



UNSW
SYDNEY



VPP User Research Final Report

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DATE: 27th November 2020. Revised 25th May 2021

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Executive Summary

Residential Virtual Power Plants (VPP) are emerging as a promising new technology to manage peak demand, control frequency and manage network augmentation costs. However, they require electricity users to configure new and existing appliances for orchestration by a third party. This report delivers findings from 10 interviews with solar PV homeowners, which included virtual home tours, and 6 focus groups with a total of 37 electricity customers with and without solar PV.

We found that energy users are **ambivalent** about the prospect of participating in Virtual Power Plants. This ambivalence relates to the four key themes found in our research: (1) the U-turn in energy user journey; (2) multiple dimensions of transparency; (3) configuration of control and (4) ambivalence about participating in another market.

For many users, this ambivalence is the result of needing to make a '**U-Turn**' in their thinking about energy resources. Many solar households – particularly those with monitoring – have a high awareness and understanding of energy flows in their house. They see a battery purchase as another tool to manage their control over home energy use and their independence from external parties. Asking them to participate in a VPP where the battery is a black box, operated by an external organisation (or its algorithm), whether to maximise their financial benefit or the stability of the network, is asking them to up-end their understanding of the role of the battery, and their relationship to energy.

A strong theme that emerged from the research was the need for **transparency** to engender trust and promote user participation. For some this means detailed information about operation of their battery, while others need to understand how the benefit of the VPP is being shared.

Some participants' attitudes to VPP participation were unaffected by having more knowledge about the energy system and the **broader benefits** of VPPs but, for others, this understanding increased the degree of control over their battery they were willing to relinquish.

Our results suggest that many users are happy to compromise on that **level of control** at the right price but retaining a clearly explained '**opt-out**' function is likely to be crucial in winning support for VPPs.

Finally, few participants were enthusiastic about participating in VPP markets with private, for-profit companies. Concerns about equity, fairness and trust were often raised by participants, as well as frustration with the difficulty of negotiating complex options for energy supply. Our research supports earlier findings that energy governance built around a model of commons is more likely to find broad support in the community.

This report concludes with recommendations for market participants and policymakers to address these concerns, while acknowledging research gaps.

Background

Project & Partners

This research was carried out as part of the **Consumer-led Distributed Energy Study (VPP)** project led by Solar Analytics (SoIA) and funded by NSW Department of Planning and Environment under the Emerging Energy Program.



The research was carried out by Dr Mike Roberts, Dr Sophie Adams and Dr Declan Kuch from the Collaboration on Energy and Environmental Markets (CEEM) at UNSW Sydney, in collaboration with the *Social Licence to Automate* Annex of the International Energy Agency's User-Centred Energy Systems Technology Collaboration Program - *Users TCP* (<https://userstcp.org/>).

Note that sections of this report have been reproduced verbatim from Adams, S., Roberts, M., & Kuch, D. *The VIPs in the VPP: Virtual power plants and conflicting user motivations*. (in preparation).



Project partners include the three NSW Distribution Network Service Providers (DNSPs), Ausgrid, Endeavour Energy and Essential Energy, and demand-side management provider Green-Sync



Research Aims

Purpose

The purpose of the user research is to interrogate the assumption that energy users will participate in a VPP under conditions that make it economically viable. Additionally, it examines the conditions under which users are willing to share their energy data with DNSPs as access to data is currently a barrier to VPP testing.

The study aims to answer concrete questions to inform inputs into, and interpretation of the results from a desktop VPP simulation.

Research Goals and Questions

The research goals were initially formulated as:

1. Determine the conditions under which battery-purchasing customers might be motivated to sign up to a SoIA VPP
2. Determine the conditions under which solar-purchasing customers might be motivated to choose solar + battery + SoIA VPP over just solar or just solar + battery
3. Determine the conditions under which solar- and/or battery-purchasing customers might agree to a data-sharing arrangement with their DNSP

In pursuit of these goals, broader research questions relating to user attitudes and motivations have been explored:

- How do users understand the function of VPPs in addressing challenges in the electricity system, and their own role in being part of such an initiative?
- What motivates energy users to participate in a VPP?
- What discourages energy users from participating in a VPP?
- How do users expect that participation in a VPP would affect them?
- Does the potential for VPP participation incentivise battery purchase?
- What (types of) organisations do users trust to run a VPP, and to what do users attribute this sense of trust?
- What aspects of VPP design can mitigate users' reservations about participation?

Existing Research and Hypotheses

The development of VPPs is the culmination of key recent trends in the Australian energy sector, especially an increasing interest in user- and customer-centred thinking across the sector, decarbonisation, and the decentralisation of energy assets. A considerable body of research has been developed bringing together industry, coalitions of energy users, government bodies, networks, generators, retailers, and new commercial and non-commercial entrants¹. At the broadest level, VPPs are part of a trend towards distributed clean energy communities that will see new centralised coordinators allow dispersed investment based on diverse household preferences². Distributed communities of energy users through technologies like VPPs are in many ways at the leading edge of the energy transition. Thus, they are likely to undermine incumbent business models, while also facing complexity in the rollout of the technologies.

Australian VPP trials

Knowledge sharing from the several recent and ongoing Australian VPP trials largely focused on the challenges of technical co-ordination of batteries and their interaction with various energy markets. However, some initial findings relating to user engagement have emerged.

- AGL report 82.7% customer satisfaction with Stage 1 (2017) of their VPP in South Australia and suggest that the response to the trial reveals a “significant latent demand for batteries”, much of it based on a desire for back-up power, with stage 1 VPP participants characterised as ‘tech savvy early adopters’
- Ausgrid reported strong customer interest in their Battery VPP trial, with 97% of Reposit customers participating, only 3% opting out during the first phase of the trial and 74% of participants expressing satisfaction with the trial. The most popular reasons for participation in the first phase (selected from a list) were “helping the electricity grid to be managed more efficiently” (43%), “It is better for the environment” (20%) and “financial reward” (18%). For the second phase of the trial in 2020, the proportions selecting these answers were 72%, 64% and 72%, respectively.
- By contrast, Simply Energy report “reducing electricity bills” as the motivation for the overwhelming majority of customers interested in their VPP product. The report recommends a ‘BYO’ approach to VPPs in order to separate the sale, installation of maintenance from the operation of the VPP.

