Energex Carseldine Village Demand Diversity and Response Report

Demand and Energy Management

19 November 2025

Part of Energy Queensland

EXECUTIVE SUMMARY

Carseldine Village is a net zero emissions mixed-use residential project 15km north of Brisbane City developed by Economic Development Queensland (EDQ). Carseldine Village was an opportunity to test demand response and energy efficiency across a consistent cohort of residential buildings supplied from a single transformer against a control group of 192 similar townhouses nearby. Energex funded installation of HEMS in 25 homes, each with Solar Photovoltaics (PV) (4.2kW array with inverters limited to 3kW) and battery energy storage systems (BESS) (10.5kWh) and heat pump hot water.

Baseline data from smart meters shows that the Carseldine Village HEMS customer peak demand (1.15 kVA) was lower than comparable non-HEMS townhouses (1.62kVA).

Energex ran a series of Peak Demand (ten) and Minimum Demand events (three). Events had a mixture of different start time, duration and notification lead times to assess Evergen's ability to deliver a response and its relative magnitude.

During network peak demand events the average peak demand for HEMS customers were 2.99kW. BESS discharge provided an average of 1.54kW, with network delivering 1.45kW per customer. In comparison, non-HEMS customers added 0.47kW diversified maximum demand during peak events (compared to HEMS customer's -1.54kW) and the control group added 1.68kW. When fully charged, a managed BESS can make a significant difference to the impact on peak demand with unmanaged BESS still being of value.

Minimum demand events did not experience the same benefit. Evergen could only control BESS charge/discharge rates. No control of PV generation control was available. Evergen discharged BESS as fully as possible prior to an event, but the PV generation was such that the battery solar soaking was relatively ineffectual.

Peak demand responses on events days were favourable when compared to the seasonal peak demand, with batteries fully charged by solar generation. However, when the batteries needed supplemental network charging prior to an event (without diversification of charging), the incidental peak demand of the HEMS participants exceeded that of the non-HEMS participants. Should Aggregator access to BESS reach a critical mass in a local area and mass coincidental grid-charging occurs (low state of charge and an impending increase in a cost-reflective retail tariff rate), the impact on a local network's peak demand could be significant. Dynamic connections with import-limit signalling could resolve this issue.

Conclusions

It is clear that, for some customer cohorts the combination of energy efficiency building envelopes, inclusion of energy efficient appliances and export limited generation with managed BESS solution can have a major influence on network demand while improving network utilisation. The more loads that can be coordinated with generation the greater the potential for significant customer and network benefits being achieved. Active management of PV generation is needed to mitigate the network impact of minimum demand.

Recommendations

With a small cohort of participants and the limitation of only managing generation and load of the BESS, further research of a larger participant group with more orchestrated loads to generation is required. It will more clearly identify which customer cohorts will benefit from a HEMS sufficiently to offset potential upfront costs and maximise their value from both market and network opportunities.

CONTENTS

1 PURPOSE AND SCOPE

The purpose of this report is to provide analysis of the network impacts of an energy-efficient, residential sub-division (building envelopes, energy-efficient appliances and behind-the-meter generation and storage) and outcomes to specific demand response requests from Energex.

2 GLOSSARY

BESS	Battery Energy Storage System – an electricity storage system that is able to discharge its stored energy.
CER	Customer Energy Resources – predominantly includes generation such as PV and BESS but can also include larger loads that are able to be managed remotely (electric vehicle chargers and vehicle to grid capabilities, hot water, pool pumps)[1].
DER	Effectively the same as CER but seen from the network perspective.
EDQ	Economic Development Queensland – a group within the Department of State Development, Infrastructure, Local Government and Planning that is a developer of commercial and residential sub-divisions. It does not need to follow local planning laws as it is chartered to deliver ground-breaking building to improve the energy and sustainability of the buildings it commissions.
Event	A signalled requirement, from Energex to the market, to reduce or increase demand or generation at certain sites.
HEMS	Home Energy Management System – a combination of hardware (installed in your home) and software that monitors, displays and allows control of your energy consumption, usually via a smart phone app, website or HEMS provider.
NatHERS	Nationwide House Energy Rating Scheme - provides energy ratings for new dwellings. This is helping create energy efficient, resilient and comfortable homes for the future that cost less to run.
PV	Solar photovoltaics – rooftop solar generation
QUT	Queensland University of Technology
SoC	State of Charge of a battery energy storage system

[1] Unlocking the Full Potential of Consumer Energy Resources | AEMC

3 BACKGROUND

Carseldine Village is a residential project developed by Economic Development Queensland (EDQ) to analyse the impact of energy efficient homes, solar, battery and Home Energy Management Systems (HEMS). Each household is equipped with a 4.2kW solar system (PV), rooftop solar, and 7-star energy efficiency building envelope. 23 of the 52 households developed in Stage 1 have HEMS systems installed from Evergen. This project aims to develop a best practice model for the integration of distributed energy resource (DER) into infill and master planned communities.

This paper investigates the impact of:

(i) combining CER with HEMS and with an energy efficient building design on network peak demand, and

(ii) demand response capabilities to events called by Energex.

4 INTRODUCTION

Carseldine Village, a mixed-use residential project, being developed by Economic Development Queensland (EDQ), part of the Queensland Government, is pushing to change traditional electrical sub-division boundaries by delivering 196 terrace homes with 100% solar PV and battery within the Brisbane region to create all-electric, low energy, net-zero emission, comfortable homes over four stages commencing in 2020. The project aims to be a model for best practice integration of distributed energy resources (DER) in new infill and master planned communities with learnings to be shared with the property sector.

Economic Development Queensland (EDQ's) Carseldine sub-division will include Solar Photovoltaics (PV) (4.2kW array with 5kW inverter limited to 3kW export) and battery energy storage systems (BESS) (10.5kWh) in every home (over time 196 terraced homes). Sub-division also includes retirement living and an aged-care centre (with PV) and some commercial and retail to follow. The Carseldine Village project provided a perfect opportunity for Energex to have a clearer view on the behaviour created from a high uptake DERs in a consistent cohort of residential properties (2- and 3- bedroom townhouses) in a very localized area on the distribution network within the context of a broader energy system.

Energex was invited to financially support installation of free HEMS in up to 25 of Stage 1's 53 homes (Figure 1) and direct support funding of $20,000 under the Demand Management Innovation Allowance Mechanism (DMIAM) was agreed. This funding was matched with co-funding by EDQ. Under the funding agreement Energex was to be able to call up to 20 events (peak demand and minimum demand) to establish the value of the managed appliances in the HEMS homes. Energex involvement would be dependent upon certain caveats:

- HEMS to be compliant with IPDRS Functional Proposal v7 (See Appendix 4).
- HEMS to manage Solar, BESS, Hot Water and a/c as a minimum.
- Assess the requirements for any particular retail tariff conditions for a free HEMS (eg. Demand tariffs).

During the build stage of the program it was evident that significant development by Evergen was required to integrate communications to the Daikin control platform. An additional $20,000 support was requested of the Energex DMIAM funding to assist with this expense. This was agreed. For a breakdown of the project costs to DMIAM funding go to Appendix 5.

A key feature of the proposed project is to improve the visibility of DER loads on the LV distribution network (between terrace houses, transformers and substations) to drive the better integration of DERs. Providing real-time information on loads and voltages in the local network (Figure 2) will help to understand and predict where local constraints exist or are likely to exist in the future. The inclusion of smart technology (such a HEMs) will enable systems to be continuously analysed, optimising home energy use.

Energex was to only have a direct relationship with EDQ (as the sub-division developer), to try to establish a "business as usual" approach to the delivery and installation of the HEMS. The HEMS provider was chosen by EDQ and the project builders following a Request for Information and presentation by up to five (5) suppliers. Evergen was the successful applicant.

At the request of Queensland University of Technology – QUT - (a late addition to the program under the *Race for 2030* project) WattWatcher hardware was also installed to provide granular date on certain circuits in the HEMS homes. The WattWatcher data was to provide data on "Whole of House", hot hater, living space air conditioner and PV/BESS. "Whole of House" and PV/BESS was to be checked against Smart Meter and Evergen data for robustness.

To engage the potential residents to be participants in the program, EDQ held an open day on 1 February 2020.

- 600 potential purchasers attended
- 66 attendees subscribed to EoI on the Stage 1 terrace houses (first 53).
- <5% investors.

Residents planned to be moving into homes for February/March 2021. Due to Covid-19 and then supply and skilled labour shortages the first homes began occupancy in June 2023 and were fully occupied by March 2024. Due to the delay in the occupancy of the properties, the program was extended to May 2025.

5 PROJECT PARTNERS

- EDQ/builders – PV, BESS, 7-star NatHERS rating, WiFi enabled air conditioning, dwelling air tightness, heat pump hot water. The builders are Vantage and Thompson Builders.
- Queensland University of Technology (QUT) – WattWatcher data and indoor sensor supplier for customer behavioural data.
- Evergen – HEMS service provider

The Carseldine local network does not have a forecast peak demand constraint, however network minimum demand is more constrained. This gives the freedom to experiment and learn what the realistic expectations ought to be when managing both network issues.

