VPP Demonstrations on the appropriate cyber security measures to put in place for the Demonstrations before the terms and conditions of participation are finalised. AEMO invites stakeholders to include any initial thoughts on this topic in their feedback to this paper.

2.3.7 Testing new arrangements

AEMO intends to use the VPP Demonstrations framework to facilitate testing of new capabilities or arrangements that are relevant to the long-term integration of VPPs into the NEM, subject to consent from all relevant parties. An example of this could be to test VPPs responding to an instruction from AEMO under section 116 of the National Electricity Law.

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[23] AEMO, *Market Ancillary Services Specification* v 5.0, effective 30 July 2017, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

[24] AEMO, 2018. *Specification for Distributed Energy Resources to provide Contingency FCAS (draft)*, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

2.3.8 Proposed indicative timeframes

Table 1 Indicative timeframes prior to VPP Demonstrations launch

Milestone	Specific date or indicative timing
Consultation webinar	4 December 2018, 11am (AEDT).
Due date for written submissions	21 December 2018
Publish draft API specification	Q1 2019
Publish terms of reference for participation in the VPP Demonstrations	Q1 2019
AEMO build system requirements to facilitate VPP Demonstrations	Q1 2019
Launch VPP Demonstrations	Q2 2019

Please contact AEMO at DERProgram@aemo.com.au to:

- Register and obtain details for the VPP Demonstrations webinar. Webinar registration details will also be posted on the VPP Demonstrations webpage.[25]
- Send in a written submission by 21 December 2018.
- Ask any questions or request further information at any time.

Written submissions will be published on the AEMO website. Please indicate if there are any parts of your submission you would like kept confidential.

Question 2.3: Is AEMO's high-level approach to the VPP Demonstrations appropriate? What other arrangements could be tested under the VPP Demonstrations framework?

[25] AEMO, *VPP Demonstrations*, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/DER-program/VPP-demonstrations.

3. Trial participation

This section outlines some proposed information about participating in the VPP Demonstrations.

3.1 Why would you join the VPP Demonstrations?

The Demonstrations will be used by the AEMC, AER, and AEMO to:

- Assess the appropriateness of the current regulatory arrangements affecting participation of VPPs in energy and FCAS markets, and
- Inform consideration of future changes to the regulatory arrangements.

Participating in the VPP Demonstrations will provide an opportunity to be directly involved in shaping the frameworks that will determine how VPPs interact with energy and FCAS markets in future. The value of this collective learning exercise increases as more VPPs participate, so AEMO encourages all VPP proponents to engage in this process.

Participants will also benefit from operating under the approaches that AEMO will test under the trial framework, discussed in Section 2.3, which are intended to enable VPP to more easily participate in energy and FCAS markets.

3.2 How do you qualify to participate in the trials?

The VPP Demonstrations will be conducted under the current energy regulatory framework. To participate in the trial, intending participants must:

- Be appropriately registered in the NEM as a market customer or market ancillary services provider, or form part of a consortium in which one of the applicants is appropriately registered); and
- Have qualifying systems in place to meet both:
  - The minimum technical specification (refer to Appendix A2).
  - The data specification (refer to Chapter 4).

3.3 Registration process

This section outlines some proposed details about how intending participants will register for the VPP Demonstrations.

3.3.1 Different models for VPP trial participation

Prior to participating in the trial, an applicant must apply to AEMO to be registered to participate in the trial. Each intending trial participant must ensure the devices used to provide the registered services comply with the NER, National Energy Customer Framework (NECF), and other applicable law and regulations.

Trial participants may apply to register their VPP as participating in either:

