Ausgrid's Virtual Power Plant

Progress Report

NOVEMBER 2020

Contents

1 Introduction

Ausgrid's battery Virtual Power Plant (VPP) trial is part of Ausgrid's broader Demand Management Innovation program, one way Ausgrid is engaging with market providers and customers to shape the future of energy, by working smarter with customers.

Ausgrid's partnership with Reposit Power marked the first stage of the program with hundreds of customers combining to form a 1 megawatt VPP. An Interim report[1] was released in August 2019 detailing the results of the first stage. Ausgrid is currently in the second stage of the trial with two new VPP providers, Evergen and ShineHub, joining the trial.

This progress report seeks to present the key preliminary results of stage 2. Additional information on Ausgrid's VPP is published on our website at www.ausgrid.com.au/vpp.

2 Background

2.1 What is a Virtual Power Plant?

A VPP links decentralised and independent small-scale resources (such as solar power systems and batteries) into a network, forming a centrally controlled virtual generating unit. VPPs can be coordinated to provide support to electricity networks on days of high demand or can be used to trade electricity at times of high wholesale electricity prices. This trial is primarily focused on testing the capabilities and benefits of enrolling behind the meter batteries in a VPP. Participating customers are paid for use of their batteries, lowering their energy costs. VPPs offer Ausgrid greater flexibility of choice in optimising planning and operation of the grid by providing services during constraint times, leading to lower costs for all customers on the network.

Over the course of Ausgrid's VPP trial, participants are occasionally called upon to dispatch energy from their battery systems. Each Ausgrid dispatch event is crafted to explore a research objective in areas such as the observed reduction in demand on the grid and the performance of battery management systems. When Ausgrid activates signals to customers' batteries through their battery VPP provider, the stored energy is used within the home with any excess exported to the grid. In return, participating customers are paid for the energy they dispatch from their battery, increasing the value of their investment in batteries.

2.2 Other research

Ausgrid has been exploring the potential for behind the meter and grid-based batteries for peak demand reductions since 2012. A residential battery trial in 2012 involved the installation of zinc bromide RedFlow batteries for 60 residential premises (5kW / 10kWh batteries) at Scone and Newcastle in the Hunter region. Although RedFlow batteries were just emerging from the research and development

[1] VPP Interim Report 2019: https://www.ausgrid.com.au/-/media/Documents/Demand-Mgmt/DMIA-research/Ausgrid-Battery-VPP-Phase-1-Summary-Report.pdf

phase, this trial highlighted the significant potential of batteries for grid support. The trial also identified several obstacles, such as battery stability, reliability and costs.

The Newington Grid Battery trial[2] in 2014 involved the connection of a 60kW / 120kWh lithium ion battery to the low voltage distribution network in the Sydney Olympic Park area. The trial again demonstrated the value of batteries for grid support, but highlighted issues related to battery management system reliability and the need for further reductions in battery storage costs before batteries could be considered a firm and cost competitive demand management resource.

Since these early trials, there have been significant technological and market improvements which have made the reassessment of behind the meter batteries for network support particularly relevant. These developments include maturing of battery technologies in terms of size, capability and cost, the emergence of the VPP concept to meet multiple network and market needs, and the emergence of VPP market providers and aggregators. Across Ausgrid's network there are over 4,000 battery installations and this number is expected to grow significantly in the future as battery costs continue to fall.

In addition to behind the meter batteries, another growing area of interest is in front of meter community-sized batteries connected to the local distribution network. Community batteries can act as a shared battery solution that allows customers to store their solar energy during the day and retrieve it later for self-use. First trialled by Western Power, they offer an alternative to individual households purchasing their own battery storage system, saving them thousands of dollars and opening up additional options for integrating intermittent renewable energy into the system. As part of Ausgrid's commitment to clean energy, the intention is to progress plans to trial shared community batteries in what could be a first for NSW. For more information, please visit Ausgrid's website at https://www.ausgrid.com.au/In-your-community/Community-Batteries.

2.3 Current VPP trial

Ausgrid's current battery VPP project is seeking to build from previous trials to assess whether market providers can provide a commercially and technically viable demand management option, utilising existing residential customer batteries. Reposit Power was selected as the VPP provider for phase 1 due to their proven experience with residential battery management and dispatch, significant experience with R&D and demonstration VPP projects, and their established customer base.

In 2019, Ausgrid completed an open tender process to add new VPP providers to the trial, which received 11 responses from the market. As part of the process, Evergen and ShineHub were selected to join the trial.

[2] Newington Grid Battery Trial: https://www.ausgrid.com.au/-/media/Documents/Demand-Mgmt/DMIA-research/Ausgrid_Newington_Grid_Battery_Report_Final.pdf

Currently there is a combined total of more than 350 battery customers in the trial across the three VPP providers, with an average storage capacity of 10kWh/customer and an average maximum discharge power capacity of 4.1kW/customer.

Ausgrid initiated VPP dispatches and reports are managed via user-friendly platforms developed by the VPP providers, where dispatches and reports can be quickly generated.

3 Objectives

Ausgrid's VPP trial seeks to leverage the existing customer battery capacity of VPP providers and provide additional value to customers to support additional market uptake.

Primary research objectives:

- whether VPPs can provide reliable short-term demand reductions (typically 2 – 4 hours) during hot summer and cold winter evenings when demand peaks;
- whether VPPs can provide reliable sources of voltage support in conditions of over-voltage (typically during sunny Spring and Autumn days) or under voltage; and
- determining the typical battery charge and discharge profile, to assess Business-As-Usual (BAU) battery operation and to provide a baseline operating condition for the assessment of VPPs.

4 Peak demand dispatch events

A total of 39 separate VPP dispatch events were conducted targeting peak demand reductions in summer 2019/20 and winter 2020 across customers in Sydney, Central Coast, Newcastle and Upper Hunter. Dispatches were typically scheduled for 2 to 4 hours between 16:00 and 21:00 with customer numbers varying between 20 and 260 for each dispatch.

This section presents the results of selected representative VPP dispatch events on two hot days during the summer and one cool winter day. These events were assessed against a reference capacity constraint on an 11kV feeder to explore the potential for battery VPPs to offer a viable alternative to network investment and quantify demand reduction performance.

4.1 Reference network need

Due to load growth, there is a forecast capacity constraint on 11kV feeder 80923 at Kurri zone substation in the Hunter region (refer to Table 4.1). This feeder was part of Ausgrid's Gillieston Heights Demand Management RFP published in 2019, in which Ausgrid invited non-network option providers to propose demand management initiatives to address capacity constraints in the area. There are approximately 1,300 customers on the feeder with 220 solar customers (17% of the feeder customers) and negligible battery customers[3].

This capacity constraint will be used as a reference network need to assess VPP performance.

Table 4.1: Annual forecast capacity constraint for 11kV feeder 80923 at Kurri zone substation

	Year 2020/21	**Year 2021/22**	**Year 2022/23**	**Year 2023/24**
Capacity Constraint (kW)	790	1,380	1,980	2,570

4.2 BAU battery profile

A battery management system is typically designed to minimise electricity costs for the customers. Residential battery systems typically charge during the day, absorbing excess solar energy generated from the customers' solar power system. For customers on flat retail tariffs, residential battery systems typically discharge when household energy usage is greater than solar energy generation, where the goal is to maximise self-consumption and therefore minimise grid import. For customers on Time-Of-Use (TOU) retail tariffs, the batteries discharge during peak and shoulder periods and therefore minimising the import of electricity at higher retail prices.