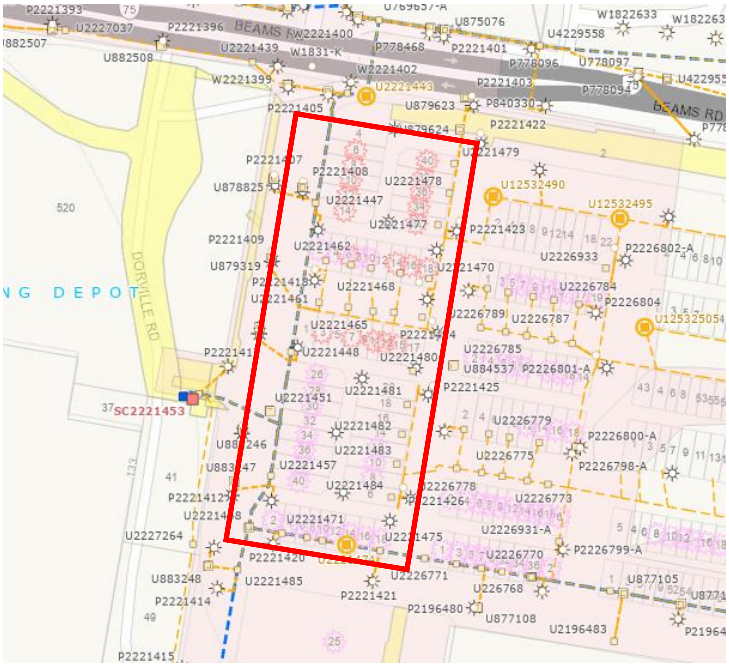
Participants must not experience more than 20 events between commencement and May 2025.

- Peak demand events are conducted during summer (December – March annually)
- Minimum (negative) demand events during autumn and spring (April/May & October/November).

- Participants should not be inadvertently negatively impacted in comfort/amenity during our events (e.g. no a/c off – max AS4755.3.1, Demand Response Mode 2 only).

Figure 1. Carseldine residential (Stage 1) – subdivision aerial view, red boxed area

Figure 2. Electrical underground construction plan – Stage 1 homes fed from Distribution Transformer SC2221452 (500kVa)



6 GENERAL FINDINGS

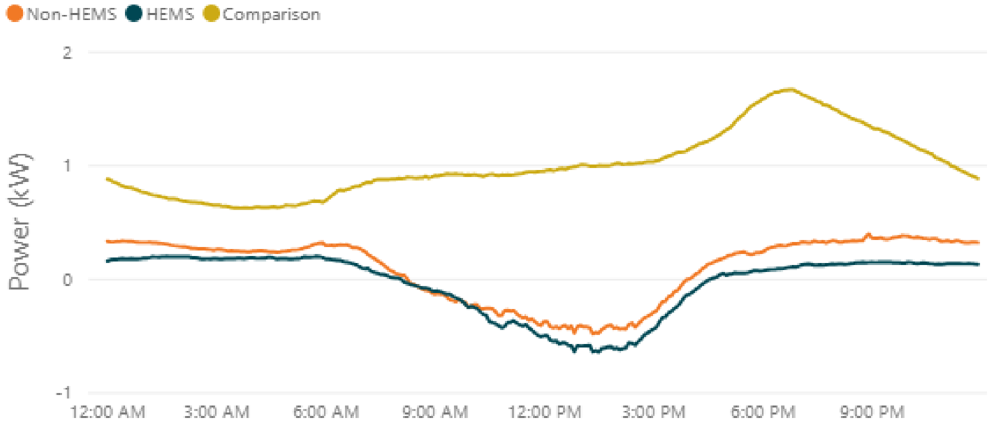
Prior to Energex calling any events, it was important to establish baseline data to allow comparison between the HEMS and non-HEMS energy profiles. Comparison to similar sub-divisions (terraced homes within the greater Brisbane area) as a control group was also included. The control group was without the stringent building envelope requirements - in effect a normal sub-division. The control group, comparison sites consist of 192 two-bedroom townhouses developed in the last 5 years for Smart Meter data (one site in Kallangur and the other in Nudgee) with no solar or batteries connected. It does not appear that reticulated gas at either site, but some homes do have gas for cooking (probably bottled LPG), and potentially for hot water.

The Evergen HEMS was programmed with customer retail tariffs and was able to actively access the customers' batteries for best use of stored energy compared to those tariffs.

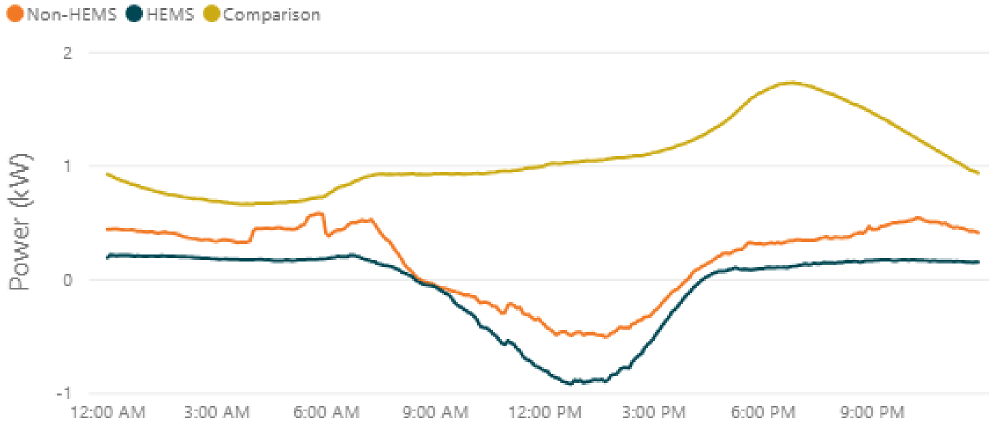
Smart meter data for the four seasons in 2024 shows a consistency of the daily load profile across each comparison customer sets, with the Carseldine customers showing a marked difference to the Comparison, control group. Of interest is the more pronounced load profile (though still small) in the early morning (4am) for the non-HEMS customers in Winter, Spring and Summer that is not evident for HEMS customers. This is illustrated in Figure 3 (following page). While it is not confirmed what is causing the variance for non-HEMS customers, HEMS customers at the same time are experiencing increases in air conditioning use (WattWatcher data). Evergen data shows the battery is discharging for HEMS customers to meet this early morning demand.

Figure 3. Smart Meter average daily load profile data (by season)

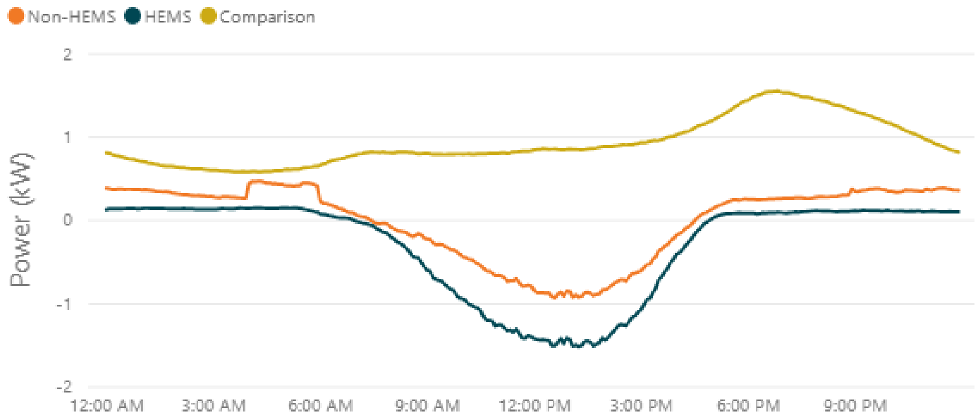
Autumn 2024



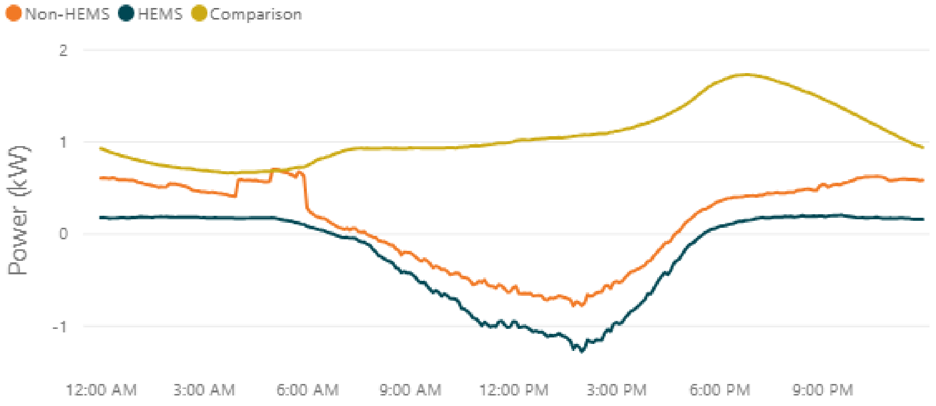
Winter 2024



Spring 2024



Summer (2024/5)



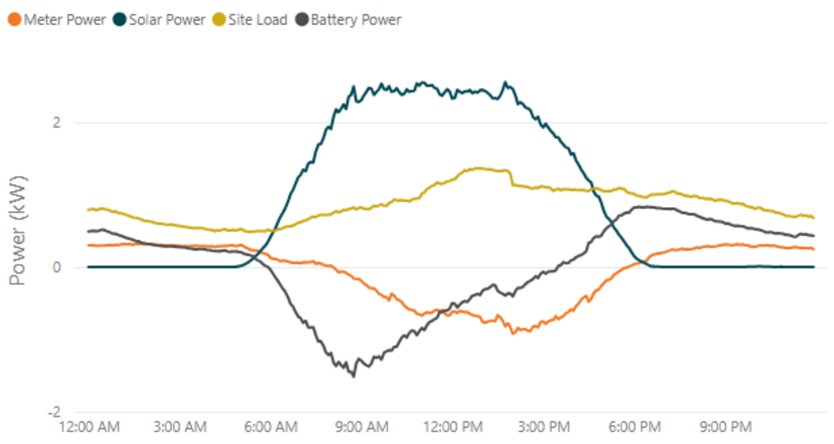
PV generation across the homes in Stage 1 were not unduly influenced by their orientation or angle. All PV was installed on skillion (flat, low angle) roofs that meant solar irradiation for generation across the day was similar on all PV.