¹ See especially projects such as ‘Power Transformed’ <https://energyconsumersaustralia.com.au/great-grants/power-transformed-understanding-consumer-decision-making-in-the-complex-and-transforming-energy-market>; ‘Taking Advantage of Electricity Price Signals’ <https://www.citysmart.com.au/news/wallaby-or-beehive-meet-the-australian-electricity-consumer/>; and the ‘Engaging Households Towards the Future Grid’ project <https://cur.org.au/cms/wp-content/uploads/2019/03/future-grid-homes-household-report-final-1.pdf>

² Gui, E.M. and MacGill, I., 2018. Typology of future clean energy communities: An exploratory structure, opportunities, and challenges. *Energy research & social science*, 35, pp.94-107.

- Questioned before the trial, 58% of Ausgrid VPP participants said they would be unconcerned or only a little concerned if their battery was discharged to its minimum level, while 42% were reasonably to very concerned and *“wanted to know if they still had control over the battery settings or were concerned that they would not have enough stored energy to power their own home’s needs.”*

Drawing on these reports, the wider published literature from recent years and our initial research, we have identified key issues as they relate to the new technology and business model implied by VPPs. Thus, we formulated five research hypotheses to guide our data gathering:

1. VPP participation does not align with motivations for investing in solar or batteries
2. People without solar and batteries are more open to VPPs as a purely financial proposition than those who have started their ‘sustainable energy journey’
3. Understanding of community, environmental and grid benefits can help motivate electricity users to participate in a VPP
4. VPP participation is constrained by restricted flexibility capital (including lifestyle, economic resources, etc.), reliability concerns, concerns about being taken advantage of, ...
5. Willingness to participate is dependent on a VPP being run by a trusted party, and on a transparent and fair allocation of benefits.

Research Methods and Dataset

The research was carried out in 2 stages. **Stage 1** aimed to get a broad understanding of customer attitudes towards data sharing and VPPs, and of what kind of arrangements are attractive. This stage was restricted to existing SoLA customers (i.e. residential energy users with rooftop solar and above-average energy engagement), due to ease and speed of access.

Emails were sent to 3830 SoLA customers in NSW with a link to a brief online survey / consent form. 137 SoLA customers registered for the study and a subset of these was invited to participate, with a view to achieving a representative sample by gender, age group and network area (AusGrid, Endeavour, Essential) and to include participants with and without batteries. No incentives were offered for participation.

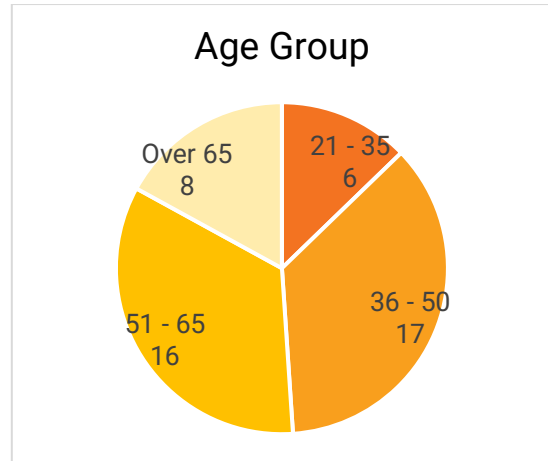
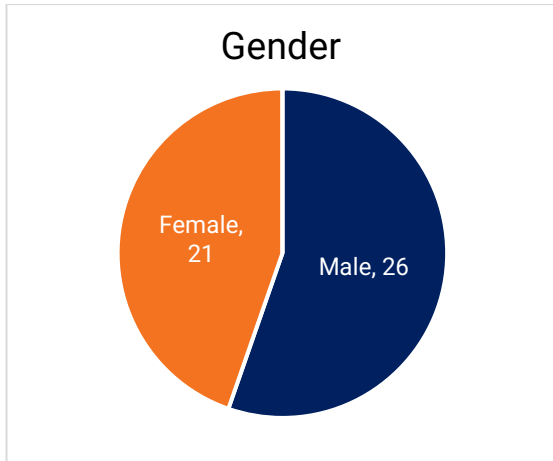
Semi-structured interviews were carried out with 10 participants and 15 users participated in 2 focus groups.

Stage 2 extended the research to a broader group of participants, including from non-solar households, and solar households without SoLA monitoring, recruited through an external agency. These participants were given an incentive of \$75. A pre-screening questionnaire was used to achieve a mix of gender, age, state and rural / urban. The first three focus groups were restricted to homeowners, one group with solar, one without and the third mixed. The fourth group was restricted to South Australia, in order to explore how recent network outages have influenced users' understanding and motivations, and included renters as well as owners, from a mix of income brackets.