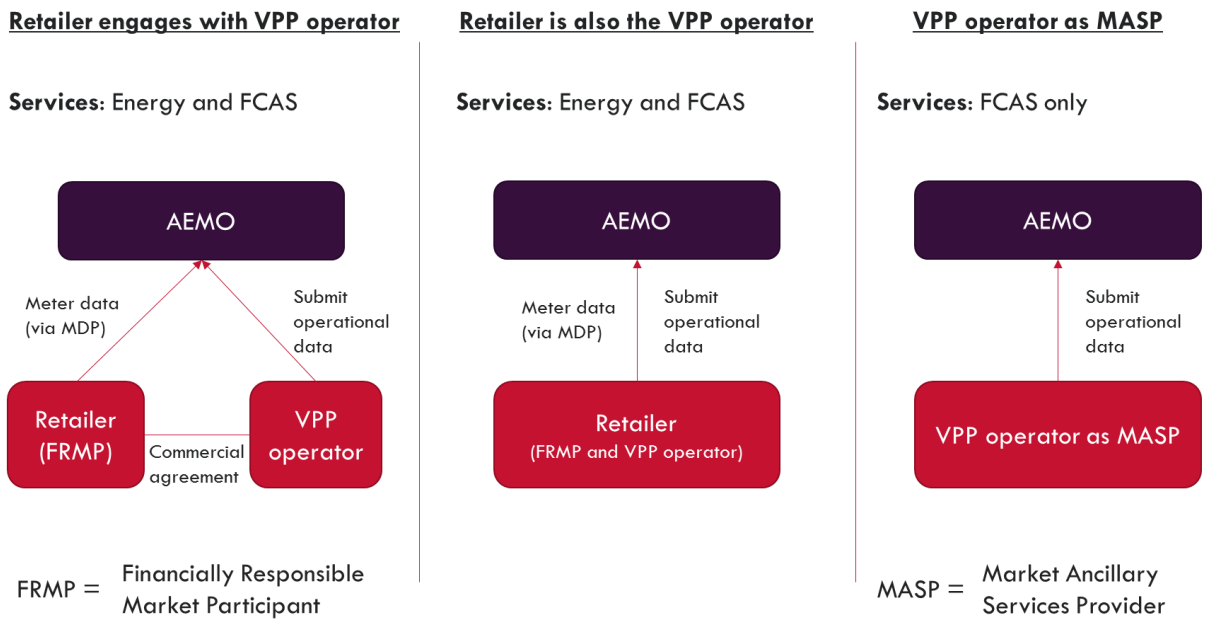
- Energy markets and FCAS markets, or
- Energy or FCAS markets only.

VPP proponents may participate in the VPP Demonstrations through any of three different models:

1. A retailer and a separate VPP operator (who may not be a registered participant) may jointly participate in the trial in respect of connection points where the retailer is the FRMP. This arrangement will require the retailer and separate VPP operator to enter into a commercial agreement, and the retailer will participate as the market customer, in both energy and FCAS markets for the trial.
2. A retailer, who is also the VPP operator, can participate as a market customer with respect to multiple connection points at which it is the FRMP. Under this arrangement, the retailer can participate in both energy and FCAS markets.
3. A VPP operator who is registered as a MASP may participate in the trial in FCAS markets only.

These options are shown in the figure below.

Figure 1 Three models for participation in the NEM VPP Demonstrations



MDP = Metering data provider

3.3.2 How to register as a trial participant?

Intending participants will be required to agree to terms and conditions of the VPP Demonstrations as part of the registration process for the trial. The terms and conditions will capture the key principles of the VPP Demonstrations and will be developed after feedback is received on this paper.

AEMO will also retain a right to suspend or cancel participation in the Demonstrations for a range of reasons, including the relevant participant failing to comply with the requirements of the VPP Demonstrations or posing a risk to reliability or system security.

3.3.3 Possible information required for registration

AEMO will determine the information required for registration in the VPP Demonstrations when defining the terms and conditions of participation.

The tables below indicate the information that could be required by providing overview of the information currently required:

- To register for FCAS as a MASP or Market Customer (Table 2).
- For the FCAS assessment that must be completed prior to gaining approval to be enabled for FCAS delivery (Table 3).

Table 2 Standing data currently required for registration as a MASP or Market Customer

Standing data currently required for registration as a MASP or Market Customer
Name – for the VPP Demonstrations, AEMO will require the names of all parties in the VPP Consortia
NMIs in the VPP portfolio
Confirm NMI sites are under ownership, operation and/or control of the MASP or Market Customer (Y/N)
Postal code of installed sites
NEM Region
DNSP
Device manufacturer
Device model/ version
Device control box model/version
Device capacity (kWh)
Max raise capability (kW)=max - for all FCAS markets that are being registered for
Max lower capability (kW)=max - for all FCAS markets that are being registered for