On average, the HEMS participants present a lower demand to the network than the non-HEMS customers. It needs to be noted that this is "on average" and there are times when they have greater loads or export less to the network than their non-HEMS counterparts. However, in general terms, the BESS for all Stage 1 premises are fully charged early in the day with PV generation and the management of the BESS by Evergen, in line with HEMS customer tariffs, is seeing that on average they present more favourably to the network for peak demand periods than non-HEMS customers.

6.1 Impact on network peak demand

Figure 4 shows BESS contributing significantly to reducing network peak demand for HEMS participants by supporting the average site load from 5.15pm onwards. The maximum site demand on average at 5.30pm is 1.08kW, with PV and BESS combined supplying 0.96kW.

Figure 4. Evergen average day data (2024)



Under these HEMS conditions, the average BESS has 5.7kWh charge available at 9pm (Figure 5).

Figure 5. Average battery state of charge – daily profile (2024)

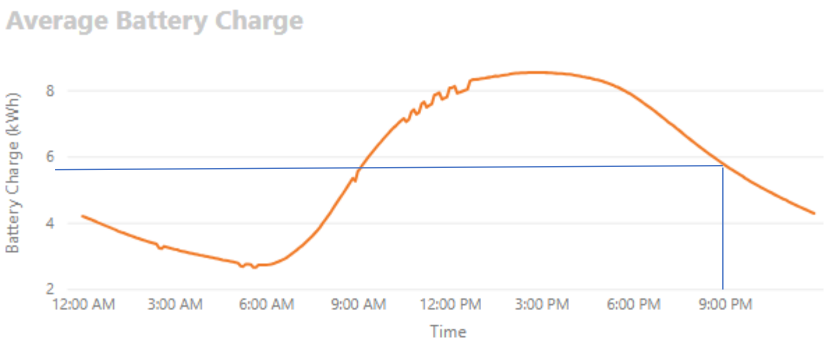
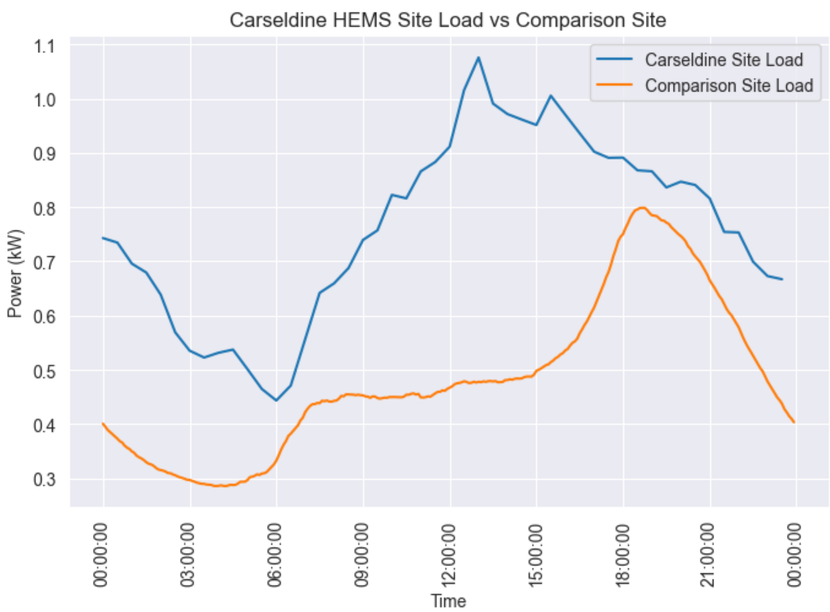


Figure 6 compares HEMS household consumption vs the comparison sites.

Figure 6. Diversified site load for Carseldine -v- Comparison Control Group (February 2024)

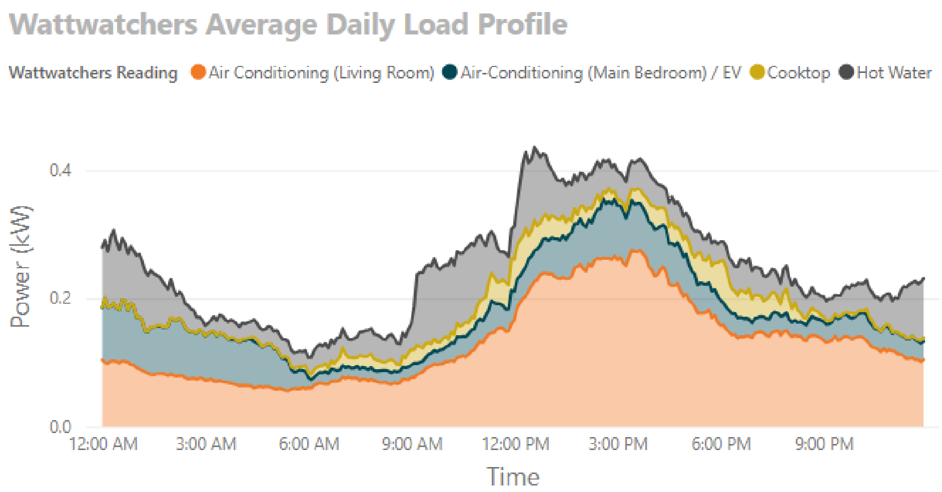


The average site load at Carseldine is higher than the comparison control sites (where LPG for hot water and cooking can be present). The higher load in the HEMS households can possibly be explained by the increased electrification of these residences (Air conditioning in every room, heat-pump hot water and electric cooktops). The smaller sample number of Carseldine customers may also have an effect on the comparative site loads. The extent of the use of gas at the comparison control group is not known.

WattWatcher data was assessed early on in the program and found to have some inconsistencies and issues with robustness. The installers had to return to relocate monitoring equipment onto the correct circuits but even then, full confidence in the circuits being monitored is still wanting. With the only electrical product under management being the BESS by Evergen this was not a significant issue. However, where appropriate, WattWatcher data has been included in this report, but network is more concerned with aggregate data outcomes.

An example of WattWatcher data is in Figure 7 and is indicative of the loads under observation. Without heat pump hot water under management for HEMS participants there is an opportunity that it is still presenting during peak demand times (no secondary load control tariffs were in place) and, as such while demand is low an opportunity exists to lower peak demand further.

Figure 7. WattWatcher data – average daily load profile of given circuits.



For HEMS participants, events on 4 and 11 March 2024 (and to a lesser extent 24 January 2025) demonstrate a perverse outcome from a peak demand perspective. With poor solar charging prior to the events, Evergen called upon network supply to have the BESS charged appropriately to meet the event requirements. This forced a network demand peak. While this coming together of poor weather and a network event would be rare, poor solar charging combined with a time of use (ToU) evening peak or cost-reflective retail rate could easily trigger a mass of managed BESS to be charged from the network on a regular basis[2]. There is a fine line to tread here though; any undercharged BESS that a customer relies upon to counter cost-reflective retail tariff rates could inflict an unexpected, network induced cost on the customer if the shortfall in stored energy is due to an import limit dynamic operating envelope signal.

7 ENERGEX EVENT REQUESTS AND OUTCOMES

Between 6 February 2024 and 24 January 2025, Energex requested of Evergen 13 network support requests; for both peak and minimum demand. Weather conditions expressed for the day of any event represent the temperature or otherwise as close to the event time as possible (source: Bureau of Meteorology, Brisbane Observations).

Events were separated for specific periods of the year: summer to evaluate impacts on peak demand and then spring and autumn which are associated with maximum rooftop solar generation and so minimum demand. Winter is not associated with peak demand or maximum generation and so no events were called during this period of the year.

[2] Further exploration of randomised start for residential BESS charging and/or dynamic operating envelopes, could yield greater understanding of the network and customer impacts

For the network called events different lead times for notice to Evergen (who would be managing the response to the events request made), event times of day and duration of event. This allowed us to evaluate the differential between outcomes and, to some degree, the diversified maximums and minimums that could reasonably be expected. It is noted that the sample set of participants is small, and some bias could possibly be seen in in the data presented. Detail of all the called events can be found in Appendix 2.