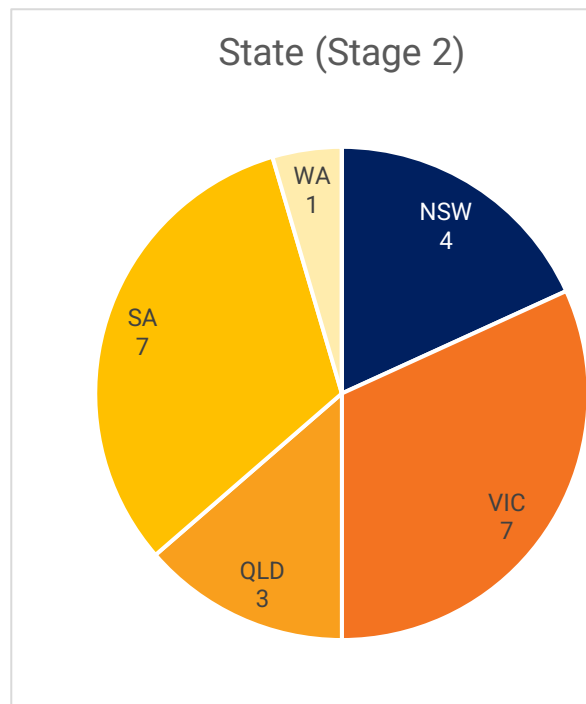
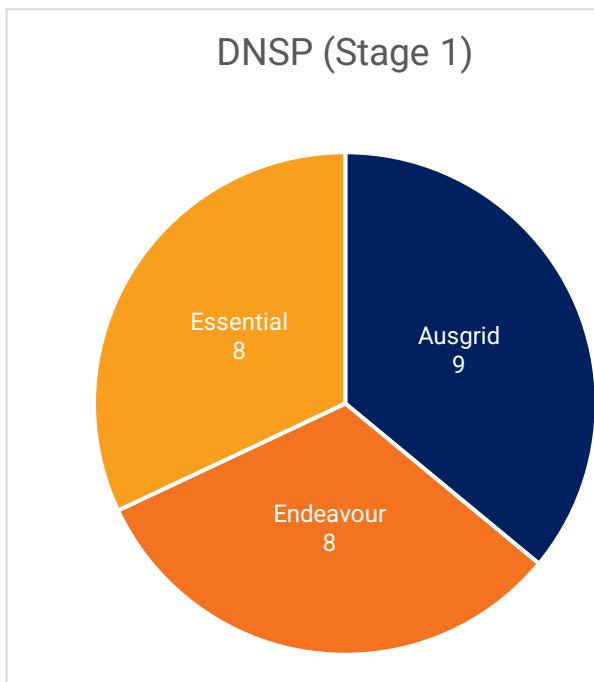
Initial findings from Stage 1 were used to inform inputs into SoLA's desktop VPP simulation and early outputs from the VPP simulation were incorporated into the questioning for Stage 2. The 4 focus groups in Stage 2 were restricted to 6 participants (as opposed to 8 for Stage 1) to enable greater participation and discussion. Due to a power outage with a keen sense of irony in South Australia, the final group only had 4 participants.

Demographic breakdown of participants

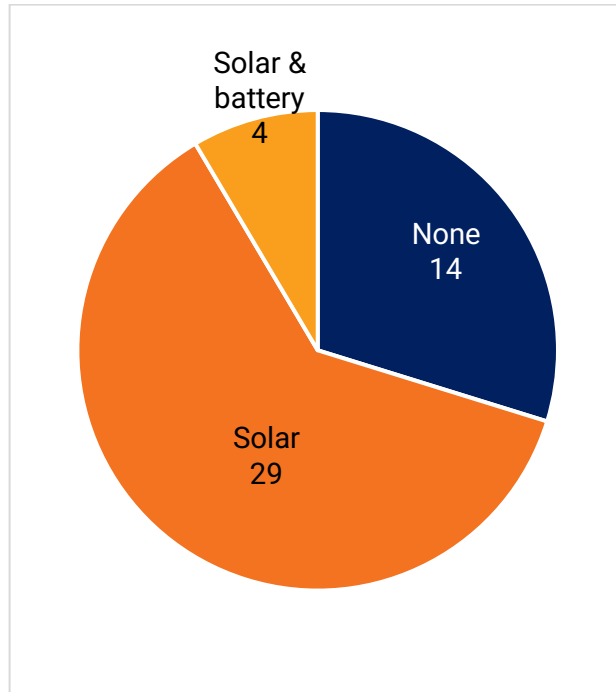
Recruitment was targeted to achieve a balanced sample by gender and age. However, no participants under 21 were recruited and older participants were over-represented, in part because recruitment was restricted to home-owners, except for the final focus group.



Stage 1 participants were recruited from NSW, distributed across the 3 DNSP areas. Stage 2 participants were recruited nationwide, except for the final focus group which was focused on South Australia



All but one of the 25 stage 1 participants had solar and SoLA monitoring; 3 had batteries. 9 of the 22 Stage 2 participants had solar and one had a battery. 14 participants had neither solar nor battery.



Research Findings



Factors that influence battery purchase

The most commonly expressed motivations for battery purchase were energy independence, increased self-consumption of solar and security of power supply. Security of power supply was understood to mean blackout protection, and was considered particularly important in remote areas, for facilities for vulnerable groups (e.g. childcare centres, community facilities) and for small/home businesses. *'Going off-grid'* was a widely articulated aspiration among those participants who already have solar systems installed in their homes. For these participants, using their *'own energy'* is a source of satisfaction. One who had already installed a battery described being able to run air-conditioning in the evening without drawing from the grid as a *'nice feeling'*, for example.

Financial factors were less frequently offered as a reason for battery purchase, although energy prices likely influence the interest of many participants in energy independence. One participant who already has a solar system and battery stated that his *'goal is to try and ensure [sic] how much money you can make out of solar'*. When financial motivations for battery purchase were expressed, it was more likely to be in terms of reduced bills (due to the disparity between feed-in-tariffs and peak electricity tariffs) than overall financial benefit (*It's not so much the actual dollar value. It just annoys me that I pay 29 cents and they pay me 21.*) Another factor cited was the environment and, for one participant who had already installed a battery, this outweighed financial considerations: *'it's not really about the money. It's just about not utilising coal-fired power'*.

Other expressed benefits of battery ownership include:

- Convenience and the ability to use appliances at any time, including in cases in which participants' capacity to load shift is restricted by their lifestyle
- Ability to manage higher energy use
- Battery as an element of a 'smart' home
- Perceived social status
- Potential source of income (through VPP participation or time-of-use arbitrage)

Most interviewees gave financial reasons for not buying a battery, expressed as high costs, long payback period (greater than the battery lifetime or greater than intended residence in the home), and lack of access to capital. This suggests that enabling financial circumstances must accompany other, typically non-financial motivations to drive battery purchase.

