AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

AEMO Virtual Power Plant Demonstrations

February 2021

Knowledge Sharing Report #3

Important notice

PURPOSE

The purpose of this document is to provide a third update to the Australian Renewable Energy Agency (ARENA) and the industry regarding the Virtual Power Plant (VPP) Demonstrations progress and lessons learnt.

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VERSION CONTROL

Version	Release date	Changes
1	9/2/2021	Initial release

ARENA summary

Activity title	AEMO Virtual Power Plant Demonstrations
Contract number	2019/ARP003, dated 29 March 2019
Recipient	Australian Energy Market Operator Limited
Sub-contractors	Intelia Pty Ltd The Customer Experience Specialists
Ref	Knowledge Sharing Report #3
Applicable time period	18 months from trial commencement
AEMO contact	Jacqui Mills

Executive summary

This report provides a third update to the Australian Renewable Energy Agency (ARENA) and the industry regarding the Virtual Power Plant (VPP) Demonstrations progress and lessons learnt.

General insights

- AEMO has onboarded an additional five participants since July 2020, bringing the total to seven and increasing valuable diversity in technology and location of the VPPs.
- The amount of revenue earnt by VPP participants is strongly correlated to the occurrence of power system events, how responsive they are to market signals, and how many contingency Frequency Control Ancillary Services (FCAS) markets (6 second, 60 second and 5 minute, Raise/Lower) they participate in.
- The VPP industry is becoming more sophisticated, reflected in dynamic switching controllers, response to minimum demand and diversified consumer offerings.

Performance insights

- VPPs assisted in elevating the South Australian operational demand by approximately 5 megawatts (MW) during the record minimum demand period on 11 October 2020, which reduced the severity of the event.
- Normalised earnings ($/MW) show VPPs prioritise fleet availability for FCAS markets over other value streams (customer value prioritisation, energy arbitrage). This makes accurately forecasting behaviour as VPPs scale more complex; AEMO is considering what forecasting/ operational data may be required from VPPs in future to minimise forecasting errors and costs.

Consumer insights

- Consumers are motivated by a variety of factors, like saving money on their energy bills (42%), utilising governments' subsidies/discounts on hardware (19%), and having a backup energy supply (14%), indicating that competitive offers are required to entice consumers.
- Positive expectations mostly translate into high levels of satisfaction; keeping consumers informed about financial, environmental and societal benefits is encouraged to maintain high levels of satisfaction.

Beyond the demonstration

- AEMO has initiated a DER Market Ancillary Service Specification (MASS) consultation with the industry regarding the ongoing arrangements for FCAS participation.
- Future demonstrations and market design initiatives must prioritise creating a simple user experience for participants to enhance satisfaction, engagement and successful implementation.
- The VPP Demonstrations indicate new entrants will want to participate in markets in future. AEMO needs to improve its onboarding process to provide new types of entrants with a valued user experience.

Regulatory barriers to VPP market participation

- AEMO notes the intent of the Energy Security Board (ESB) Directions Paper[1] to evolve the Small Generation Aggregator framework to allow participation in ancillary services
- Ongoing collaboration with industry and development of operational visibility, forecast-ability and dispatchability of VPPs will be critical to ensuring efficient integration into the power system.
- Beyond the VPP Demonstrations, further work and collaboration with the industry is required on how VPPs could provide regulation FCAS and wholesale demand response, and act as 'Relevant Agents'.

[1] At https://esb-post2025-market-design.aemc.gov.au/32572/1609802925-p2025-january-directions-paper.pdf.

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1. Introduction

1.1 Background

The Virtual Power Plant (VPP) Demonstrations developed by the Australian Energy Market Operator (AEMO), in collaboration with the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER), and members of the Distributed Energy Integration Program (DEIP), aim to understand how VPPs can integrate into the future energy landscape.

The Final Design Document[2] for the VPP Demonstrations outlines the objectives, the approach taken, and various research questions. The objectives include:

- Identifying if VPPs can reliably control and orchestrate a portfolio of distributed energy resources (DER) to deliver network support services such as contingency frequency control ancillary services (FCAS).
- Understanding how VPP systems can provide operational visibility to AEMO.
- Informing new or suggesting amendments to regulatory arrangements affecting potential participation.
- Providing insights into consumers' experience, and what type of cyber security capabilities are required.

The VPP Demonstrations' first Knowledge Sharing Report[3], published in March 2020, addressed early findings relating to the ability of VPPs to respond to power system and market events, provide FCAS to maintain power system security, and value stack, and considered associated revenues.

The second Knowledge Sharing Report[4], published in July 2020, delved further into how VPPs interact with the power system and responded to the islanding of South Australia in February 2020. It also addressed several of the research questions as stated in the Final Design Document.

This third knowledge sharing report will cover:

- An update on participation and associated revenue.
- Operational insights regarding switched controllers' response to contingency FCAS events.
- Initial insights from consumer research undertaken by Customer Service Benchmarking Australia (CSBA).
- Operational visibility.
- Market dynamics and planning.
- Future regulatory considerations.

1.2 Participant update

As at February 2021, and since the second Knowledge Sharing Report was published in July 2020, five additional participants have joined the VPP Demonstrations:

- Simply Energy.
- sonnen.
- ShineHub.
- Energy Locals (Members Energy).
- Hydro Tasmania.

[2] At https://aemo.com.au/-/media/files/electricity/nem/der/2019/vpp-demonstrations/nem-vpp-demonstrations_final-design.pdf?la=en

[3] At https://aemo.com.au/-/media/files/electricity/der/2020/aemo-knowledge-sharing-stage-1-report.pdf?la=en

[4] At https://aemo.com.au/-/media/files/electricity/der/2020/vpp-knowledge-sharing-stage-2.pdf

These additions, with earlier participants Energy Locals (Tesla) and AGL, bring the total to seven and bring the VPP Demonstrations greater diversity in participant size, jurisdiction, registration type, battery technology, controller type and VPP size. Increased diversity will provide valuable insights and learnings into the technical, market and consumer impacts of DER participation in the contingency FCAS markets. This information will inform the DER MASS Consultation, with consultation planned for early 2021, and transitioning the VPP Demonstrations to a fully operationalised end state.