7.1 SUMMARY OF PEAK-DEMAND EVENTS

For peak-demand events the request form the network was to maximise peak demand reduction available from all energy under management. In practice the BESS was the only appliance under management. In assessing the overall impact of HEMS participant households, non-HEMS households and the comparison control group, the response to the events of the HEMS participants is compared in Table 4. The events with 24-hours' notice (or lead time) deliver the greatest value (on average) in respect to reducing peak demand, whether one hour or two hours in duration. The earlier the event is called (event 10), the opportunity to take advantage of solar generation too is quite apparent.

Table 4. Summary of peak demand events - comparison

				HEMS participants			Non HEMS participants	Comparison (control group)
Event	Summary details	Duration	Notes	Maximum peak impact (kW exported)`	Household load (kW average)#	Customer diversified load (max. kW)`~	Maximum peak impact (kW)	Maximum peak impact (kW)
2	12 Feb 24, 5-6pm	1 hour	24 hour notice	**-1.81**	1.17	2.98	**0.43**	**1.65**
3	22 Feb 24, 5-6pm	1 hour	24 hour notice	**-1.82**	1.37	3.19	**-0.14**	**1.66**
4	4 Mar 24, 5-6pm	1 hour	24 hour notice	**-1.24**	1.27	2.51	**0.56**	**1.66**
5	11 Mar 24, 5-7pm	2 hour	24 hour notice	**-1.48**	1.03	2.51	**0.53**	**1.74**
10	16 Jan 25, 3.30-5.30pm	2 hour	24 hour notice, early event, solar assist	**-2.33**	1.72	4.05	**0.36**	**1.55**
11	22 Jan 25, 5.30-7.30pm	2 hour	8 hour notice	**-0.8**	2.04	2.84	**1.11**	**1.74**
12	23 Jan 25, 4.30-6.30pm	2 hour	8 hour notice	**-1.65**	1.36	3.01	**-0.26**	**1.72**
13	24 Jan 25, 4.30-6.30pm	2 hour	8 hour notice	**-1.18**	1.67	2.85	**1.15**	**1.73**
Diversified Average				**-1.54**	**1.45**	**2.99**	**0.47**	**1.68**
Net differential HEMS/Non-HEMS homes -v- Comparison control group				-3.22			-1.21	
Net differential for HEMS homes -v- non-HEMS				-2.01				

Average across the duration of each event (Evergen data observed)
` Smart Meter data

Not unexpectedly, when a shorter lead time is given, it is potentially the more difficult to attain the same level of response as when 24-hours' notice is provided. However, as can be seen in event 12, when the battery can get to full charge, significant results can still be achieved.

NOTE: the maximum peak impact figures and loads in Table 4 are not necessarily representative across the duration of the event.

With most events seeing an initial maximum impact from the BESS that then decreased over the duration of the event, it could be said that if other loads were able to be managed in coordination with the BESS discharge, that its value would be extended for far longer for the event or, for the same result. It could also mean its discharge is less and it is more able to cope with loads over-night and charge from a higher SoC the next morning. Overall, the results for peak-demand reduction were very satisfactory.

Comparison in Table 4 does show a generally lower contribution to peak demand by the control group (1.3kW less) than the HEMS customers diversified maximum load (without BESS support) during peak events. This would indicate that other energy sources might be available for the control group customers – potentially gas cooktops and hot water.

7.2 SUMMARY OF MINIMUM-DEMAND EVENTS

The same outcome for response to minimum demand events was not achieved. Event requests sought to stop export from behind the meter generation, while allowing in home use.

Evergen were only able to manage the import and export of the BESS, not the generation capacity of the PV. So, to minimise export during the requested time, they discharged the battery just prior to the event so that it was then able to absorb as much solar energy as possible during the events period. There is no demonstrable reduction in export compared to the non-HEMS customers during the event period. This shows that the emptying of battery stored energy is not enough to counter the solar generation. The average discharged energy per home was 30 minutes of 2kW = 1kWh (10%) of a 10kWh battery. The PV generation capacity far outweighs the recharging of the BESS and the net impact is that the “stop export back to the network” is not achieved.

8 CONCLUSIONS

The Energex experience from involvement in the Stage 1 of the Carseldine Village residential sub-division has seen not only the improvement of the aggregate impact on the network of actively managed BESS behind the customer meter.

While there is a benefit of the energy efficiency of the building envelopes of the build environment compared to a control group of similar homes that is largely not able to be measured directly from a network perspective. The inclusion of energy efficient heat pump hot water (traditionally one of the larger demand loads in a home) and latest technology air conditioning solutions make a significant difference to the demand within the home; the inclusion of export limited generation with managed BESS solution has been a major difference in influencing network demand. The ability to export more when wanted by the network may also be advantageous.

Active management of PV generation is a requirement if we are to have the impact of minimum demand on the network mitigated. A previous network trial[3] had explored the impact of directly managing the generation of the PV and introducing loads to reduce export. Extracts from the trial’s final report are provided in Appendix 3.

The results for response to network-called, peak demand events are evident and significant through the managed discharge of the BESS; 1.54kW from discharging BESS, meaning that the network only needs to support 1.45kW of diversified load per customer. Should the air conditioning have been under effective HEMS management too, the prospect of a greater beneficial peak demand outcome would have been achievable (see Appendix 2 for reflections of PeakSmart events to which all homes in Stage 1 were participants). Management of hot water would have also been useful; WattWatcher data shows all but two homes presenting hot water as a load during peak times (an average demand of 0.50kW in summer; not their electric element boost) across the program[4]. Even though these are heat pump hot water systems and perform best during the warmest parts of the day, not having this load present at peak times is preferable.

[3] Energy Queensland network report: *Market Delivered Demand Response Pilot (January 2022)*
[4] *Race for 2030: Theme 4 Carseldine Living Laboratory – Energy Industry Impact Report. Section 4.3*

The results from Carseldine Village, when effectively only having BESS under management, would indicate that active management of more CER more broadly would be very beneficial to a network. However, caution also needs to be exercised in that the primary benefit for accessing CER should be direct to the customer. Managed CER should always take account of the customer retail tariffs and potential earning capacity in the electricity market. Should the network call events for its own benefit that might be prejudicial to a customer advantage then the customer would need suitable compensation to negate that loss.

While peak demand appears to be significantly improved compared to a normal residential sub-division, more work is required to assert the true impact that Carseldine Village is demonstrating.

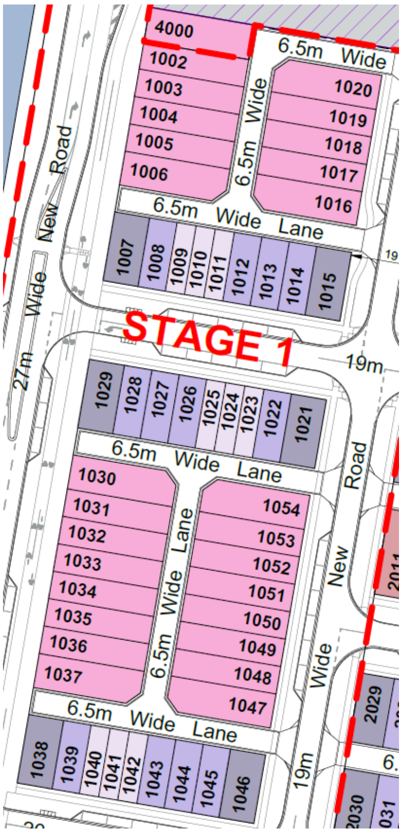
9 RECOMMENDATIONS

With a small cohort of participants and the limitation of only managing generation and load of the BESS, further research of a larger participant group with more orchestrated loads to generation is required. It will more clearly identify which customer cohorts will benefit from a HEMS sufficiently to offset potential upfront costs and maximise their value from both market and network opportunities.

It is recommended that the market and policy makers promote connection of dynamic connections to allow for greater export of generation if required by the network while also helping to manage unintended consequences of market vagaries. Dynamic connections remove the need to impose fixed export limits. The more CER (generation and loads) accessible for orchestrated management by an Aggregator within a dynamic connection, the greater flexibility for the customer and their aggregator to respond to and benefit from external influences (retail tariffs, wholesale market pricing, FCAS and network called events).

10 APPENDICES

Appendix 1 – Carseldine Village Stage 1



HEMS participants (23 – one has added extra solar, orange rectangle overlay)
Courtyard = 6 (additional exposed western wall)
External western facing wall = 9
End of terrace = 6
House & Solar orientation (all skillion roof, no solar framing)
N/S = 12
E/W = 8

Non- HEMS participants (32)
Courtyard = 11 (additional exposed western wall)
End of terrace = 8
External western facing wall = 19
House & Solar orientation (all skillion roof, no framing)
N/S = 11
E/W = 19

Orientation, within terrace or corner block seems to make little difference to the solar generation (due to the very low pitch of the rooves of all the homes) nor the energy use.

Appendix 2 – Detail of individual network called events (peak and minimum demand)

1. Summer: Feb 2024 – March 2024

Event 1

Peak Demand signalled event
Date: Tuesday 6 February, 24-hour lead time
Time: 17:00 – 18:00
Request: Provide network support
Aggregate Quantity: Maximum available from air conditioning at DRM2 (50% reduction of label rating).