For reference, seasonal BAU battery profiles for the fleet of dispatched batteries are provided in the graphs below. The BAU profiles are calculated by averaging the charge and discharge profiles of the batteries on weekdays, excluding public holidays and dispatched days. The summer BAU profile is calculated using hot days (maximum temperature above 30°C) during the summer of 2019/2020 and the winter BAU profile is calculated using cool days (maximum temperature below 18°C) during the winter of 2019. With more than 80% of the dispatched battery customers on a Retail TOU tariff, the BAU battery profiles are driven by electricity cost optimisation, with the main discharge period coinciding with the peak and shoulder periods for a typical TOU retail tariff in Ausgrid's service area.

4.3 Dispatch day 1

On 23 January 2020, Ausgrid dispatched 69 battery VPP customers in the Hunter region between 18:30-21:00. The customers have an average battery storage capacity of 9.1kWh/customer and an average maximum discharge capacity of 3kW/customer. This was a hot day with temperatures peaking at 42.6°C at Maitland Airport. The dispatch was set up at around 15:10, approximately 3 hours and 20 minutes prior to the dispatch window. Ausgrid did not schedule any manual pre-charging of the battery prior to the dispatch.

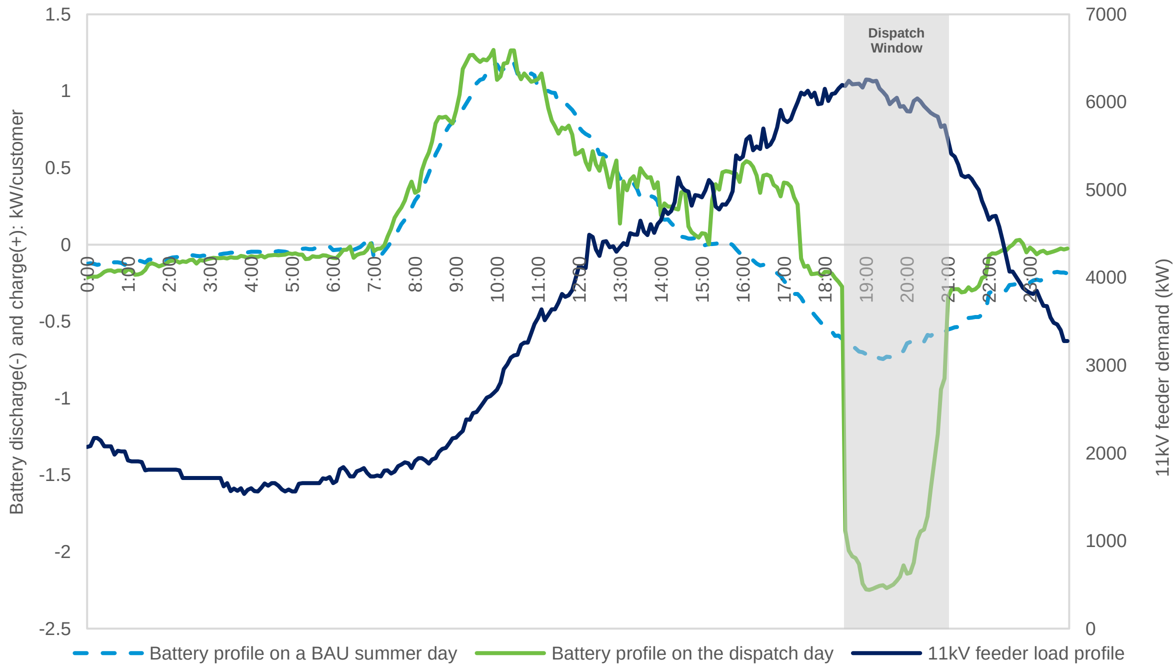
[3] There are currently less than 10 battery customers on the feeder. For the analysis in this report, it will be assumed that currently there are no battery customers on the feeder.

The dispatch was initially scheduled for 17:00-21:00, however the dispatch period had to be adjusted because the VPP was pre-activated as part of the RERT[4] (Reliability and Emergency Reserve Trader) response to LOR2[5] (Lack of Reserve) condition in NSW. Note that while AEMO's RERT pre-activation event delayed the Ausgrid dispatch until 18:30, the pre-activation did not progress to a dispatch of the battery energy for the RERT event.

4.3.1 Original dispatch

On average 4.75kWh/customer of battery energy was discharged during the dispatch period on 23 January 2020. As shown in Figure 4.1, while the dispatch period coincided with the peak demand of the feeder, it did not align with the entire peak period of the feeder due to the override by AEMO for the RERT event.

Figure 4.1: VPP dispatch profile compared against load profile of 11kV feeder 80923 at Kurri zone on 23 January 2020



4.3.2 Adjusted dispatch profile

In order to explore the potential of battery VPP dispatch, the original dispatch profile on 23 January 2020 is 'stretched' across the peak period between 17:00-21:00. Figure 4.2 shows an adjusted VPP profile with the same amount of dispatched energy distributed across a longer time period.

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[4] RERT is a mechanism that allows AEMO to contract for emergency supply reserves typically during high demand or short supply periods.

[5] LOR is a market notice issued by AEMO to communicate tightening of supply reserves.

Figure 4.2: Adjusted VPP profile compared against load profile of 11kV feeder 80923 at Kurri zone on 23 January 2020

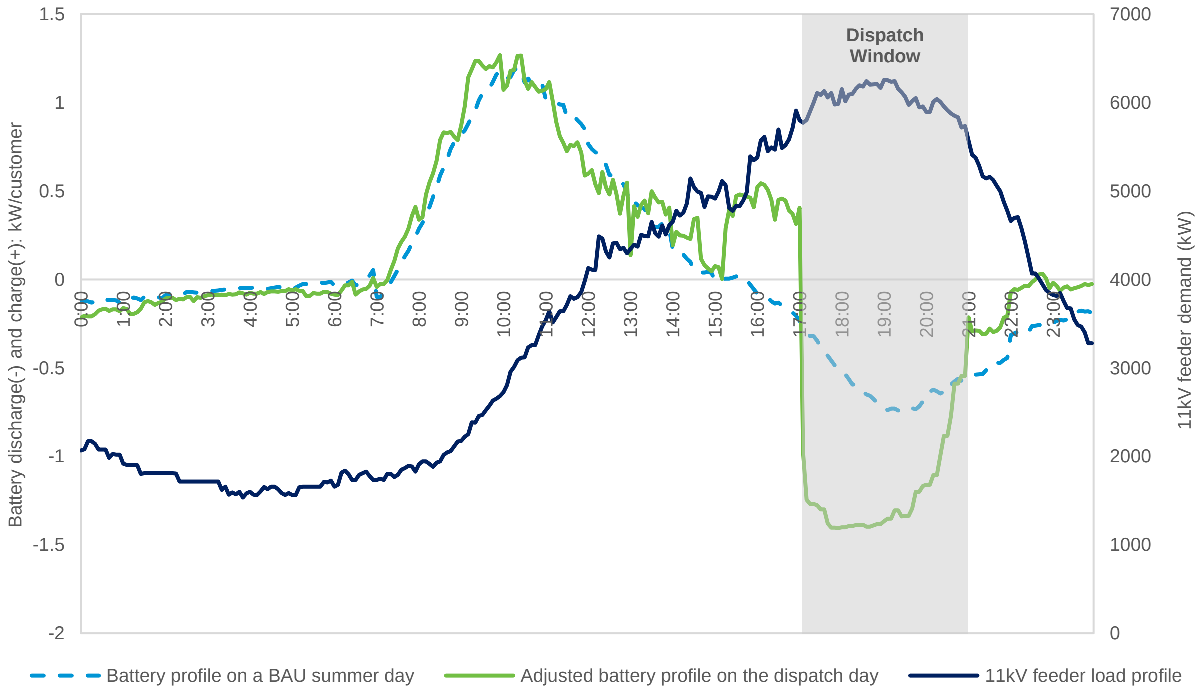


Table 4.2 shows projected peak demand reduction on the feeder with various percentages of battery customers on the feeder based on the adjusted dispatch profile in Figure 4.2. The results show that in the scenario where 20% of the feeder customers have a VPP enabled battery, the demand reduction from the VPP dispatch would address about 33% of the sample capacity constraint on the 11kV feeder for 2020/21.