It is important to note that due to the Application Programming Interface (API) integration timing, operational data and findings from the five most recent participants was not available at the point of conducting much of the analysis; it will be included in the fourth and final knowledge sharing report in July 2021.

Table 1 VPP participant summary table

	Energy Locals (Tesla)	AGL	Simply Energy	sonnen	ShineHub	Energy Locals (SolarSG/ Members Energy)	Hydro Tas
Employees	Tesla - 48,016 (2019)	3,714 (2018)	Engie Global - 160,000 (2018)	300 (2017)	55 (2020)	ME - 18 (2020) SolarSG – 90 (2020)	1,300 (2019)
DUID	VSSEL1V1	VSSAEV1	VSSSE1V1	VSNSN1V1	VSSSH1S1	VSVEL2S1 VSNEL2S1	VSQHT1V1
Jurisdiction	SA	SA	SA	NSW	SA	Vic and NSW	QLD
Registration type	Market Customer	Market Customer	Market Customer	MASP	MASP	Market Customer	MASP
Battery technology	Tesla PowerWalls	Tesla PowerWalls	Tesla PowerWalls	sonnen	AlphaESS	Alpha ESS Saj/Everready	Tesla PowerPack
Controller type	Proportional	Proportional	Proportional	Switched	Switched	Switched	Proportional
Size, market	13MW All 6 cont FCAS	3MW Raise 2MW Lower All 6 cont FCAS	3MW All 6 cont FCAS	1MW, All 6 cont FCAS	1MW, All 6 cont FCAS	1MW All 6 cont FCAS, except L6	1MW All 6 cont FCAS

1.3 COVID-19 impact and extension update

The second Knowledge Sharing Report noted that the VPP Demonstrations had a slow uptake in participation, in part due to COVID-19 and the need for VPP operators to reach the necessary scale and sophistication. As a result, AEMO sought to extend the VPP Demonstrations to allow more opportunities to participate. On 1 November 2020, AEMO confirmed the extension of the VPP Demonstration to 30 June 2021, which was conditional on obtaining three additional participants.

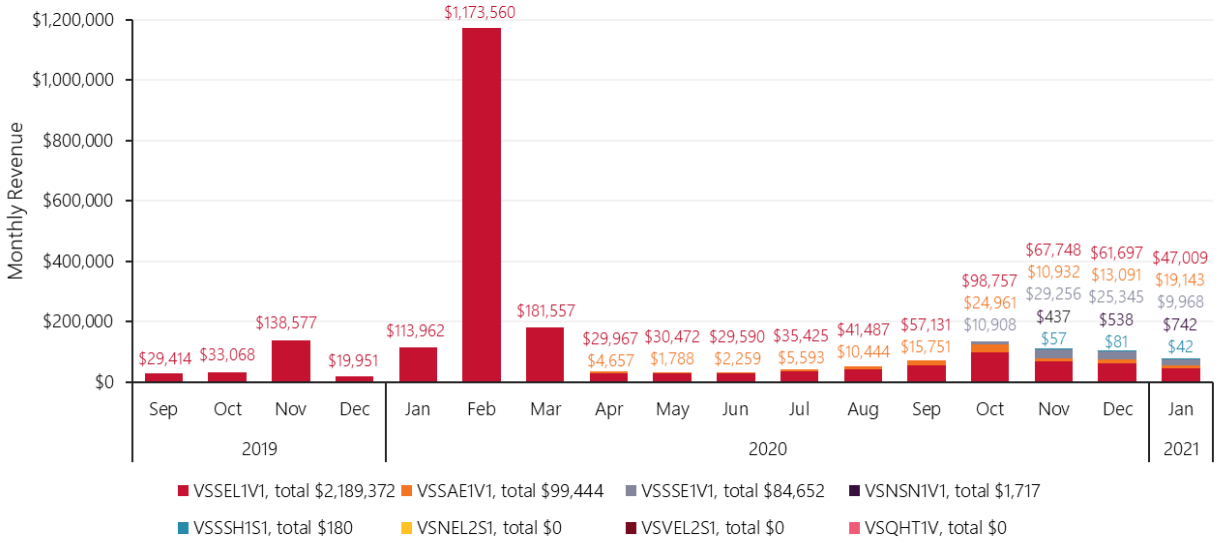
No other notable COVID-19 impacts have been identified. AEMO will continue to monitor changes in VPP behaviour that may arise from having a large portion of the population working from home while restrictions ease.

1.4 Participant revenue

All current VPP Demonstrations participants have been able to earn revenues in the six contingency FCAS markets. The high revenues earned by Energy Locals (Tesla) in February 2020 occurred during the South Australia islanding event (31 January to 17 February 2020); since then, earnings and contingency FCAS prices have reduced to normal levels. Higher prices typically occur during the summer months when there are more plant outages causing contingency events.

Energy Locals (Tesla) has steadily grown its portfolio by ~1 MW per month, which is also reflected in the earnings.

Figure 1 Monthly participant revenue



2. Insights

2.1 Operational insights

The previous knowledge sharing reports provided proportional controller response examples. This report also examines two different approaches to a switching controller response, provided by Shinehub and sonnen.

The response from a variable (proportional) controller varies depending on the local frequency measurements; that is, a greater frequency excursion will result in more FCAS being delivered.

A switching controller is assigned a frequency deviation setting. If the frequency goes below the raise service frequency deviation setting or above the lower service frequency deviation setting, the switching controller will be triggered and must deliver a step change in active power.

A variable (proportional) or switched controller is used to define the control system or logic that is being implemented to deliver FCAS. It is not necessarily a component of any hardware. For a battery system, it is the logic programmed to control what the battery does if there is a frequency disturbance.