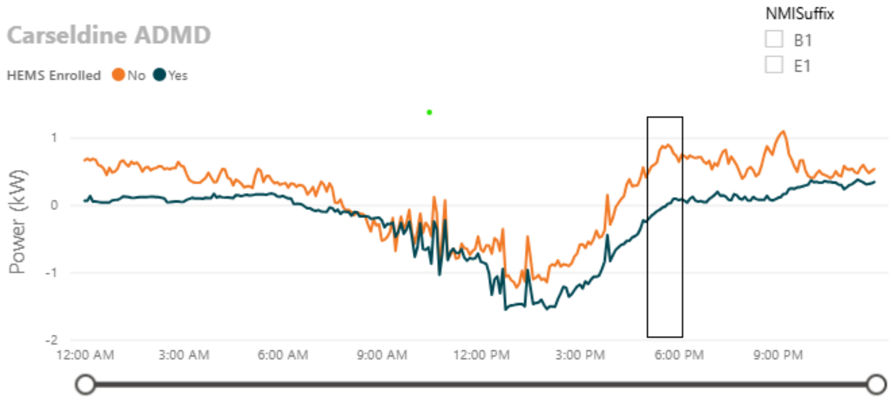
Evergen intent:

Set all online aircon to DRM2 (50% capacity) between 17:00-18:00

Reasoning - for the first test we want to ensure commands can be sent to all Daikin units - so best to attempt to control all assets regardless of if the house is already a net exporter during event time. Figure 8 shows the outcome from the event.

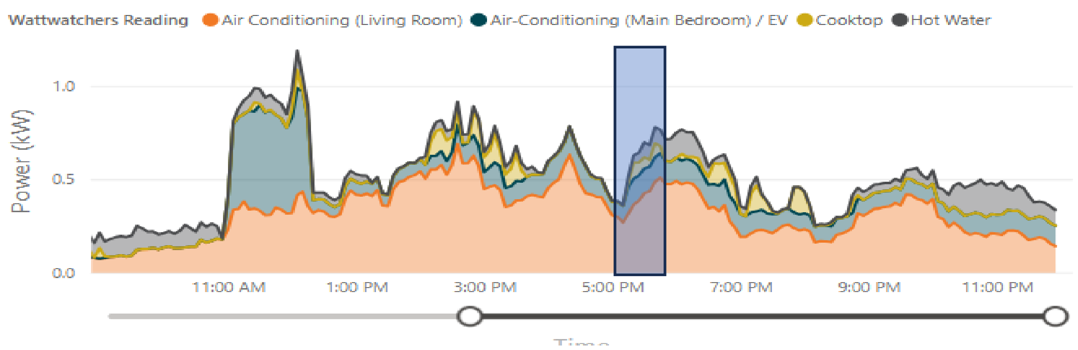
- 3 a/c seemed to have responded 3120789807, 3120764411 (more than 50%), 3120764417
- 9 did not respond
- 9 were not on at the time of signalling.

Figure 8. Smart meter data (net import/export)



WattWatcher data for event 1 (Figure 9), other than an initial, small dip in demand for 10 minutes doesn't show any demonstrable value for managing the living room air conditioning in DRM2.

Figure 9. Living-room a/c data (aggregate of HEMS customers – 6 Feb)



Event 2
Peak Demand signalled event
Date: Monday 12 February, 24-hour lead time
Time: 17:00 – 18:00
Request: Provide network support
Aggregate Quantity: Maximum reduction available from all energy under management (separate a/c data from solar/BESS data).

Evergen intent (21 participants)

Solar/BESS:

- Scheduled Charge command to the Carseldine HEMS list - 105kW from 14:00 - 15:00 to ensure all BESS are available for the peak demand delivery
- Scheduled Discharge to Carseldine HEMS list – potential for 105kW from 17:00-18:00 pending other loads in the homes at that time.

A/C:

- Set all online aircon to DRM2 (50% capacity) - 17:00-18:00
  Following Event 1 ensuring commands were sent to Daikin units was seen as necessary.

Figure 10. Smart meter average data (net import/export) – 5 air conditioners unable to respond

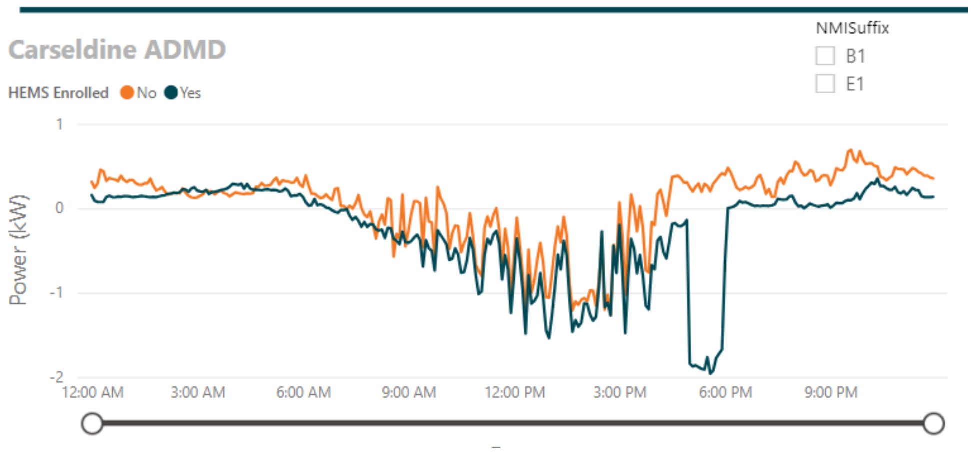
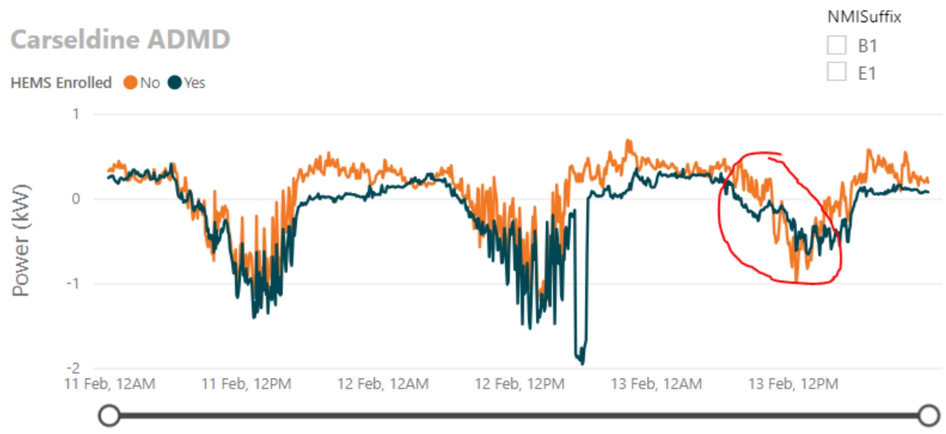


Figure 10 illustrates an average of 1.9kW export per home = 40kW net export. From the potential of 105kW, this suggests aggregate loads in the homes was a sustained 65kW (or 3kW average).

Figure 11 (following page) may illustrate the HEMS battery recharging "harder than the non-HEMS customers" following the load discharge the previous day. At 6am on the day of event 2 the BESS had 2.77kW of stored energy. At that time the day after event 2, the BESS had 1kW of stored energy.

Figure 11. After Diversity Maximum Demand for HEMS and Non-HEMS sites



Non-HEMS households in general are using slightly more energy than their HEMS counterparts. It is not known why.

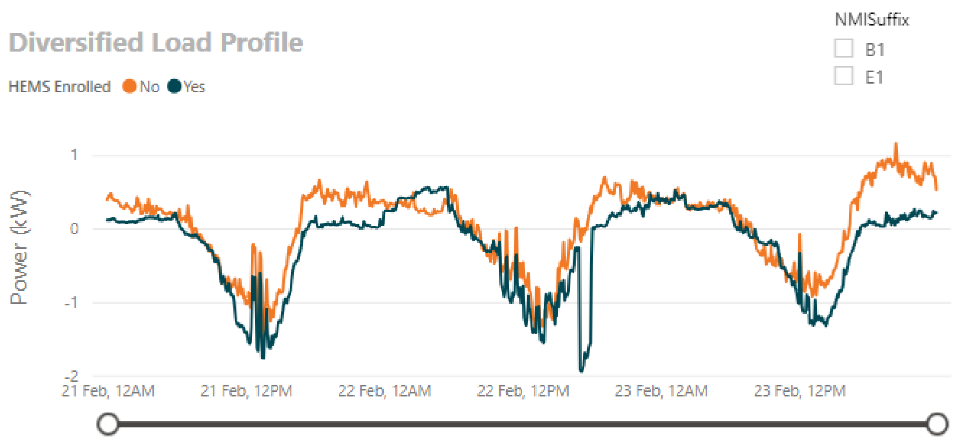
Event 3

Peak Demand signalled event
Date: Thursday 22 February, 24-hour lead time
Time: 17:00 – 18:00
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management (separate a/c data from solar/BESS data).

This date was chosen as it is anticipated that there will be multiple days prior of poor weather (rain and cloud cover) and if this impacted the BESS ability to support the network.