Other reasons for not buying a battery include:

- Living in rental property
- Lack of excess generation – either small solar system or high daytime consumption
- Technical constraints (3-phase grid connection)

A large proportion of solar owners are *waiting* for 'the right time' to buy a battery. This point in time is defined variously, including as 3 to 5 years from now; when the price drops from \$15k to \$9K or \$10K; when a 21c feed-in tariff is no longer available; when the participant can access a government grant; after they have installed a larger solar system; or when they can afford an EV. Some participants are concerned about purchasing a battery now when, 'just around the corner', the technology may improve and become more affordable.



Attitudes to data sharing

Attitudes to energy data sharing among participants are diverse, ranging from a lack of concern (typically expressed with reference to a sense of inevitability and the idea that much general personal data is shared through other means, such as smartphones, anyway) to a concern that their energy data could be exploited by unknown parties for economic advantage. Some participants are willing to share their energy data provided it is anonymised. Many participants indicated that their willingness to share their energy data would depend on an understanding of what it is being used for – and in particular that it is being used for a legitimate purpose: *'if there was a reason for them to have it'; 'I want it to be purposeful'*. Perceived legitimate purposes include those that are:

- Not driven by profit
- In the community's interests: *'if it was for the greater good of the community'*
- Environmental: *'Going to help us have better ways to use our energy more efficiently, to use [...] new kinds of energy that are going to [...] benefit the environment'*
- Supporting the grid: *Going to 'help them maintain their network'*



Understandings of VPP

One participant understood a VPP as orchestrated batteries; another as *'somebody is going to manage the power that everybody is producing so that the grid works'*. However, in general, levels of understanding were low, even among the self-selecting and highly engaged cohort of Solar Analytics customers. A common perception is that a VPP is about sharing energy and, more specifically, sharing excess solar generation with other customers, particularly in the local area: *'It's like a power co-op'*. Several interpreted a VPP as a local microgrid or peer-to-peer local energy trading scheme, while others confused it with a community battery. Two thought that a prosumer is effectively a VPP: *'I feel like a power station'; 'My understanding of a VPP is literally I'm a power station and I send power to the grid when it's requested, if I have excess, and I get paid for it.'*

Once the basic principles of a VPP were explained to the participants, most would consider participating, but emphasised that they would require more information before making a decision.



Reasons for participation

Most participants indicated that it is essential that they are getting something out of participation in a VPP – *‘the feeling that I’m getting what I believe is an adequate return’* – but this ‘return’ is not necessarily (only) financial and varies among participants.

Economic benefit, expressed as bill savings or income, was cited as a reason to participate. For some, this entailed making profit from participation while for others compensation for lost income and/or battery degradation would be sufficient, provided the VPP is achieving other community or environmental benefits. Others saw VPP participation as an opportunity to overcome the financial barriers that have prevented battery purchase, stating, for example, that *‘to have something like that to actually actively assist in the payback of the battery would be fantastic’*.

Research participants also mentioned different types of **community benefit** as motivating factors. For some, supporting management of the grid is understood as contributing to the community through:

- Grid management (e.g. voltage control), which can be understood as a safety issue and for some justifies giving up some level of control: *‘I’m okay with allowing some level of control to make sure that things are not dangerous for me or for other people’*
- Reduced energy costs for everyone, which is cited as a reason for participation (and indeed failure to achieve that as a deal-breaker) by a couple of participants
- Preventing blackouts, which was another reason for participating or for opting for a higher level of VPP control over the battery, especially for research participants based in South Australia – although, conversely, being located in an area with a high frequency of blackouts was a reason for some participants to be wary of loss of control of their battery (see below).

Environmental benefit was also important for many participants, and for some the most important factor. Although the VPP proposition can sit at odds with some people’s reasons for having purchased a battery (see discussion of this below), one participant stated that *‘the other reason that we have solar is also the clean energy aspect of it. Yes, the savings and costs go that way, but I also would prefer to see clean energy. And I think that this would be a way as well of having more clean energy generated for all’*.

These three main categories of benefit carried different relative weight for the participants and, in particular, participants differed in the importance they ascribed to personal, financial benefits compared to the wider social and environmental benefits. For some, a VPP was seen as a way to achieve both personal and wider societal ends, as is captured in the statement that *‘it would be good to help the community and help yourself’*. For others, the wider benefits are more important than personal benefits, provided that they incur no expense: *‘I don’t want to be paying for something that I’m not getting absolutely anything out of it all, but I care a lot more about making sure that it benefits everyone’*. And for yet others, financial benefits must be achieved first and wider benefits are considered a bonus: *‘[if participating in a VPP was financially viable] then – yeah, sure, I would be more than happy to share any energy that we had with the greater community’*; *‘I’m putting a battery on for my benefit first rather than a grid benefit’*; *‘if it helps others, then that’s fine as well but as long as there’s financial benefit for ourselves’*.

When asked if they would accept lower financial compensation given the wider benefits of VPPs, some research participants said no (*'there's only so much I'm willing to do'*) while others said yes (*'if I was given the transparency of what the benefit was'*). In the second stage of the study, we discussed the wider issues in the energy system with the focus group participants after initially showing them some VPP compensation models, and then asked if better understanding some of the challenges in the grid changed their perspective. For some, it made them more willing to give up control of the battery: *'it swayed my decision a little bit through the spectrum... it's moved me more towards the VPP having a greater control of the system'* (2/FG). Others remained unmoved in their willingness to participate and preference for the compensation model.