Table 3 Information required for the FCAS assessment prior to approval to be enabled for FCAS delivery

Information required for the FCAS assessment prior to approval to be enabled for FCAS delivery
Confirmation whether they meet all the conditions in the DER FCAS specification
Number of devices installed
Frequency deviation test on each type of devices – high speed data and low speed data to be provided
Frequency deviation test to observe aggregated FCAS response of the VPP following a +/-0.5Hz frequency deviation
Number of high speed meters to be installed
After registration, conduct a frequency injection test to prove FCAS capability is as per the maximum ancillary service capacity registered

3.4 Waiver of registration fees

AEMO is proposing to waive market registration fees for participants in the VPP Demonstrations for the duration of the trials. AEMO acknowledges that these Demonstrations are intended to be a learning exercise that will inform what permanent arrangements will be implemented for VPPs to participate in energy and FCAS markets once the VPP Demonstrations have been completed.

A summary of the registration fees that AEMO is proposing to waive is shown in the table below. This schedule is based on AEMO's electricity fee schedule, which may be subject to change prior to the launch of the VPP Demonstrations[26].

[26] AEMO. *Electricity fee schedule*, available at http://www.aemo.com.au/-/media/Files/About_AEMO/Energy_Market_Budget_and_Fees/2018/Final-AEMO-Electricity-Revenue-Requirement-and-Fee-Schedule-18-19.pdf.

Table 4 Registration fees proposed to be waived for participating in the VPP Demonstrations

Application type	2018-19 ($)
Registration as Market Ancillary Service Provider	10,000
Classification of load for frequency control ancillary services purposes – new ancillary service load or aggregated ancillary service load (adding a new dispatchable unit identifier [DUID] to a region)	5,000
Updating portfolio details for an existing DUID	500 per update

VPP Demonstrations participants will be subject to market customer fees outlined on page one of the *Electricity fee schedule*, which are allocated per megawatt hour of customer load[27].

[27] AEMO. *Electricity fee schedule*, available at http://www.aemo.com.au/-/media/Files/About_AEMO/Energy_Market_Budget_and_Fees/2018/Final-AEMO-Electricity-Revenue-Requirement-and-Fee-Schedule-18-19.pdf.

4. Data requirements and sharing arrangements

The purpose of this chapter is to describe, at a high level, the nature and rationale for data proposed to be collected by AEMO to facilitate the VPP Demonstrations. These data requirements are designed to enable AEMO to meet its obligations to securely operate the power system[28] and also provide a basis to consider fit-for-purpose regulatory arrangements that should apply to VPPs in future.

AEMO anticipates that operating a more decentralised power system with two-way power flows in many areas will require a much greater level of operational awareness of electricity networks, supported by larger and more frequent exchanges of operational and network data between stakeholders.

The data requirements described in this chapter are not intended to act as ongoing data specifications for VPPs, but will be collected and used for the Demonstrations to meet the objectives specified in Section 2.1 and to define what ongoing data specifications should be required. AEMO, the AEMC, and the AER are sensitive to the need for longer-term data requirements to be devised carefully in consultation with consumers, equipment manufacturers, and electricity market participants.

AEMO is proposing to establish APIs to facilitate data transfers to AEMO. After feedback from this initial consultation has been assessed, AEMO will publish a further consultation paper requesting detailed feedback on proposed API design.

4.1 VPP Demonstrations data requirements

Participants in the VPP Demonstrations will be obliged to provide data to AEMO, including:

- Aggregated VPP dataset – an aggregated forecast of anticipated active power flows, and aggregated actual performance data, from each VPP for a given NEM region (for example, VPPs located in South Australia will be obliged to provide a forecast of energy provided to the South Australia region).
  - Function: to be used by AEMO's Operational Forecasting team to monitor the regional balance of supply and demand. Because VPPs participating in these Demonstrations will be operating as *non-scheduled* price takers when injecting energy (as distinct from FCAS) into their local network, AEMO will not have visibility of these power flows unless a forecast is provided. Awareness of VPP operation could be critical to managing the power system in high demand periods where reserves (spare capacity) have dropped to historic lows in recent years
- Device level dataset – a set of key DER system variables sampled at 5-minute resolution. This dataset is similar to the Schedule D data specification produced by the ACT Government as part of their *NextGen Energy Program*.
  - Function: the primary purpose of this dataset is to provide a clear technical record of how DER aggregated into VPPs operate in the NEM under the current NER. This dataset will be carefully analysed by AEMO, the AEMC, and the AER to assess whether the breadth of current rules and procedures applicable to VPPs adequately incentivise consumer and power system benefits.