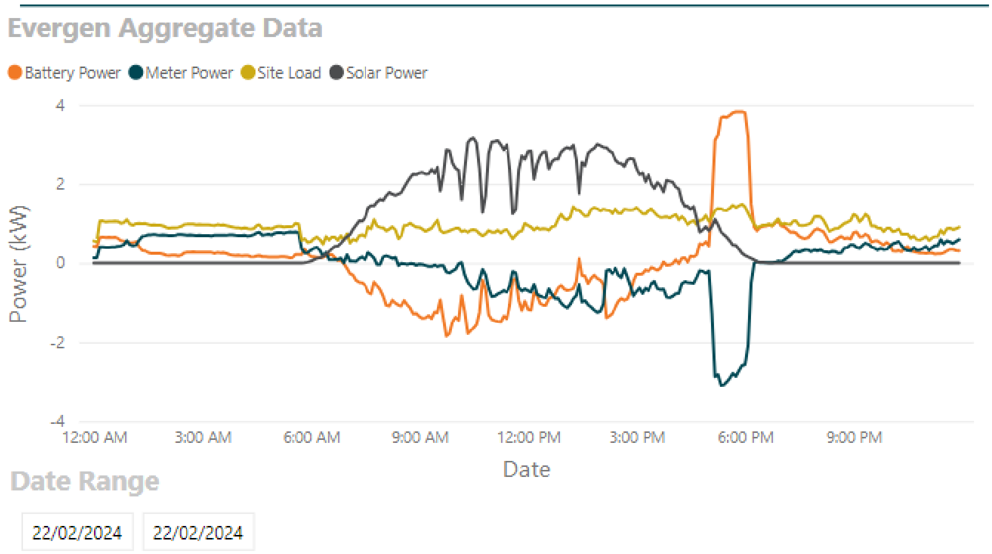
Weather day prior; light cloud but predominantly sunny day. 31^{0}C max.
Weather day of; light cloud but predominantly sunny day. 31^{0}C max
Weather day after; light cloud but predominantly sunny day. 32^{0}C max

Figure 12. Smart Meter data



The Smart Meter data in Figure 12 suggests that the BESS were able to support the network request with PV adequately charging the BESS by 3pm. While network support was almost as good as event 2, over the duration of the event the BESS support did decline. However, this was due to a slight increase in household load 15 minutes into the event (as can be seen in Figure 13), predominantly through air conditioning (in both living space and main bedroom as well as cooktop use – from WattWatcher data).

Figure 13. Evergen Aggregate data – event 3



Support shown to be from consistent battery discharge during the event itself. Solar generation charging the battery during the day adequately in time for the network support requested.

Event 4

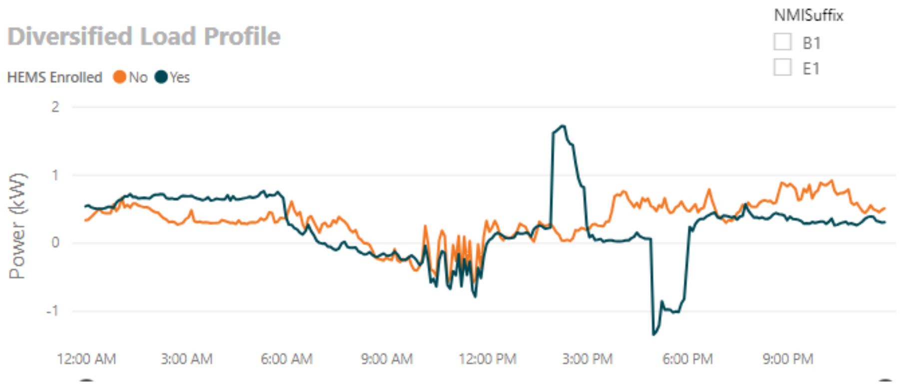
Peak Demand signalled event

Date: Monday 4 March 24-hour lead time
Time: 17:00 – 18:00
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management (separate a/c data from solar/BESS data)

As event 3, this date was chosen as it is anticipated that the Sunday prior would be poor weather (rain and cloud cover) and if this impacted the battery's ability to support the network.

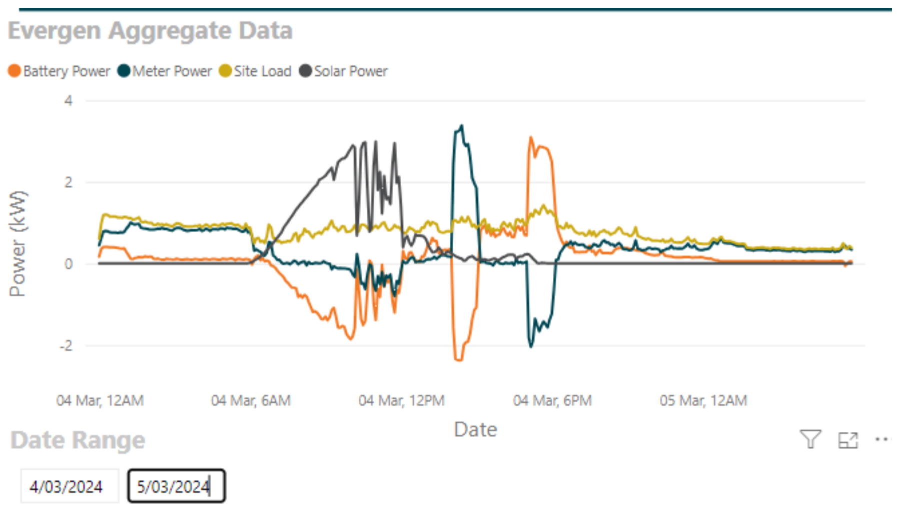
Weather day prior; overcast but predominantly humid day. 31^{0}C max.
Weather day of; sunny morning but cloud from midday and showers from 2.30pm. 31^{0}C max
Weather day after; broken cloud with scattered showers. Max of 25^{0}C

Figure 14. Smart Meter data - event 4



To support the event request, the solar on the day was not able to fully charge the BESS as well as support the participant loads too. The network charged the BESS between 2-3pm (Figure 14 for Smart Meter data and Figure 15 for Evergen data[5]), but even then the BESS average charge was 8.76kW at 3pm and 7kW at the commencement of the event. The BESS was only able to net export an initial maximum 1.24kW and then settling at circa. 0.92kW for the remainder of the event, while supporting a maximum of 1.5kW of load in the homes. Providing as much lead-time to Evergen as possible helped them establish a BESS program to meet the network requirement, while also primarily supporting customers.

Figure 15. Evergen data – event 4



The event support stabilised at 0.91kW export and a net difference of 1.5kW to the non-HEMS customers.

[5] Undiversified network charging of the BESS prior to the event led to a jump in peak demand. It needs to be noted that in such circumstances, staggered charging of BESS well in advance of an event will minimise any impact. The same impact was observed for event 5.

Event 5

Peak Demand signalled event

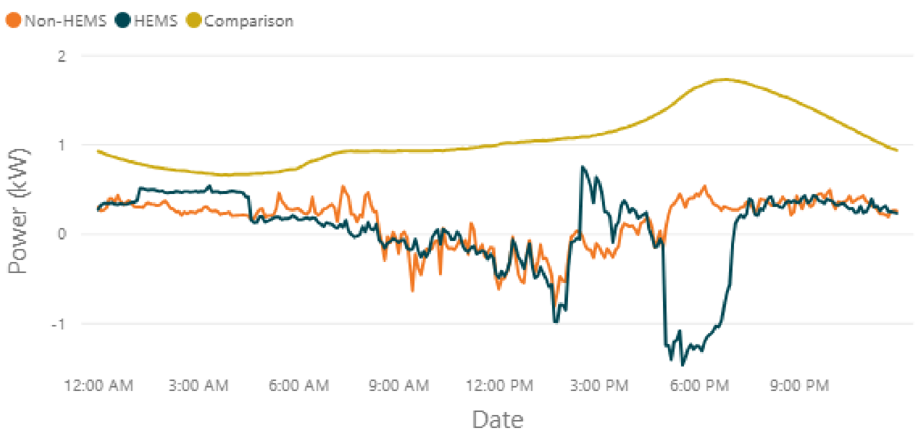
Date: Monday 11 March (advised on 8 March)
Time: 17:00 – 19:00
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management (separate a/c data from solar/BESS data).

Date chosen as it is anticipated that the Sunday prior would be poor weather (cloud cover) and if this impacted the battery's ability to support the network.

Weather day prior; sunny morning then overcast but normal humidity. 23.3^{0}C max 52% humidity.
Weather day of; overcast and rain (heavy showers) throughout the day. 24^{0}C at 4.30pm, 89% humidity that dropped to 56% by 3pm.
Weather day after; fine weather throughout the day.

A two-hour duration of assistance was requested for this network event and though the batteries had to take network supply to charge between 3 – 4pm (maximum diversified demand 0.75kW), the supply during the first half of the event was circa. 1.2kW export (effectively a 2kW differential) as seen in Figure 16. From 6.05pm (just over 1 hour form the event commencing) the supply from the batteries began to wane and by 7pm barely exporting.

Figure 16. Smart Meter data



However, when compared to non-HEMS customers (Figure 16) the maximum diversified benefit of a managed battery to the network during this event was 1.76kW (5.30pm). When compared to the comparison base the maximum diversified differential is 3kW (5.35pm). Figure 17 (next page) shows the Evergen data and use of the battery to support the requested event.