Table 2 Controller terms as defined in the Market Ancillary Service Specification

Variable (proportional) controller	A control system that delivers a variable amount of market ancillary service commensurate with the size of the frequency disturbance
Switching controller	A control system that delivers a specific amount of service when one or more specified conditions are met

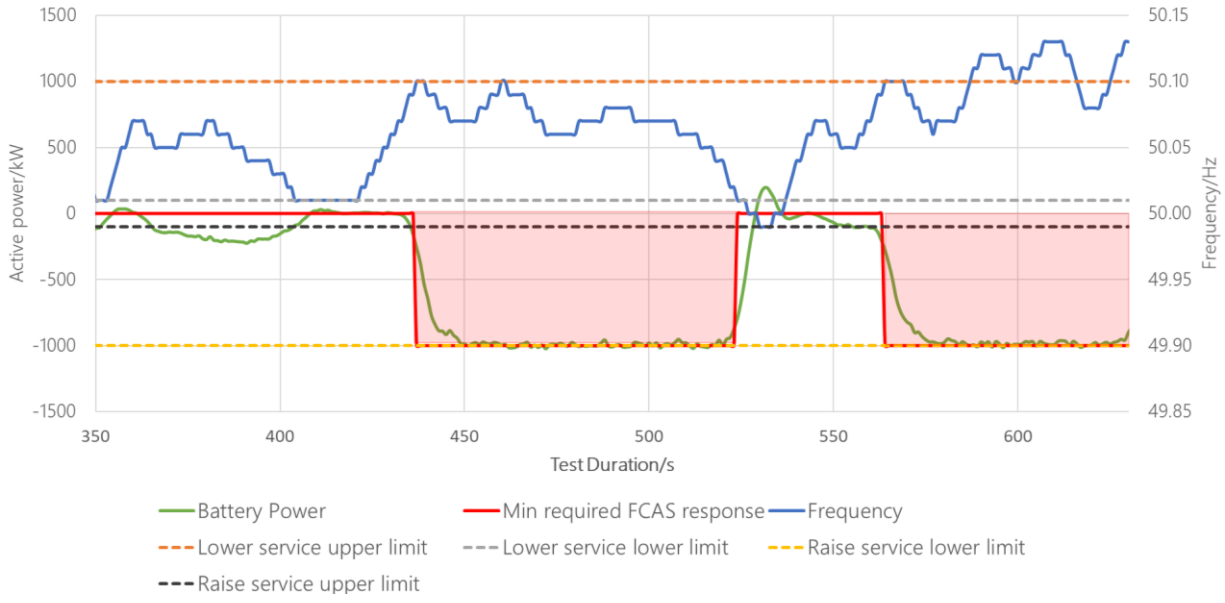
2.1.1 Shinehub VPP switching controller response

The contingency FCAS response from Shinehub's 1 MW VPP was observed during the VPP wide field test as part of the registration process. A narrower dead-band and recovery band was applied for the purpose of this test to observe the lower contingency FCAS response, as shown in Figure 2.

The delivery of the lower service started when the local frequency went over 50.1 hertz (Hz) (lower service upper limit) and stopped when the frequency was back within the dead-band of 49.99 Hz to 50.01 Hz.

Shinehub has static raise and lower frequency deviation settings on all the AlphaESS systems. The overall response is a step change in active power when the frequency exceeds the assigned settings.

Figure 2 Shinehub VPP wide test, switching FCAS response



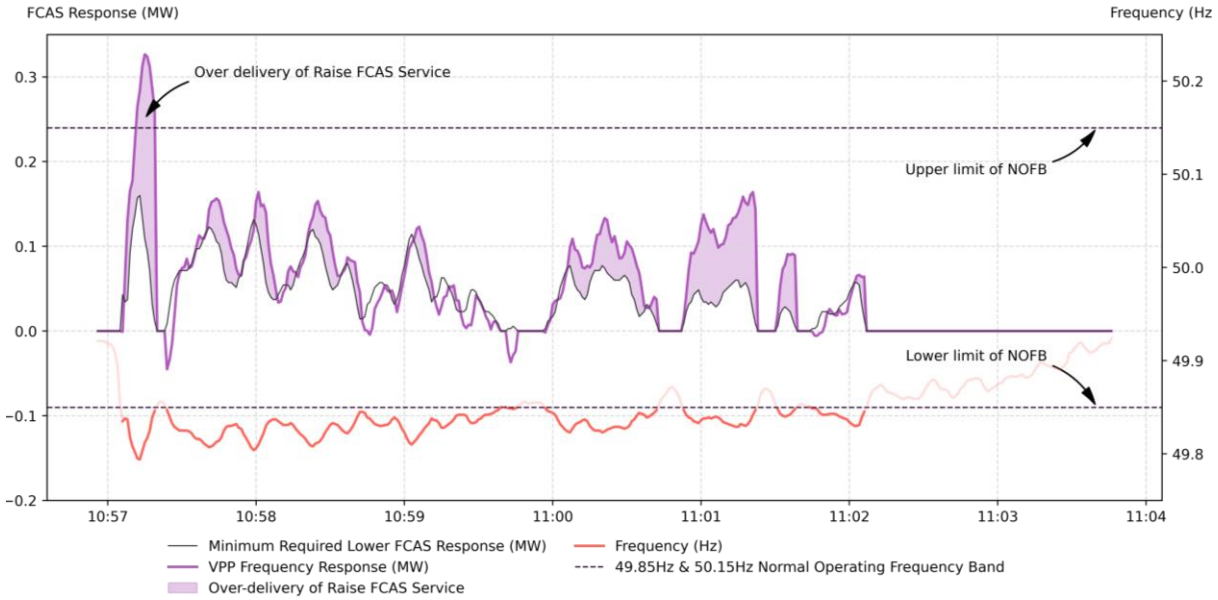
2.1.2 sonnen VPP switching controller response

sonnen's VPP was enabled for slow and delayed FCAS when Callide C3 and C4 (Queensland generators), simultaneously tripped from approximately 422 MW and 406 MW respectively at 1057 hrs on 13 January 2021. The minimum mainland frequency observed was 49.786 Hz, and the data provided in Figure 3 shows that the VPP met its FCAS requirement for a 1 MW enablement.

The frequency deviation trigger setting of each battery system can be dynamically adjusted so the aggregated response from the VPP is proportional to the frequency excursion, even though each system essentially makes a step change in active power.