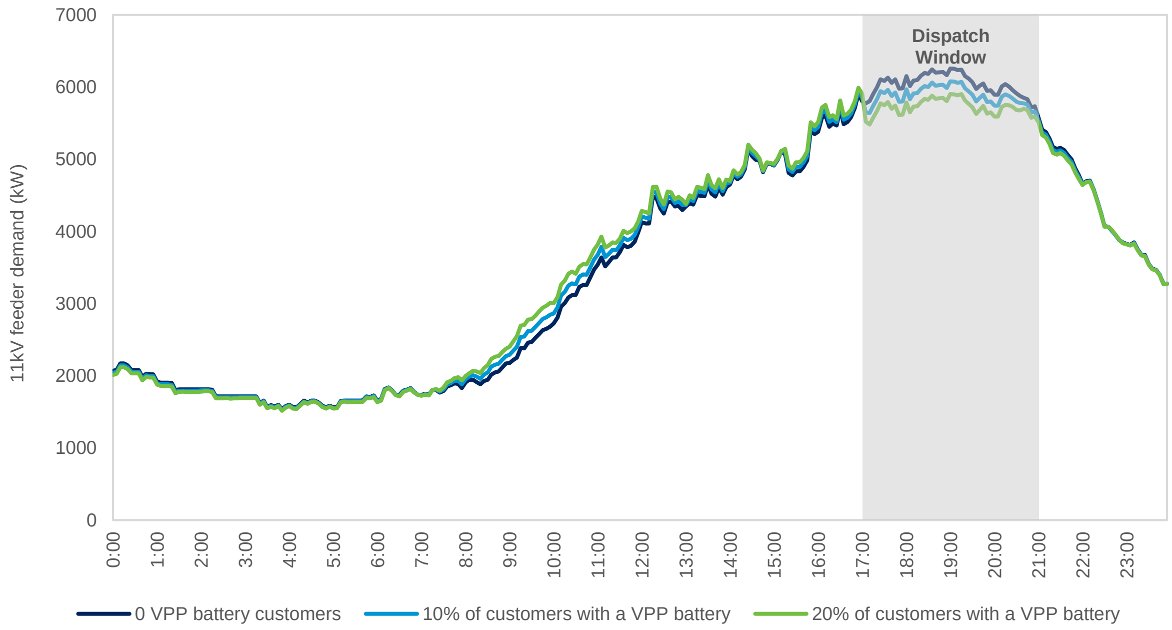
In these possible future scenarios, the VPP battery profile produces a larger peak demand reduction in comparison to the BAU battery profile. As can be seen in the table, the improvement from the VPP dispatch in the demand reduction relative to the BAU profile is about 190% at the 5% battery customer level and 150% at the 20% battery customer level.

Table 4.2: Projected VPP impact on 11kV feeder 80923 at Kurri zone for the adjusted dispatch on 23 January 2020

		VPP			BAU		
Percentage of customers on the feeder with a battery	Number of battery customers	Max feeder demand (kW)	Time	Peak reduction (kW)	Max feeder demand (kW)	Time	Peak reduction (kW)
0 (as is)	0	6257	19:00	0	6257	19:00	0
5%	65	6168	19:00	89	6210	19:00	46
10%	130	6079	19:00	178	6164	19:00	93
20%	260	5990	16:55	266	6073	18:35	183

Figure 4.3 shows the projected impact of the dispatch in scenarios where 10% and 20% of the customers on the feeder have a VPP enabled battery equivalent to the average battery size in the Ausgrid trial.

Figure 4.3: Projected impact of VPP dispatch on 11kV feeder 80923 at Kurri zone for the adjusted dispatch on 23 January 2020

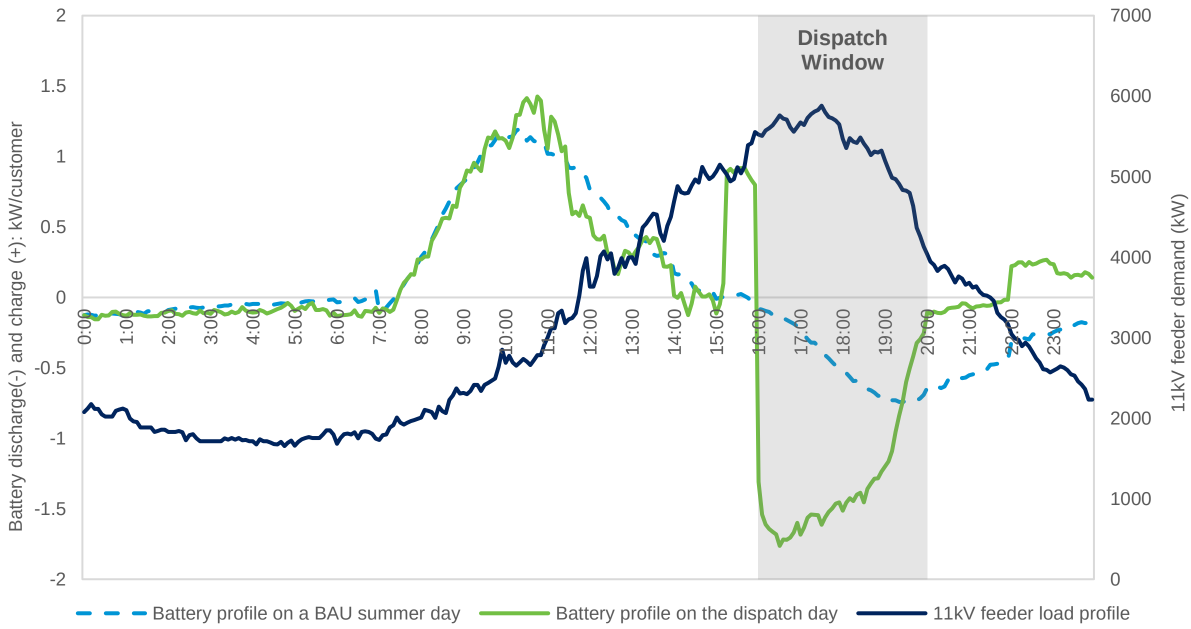


4.4 Dispatch day 2

On 28 January 2020, Ausgrid scheduled another dispatch with the same 69 VPP battery customers in the Hunter region between 16:00-20:00. This was also a hot day with temperatures peaking at 39.6°C at Maitland Airport. The dispatch was called at around 15:15, approximately 45 minutes prior to the dispatch window. Ausgrid did not schedule any manual pre-charging of the battery prior to the dispatch.

4.4.1 Original dispatch

Figure 4.4: VPP dispatch profile compared against load profile of 11kV feeder 80923 at Kurri zone on 28 January 2020



An average of 5.1kWh/customer of battery energy was delivered during the dispatch window. Figure 4.4 shows that the VPP dispatch coincided with the peak period of the feeder. Due to the dispatch being called 45 minutes prior to the dispatch window, the battery systems had a short amount of time to prepare for the dispatch and this resulted in significant pre-charging of the batteries just prior to the dispatch window between 15:15-16:00.