One Stage 2 focus group participant, who stated that personal financial benefit would have to be assured and considered wider social benefits as only a secondary bonus, had previously mentioned that he perceived it to be the responsibility of governments rather than individuals to manage transitions in the energy grid. It appears that this participant was approaching battery purchase and VPP participation as a primarily financial investment because he did not consider any other objectives to be their responsibility.

Conversely, participating in a VPP was seen by a couple of the participants as 'empower[ing]' and about playing a different and important role in the energy system: *'What we're not waiting for is for the bigger companies to be putting in massive batteries. I see it as the individual joins with its community to take charge of its destiny in electrical supply systems and doesn't wait around for the politicians or the big corporates'*.

Some research participants describe VPP participation as the next logical step on a renewable energy pathway that began with their solar system installation, followed by battery installation. Some see it as an indicator of being 'ahead of the curve', or are interested out of 'nerdy' curiosity or love of new technology: *'I'm looking for something else to do now, like, I've put in solar, now what can I do?'*



Barriers to participation

Given current battery costs, people who have purchased or are considering purchasing a battery tend to be motivated primarily by energy independence and security rather than by financial benefits, as discussed above.

VPP participation was understood by some participants to undermine these benefits, as widely expressed in a concern about loss of autonomy or control over their battery: *'I'm not sure how much control we would have to give over'*. One participant stated that *'I'd really wanna look at my own figures first and what my outputs and what I had before signing up to any of these things 'cause the whole point of having solar and having a battery would be to maintain your own personal power supply'*. This issue is particularly pronounced among participants who experience blackouts frequently: *'What happens if you get a blackout? If I – you're out for a couple of days no power.'* Some participants articulated reservations that loss of access to energy stored in their battery could lead to a loss of comfort in their home: *'I think it would be very difficult to relinquish control around comfort'*.

Some participants found it difficult to conceptualise VPP functionality that was optimised to maximise their household income, instead seeing VPP use of a battery in opposition to its use for minimising household bills. Accordingly, they anticipated that they would not benefit, or may even be financially disadvantaged, because they would have to purchase electricity if

it was not possible to access electricity stored in their battery – potentially at a higher rate than they were compensated for participating in the VPP. They reasoned that *'if I don't use my battery [...and] what I'm paying for my power is more than what I'm getting back, it might not even be worth it'* or even that *'you're actually losing money on the virtual power plant'*. One research participant expressed disappointment at what he saw as the lack of a financial case for VPP participation: *'So in one way, I'm a little disappointed. I was hoping there was some magic'*.

Other barriers to VPP participation raised by the research participants included that the VPP might undermine their environmental reasons for battery purchase if it would require them to draw electricity *'from the grid because I don't know where that's coming from. If that's coming from coal-fired power station then I don't want to do that.'* Other concerns were the impact of frequent discharging on battery life and, relatedly, the limitations of battery recycling at present. Others were related to battery malfunction, safety and insurance, and research participants raised questions about which party would be responsible in the event that a battery controlled by a VPP malfunctions or causes damage, and what would happen if a battery owner is contracted to provide capacity to the VPP but the battery is not available.

In general, the lack of information about or understanding of a VPP is a significant barrier and was mentioned by most participants. The sense of not knowing how it operates and would impact them – and the suspicion that they may be taken advantage of in the absence of more information and transparency – was a strong one among participants. They stated *'I need to understand who is benefiting from this'* and asked *'Is there any way it can be used... against me?'* This concern about exploitation was particularly directed towards some actors considered untrustworthy; *'Retailers are evil'*, for example. The reservations of some participants appeared to be related to the term 'virtual' and the perception that something intangible cannot be understood or relied upon: *'Is it actually there?'* One participant stated that *'the last thing you need'* is more complexity in the grid; *'they should have left it as easy as it was to start with'*.

Conditions and incentives for participation



As discussed above, a lack of information and understanding of a VPP is a significant barrier to VPP participation. Accordingly, among the factors that would put the research participants at ease, the most common theme was more information. They expressed a desire for transparency, both:

- before entering a VPP program, with some indicating that they would want advice tailored to their particular circumstances, and
- during the program, with some expressing a wish to be able to monitor exactly when and how their battery is participating in a VPP at any given time: *'I want visibility [to know] exactly what you're doing with my battery'*. One or two others noted that they would not want to have to monitor it constantly, however.

Participants expressed that they need to understand the financial costs and benefits for their household, perhaps through a simple interface providing information about energy and financial flows and greater clarity of non-financial costs in terms of the loss of control of a proportion of their battery use (conveyed as time, energy, and number of occasions). They want to know *'what am I giving up?'* They also want to see the wider implications and *'who else is benefiting'* evidenced – for example, that *'a 30% uptake of people into this scheme*

would mean – the benefit would mean we might not have to build another power station or something’.

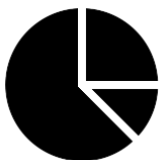
For households who purchased batteries for largely non-financial reasons, participation may be contingent on ‘home energy needs’ being met first: *‘I want to make sure we have enough left over’*. But what these ‘needs’ are, and how they are met by a battery, is unclear and complex – and vary according to PV and battery sizes and household loads as well as lifestyles and perceptions.

More broadly, participants want the assurance that the VPP is operated in such a way ‘that the person who has the battery isn’t disadvantaged’. They want the sense – perhaps less easily achieved than provision of the data outlined above – that the VPP is well considered and designed: *‘I would be happy being a part of something if I felt like it was worth – if I felt that it had been well-researched, thought about’*.

For some research participants, the opportunity to first trial battery use and then decide whether to participate in a VPP is important, partly because this would allow them to assess their particular financial circumstances with a battery and better weigh up the value of VPP participation: *‘I would probably wanna get the battery and see how much we were benefiting from that’*. Another research participant also suggested a VPP trial period before participants commit to a longer-term contract.

The ‘deal-breakers’ for VPP participation, on the other hand, include:

- data insecurity
- pressure to participate
- not having the ability to opt out
- significant upfront costs
- not owning the battery *‘at the end of it’*, and
- lack of transparency.