These additional controller types are important to ensure diverse insights can be gained in the VPP Demonstrations. The insights will be considered in the upcoming DER MASS review and for the long-term operational, regulatory and policy arrangements for VPPs.

Figure 3 sonnen response to Callide trip on 13 January 2021



2.2 Early consumer insights – social research findings

The following summary was provided by CSBA, which has been engaged by AEMO (with the support of ARENA) to undertake a consumer insights study for the VPP Demonstrations. The Consumer Insights Report[5] provides more understanding of the objectives, program design, methodology and progress achieved.

> This report is based on interim findings resulting from the return of 470 completed digital surveys and 23 one-on-one in depth interviews, conducted by CSBA with VPP consumers. These survey and interview results have been collated across two VPPs based in South Australia, and provide a preliminary snapshot of findings, with full research results planned to be completed by mid-2021. Note that data and insights presented at this early stage may not represent the future VPP consumer cohort, because consumers to date have benefitted from government-funded programs with some of the Energy Locals (Tesla) consumers not owning the systems installed where they reside.
>
> The objectives of the consumer insights research are to answer three critical questions:
>
> - What are consumers' experiences of participating in Australia's early stage VPPs?
> - Is VPP participation attractive enough for consumers to give up control of their assets?
> - How can the consumer experience of VPP participation be improved to make it more attractive for consumers to sign up in future?
>
> **Interim findings**
>
> The VPP consumer profile is skewed towards certain demographic groups. The majority of consumers were male, aged 50 and over, did not have children in the household, owned/lived in a free-standing home, were located in metro areas, and had been part of a VPP for less than a year.

[5] The Consumer Insights Report will be made available by the end of February 2021, at https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations.

Qualitative research indicated that consumers can be classified into four categories based on their primary motivations for participation in a VPP. Motivations are defined by **two dimensions: the level of engagement with the VPP and a community vs individual focus on the benefits.**

While some consumers tended to be more focused on the experience of being a part of a potential solution to energy supply and environmental issues, others focused mainly on saving money on energy bills. The four emerging categories were: The Early Adopters, The Caring Community, The Personal Gain and The Going with the Flow.

While benefits to community and environment were strong considerations, a strong driver of interest in joining a VPP was personal financial benefit, such as savings on the bill (42%) and advantage of government subsidy and discounts on hardware (19%).

Interestingly, 72% indicated they did not have any hardware installed at home before joining the VPP. Some of these consumers reported noticing an impact on their bills when they installed solar panels and battery at the same time as joining the VPP. For others already equipped with the relevant hardware, further savings on their bills were also noticed.

Satisfaction with the VPP, as well as likelihood to recommend to others, was high. However, as most had only had experience of the VPP for a short period of time, part of this goodwill was based on anticipation of future benefits as much as the benefits already experienced.

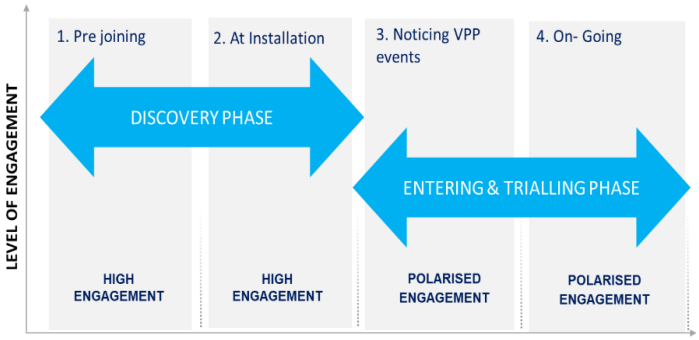
The primary drivers of satisfaction are:

- Lowering energy bills and achieving faster payback on hardware for consumers.
- Willing to be part of the latest technology and pioneering in energy solution.
- Opportunity to utilise more cleaner energy.
- VPP positively holding very high potential for the community (e.g. avoiding outages).

The consumer journey: Initial excitement with the VPP can be consolidated throughout the journey with more information provided to consumers

Through the Discovery phase, consumers hope to be comforted in their choice to participate, seeing both personal savings and benefits for the grid and environment.

In the Entering & Trialling phase, many consumers reported they would like to be further engaged to understand how their VPP is operating in the market, the impact on their bill, and how much of their home energy is derived from green energy sources.



Improving consumers' experience of participating in a VPP

- Early stages of discovering the VPP and making the decision to participate are critical touchpoints, setting up expectations and shaping the overall consumer journey and perceptions of the VPP.
- Positive expectations at early stages are mostly translating into high levels of satisfaction. However, satisfaction and engagement with the VPP can be further reinforced beyond the on-boarding process, through improved communications to consumers, to help them understand and appreciate the financial, environmental and societal benefits arising from their participation in the VPP.

Additional insights will be gained by including the feedback of additional participants in this study. These will be shared in the final consumer insights report in July 2021.