4.4.2 Adjusted dispatch profile

When modelling scenarios with higher battery customers for the original dispatch on 28 January 2020, the size of the pre-charge increased to the point that it created an ‘artificial’ peak, limiting the size of demand reduction of the dispatch. In order to model the potential of battery VPP without the interference of the battery pre-charge, the battery pre-charge is removed from the original dispatch profile on 28 January 2020 (see Figure 4.5). This is equivalent to locking out the batteries (no charge or discharge), a feature that is available for the majority of the VPP batteries. There is no adjustment made to the battery profile within the dispatch window. The aim of the adjustment is to model a scenario where the pre-charging occurs at a time (e.g. early hours of the morning) that doesn’t interfere with the peak period while maintaining the same level of available energy for dispatch.

Figure 4.5: Adjusted VPP profile compared against load profile of 11kV feeder 80923 at Kurri zone on 28 January 2020

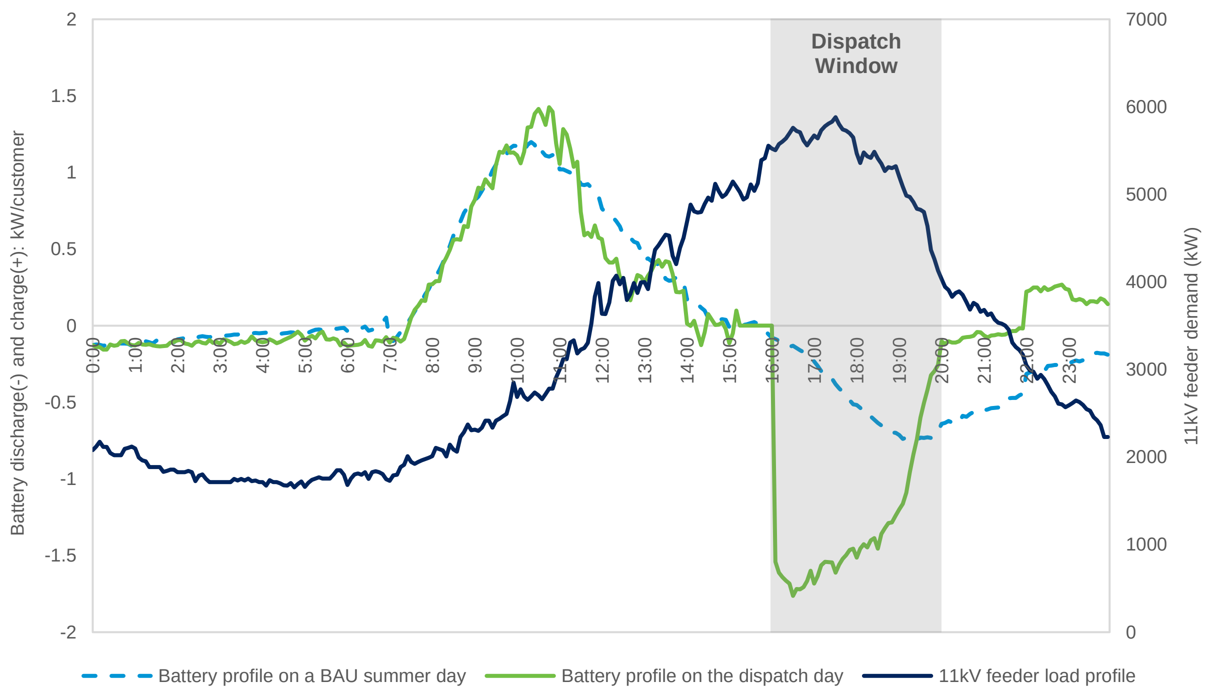


Table 4.3 shows projected peak demand reduction on the feeder with various percentages of battery customers on the feeder, based on the adjusted profile in Figure 4.5. The results show that in the scenario where 20% of the feeder customers have a VPP enabled battery, the demand reduction from the VPP dispatch would address about 40% of the capacity constraint on the sample 11kV feeder for 2020/21.

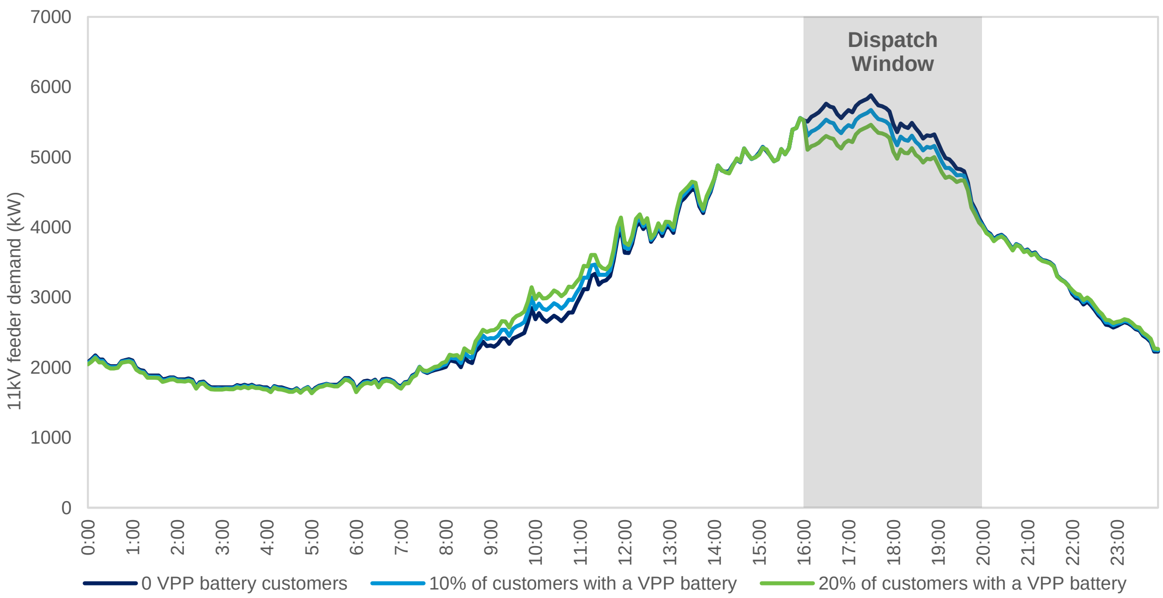
Similar to the results for the dispatch day 1, the VPP battery dispatch produces a larger peak demand reduction compared to the BAU battery operation. As can be seen in the table, the improvement from the VPP dispatch in the demand reduction relative to the BAU profile is about 420% at the 5% battery customer level and 330% at the 20% battery customer level.

Table 4.3: Projected VPP impact on 11kV feeder 80923 at Kurri zone for the adjusted dispatch on 28 January 2020

		VPP			BAU		
Percentage of customers on the feeder with a battery	Number of battery customers	Max feeder demand (kW)	Time	Peak reduction (kW)	Max feeder demand (kW)	Time	Peak reduction (kW)
0 (as is)	0	5881	17:30	0	5881	17:30	0
5%	65	5777	17:30	105	5857	17:30	25
10%	130	5672	17:30	210	5832	17:30	50
20%	260	5555	15:55	327	5782	17:30	99

Figure 4.6 shows the projected impact of the dispatch in scenarios where 10% and 20% of the customers on the feeder have a VPP enabled battery equivalent to the average battery size in the Ausgrid trial.