Figure 17. Evergen aggregate data – grid battery charge 3-4pm

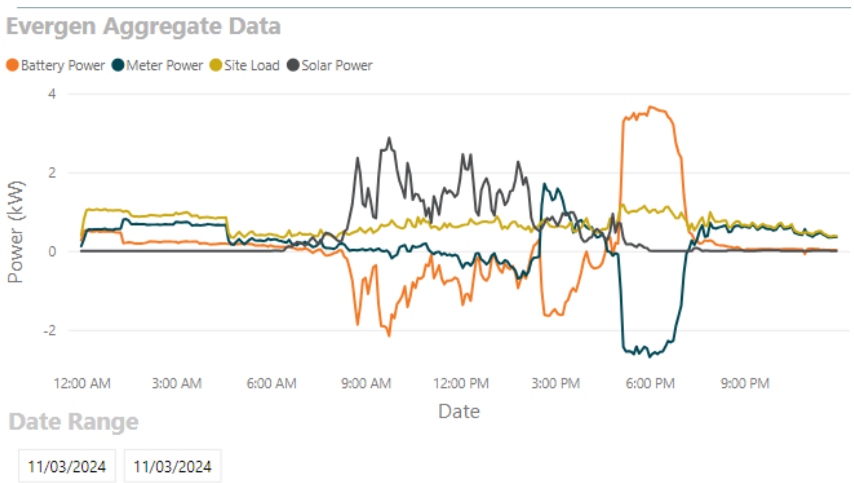


Figure 18. Evergen average battery charge - grid battery charge 3-4pm

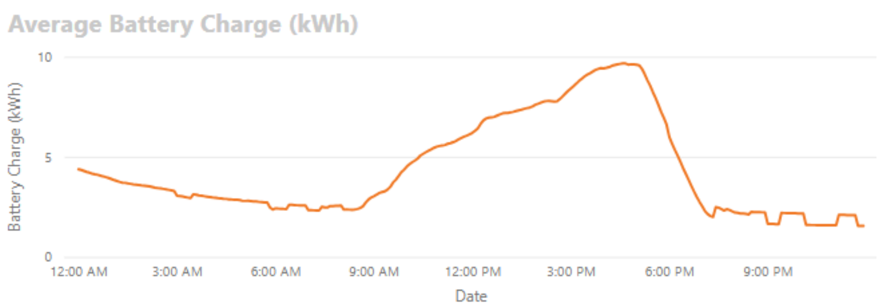


Figure 18 shows the BESS SoC at the end of the event as 1.99kWh.

2. Autumn: April 2024 – May 2024

Event 6

Minimum Demand signalled event

Date: Friday 29 March 2024, greater than 48 hours lead time.
Time: 11:00 – 13:00
Request: Provide network support
Aggregate Quantity: Stop export only

Date chosen as Good Friday, many people away, little load to soak up generation on site.

Weather day prior; broken cloud, mostly sunny, OK solar generation, 28^{0}C max (relatively cool)
Weather day of; broken cloud but bright and sunny until later in the afternoon (after 2pm) 28.8^{0}C max
Weather day after; broken cloud with scattered showers. Max of 28.2^{0}C

Evergen were only able to manage the import and export of the BESS, not the generation capacity of the PV. So, to minimise export during the requested time, they removed stored energy from the battery so that it was able to absorb as much solar energy as possible during the requested event period. The battery export can clearly be seen prior to 11am (Figure 19). There is no demonstrable reduction in export compared to the non-HEMS customers during the event period. This shows that the "dumping" of battery stored energy is not enough to counter the solar generation. The average dumped energy per home was 30 minutes of 2kW = 1kWh (10%) of a 10kWh battery. The PV generation capacity far outweighs the recharging of the BESS and the net impact is that the "stop export back to the network" is not achieved.

Figure 19. Smart Meter data

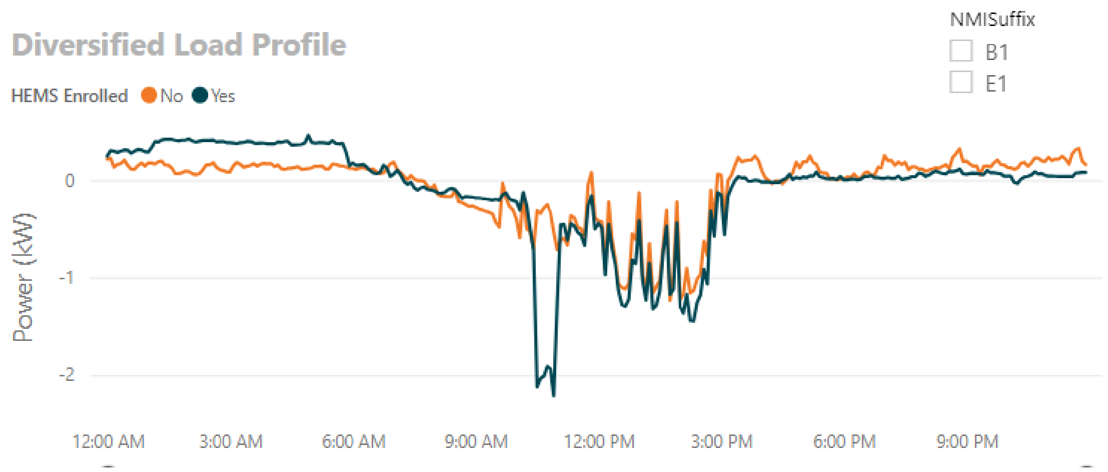
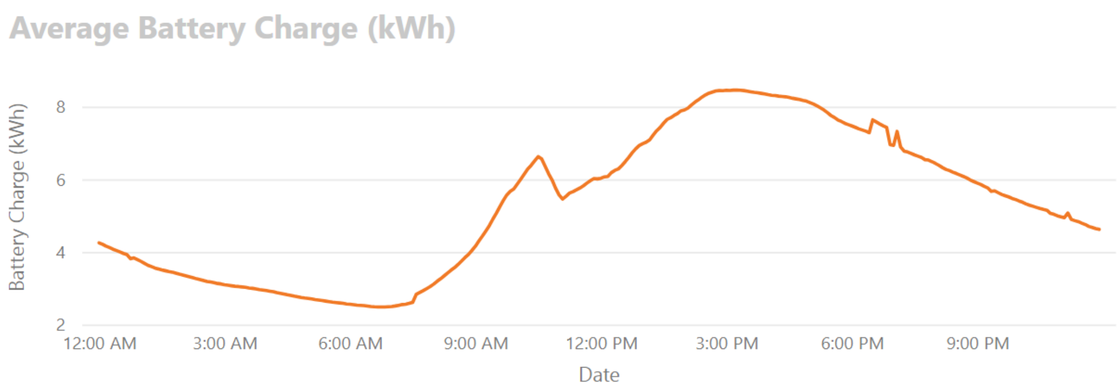


Figure 20 shows the BESS discharge at 11am but the rate of charge recommences at a slower pace than the PV is generating.

Figure 20. Evergen average battery charge



Event 7

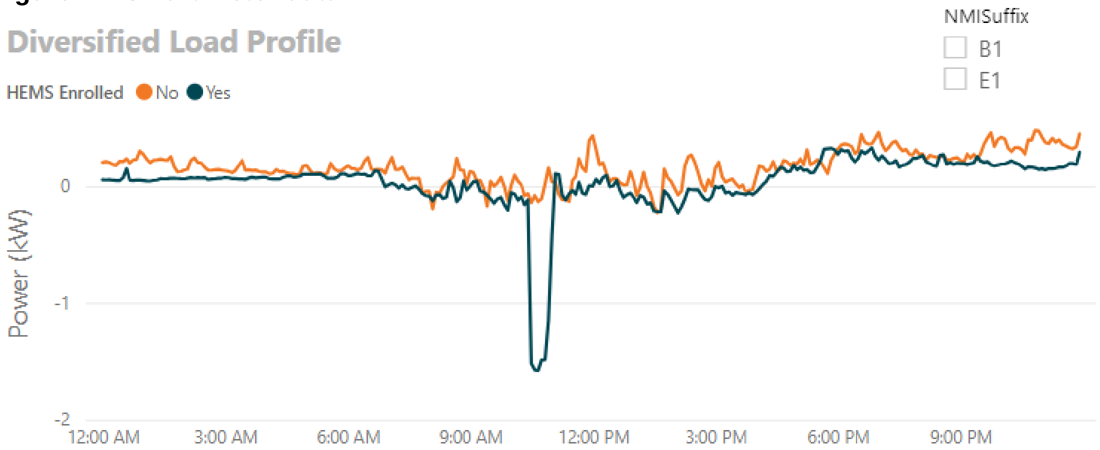
Minimum Demand signalled event

Date: Monday 1 April 2024, greater than 48 hours lead time.
Time: 11:00 – 13:00
Request: Provide network support
Aggregate Quantity: Stop export only

Evergen additional date chosen as Easter Monday, still many people gone away from home, potential for little load to soak up generation on site.