3. Research questions and other considerations

3.1 Operational visibility

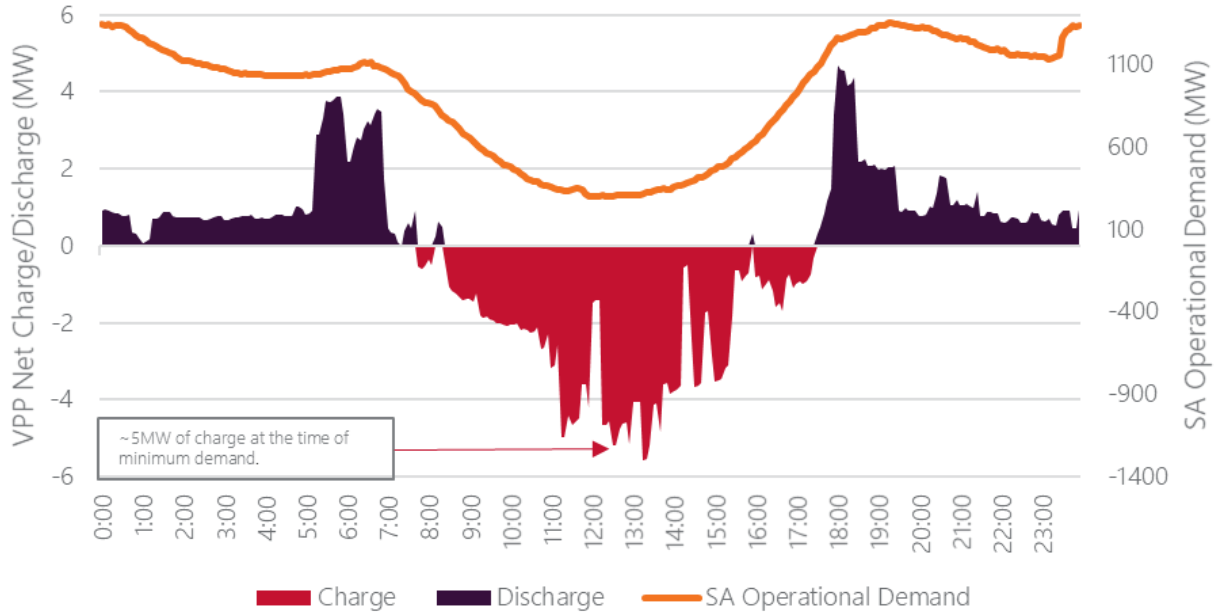
Previous knowledge sharing reports have observed that VPPs have demonstrated price-responsiveness and flexibility (very quick to respond bi-directionally).

As VPPs continue to grow, the current market conditions and incentives may result in very volatile behaviour. At scale and without adequate visibility, forecasting and dispatchability ahead of time, such resources may adversely impact AEMO's ability to maintain power system security and reliability:

- AEMO's ability to provide accurate central forecasts will degrade, reducing the reliability of signals to the market for unit commitment decisions and power system planning.
- Large ramps or swings in output may result in power swings on the network, potentially jeopardising power system security and AEMO's ability to dispatch the market.

Figure 4 plots the aggregate net charge and discharge of both Energy Locals (Tesla) and AGL VPPs and South Australian operational demand on 11 October 2020, when the current (February 2021) minimum operational demand record of 300 MW was observed during the 1230 hrs trading interval.

Figure 4 South Australian operational demand and VPP net charge and discharge, 11 October 2020



The import/export capacity of VPPs in South Australia as at November 2020 is estimated to comprise up to 8% (~25.5 MW)[6] of the minimum regional demand.

In this instance, VPPs assisted in elevating the South Australian operational demand by approximately 5 MW during the minimum demand period. The VPP load profile is a result of the underlying modes of the batteries

[6] Data provided by the South Australian Government Home Battery Scheme. Note: the total number of installed batteries (31 December 2020) in South Australia is 12,400, with 5,117 enrolled in a VPP. This does not directly translate to the number of households operating in the AEMO VPP Demonstrations.

that make up the fleet – in this instance, a combination of normal load following solar self-consumption and more price-responsive modes.

While dispatch prices were low for most of the day prior to the evening peak, the 1330 hrs dispatch interval was the only interval where the price was negative ($-4.89).

VPP Demonstrations participants are required to provide forecasts over various time periods of the controlled generation and load's expected output. This is the first time AEMO has gained such visibility. The second Knowledge Sharing Report noted that a promising performance has been observed.

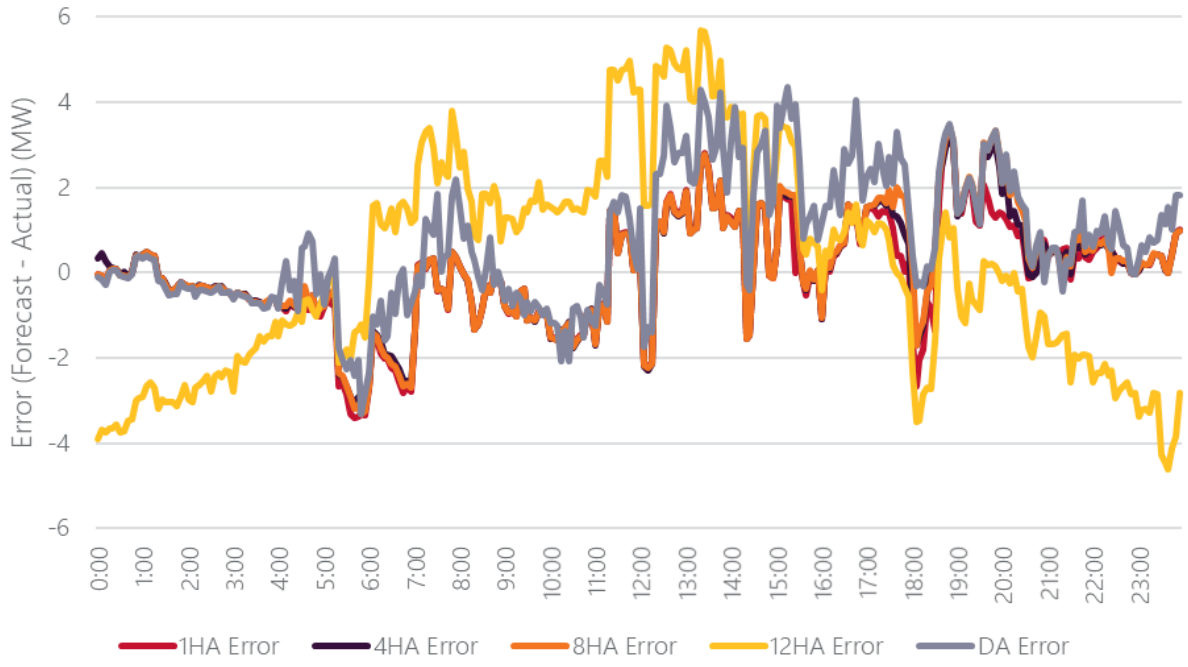
To date, the observed benefits include a deeper understanding by AEMO of:

- How accurately VPP operators can forecast their capability.,
  - Challenges remain due to the highly dynamic nature of the VPP responsiveness to market signals.
  - Forecasts are best when the VPP is operating in household self-consumption mode.
- How these forecasts may feed into existing AEMO forecasts.
- How and at what threshold VPPs should become scheduled resources.