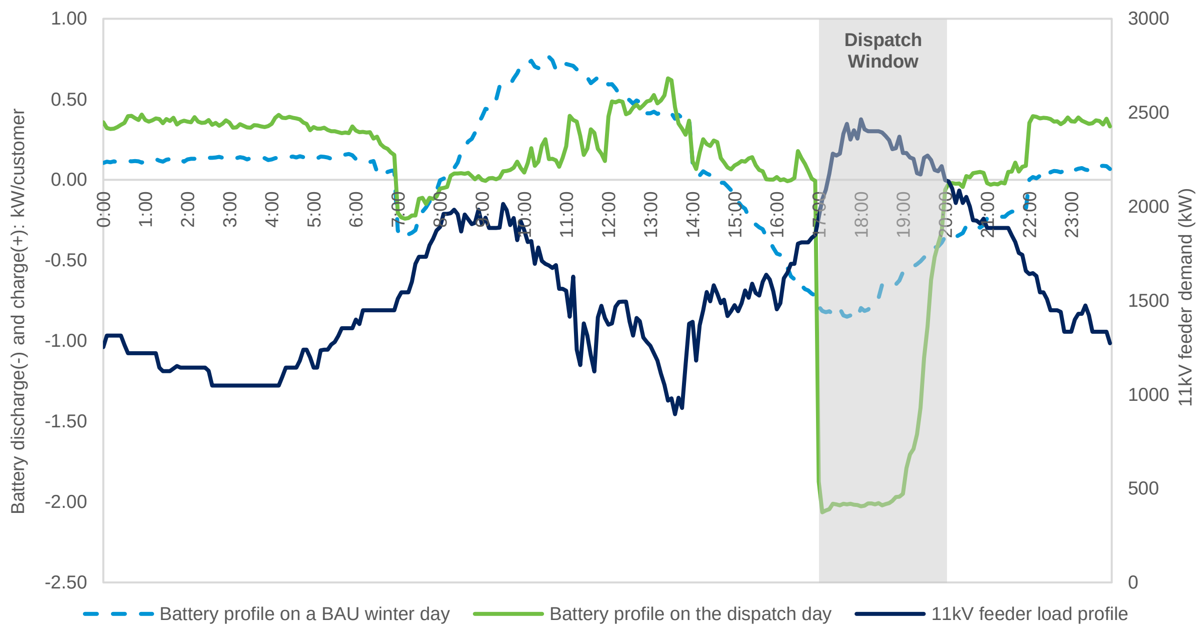
Figure 4.6: Projected impact of VPP dispatch on 11kV feeder 80923 at Kurri zone for the adjusted dispatch on 28 January 2020



4.5 Dispatch day 3

On 14 July 2020, Ausgrid scheduled another dispatch with the same 69 VPP battery customers in the Hunter region between 17:00-20:00. This was a cool day with temperatures peaking at 16.5°C at Maitland Airport. The dispatch was called at around 17:00 on 13 July 2020, approximately 24 hours prior to the dispatch window.

Figure 4.7: VPP profile compared against load profile of 11kV feeder 80923 at Kurri zone on 14 July 2020



On average 5.3kWh/customer of battery energy was discharged during the dispatch period on 14 July 2020. Figure 4.7 shows that the VPP dispatch coincided with the peak period of the feeder. With the dispatch being called 24 hours prior to the dispatch window, the batteries were able to pre-charge during the off-peak period (12-7am), which avoided the need for any significant pre-charging of the batteries prior to the dispatch window.

Table 4.4: Projected VPP impact on 11kV feeder 80923 at Kurri zone for the dispatch on 14 July 2020

		VPP			BAU		
Percentage of customers on the feeder with a battery	Number of battery customers	Max feeder demand (kW)	Time	Peak reduction (kW)	Max feeder demand (kW)	Time	Peak reduction (kW)
0 (as is)	0	2465	18:00	0	2465	18:00	0
5%	65	2333	18:00	132	2413	18:00	52
10%	130	2201	18:00	264	2361	18:00	103
20%	260	2127	20:05	338	2258	18:00	207

Table 4.4 shows projected peak demand reduction on the feeder with various percentages of battery customers on the feeder, based on the dispatch profile on 14 July 2020. The results show that in the scenario where 20% of the feeder customers have a VPP enabled battery, the demand reduction from the VPP dispatch would address about 43% of the capacity constraint on the sample 11kV feeder for 2020/21.

Similar to the other two dispatch days, the VPP dispatch produces a larger peak demand reduction in comparison to the BAU battery operation. As can be seen in the table, the improvement from the VPP dispatch in the demand reduction relative to the BAU profile is about 250% at the 5% battery customer level and about 160% at the 20% battery customer level.

Figure 4.8: Projected VPP impact on 11kV feeder 80923 at Kurri zone for the dispatch on 14 July 2020

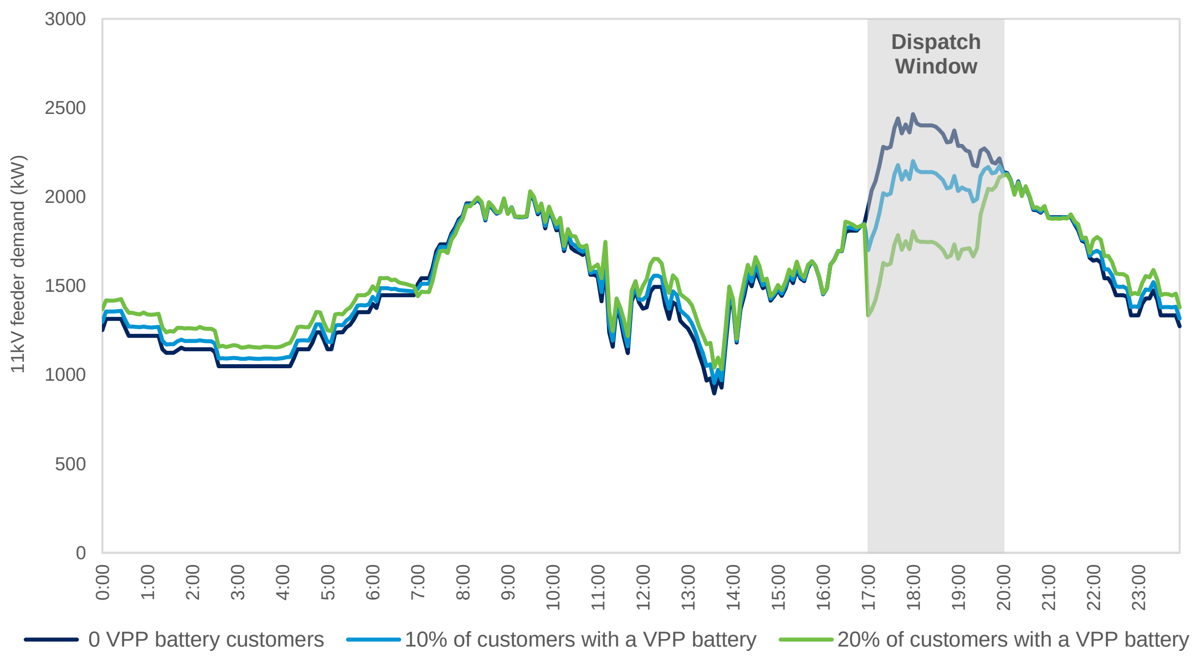


Figure 4.8 shows the projected impact of the dispatch in scenarios where 10% and 20% of the customers on the feeder have a VPP enabled battery equivalent to the average battery size in the Ausgrid trial.