[28] See NER clause 4.3.1 (f), (l).

- FCAS verification data – information required to verify delivery of FCAS is published in the MASS and the draft specification for DER to provide FCAS, both of which are available on the AEMO website[29].
  - Function: AEMO requires participants to submit measurement data to verify that a contingency FCAS response has been delivered.

4.1.1 Aggregated VPP dataset

Participants in the trial will be required to provide aggregated forecast and actual performance data to AEMO via an API. This data will be used to gain visibility of the behaviour of VPPs, enabling development of future forecasting models that can be integrated into AEMO's operational forecasting systems. By providing this data, participants will ensure AEMO has adequate data on which to train its forecasting models, and that the IT systems used to provide this data are fit for purpose.

Data requirements

It is expected that the information requested here can be provided by the regional operator of each VPP, who will be maintaining supervisory awareness and control of the DER comprising each VPP.

The table below describes the key data streams in the aggregated VPP dataset – the operational forecast, the availability forecast, and actual performance data.

Table 5 Aggregated VPP data streams

Data stream	Timestep	Description
Operational forecast	5-minute resolution covering pre-dispatch timeframe	Forecast of aggregated generation or load under control in each VPP portfolio. Refreshed every five minutes.
Availability forecast	30-minute resolution covering pre-dispatch timeframe and STPASA timeframe	Aggregated available capacity of generation or load, and state of charge in each VPP portfolio. Refreshed every five minutes.
Standing data	30-minute resolution	Updated as required – only when there is a forecast change or has been a change in the data.
Actual performance data	5-minute resolution	Actual aggregated generation or load under control in each VPP portfolio. Refreshed every five minutes.

The information required to assess the actual output of each device is expected to be derived from telemetered terminals of each battery smart inverter/third party control unit (rather than traditional 'NEM standard' metering).

The aggregated VPP data specification is shown in the table below. Data must be provided separately for each VPP. A separate VPP is defined for the Demonstrations as the total assets under the control of the VPP operator in each NEM region.

[29] AEMO. *Market ancillary services specification and FCAS verification*, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

Table 6 Aggregated VPP data specification overview

Parameter	Units	Description	Operational forecast	Availability forecast	Standing data	Actual performance data
Controlled generation or load	MW	Sum of actual generation and load (net)	Y	N	N	Y
Generation capacity	MW	Maximum possible generation (for each interval)	Y	Y	N	Y
Load capacity	MW	Maximum possible load (for each interval)	Y	Y	N	Y
Installed generation capacity	MW	Total nameplate generation capacity (system size)	N	N	Y	N
Installed load capacity	MW	Total nameplate load capacity (system size)	N	N	Y	N
State of charge	MWh	Stored energy available for discharge	Y	Y	N	Y
Total storage	MWh	Maximum energy storage capacity	Y	Y	N	Y

Best endeavours obligations

All demonstration participants are obliged to submit forecasts that represent their best reasonable expectation of plant operation. Participants should provide these forecasts on a *best endeavours* basis and ensure they are not false or misleading.

Question 4.1: AEMO would like the aggregated VPP dataset to be refreshed every five minutes to align with its operational forecasting function. Are VPP operators able to provide this data on a 5-minute refresh basis?

Question 4.2: Should the values be reported as an average value across the 5-minute interval, or an instantaneous value at the end of the 5-minute interval, or both?

4.1.2 Device level dataset

All demonstration participants will be obliged to provide the device level dataset (time series dataset at 5-minute resolution) described in this section. AEMO is proposing to collect this data from individual DER installations during this demonstration exercise to characterise the technical and market impacts of VPP operation as completely as possible.

The data specification described below was developed by the ACT government and is required to be collected by grant recipients under their *Next Generation Energy Storage Grants*[30] program in 2016. The feasibility of collecting this data at reasonable cost was tested with industry stakeholders (retail market participants and battery operators/aggregators) through the ACT Government's consultation and implementation processes. AEMO has conducted further informal consultation on costs and additional equipment required by VPP operators to collect and transmit the data shown below in Table 7.