The minimum demand on 11 October 2020 presented AEMO with an opportunity to understand how well the Energy Locals (Tesla) VPP's forecast performed during this challenging power system condition. This is an important learning because, if extrapolated out for a large (several hundred MW) VPP, without operation visibility via a form of scheduling, these errors could impact the safe and secure operation of the power system (noting that forecast improvements continually take place by the participants).

Some of the largest forecast errors occurred around the time of record minimum demand for South Australia and reflect a deviation in the charging schedule of the VPP away from what was forecast, as seen in Figure 5. During this record interval, forecast errors ranged between 9% and 25% of total load capacity (10.92 MW), for 1 hour and day ahead forecasts respectively. The 12 hour ahead forecast errors were the highest at 42%, or ~4.6 MW. Note: AGL forecasts were not available for these intervals.

Figure 5 **Energy Locals' (Tesla) forecast errors for net power (forecast – actual) calculated using 5-minute intervals from 11 October 2020**



As the VPP Demonstrations draw to a close, AEMO will no longer receive this operational visibility through the project, because data sharing is a project requirement and not mandated under the National Electricity

Rules (NER). AEMO is currently considering what level of ongoing operational visibility of VPPs is required, and how this should be facilitated from both regulatory and technical perspectives.

AEMO's Power System Requirements reference paper[7] identifies the capabilities required for AEMO to operate the power system securely and continually keep supply and demand balanced. The system must be:

- Dispatchable: so AEMO can co-ordinate resources and power system services to maintain system security and reliability.
- Predictable: so AEMO can:
  - Access appropriate data relating to network power flows and the activity of participating resources, across numerous time frames, as key inputs into operational decision-making and planning.
  - Forecast upcoming power system conditions and have confidence in how the system will perform.

As VPPs grow in size, and materiality in the context of the broader supply demand balance, their collective capabilities must also contribute (over time) towards the operability of the system. These capabilities should progressively deliver:

- Visibility: submission of near real-time operational data so AEMO is aware of how VPPs are responding to energy market price signals (as they have done in the VPP Demonstrations).
- Forecastability: which could be achieved either through increased sophistication of AEMO operational forecasting capabilities to accurately predict VPPs' operational behaviour, or through VPPs providing operational forecasts (as they have done in the VPP Demonstrations).
- Dispatchability: which could be achieved by VPPs participating in central dispatch as a form of scheduled resource (this could also cover the forecastability requirement). The Two-Sided Market design initiative in the Post 2025 ESB market reform program is examining how fleets of DER may participate in central dispatch in the long term (five years or more).[8] This is also going to be explored practically in Project EDGE, a collaboration between AEMO, AusNet Services and Mondo.[9]

The VPP Demonstrations have identified the value of VPPs providing operational visibility and basic forecasts to AEMO. Ongoing collaboration with the industry and development of operational visibility, forecastability and dispatchability of VPPs (over time) will be critical to ensuring efficient integration into the power system as the technology matures.

3.2 Market dynamics and planning

Generally, there are three modes in which participating VPPs operate their fleet:

- Household self-consumption – a load-following mode where the battery will charge when there is excess solar generation during the day, and discharge to offset excess household load in the evenings
- Responding to contingency FCAS events – a mode that is set on the local device that causes it to charge or discharge at times when the grid frequency leaves its normal range
- Energy market responsiveness – a mode of operation where each energy storage system is seeking to manipulate its charge and discharge pattern to optimise revenue, subject to a set of constraints imposed on it, like network charges, site export limits, or customer contract constraints, for instance

VPPs are by definition seeking to optimise the value created by each battery, so are responsive to prices both in the six contingency FCAS markets and the energy market. The level of price-responsiveness varies between VPPs but is likely influenced by a number of factors:

- Weather prediction.

[7] At https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf.

[8] ESB, 2020. At https://esb-post2025-market-design.aemc.gov.au/#message5.

[9] See https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge.

- Diversity in consumer contracts .
  - Some VPP providers include boundaries on the impact of VPP battery use as a feature of offers, such as;
    - A limit on the number of VPP battery uses per year.
    - A limit on the financial impact of VPP battery uses for the customer.
    - A limit on the kWh throughput of VPP battery uses over a defined period.
  - Others assume unlimited ability to use the battery in exchange for a fixed daily rebate or an improved energy tariff.
  - Some VPP providers offer flat tariffs, whereas others offer time of use tariffs to their consumers.
- Bidding software automation and maturity.
- Market position – a net short position has a weaker commercial incentive to respond to negative spot prices, but a stronger commercial incentive to respond to very high prices.

Over the study period (1 June 2020 to 1 January 2021), analysis shows that different participants prioritise the availability of their fleet for the FCAS markets over other value streams (customer value prioritisation, energy arbitrage) differently.

This is reflected in their FCAS revenues, normalised below for each participant per MW of registered capacity:

- Energy Locals (Tesla): $56,309/MW.
- AGL: $27,668/MW.

This demonstrates that VPPs are responding differently to market signals. As VPPs scale in size, and in the absence of a scheduling obligation, different behaviours in response to market price signals will make it more difficult for AEMO to forecast the supply demand balance accurately and operate the power system efficiently and securely. AEMO will examine the differences in VPP responses to price signals more fully in the next knowledge sharing report, once more data from all seven VPP Demonstrations participants is analysed.

4. Next steps

4.1 Beyond the VPP Demonstrations

4.1.1 DER MASS consultation

The VPP Demonstrations provide the opportunity to trial the capability for DER to deliver contingency FCAS through VPPs using a specific set of measurement requirements (VPP demonstrations FCAS specification[10]).

AEMO is conducting a review of the MASS in the first half of 2021 to consult with the industry regarding the ongoing arrangements for DER to participate in the FCAS markets. The following arrangements are in scope for the consultation:

- Measurement sampling rate requirements for Aggregated Ancillary Service Facilities participating in the Fast Contingency FCAS markets.
- Location for measurement of the delivery of FCAS from controllable devices in a VPP.