4.6 Discussion of dispatch results

The dispatch results highlight that with an appropriate size battery fleet, VPPs could be a viable option for demand management. As with all demand management options, factors such as cost and reliability will also play a part in the selection of a solution. These factors will be investigated further in the trial. Importantly, the results demonstrate that the VPP dispatch generally produces a higher peak demand reduction compared to BAU battery operation with the incremental benefit ranging from 1-1/2 to 4 times the BAU performance across the sample dispatch events and future battery take-up scenarios.

The results also highlight the impact of a non-optimal alignment of the dispatch with the peak period of the network asset. Due to the override from AEMO, the original dispatch on 23 January 2020 did not align with the entire peak period of the feeder, which limited the peak demand reduction. In terms of aligning the battery discharge period to the peak demand period of the asset, a battery VPP offers a more flexible option compared to BAU battery operation as a VPP dispatch can be adjusted and targeted to align with the peak demand period of any network asset, taking into account local conditions.

Pre-charging of batteries also played an important role during the VPP dispatches. On 28 January 2020, the dispatch was called 45 minutes prior to the dispatch window, allowing only a small period of time to pre-charge the batteries. As Ausgrid did not scheduled any manual pre-charge, the battery management system automatically scheduled a pre-charge to prepare the batteries for the dispatch, resulting in a significant power increase that added to the load demand just prior to the dispatch window. The dispatch on 14 July 2020, where the dispatch was called 24 hours in advance, highlighted that with more time to prepare for a dispatch, the battery management system can pre-charge the batteries during the off-peak period and avoid pre-charging just prior to the dispatch window. While calling the dispatch with an advance notice (e.g. 24 hours) prior to the dispatch window is ideal, this may not always be possible as a network outage event may necessitate the need for demand reductions at short notice. Another option in this scenario is to avoid pre-charging by locking out the battery prior to a dispatch and dispatching whatever energy is stored in the battery at the time of the dispatch. This will prevent the pre-charging of batteries seen on 28 January 2020, however it may also result in a lower energy output during the dispatch.

5 Value stacking

'Value stacking' allows customers to maximise their income streams by making their batteries available to multiple applications. For example, a battery could be dispatched by:

- the market operator to provide broader system stability support;
- network service providers, such as Ausgrid, to address a network constraint; and
- retailers in response to market price signals to manage the cost of electricity.

On 23 and 31 January 2020, the VPP was dispatched by Ausgrid and was also pre-activated as part of RERT event in response to LOR2. A retailer could have also dispatched the batteries as spot market prices for electricity were relatively high on those days.

There can be a difference in the timing of the local network peak, broader system peak and market price signals, which means that the dispatch periods can be different depending on the stakeholder that is scheduling the dispatch. As batteries have limited storage capacity and with multiple stakeholders intending to use the batteries for different purposes, there is likely a need for a priority or co-ordination system. Further research is required to evaluate risk, identify commercial constraints and explore customer preferences so as to optimise battery operation.

6 Dispatch profiles

The following section presents various dispatch profiles that Ausgrid has encountered during the trial across the three VPP providers. The dispatches scheduled during this trial have been static dispatches, where the aim is to deliver a constant power output that aligns with a fixed target value set at the start of the dispatch.

Figure 6.1: Dispatch profile 1

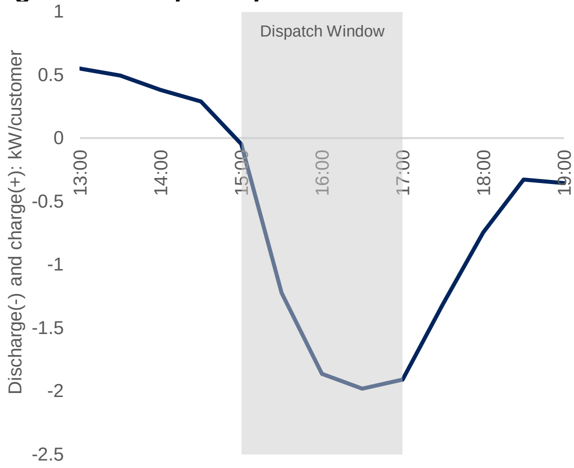


Figure 6.2: Dispatch profile 2

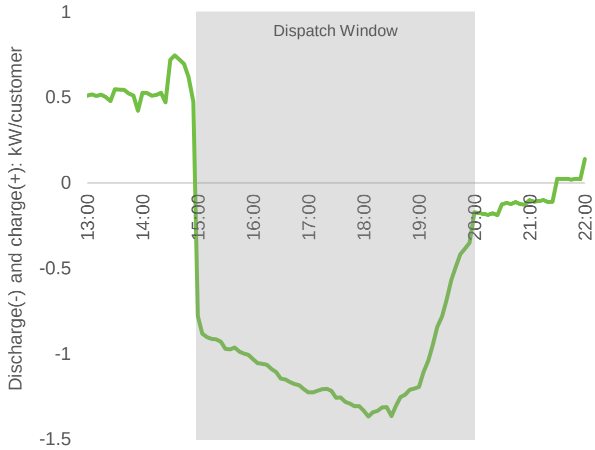


Figure 6.1 and Figure 6.2 show dispatch profiles where the VPP batteries did not reach their maximum power output until the second half of the dispatch window.

Figure 6.3: Dispatch profile 3

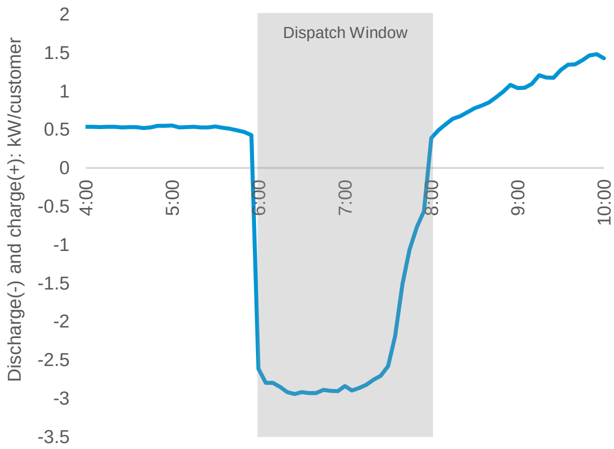


Figure 6.4: Dispatch profile 4

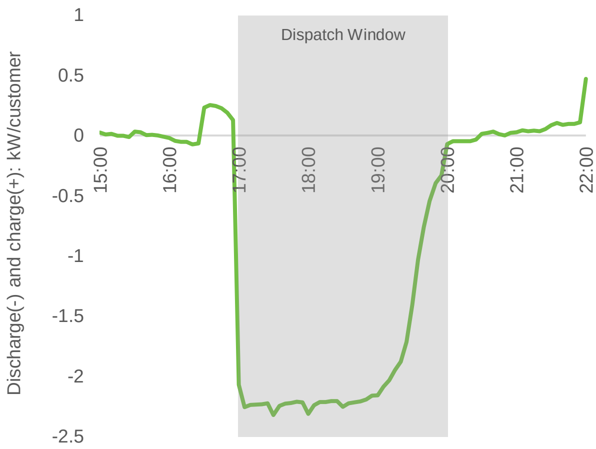


Figure 6.3 and Figure 6.4 show dispatch profiles that have a relatively consistent output for the majority of the dispatch window with a decline in output near the end of the dispatch period.