Preferences for level of participation

Both Stage 1 and Stage 2 focus group participants were shown four options representing different levels of participation in a VPP, ranging from no VPP participation, to occasional VPP use of the whole or part of the battery, to VPP use of the whole or part of battery at all times.

	Option A No VPP Battery Only	Option B Occasional VPP	Option C Shared Use	Option D Full time VPP
How often does the VPP control your battery?	Never	10 occasions per year	30 occasions per year	Constant control to <u>maximise income</u>
Proportion of Battery capacity retained for household	100%	0% VPP has control of entire battery	50%	0% VPP has control of entire battery
Information and Choices		Advance notice - able to opt out	Advance notice - no opt out	No advance notice
Annual Financial Benefit (Battery + VPP)	\$800-\$1200	\$1200-\$1600	\$1200-\$1600	\$1600-\$1900
Payback	10 years	7 years	7 years	5 ½ years

The range of options here elicited a wide range of responses among the focus group participants. Many eliminated the ‘all the battery, all the time’ model (option D), even if it was guaranteed to deliver greater financial benefits than the other models, although a few identified the financial benefit of having battery use optimised to maximise household income: ‘If you let them use all 100% of the battery all the time [...] it’ll cost you less when you buy or use it, and yeah, you make money’. One participant chose this option because of a preference ‘to have the power available for everyone, rather than ... keeping it [to] myself’, while others shifted towards this option in response to an explanation of the wider grid, community and environmental benefits of a VPP.

One participant identified that this model offered a proposition – investment in a battery for a financial return – that is completely different to buying a battery for household use and using a VPP to deliver additional value:

‘I think there’s a fundamental difference ... between B and C, and D. D is, if you like, an investment decision. I think it will depend on your mentality when you purchase the battery and why you were doing it. If you want to be able to use it to run your house and feel like you’re doing good for your own household, then option D would probably be a bit negative, and C wouldn’t be too great. But if you’re looking at as a purely investment point of view, and if option D gave you the best return and you really didn’t care what happens to the energy, then option D could be quite viable. It really depends on how you wanna think of your battery, whether it’s for you personally or if you’re doing it as an investment I guess’.

In other words, the rationale for battery purchase influenced how participants viewed the options presented to them.

One participant viewed the undertaking of battery purchase and VPP participation as a purely investment decision as a risk:

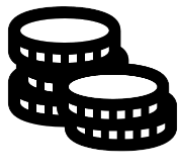
‘I think it depends on the contract or the agreement. So, the last thing I want is go to option C, run that for two or three years, and all of a sudden cost of batteries come down a lot and then the power company goes and decides to have their own batteries and basically go like, “We don’t need your battery

anymore 'cause we got our own. See you later." You've invested all this money, which, you can still use for your own good, but if I buy a battery for the sole purpose of running VPP, then I'm at risk.'

Another participant described this tension between the motivations for battery purchase and VPP participation in terms of the desire for control that solar owners have already demonstrated, in so far as they have taken control of their electricity costs and would not then want to give up this control by participating in a VPP: *'I think by virtue of me wanting solar takes some control of what I'm paying, and then to feel like at this stage hand balling that away and losing it again seems counterproductive'*.

Most participants preferred an option that allowed them to retain use of a proportion of the battery; for some this was security against blackouts, for others it was based on the perception that 'giving up' the battery to VPP control could be financially disadvantageous or undermined the rationale for having a battery.

The idea of users setting a price (e.g. \$/kWh) for use of their battery was suggested as an option that would enable customers to incorporate their own preferences by pricing other battery benefits (independence, reliability, etc) as well as lost TOU revenue, recognising that there may be limits to flexibility that result in prices set very high for non-negotiable battery capacity.



Risk and compensation preferences

Through example VPP offerings, we explored preferences for low-risk, upfront benefit versus higher-risk, ongoing benefit. Stage 2 participants were presented with several slides showing different compensation arrangements. These included a fixed payment for VPP participation (either upfront in the form of a battery discount, or as a regular payment or bill discount), a share of VPP benefits (80% or 70% depending on contract duration) or the customer receiving the full value of the VPP and paying the aggregator a fixed monthly fee. Different contract periods and levels of battery participation were also explored (see the following sections).

Payback period was the most common metric used by participants to compare the proposals, though a few focused on \$ income or % ROI. Several participants expressed the importance of payback relative to expected tenure: *'How do I know I'm gonna be in my house in ten years' time, that's one of the factors as well, whereas the six-and-a-half years is less which is more enticing'*. For others, 6.5 years is still too long and could be a deal-breaker.

While some thought the proposed compensation was inadequate, one interviewee just wanted evidenced, fair compensation for battery degradation.

Preference for low-risk upfront battery discount was explained by plans to move in a few years or by restricted access to capital, while others preferred ongoing payments if they were combined with flexibility *'to chase the income'*. The participant mentioned above who considered grid management a responsibility of the government and approached VPP participation as a purely financial question also expressed a preference for a guaranteed benefit, whether in the form of a discount on battery purchase or fixed payment, and was concerned about risks associated with the investment, including that the VPP operator could cease to offer VPP participation in two or three years and that his battery could cease to

function. For some, ongoing benefit is more attractive because *'it's generating household income'* or because it feels as if it would offer a higher level of control. The question was raised of what would happen when a customer moves house if they have bought a discounted battery or committed to a contract to participate in a VPP.

Some participants preferred to receive a proportion of the VPP value, taking on higher risk to receive likely greater investment returns, with one opting to pay a fixed fee to the VPP aggregator and retain the full value from VPP use of the battery, provided they could opt out at any time. One compromise suggested in a Stage 2 focus group was for participants to receive a guaranteed minimum monthly income from the VPP, with additional payments dependant on the number of VPP events or the value generated.