[30] Refer to ACT Government website for more information, at https://www.environment.act.gov.au/energy/cleaner-energy/next-generation-renewables.

AEMO understands that provision of some variables (for example, meter voltage on network side) may require the installation of some sensors and measurement relays not installed as standard components of DER-enabled VPPs currently on the market. AEMO has been advised that this additional measuring equipment can be procured at relatively low cost by VPP operators and that these small additional costs are justified in developing a clear evidence base to characterise VPP operation in the NEM. The equipment needed to meet the data requirements aligns with the minimum capability specification that is included in Appendix A2.

This device level dataset described here will be critical in assessing changes to the NER expected to be necessary to effectively integrate VPPs into for energy and FCAS markets. Examples of rules and operational policies that are expected to require re-consideration include, but are not limited to:

- Requirements for measurement equipment and measurement location to meter energy or verify ancillary service delivery from DER.
- Network regulations that affect how NSPs can invest in their networks to support market participation by aggregated DER, allowing active power to be injected at residential connection points when required. Examples of this include how NSPs can act to meet NER obligations for monitoring and maintaining voltage at residential connection points[31].

Data listed in the table below should be provided at a 5-minute resolution, corresponding to 5-minute NEM dispatch intervals, for each DER comprising a VPP.

Table 7 Device level dataset overview

Installation type	Parameter	Units	Basis
All	Customer gross load	kW, kVAr	Max, min, mean
Any battery	Battery state of charge	%	Mean
Any battery	Meter voltage (network side)	V	Max, min, mean
Any battery	Meter frequency (network side)	Hz	Max, min, mean
Any battery	Meter export power	kW, kVAr	Max, min, mean
DC battery	Inverter power output	kW, kVAr	Max, min, mean
DC battery	Battery DC power output	kW	Max, min, mean
AC battery	PV inverter power output	kW, kVAr	Max, min, mean
AC battery	Battery inverter power output	kW, kVAr	Max, min, mean

AEMO intends to develop an API to facilitate transmission and receipt of the device level dataset and will be releasing a draft API specification including information on dataflows and data streaming requirements for consultation with trial participants in the coming months.

Question 4.3: What is the appropriate frequency for VPP operators to submit the device level dataset to AEMO? Is there a material difference in resources required to upload the data on a daily, weekly, or monthly basis?

[31] Refer to NER S5.1.5 on obligations to design and operate networks within AS/NZS 61000.3.7:2001

4.2 Commitment to knowledge sharing

AEMO, the AEMC, and the AER are committed to sharing the insights from the VPP Demonstrations to lift the collective industry learning on how to effectively integrate VPPs into market frameworks and operational processes.

As part of the knowledge sharing process, AEMO, the AEMC, and the AER may publish or provide aggregated data in connection with the Demonstrations to third parties (including governments). The knowledge sharing process will be done collaboratively with participants to avoid compromising commercially sensitive information.

4.2.1 Rights to access, use, and share data

As part of the terms and conditions governing participation in the Demonstrations, participants will be required to provide AEMO rights to access, use, and share the data as required to facilitate the Demonstrations. This will include rights to share data provided in the Demonstrations:

- With NSPs where it is pertinent to system security; and
- More generally, to facilitate knowledge sharing around the results of the Demonstrations.

Participants in the trial will be required to comply with their obligations with respect to data under the Rules and Privacy Law. Under the Rules, metering data and NMI Standing Data is considered confidential information. Chapter 8 of the NER prevents Market Participants using or sharing that information except in accordance with the Rules. Where a consortium of market customer and aggregator is participating in the trial, the aggregator must have appropriate rights to access NMI Standing Data or other data it requires to participate in the trial.

Data from devices which are not metering installations under the rules (for example, devices located at a facility for FCAS purposes) will not be considered metering data under the Rules. Aggregators participating in the trial will be required to ensure that AEMO has appropriate rights to access and use this data, and to share the data with NSPs.

Question 4.4: Are there any regulatory or other obstacles to participants facilitating the data sharing arrangements contemplated in this section?