Figure 6.5: Dispatch profile 5

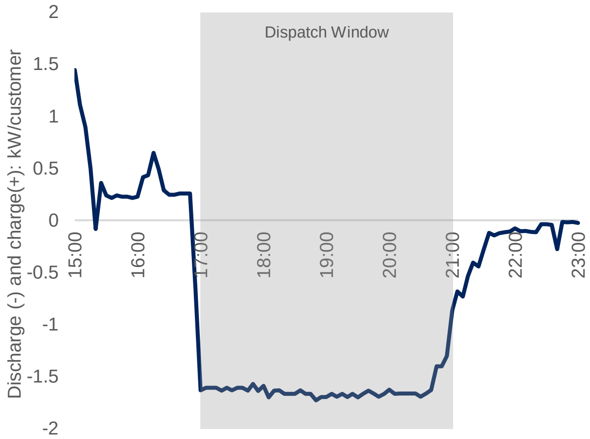


Figure 6.6: Dispatch profile 6

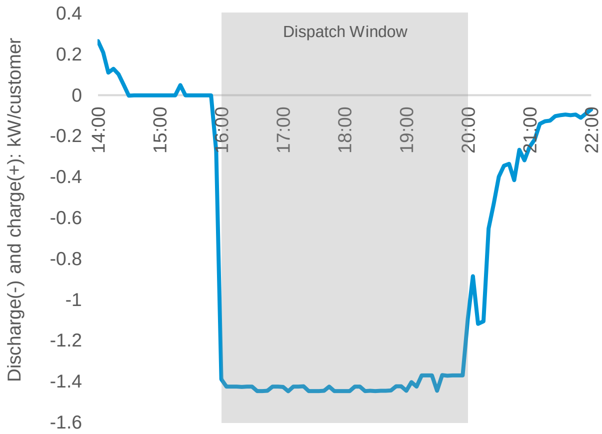


Figure 6.5 and Figure 6.6 present relatively consistent dispatch profiles that generally achieved the target power output throughout the dispatch window.

Figure 6.7: Dispatch profile for 10 of the best and worst performing batteries for 28 January 2020

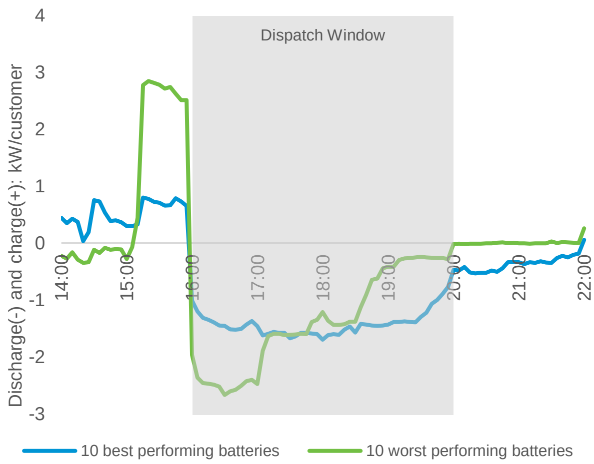


Figure 6.8: Average dispatch profile at fleet level for 28 January 2020

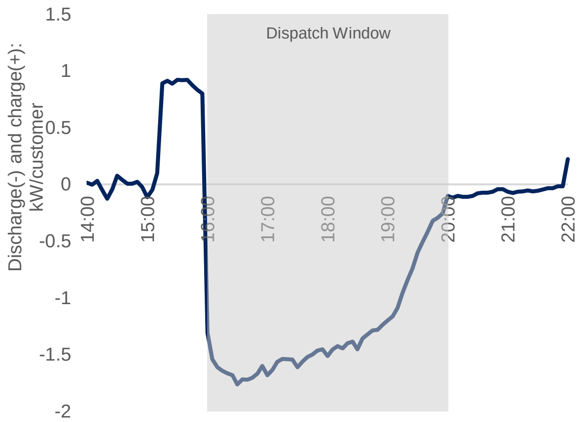


Figure 6.7 presents the average battery profile for 10 of the best and worst performing batteries based on the ratio of delivered energy to initial target energy. Figure 6.8 shows the average battery profile at fleet level for the same dispatch. These two charts highlight that battery performances within a fleet can vary widely during a dispatch and that the overall dispatch profile could be improved by addressing the output of the underperforming batteries. Numerous factors, such as battery state of charge, efficiency of the battery, site configuration and battery management systems may impact the profile of a VPP dispatch. There have been improvements in the consistency of VPP dispatch output throughout the trial.

The optimal VPP dispatch profile from a demand management perspective would involve a power output that closely matches the customer load profile. One way to achieve this output is for the battery management system to adjust the battery output throughout the dispatch window based on the overall network asset demand. Or alternatively, to dispatch the battery fleet to produce a pre-determined load shape typical for a range of customers and conditions. These possible alternative approaches will be explored as part of future trial activities.

7 Dispatched energy

Across a fleet of 214 battery customers in Sydney, Central Coast and the Hunter region that were dispatched over the previous 6 months, the average dispatched energy was relatively constant regardless of solar output, season, time of the day, dispatch duration and length of time between the dispatch being called and the dispatch window (see Table 7.1). This highlights that the battery management system, which has access to a variety of data including weather forecast and customer energy usage patterns, is able to control the batteries to produce a consistent dispatch output under a variety of scenarios.

The battery management system is responsible for preparing the batteries for a VPP dispatch with the aim of maximising energy available for a dispatch and increasing financial savings/returns for the customers. The batteries are charged using solar energy if available however there are scenarios where grid electricity is used to pre-charge the batteries in order to maximise available dispatch energy. Where a dispatch is called with a short amount of time before the dispatch window, the battery management system may quickly pre-charge the batteries using the grid electricity to increase available energy for the dispatch, which maximises financial payments received from the VPP dispatch for customers. Where a dispatch is called with more advance noticed (e.g. 24 hours prior to the dispatch window) and there is likely to be low solar output the following day due to the weather, the battery management system may pre-charge the batteries using cheaper off-peak grid electricity in the middle of the night to save costs and maximise available energy for the dispatch.

Table 7.1: Dispatch details across multiple days for a fleet of VPP batteries

Date	Average dispatched energy (kWh/customer)	Average dispatched energy as a % of average battery nameplate capacity rating	Average dispatched energy as a % of average predicted energy output	Dispatch window	Dispatch duration (hours)	Time between calling the dispatch and dispatch window (hours)	Solar output on the day (kWh/customer)
1-Feb-20	5.54	58%	82%	15:00-20:00	5	24	31
2-Mar-20	5.04	53%	87%	15:00-18:00	3	1	28
1-May-20	5.07	52%	82%	06:00-08:00	2	13	21
15-Jul-20	6.02	62%	87%	17:00-20:00	3	24	10
22-Jul-20	5.58	58%	87%	17:00-21:00	4	1	15