[10] At https://aemo.com.au/-/media/files/electricity/nem/der/2019/vpp-demonstrations/vpp-demonstrations-fcas-specification.pdf?la=en.

- Threshold to limit the new measurement requirements to smaller ancillary service units only.

Further details are provided in the Issues Paper[11] published on 19 January 2021. The paper references evidence and learnings from the VPP Demonstration and outlines key questions to the industry.

4.1.2 Wholesale Demand Response synergies

A portfolio management platform is being developed by AEMO which is leveraging learnings from the VPP Demonstration. It will cater for Wholesale Demand Response (WDR) and aggregated Ancillary Service Loads (ASL) (aka VPPs) and will support:

- Registration.
- Validations.
- National Metering Identifier (NMI) classification.
- NER compliance.

This approach will allow participants who are wanting to register as a Wholesale Demand Response Unit (WDRU) and/or ASL to submit applications and manage their portfolio using a shared platform, simplifying the process for all parties compared to the VPP Demonstrations onboarding process. This platform will supersede the solution built to cater specifically for the VPP Demonstrations.

Participant categories

As a result of the WDR rule change coming into effect from 24 October 2021, all Market Ancillary Service Participants (MASPS) will transfer to a Demand Response Service Provider (DRSP) on this date, automatically. All DRSPs will be transitioned to the aforementioned portfolio management platform once the aggregated ASL (VPP) functionality is complete.

4.2 Operational design considerations

AEMO engaged a number of current and intending VPP Demonstrations participants to understand the motivations to participate, their expectations and needs from AEMO, considering their experience in the demonstration and participation in the NEM over the long term.

The following insights were identified to assist informing operational design:

- Participants felt there are too many requirements and the rationale is not always communicated clearly and consistently by AEMO. This makes it difficult for participants to understand exactly what is required to participate in the VPP Demonstrations. Future demonstrations need to consider the rationale for requirements and lean demonstration design.
- In some cases, participants encountered considerable commercial impact to meet certain VPP Demonstrations requirements. AEMO is encouraged to consider this for operational design to assist in lowering the barriers to participate in future demonstrations and market services. The demonstration enrolment process could be clearer if communication was consistent across all touch points of AEMO including the registration team, project team, operations and AEMO website.
- The demonstration enrolment process could be simpler and faster if AEMO managed some steps in the process concurrently and identified areas to automate, transitioning away from manual processing.
- The tailored engagement and enrolment support provided to intended participants from the demonstration project team was well received, particularly by new entrants to the contingency FCAS market.

As a result of this feedback, AEMO is considering:

[11] Details of the MASS Consultation are available at https://aemo.com.au/consultations/current-and-closed-consultations/mass-consultation.

- How to reduce complexity/cost and enable a simple user experience for participants in future demonstrations or market reforms.
- How to provide an engagement and service model that effectively supports new market entrants in future.

4.3 Regulatory barriers to VPP market participation

The VPP Demonstrations have identified three important insights for market participation:

- Customer sites with solar photovoltaic (PV) and batteries aggregated into VPPs can deliver system services – specifically contingency FCAS.
- There are existing and new market participants or technology providers who are willing to invest in the capability required to bring VPPs into the market.
- The average operational profile of VPPs is largely predictable – moving local solar PV output to evening peaks, with strong responsiveness to wholesale price, with the important caveat that at peak PV or demand periods VPPs' actual operation differed, sometimes substantially from forecast (see Section 3.1).

However, there are several key barriers to enduring VPP market participation and value creation for consumers with decentralised generation, storage and controllable loads, and those without. These barriers are presented in no particular order; but they will all need to be addressed for this new type of market participant to flourish.

4.3.1 VPP access to FCAS and wholesale markets

Bi-directional FCAS provision

The NER were not written with the bi-directional capability of VPPs in mind. In parallel to the VPP Demonstrations, AEMO put in place Interim Arrangements[12] for FCAS from DER, through which AEMO recognises the provision of contingency FCAS from DER, installed at load connection points, by allowing export from these points in its classification process. These Interim Arrangements will remain in place after the VPP Demonstrations are complete, until bi-directionality is explicitly addressed in the NER (see below).

Wholesale market access as a Small Generator Aggregator

VPPs not operated by Market Customers (retailers) that want to access the wholesale energy market under the NER currently may be able to use the Small Generator Aggregator (SGA) participant category. However, there are three main issues with this category:

- It is not a bi-directional participant category – although the rule is ambiguous on the inclusion of storage installation in an SGA aggregation.
- An SGA is specifically not allowed to provide FCAS.
- The SGA rules currently require that each generating system have a separate connection point.

Future market participation arrangements

Market participation arrangements will need to evolve to make it simpler and easier for VPPs to access the FCAS and wholesale markets, allowing VPPs to make competitive commercial offers to customers.

For FCAS, a change to the rules will be needed to identify and describe a new "ancillary services unit", incorporating both the ancillary services load and ancillary services generation unit superseding AEMO's interim arrangements.

For wholesale market participation, an expanded SGA category allowing a bi-directional market access for aggregated portfolios of DER is a next step.

[12] Interim arrangements for FCAS from DER available at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/New-Participants/Interim-Arrangements-for-FCAS-from-DER.pdf.

Changes to participation models for DER is the subject of an options paper published on 17 December 2020, which is a continuation of the Integrating Energy Storage Systems (IESS) rule change[13] currently before the AEMC. In addition, the ESB published a Post 2025 Directions paper in January 2021[14] which outlines recommendations to reduce barriers to participation for DER in the NEM and introduce "flexible trading models".

4.3.2 Operational visibility and dispatchability

As the size and scope of VPP installations increase, so will the need for visibility and ultimately dispatchability of these aggregated portfolios, to maintain system security and reliability. Currently AEMO recognises the need for batteries >5 MW and generating systems >30 MW to be scheduled. It seems a similar threshold will need to be applied to aggregated decentralised generation, storage and controllable loads, although the performance standards applied to these aggregated portfolios may need to be reviewed in their application to aggregated portfolios of DER. There are now multiple VPPs exceeding 10 MW, with the aim of some aggregators to have portfolios of hundreds of megawatts in the next few years.