A1. Summary of consultation questions

The table below provides a summary of the consultation questions in this paper.

Table 8 Summary of consultation questions

Number	Question
1.1	The primary focus of these trials is to demonstrate VPP aggregating battery storage systems. Do intending participants envisage incorporating demand response resources into your aggregated portfolios, and should this be incorporated into the VPP Demonstrations?
2.1	Are the VPP Demonstrations objectives logical and achievable? Should any other objectives be considered for these VPP Demonstrations?
2.2	How can the VPP Demonstrations projects better capture consumer insights and improve customer experience and outcomes?
2.3	Is AEMO's high-level approach to the VPP Demonstrations appropriate? What other arrangements could be tested under the VPP Demonstrations framework?
4.1	AEMO would like the aggregated VPP dataset to be refreshed every five minutes to align with its operational forecasting function. Are VPP operators able to provide this data on a 5-minute refresh basis?
4.2	Should the values be reported as an average value across the 5-minute interval or an instantaneous value at the end of the 5-minute interval, or both?
4.3	What is the appropriate frequency for VPP operators to submit the device level dataset to AEMO? Is there a material difference in resources required to upload the data on a daily, weekly, or monthly basis?
4.4	Are there any regulatory or other obstacles to participants facilitating the data sharing arrangements contemplated in this section?

AEMO invites all interested parties to provide written feedback on this paper to DERProgram@aemo.com.au by 21 December 2018.

A2. Minimum capability specification

This section captures the basic communications, metering, and control requirements that should be met by individual DER systems suitable for aggregation and participation in AEMO's VPP Demonstrations. AEMO has prepared this *Minimum Capability Specification* in collaboration with state government bodies working on development of schemes to support uptake of distributed commercial and residential storage systems.

The high-level capability criteria presented here do not specify component brands or models required to meet the *Minimum Capability Specification*. Rather, this section provides guidance on the technical standards and capabilities required from the various components included in each DER subsystem being considered for aggregation as part of a VPP. This guidance is useful, as there are no widely accepted international standards for DER participating in a VPP.

The battery system or 'system', for the purpose of the AEMO's VPP Demonstrations, is the collection of electrical generation, storage, metering, control, and balance of plant elements, and will include a number of discrete components, among them:

- Battery module(s) (mandatory for DER aggregated into a VPP as a part of AEMO's VPP Demonstrations).
- Battery inverter or hybrid inverter (mandatory for DER aggregated into a VPP as a part of AEMO's VPP Demonstrations).
- Current sensor and other measurement capability to meet relevant data requirements (mandatory for DER aggregated into a VPP as a part of AEMO's VPP Demonstrations)
- Smart controller/meter (mandatory for DER aggregated into a VPP as a part of AEMO's VPP Demonstrations), and
- PV panels and electrical subsystem (optional if PV available).

This information in this section addresses, at a summary level, the requirements for:

- The product functionality and system functionality of the individual storage and control systems being installed, and
- The design, means of installation, and installer of the system.

For the avoidance of doubt, eligibility for involvement in AEMO's VPP Demonstrations will be determined by the ability of participants to fulfil the registration requirements under the Market Customer category, the VPP Demonstrations data requirements, and the technical requirements for each relevant service (for example, the Market Ancillary Services Specification (MASS)[32] and AEMO's Draft DER FCAS Specification[33].

A2.1 Minimum capability specification

The tables below provide guidance on the minimum capability requirements for both the battery system and its installation.

[32] AEMO, *Market Ancillary Services Specification* v 5.0, effective 30 July 2017, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

[33] AEMO, 2018. *Specification for Distributed Energy Resources to provide Contingency FCAS* (draft), available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