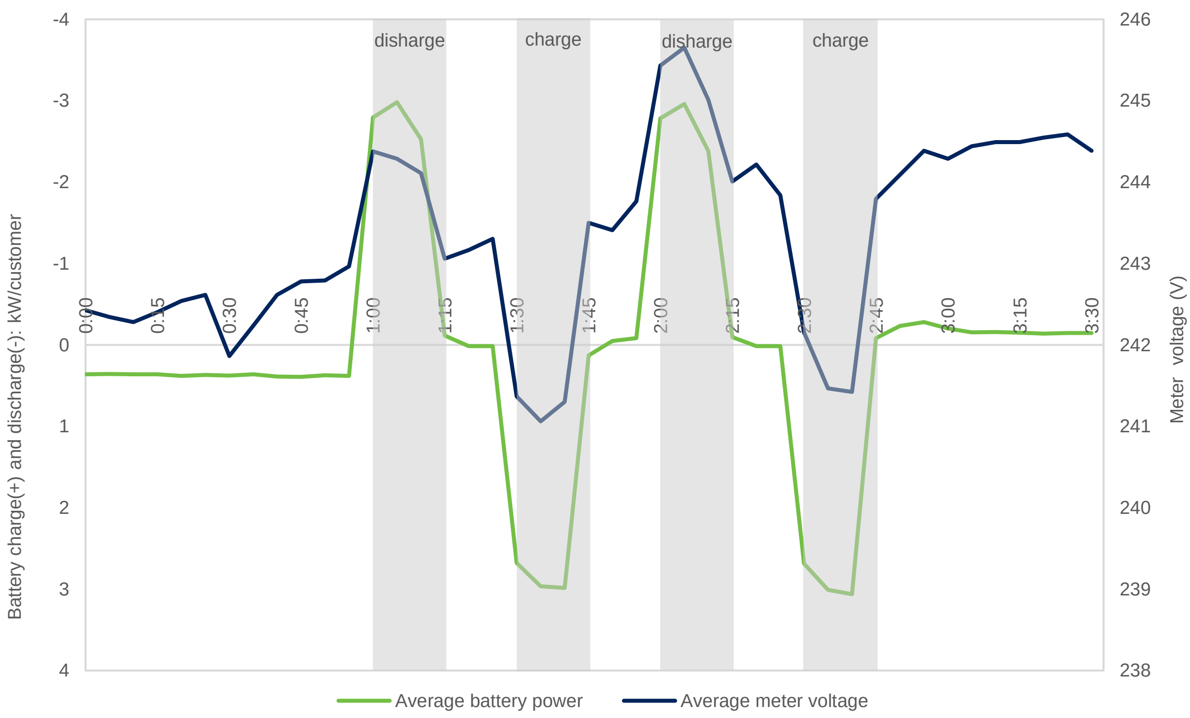
Table 7.1 shows the VPP dispatched energy as a percentage of the battery nameplate rating and predicted output energy. Many factors such as energy losses, battery state of charge and internet connectivity for the VPP control signal can contribute to a difference in the actual VPP dispatched energy vs battery nameplate capacity rating. When a dispatch is called, these factors are taken into consideration by the VPP algorithm to produce an energy output prediction for the dispatch. This is a more realistic figure than the nameplate rating of how much energy can be expected to be delivered during the dispatch. As can be seen in Table 7.1, the actual delivered energy was only 52%-62% of

nameplate energy, but was 82% to 87% of the predicted energy output figures. Ausgrid will continue to work with the VPP providers to investigate ways to optimise the amount of energy produced from a VPP dispatch and further increase the accuracy of energy output prediction.

8 Voltage Control

Voltage regulation issues are becoming more prominent as networks experience large increases in solar PV connections. Over-voltage issues can arise in the middle of the day when solar PV export is high while the load is typically low. This can cause solar PV to trip and prevent export of solar energy into the grid.

Figure 8.1: Battery profile compared to meter voltage on 10 June 2020



On 10 June 2020, a series of real power charge and discharge events (power factor =1) were scheduled at 15 minutes interval for 142 customers. The tests were completed in the early hours of the morning to minimise impact from customer load variations. As expected, it can be seen in Figure 8.1 that the average meter voltage responded to battery charge and discharge events. Where the network has high solar PV connections, the batteries can be charged to 'soak' up energy to pull volts down. Conversely, under conditions of high network demand and low volts, the batteries can be used to address both issues. Ausgrid has been limited in its capacity to test reactive battery response due to power factor limitations built into the inverters by the battery system manufacturers. Ausgrid aims to further work with VPP providers to improve power factor operating capability and investigate the use of real and reactive battery power for voltage regulation.

9 Customer Survey Results

9.1 Customer Experience and Satisfaction

Ausgrid invited participants to provide their feedback about their experience during the trial, of which Ausgrid received 66 responses. The survey was conducted during November 2019, some months after the first series of dispatches were completed. The findings are summarised below:

- Almost three quarters (74%) were overall satisfied with Ausgrid's VPP trial. Note that approximately 22% of the respondents were unsure or had difficulty recalling being part of the trial, which was most likely due to the survey being sent out a few months after the initial series of dispatches.
- Motivation to participate in the trial was also explored in the survey, where Ausgrid asked respondents to rank from a prompted list of reasons for taking part. "It helps the electricity grid to be managed more efficiently" was the most popular reason, which was selected by 43% of respondents as their top reason. The other leading answers were "It is better for the environment" and receiving a "financial reward", which were selected by 20% and 18% of the group respectively as their main reason.
- The majority of the participants recalled receiving the app notifications (71%) with almost all of them agreeing that they found receiving a notification about the event useful (92%), mainly to be kept informed about when they received a credit or to know if the operation of their battery system would change.
- 82% of the respondents stated that they were mainly satisfied with the way the information was communicated by the VPP provider to them, while 14% remained ambivalent about the communication.

9.2 Customer Expectations

Ausgrid also invited some of the participants that joined the trial in 2020 to provide their feedback about their experience before the commencement of the trial, of which Ausgrid received 36 responses.

- Ausgrid also explored participant's motivation for signing up to the trial, where participants were asked to select from a prompted list with multiple answers allowed to be selected. Similar to the customer experience survey in November 2019, "it helps the electricity grid to be managed more efficiently" was the most selected answer (72%), second highest driver was "for the financial reward I would receive for exporting my excess solar" (67%). Helping the environment was also a leading driver (64%).
- When asked what level of knowledge they had about VPPs, the respondents fell mainly into 2 groups – moderate amount (39%) or very little (31%).
- When asked how concerned they would be if their battery was discharged down to its minimum level during a dispatch, just over half said they would either not be at all concerned or a little concerned (58%). Out of the remaining 42% who said they were reasonably to very concerned

about this, they 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.

10 Future research objectives

The results highlight the potential of a VPP as well as some of the issues that need to be addressed for VPP to become a viable demand management option. Ausgrid has identified the need to explore the following areas, some of which are currently underway:

- Dispatch timing: how can Ausgrid optimise dispatch timing to maximise peak demand reduction?
- Pre-charging: the best method to manage the battery pre-charge to minimise impact on peak demand.
- Shaped/Dynamic dispatch: the dispatches completed so far have been manually set up to deliver a certain fixed power output. A VPP dispatch that is shaped to reflect typical customer load profiles or is triggered by load data and changes the output to match the customer load profile could provide better peak demand reduction and possibly address some of the dispatch timing and pre-charging issues mentioned in this report.
- Dispatch profile and battery performance: further investigation is required to understand the variation in individual battery performance and how battery performance could be improved to deliver an optimal dispatch profile.
- Voltage control: further exploration is required to assess the potential of using VPP in voltage regulation.
- Dispatch co-ordination/prioritisation: explore ways to manage VPP dispatches between different parties.
- Customer surveys: further engage with the customers that are part of the trial and learn from their feedback.

11 Conclusion

The results highlight that with an increase in battery customers, there is a potential for VPPs to provide material peak demand reductions and be considered as a viable demand management option. The results also quantify the reduction in network peak demand due to business-as-usual operation of the batteries and the incremental benefit from VPP operation of the batteries.

There are areas such as battery pre-charging, dispatch timing and battery performance that require further investigation to better manage and optimise the effectiveness of VPPs. Further, with customers offering their batteries for multiple applications, trial results highlight the need for further research and coordination amongst VPP stakeholders to optimise dispatch events for customers and all market participants.

Ausgrid is encouraged by the results of the customer surveys, which show that the trial has been a positive experience for the majority of the trial customers and that they are motivated to assist Ausgrid in making the grid more efficient. Ausgrid aims to further work with the VPP providers and customers in exploring ways to achieve the goal of making the grid more efficient.

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