AEMO will be exploring options for VPPs to provide operational visibility, with a focus on identifying options that are low cost for aggregators and device owners but still provide data to AEMO (and Distribution Networks) in a timely and effective manner. The APIs developed as part of the Demonstrations have allowed AEMO to collect a lot of useful information to base future operational and data decisions.

The likely progression of the capabilities VPPs is:

- Provide operational visibility.
- Provide more information to enable more accurate forecasting of behaviour.
- Be scheduled in central dispatch when these portfolios reach a material capacity in a region.

The so-called "Scheduled Light" option is being explored in the NEM Post 2025 Two-Sided Market design initiative. This initiative has highlighted the need for incentives for VPP aggregators to schedule aggregated portfolios (as this comes at a cost) and perhaps some penalties for not scheduling aggregated portfolios that can affect system security and market price outcomes – which will be exacerbated by the 5-minute settlement changes due in 2022.

4.3.3 Future services from VPPs

There are several ways VPPs may be able to provide services to the system which may be useful for AEMO and valuable to all consumers; and therefore, should be able to be monetised by VPP aggregators.

VPPs may be able to provide regulation FCAS, however this service is the domain of generators connected to AEMO's Automatic Generator Control (AGC) system, which monitors frequency and sends signals to generators to manage frequency excursions. Further work and collaboration with the industry will be required to understand this potential service offering from VPPs.

VPPs may be able to use their portfolios to provide Wholesale Demand Response should they be able to meet the criteria for registration as a Demand Response Service Provider (DRSP) and classification of wholesale demand response portfolios. This is currently limited to Large customers (generally >100 Mwh or >40 Mwh in Victoria) and will require the application of a baseline for load consumption at site.

As further services are specified at a system and network level, there may be opportunities for aggregated portfolios of storage and generation, including EVs to provide these services. The ESB NEM Post 2025 market redesign[15] process is seeking to define requirements in its Essential System Services (fast frequency response, inertia and voltage management) initiative and future arrangements to address minimum demand which require flexibility, VPPs could be an important component.

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[13] At https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem.

[14] ESB, 2021. At https://esb-post2025-market-design.aemc.gov.au/directions-paper.

[15] More information about the ESB Post 2025 market design project is at https://esb-post2025-market-design.aemc.gov.au/.

In addition, the South Australian Government recently introduced a Relevant Agent[16] requirement for all new solar PV to manage the remote connection and reconnection of inverters in emergency (such as minimum demand) circumstances. This is a service which VPPs/aggregators have the opportunity to provide on a consumer's behalf.

4.3.4 VPP consumer obligations

The consumer obligations associated with operating a VPP are key to any change. The Demonstrations have shown that consumers will join a VPP if these offers are made available, but the value associated with joining is opaque and may in many cases be a non-financial benefit, such as greater grid or system resilience.

In addition, there are complexities predicting VPP value, as the revenue from contingency FCAS and future wholesale energy price spikes or dips are event-driven. Careful consideration will be needed to provide information to consumers who plan to participate in a VPP, and also about whether the current retail electricity process of "explicit informed consent" will be required to change between VPP providers. The AEMC has recently explored the issue of consumer obligations and the ESB's NEM Post 2025 project has explored these issues as part of the Two-Sided Market design initiative. Detailing consumer obligations and churn provisions should parallel any changes to market participation categories.

The VPP industry is still maturing, AEMO anticipates a continued uplift in services offerings, forecasting capability, and responsiveness to power system and wholesale energy events.

The fourth and final Knowledge Sharing Report, to be published in July 2021, will cover the remaining final design research questions. Please see the appendix for an overview of progress made to date.

[16] A relevant agent is a party authorised by the owner or operator of an electricity generating plant connected to the distribution network to remotely disconnect, and later reconnect, that plant when directed by a party with the legal right to issue such a direction. Further details available at https://www.energymining.sa.gov.au/__data/assets/pdf_file/0005/369266/Technical_Regulator_Guideline_-_Relevant_Agent_Roles_and_Responsibilities.pdf

A1. Research questions progress

Section	Status	Knowledge Sharing (KS) Report #1,2,3,4
VPP capability for market participation		
Can VPPs reliably deliver the contingency FCAS that they bid, and are enabled, for?		KS#1,2,3,4
What is the typical extra fleet capacity that VPP operators dispatch, over and above the target that they have been enabled for, to reliably meet that target?		KS#2,4
What are appropriate ongoing operational arrangements for DER to participate in the FCAS and energy markets?		KS#4
Operational visibility		
To what extent are VPPs able to accurately forecast their operational capability over various timeframes?		KS#2,3,4
What VPP operational data does AEMO require to facilitate very large VPPs operating without negative impacts on power system reliability and security?		KS#4
Is it appropriate for large-scale VPPs to become scheduled resources in the energy market and, if so, at what threshold?		KS#3,4
Market dynamics and planning		
To what extent do VPPs respond to energy market price signals?		KS#1,2,3,4
If this behaviour is extrapolated to reflect the potential for very large VPPs in future, what impact could VPPs have on energy market dynamics?		KS#2,4
How much reliance should be placed on VPPs responding to energy market price signals for integrated system planning studies?		KS#4

Local power quality

To what extent do local power quality or fleet communication issues impact VPPs' capability to meet their operational objectives?		KS#2,4
Can the VPP operational data provide useful insights to distribution network service providers (DNSPs) about the real time status of low voltage networks		KS#4

Consumer insights

What are consumers' experiences of participating in Australia's early stage VPPs?		KS#3,4
Is VPP participation attractive enough for consumers to give up control of their assets?		KS#3,4
How can the consumer experience of VPP participation be improved to make it more attractive for consumers to sign up in future?		KS#3,4

Cyber security

To what extent do VPPs, and DER more generally, present cyber security risks that could pose a threat to power system security?		KS#2,4
Are VPPs appropriately incentivised to independently address cyber security risks?		KS#4