Table 9 Battery system capability requirements

Category	Requirement
Electrical interface	Battery systems may have AC- or DC-coupled connection to the grid. AC-coupled batteries are typically directly connected to the AC grid mains that service the property via a dedicated inverter separate to the inverter connecting the rooftop PV system to the grid. DC-coupled batteries are typically co-located with rooftop PV and share a hybrid inverter that serves both the battery and the PV panels, which then connects to the grid.
Physical communications interface	The battery system shall include an ethernet port that is capable of being used for communication with the system by authorised parties. It is not a requirement that the ethernet port is used in the installed system.
Internet accessibility	The system shall be provisioned with at least one means for forming a reliable internet connection accessible by authorised parties. Wired or wireless communication methods are both acceptable (examples include a cellular modem, and wired or wireless connectivity via a homeowner-provided internet-connected LAN).
Remote registration	The system shall support registration of the system via API to remote services (for example, retailer, equipment manufacturer, aggregator).
Remote monitoring	System shall include a communication function that supports remote monitoring and reporting of system state at 5-minute intervals via an API, with measured/reported parameters identified in AEMO's VPP Demonstrations Data Requirements, and that includes time-stamped information of: • Battery State of Charge. • Battery real and reactive power. • Connection Point voltage (either from a sensor attached to the inverter, or from another suitable device that can report independently to the API). The term Connection Point is defined in the NER, and for residential/commercial installations generally refers to the metering point at the boundary of the private and shared networks.
Remote control	System shall respond to remotely-provided commands from authorised parties to charge or discharge the battery.
Remote configuration	System supports remote changes to firmware and operational settings by authorised parties, for example the FRMP.
Product performance and safety	Inverters shall comply with the latest version of *AS/NZS 4777.2-2015 Grid connection of energy systems via inverters – Inverter requirements* and shall be listed on the *CEC Approved Inverter List*. AEMO and the DNSPs are considering the need for a revision of AS 4777.2 to aspects such as enabling reactive capability by default, clarification of the different types of system disturbances, and device behaviour under these conditions. This aligns with recent updates to the IEEE1547:2018 standard in the US, and other recently updated, comparable standards internationally. AEMO is also engaging with the ENA on its DER connection guideline development process, to harmonise DER connection requirements across the NEM, which determine the AS 4777:2 capabilities that are actually enabled in practice.
Security	System shall be designed such that it is protected to a suitable standard against electronic intrusion and tampering by unauthorised parties.

Table 10 Installation requirements

Category	Requirement
Installation safety	All work to be performed by a licensed electrical worker and electronic certificate of compliance submitted. System shall comply with *AS/NZS 4777.1:2016 Grid connection of energy system via inverters – Installation requirements.* System shall be installed per *CEC Battery Install Guidelines for Accredited Installers,* including*:* • Assessing battery system and environment. • Determining applicable hazards. • Applying risk reduction methods. • Applying other requirements (labels and safety signage, commissioning and testing, documentation).
Other standards compliance	System uses equipment supplied and installed in compliance with all relevant Australian and State Laws and regulations and all relevant Australian and International Standards, including, without limitation: • AS/NZS 3000—Electrical Installations (known as the Wiring Rules) for all the classes and types of construction in all buildings. • AS/NZS 4509—Stand-alone power systems. • AS/NZS 3011—Secondary batteries installed in buildings. • AS/NZS 5033—Installation and safety requirements for PV arrays. • AS 2676—Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings. • AS 4086—Secondary batteries for use with stand-alone power systems. • AS/NZS IEC 60947—Low-voltage switchgear and controlgear. • IEC 60947-3:2015 (ED. 3.2) - Low voltage switchgear and controlgear – Switches, disconnectors, switch-disconnectors and fuse-combination units. • AS/NZS 61439.2—Low-Voltage switchgear and control gear assemblies – Power switchgear and controlgear assemblies.
Requirements for solar modules, inverters and installation, when installed concurrently	Any solar modules or solar-only inverters installed concurrently with the battery system shall be supplied and installed in compliance with all relevant Australian and State Laws and regulations and all relevant Australian and International Standards. In the event that a battery system installed under the scheme requires alteration to an existing solar system, installers shall follow the CEC *Installation requirements for alterations, additions, repairs and upgrades to existing grid-connected PV arrays* *
Distribution Network Service Provider (DNSP) requirements	Systems are required to be grid-connected. Systems shall be approved for connection and installed in compliance with the relevant DNSP and Installation Rules, including inverter limits.
Design and installation accreditation	Systems shall be designed and installed by CEC-accredited designer/installer, having CEC Grid-connect Accreditation with Battery Storage Endorsement.

* Available at https://www.solaraccreditation.com.au/dam/solar-accred/installer-area/tech-info/installation-requirements-associated-with-alterations.pdf.