A guaranteed income was seen as preferable where participants saw a strong connection between VPP activity and grid management. They reasoned that *'if it's not called upon for whatever reason, then there's no income coming in from it and, certainly, in the area where we are, we've had very little power issues I think we've maybe gone out once or twice in last year'*.

Presenting different VPP arrangements on slides revealed the difficulty of explaining the concept and operation of a VPP. Some focus group participants reacted strongly against all the VPP arrangements presented, with one declaring *"I'm not even interested in buying a battery – if anything I'd go completely off the grid!"*. The conceptual complexity of a VPP, and it's potential business models, may combine with distrust of retailers to generate concern that the VPP is just another way for energy companies to take advantage of energy users. Moreover, a household battery is seen by many solar households as a step towards energy autonomy and independence from electricity companies; attaching it to a complex and opaque business arrangement with – potentially – those same companies makes it considerably less attractive.



Contractual preferences

Having advance notice of VPP battery use, ideally combined with the ability to opt out of an 'event', was popular. The capacity to opt out of any given event was seen to make giving up a larger proportion of the battery palatable because people felt they retained control of the circumstances in which they would give up that control.

Similarly, many participants preferred a rolling arrangement or the ability to opt out of contractual arrangements and reacted strongly and negatively to the possibility that they might be locked into a contract. Some cited concerns that the VPP benefits could change within the period of the contract (through changes in the market or reduced solar generation through climate change) such that they end up worse off, or that they wanted to be able to switch to *'a better deal'* if it became available. Some cited the removal of subsidised solar feed-in-tariffs as an example of *'moving goalposts'* and a reason to avoid a long-term commitment to a VPP.

A smaller proportion of respondents were more comfortable with the idea of a fixed contract, if justified by a fixed income, or mentioned that they enter such contracts in other parts of their lives, but specified a limit of 1 or 2 years, comparable to lock-in periods for

electricity, phone or mortgage. One participant stated that they would accept a 5-year contract, however, if it paid for the battery and gave them, potentially, another 5 years of unencumbered battery use.



Preferences for operator

While some participants had no preferences for who would run a VPP, others identified a range of trusted parties: an Australian company or one with Australian datacentres (due to data security concerns); an organisation with perceived technical expertise; or one with evidenced good customer support (due to poor experience with an energy retailer). Retailers and generators (particularly those linked to the coal industry) were commonly identified as untrusted organisations. Others indicated that a public, not-for-profit or environmental organisation would be preferred, while some comment that market competition would be required to ensure value for participants. There were also suggestions that community organisations would lack the required expertise or decision-making abilities. Others stressed the importance of government oversight.

When asked if they would be willing to change retailer in order to be able to participate in a VPP, participants offered mixed responses. For some, changing energy retailers to participate would present an administrative barrier, while others thought it a simple process but would need detailed information about the retailer, including country of ownership, customer service model and electricity tariffs.



Preferences for geographic scale

Most participants expressed a preference – or indeed an assumption – that the VPP would be local in scale. This is perhaps partly associated with the typical initial understanding of a VPP as energy sharing and the attraction of many who are motivated by community benefit to the prospect of supplying excess generation to other (local) energy users. Some suggested a geographic hierarchy of community beneficiaries, from immediate neighbours to residents of their state and beyond. In some cases, this preference for local benefit appears to be based on a desire for assurance of the positive impact of the VPP: *'If I couldn't see a really tangible reason for it; if it didn't make a big difference to people, then I would feel very uncomfortable handing over the keys to the battery'*. For others, the preference for a more local scale is associated with what they consider manageable and trustworthy: *'once it gets bigger than that, I just feel that there are too many forces just way beyond my imagination that could mess it up'*. Some of these participants, when questioned, admit there is not necessarily a good reason for the VPP to be at this scale. Others expressed no preference for any particular scale, indicating that it was more about where there is need: *'I don't care who it goes to. Wherever the system takes it.'*

Discussion

The research findings set out above allow us to return to the research hypotheses we developed during the study and draw the following conclusions. **All five hypothesis were, to varying degrees, supported by the data.**

1. VPP participation does not align with motivations for investing in solar or batteries

Many of the research participants who own solar systems – particularly those with monitoring as well – have increased awareness and understanding of the energy flows in their house and see a battery purchase as an additional tool to manage this energy and to maximise their solar consumption. Asking them to participate in a VPP where the battery is a black box, operated by an external organisation (or its algorithm), whether to maximise their financial benefit or the stability of the network, is asking them to pivot 180 degrees in both their understanding of a battery and in their relationship to energy. This suggests that, while many participants are interested to better understand how a VPP can offer a range of benefits, and some appear open to considering different ways of utilising their batteries, considerable engagement is required to achieve such alternative understandings.

2. People without solar and batteries are more open to VPPs as a purely financial proposition than those who have started their ‘sustainable energy journey’.

The possibility of a VPP may be more appealing to people who do not yet have either solar or a battery, as suggested in the following statement:

‘Now that I know, other than those traditional views I had about how solar works, knowing that other options like VPP are available. I think I will a bit more actively looking into my options. I think I’m more inclined now to have solar, definitely, more than I had before tonight’s session because I know that there are different options and there are ways that I could save’.

It may be the case that they could be engaged to invest in solar and a battery and participate as a more purely financial proposition, without the strong emphasis on maximising self-consumption that existing solar owners tend to have.

3. Understanding of community, environmental and grid benefits can help motivate electricity users to participate in a VPP

Recent social science research on electricity pricing and tariff reform has tended to emphasise the need to simplify communication about electricity. QUT researchers, for example, have argued that, “Consumers emphasised the need to use plain language, with no jargon, to focus on key benefits and the consumer actions required to activate the benefits rather than explaining the technical aspects of why pricing signals were needed” (QUT and CitySmart, 2017:36).

However, too much simplification about VPPs is likely to be met with scepticism. Our respondents tended to appreciate the common problems for which VPPs would be a part of the solution. This was particularly the case when a definition of VPPs was provided in interviews and focus groups. Participants articulated a range of reasons for their interest to

participate in a VPP that extended beyond that of personal financial benefit. These included environmental reasons, including helping to enable the integration of more renewable energy into the grid, and community benefits, including helping to ensure safer, more reliable and affordable electricity for the wider community. As described above, some also indicated that these broader motivations outweighed that of personal gain, e.g. *“I don’t want to be paying for something that I’m not getting absolutely anything out of it all, but I care a lot more about making sure that it benefits everyone”*.

In the Stage 2 focus groups, we tested this hypothesis by asking participants about their willingness to participate in a VPP before we outlined some of the wider benefits – of which few were already familiar. We then asked them whether a greater understanding of those benefits changed their preferences. Some responded that it would make them consider greater participation of their battery in a VPP for more of the time, moving towards Option D in the participation models in the diagram above: *‘I’ve got to admit, it swayed my decision a little bit through the spectrum’* and *‘It makes me more confident in my decision to say option D... knowing that you’re working for the greater good bit’*.

Not all participants were influenced by these benefits, but these findings show that the broader implications of a VPP is an important part of the conversation with prospective VPP participants – especially in the context of generally low levels of understanding of the challenges currently faced in Australia’s rapidly changing energy system.



4. VPP participation is constrained by restricted flexibility capital (including lifestyle, economic resources, etc.), reliability concerns, concerns about being taken advantage of, etc.

As outlined above, there are a number of barriers to willingness to participate in a VPP, including the financial commitment associated with battery purchase, perceived loss of control and power security, and concerns about being financially disadvantaged by VPP participation.

One of the most significant barriers identified centres around the VPP participant’s sense of control. What this sense of control means varied among the research participants, however. People looked to different aspects of the VPP compensation models we showed them for a sense of control: proportion of battery retained for household use, possibility to opt out of individual events or to opt out of a contract at any time, ‘some form of blackout protection’, sufficient compensation (*‘I’m just better off just accepting that control because the financial return is so high’*), etc. This means that it may be necessary to offer different VPP participation models to allow for participants’ diverse circumstances and preferences.

Some of the barriers identified in this study can be addressed in the design of the VPP. For example, a model that includes an upfront battery discount may allow some households to participate that might not otherwise be able to. Other barriers may be more intractable, such as the desire for energy independence for those who purchased PV systems and a battery as a step towards going ‘off-grid’. In general, information and transparency were found to be highly important to most participants and have the potential to address and allay prospective participants’ reservations about a number of aspects of the VPP.



5. Willingness to participate is dependent on a VPP being run by a trusted party, and on a transparent and fair allocation of benefits

As outlined above, transparency in the distribution of risks and benefits for the actors involved in the VPP was found to be important for all participants. In addition, many participants' preferences for how a VPP would run referenced community in direct and indirect ways. Some expressed a preference for a community organisation to operate it; others for a not-for-profit body, an Australian company, or a public body. Many participants' expectations of the wider benefits of VPPs focused on the local level, as outlined above. Some also referenced issues of equity, e.g.:

'a big concern for me, how is it run, particularly if it was on a federal level, how is it dispersed, is it equitable? We have huge issues at the moment where we've got, say, indigenous populations who are in really remote areas and you know only have electricity few hours a day, and that is a huge problem I think in our society, so is this kind of thing going to be addressing equitable power?'

For others a sense of fairness in the contribution that VPP participants would make for the benefit of the wider, shared grid infrastructure was important. For example, several participants expressed that they would not want to put their battery in the service of the grid if other people are using energy irresponsibly, e.g.:

'there's a thousand people out there who are just ramping their air conditioners up. So, he's taken a hit, so that irresponsible people can go on being irresponsible and that's why I say no. I don't trust the people... they just don't take responsibility and that's okay for them, but I'm not gonna bear the cost of it.'

This suggests that trust is required not just in retailers, networks, governments, etc., but also in other energy users participating in the system, and this is another factor to be taken into account in the design and communication of a VPP program.

Response to Research Questions

The discussion above identifies some broad terms for customer acceptance of a VPP that enable response to the research questions posed above.

- 1 The conditions under which battery-purchasing customers might be motivated to sign up to a SoIA VPP include:
 - some degree of battery capacity and control retained by the customer
 - a trusted operator, providing transparency of the financial arrangements specific to the customer's circumstances, with the customer able to opt out
 - financial incentives combined with clarity around the broader benefits of the VPP
- 2 The conditions under which solar-purchasing customers might be motivated to choose solar + battery + SoIA VPP over just solar or just solar + battery include:
 - a compelling financial case – lower energy bills and return on investment, paid back within a few years - that justify the battery as a purely financial transaction
 - some degree of retained battery capacity and control and/or clarity around the broader benefits of the VPP may justify lower incentives
 - a trusted operator, providing transparency of the financial arrangements specific to the customer's circumstances, with the customer able to opt out
- 3 The conditions under which solar- and/or battery-purchasing customers might agree to a data-sharing arrangement with their DNSP include, for different customers:
 - transparency around the end users and end uses of the data, including understanding of how the data helps the DNSP operate the network and the broader societal benefits
 - assurances of data security including, for some, Australian datacentres and business ownership

Recommendations

1. **Close engagement** is required with all prospective participants – both those who already have solar and those who do not – to ensure that VPP participation would align with their interests and needs.
2. Articulating the **common problem** VPPs solve – for the network, environment or wider community – can encourage some users to allow to engage with VPP contracts for their batteries.
3. To maximise user engagement, VPP providers should offer models that allow participants to retain **different degrees of battery control** and make it easy for them to opt out of the VPP.
4. **Transparency** around both VPP utilisation of the battery and how the benefit of the VPP is shared between different actors can help engender trust and motivate participation.
5. **Further work** is required to understand the role of installation, service, fault-finding and maintenance in willingness to participate in VPPs.