Weather day prior; plenty of broken cloud, mostly sunny, OK solar generation, 27.3^{0}C max (relatively cool)
Weather day of; cloudy but bright, 25.8^{0}C max
Weather day after; broken cloud with scattered showers. Max of 28.6^{0}C

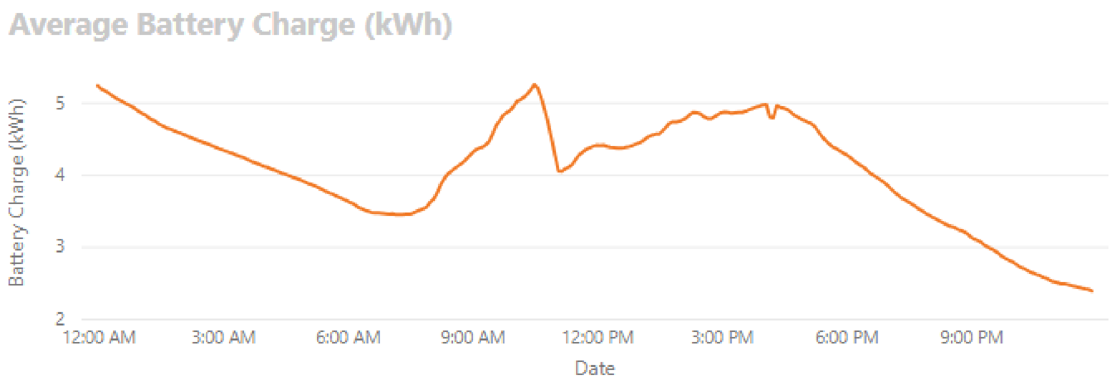
Figure 21. Smart Meter data



With Evergen using the same technique to try to achieve the stop network export, the outcome is far better, but this is more due to the inclement weather and the inability to recharge the battery as quickly from the rooftop solar. Figure 21 shows the PV generation being below normal capacity due to cloudy cover and Figures 22 and 23 (next page) illustrate the utilisation of the batteries prior to and during the event.

Figure 22. Evergen aggregate data

Figure 23. Evergen average battery charge – 10.30am discharge with slow recharge



Event 8

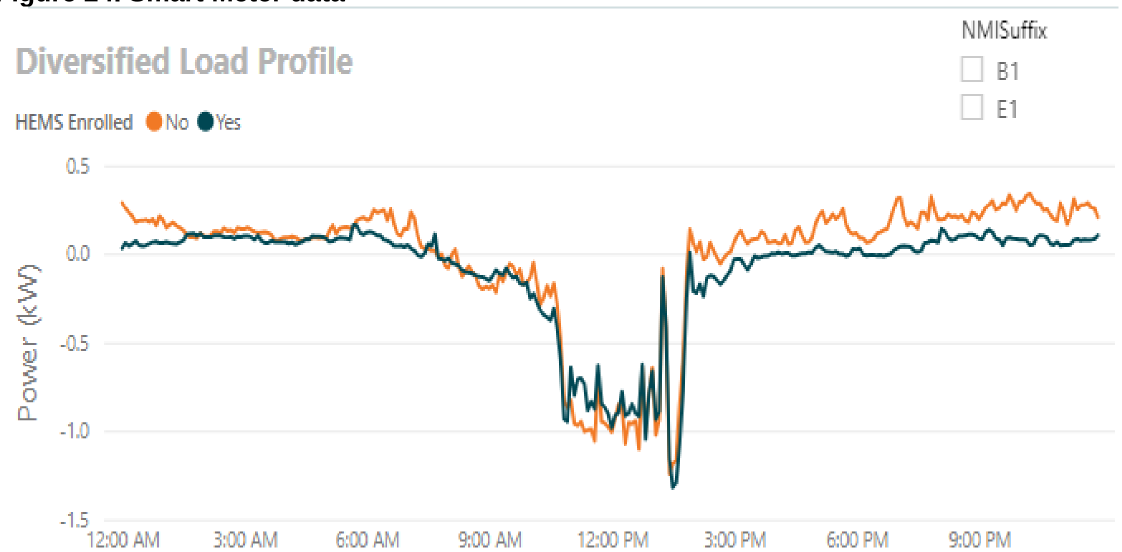
Minimum Demand signalled event

Date: Thursday 25 April 2024, greater than 48 hours lead time.
Time: 11:00 – 13:00
Request: Reduce export to grid
Aggregate Quantity: stop export and bring as much load as possible during minimum demand period.

Weather day prior; plenty of broken cloud, mostly sunny, OK solar generation, 27.^{0}C max (relatively cool)
Weather day of; cloudy but bright, 28.6^{0}C max
Weather day after; broken cloud. Max of 24.3^{0}C

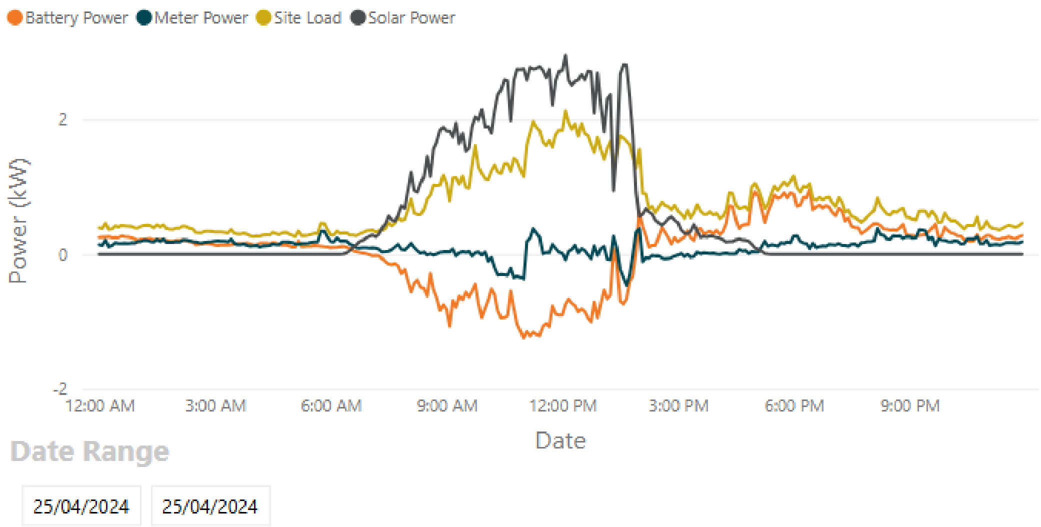
There appears to be no demonstrable activity at the homes of the HEMS enrolled participants by Evergen compared to the non-HEMS customers (Figure 24). As this is ANZAC public holiday in the middle of the week, it is presumed that most participants stayed at home.

Figure 24. Smart Meter data



When looking at the Evergen aggregate data (Figure 25, following page) there is a dramatic increase in customer loads at 11am that lasts until just before 2pm, in which the BESS assists in supporting. Figure 25 presumes that this therefore would be the same for non-HEMS customers also as the graphs coincide so closely.

Figure 25. Evergen aggregate data



WattWatcher data suggest that a sustained jump in air conditioning use was responsible. Though the day was relatively cool at 28.6^{0}C, humidity was at 83% in the morning. This gives an equivalent “feels like” temperature of over 34^{0}C.

Event 9

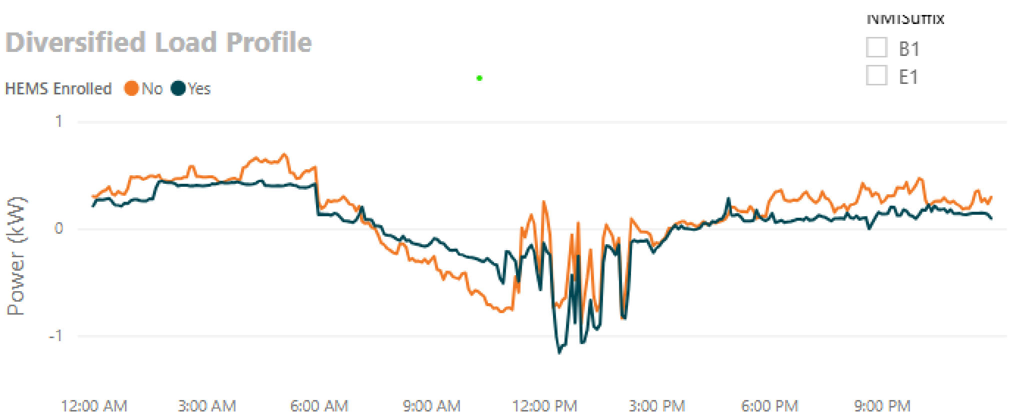
Minimum Demand signalled event

Date: Monday 6 May 2024, greater than 48 hours lead time.
Time: 11:00 – 13:00
Request: Reduce export to grid
Aggregate Quantity: stop export/bring as much load as possible during minimum demand period.

Weather day prior; broken cloud, mostly sunny, OK solar generation, 26.4^{0}C max (relatively cool)
Weather day of; sunny morning, midday a lot of cloud cover 23.6^{0}C max
Weather day after; broken cloud with scattered showers. Max of 28.6^{0}C

Figure 26 continues to illustrate that despite best efforts, use of a BESS to support minimum demand events is limited in effectiveness.

Figure 26. Smart Meter data



The main learning for networks from the minimum demand events are:

- The PV generation capacity needs to be managed and is preferable to use of a BESS to try to deliver value.
- If a BESS is all that is available to mitigate minimum demand then it needs to be discharged to a significant degree if PV generation is anticipated to be high. To prepare for such an event for the HEMS provider may require as much lead-time as possible. However, customer retail tariffing needs to be taken in to account, including feed-in tariffs, as to whether this delivers a good customer outcome.

3. Summer: January 2025

Event 10

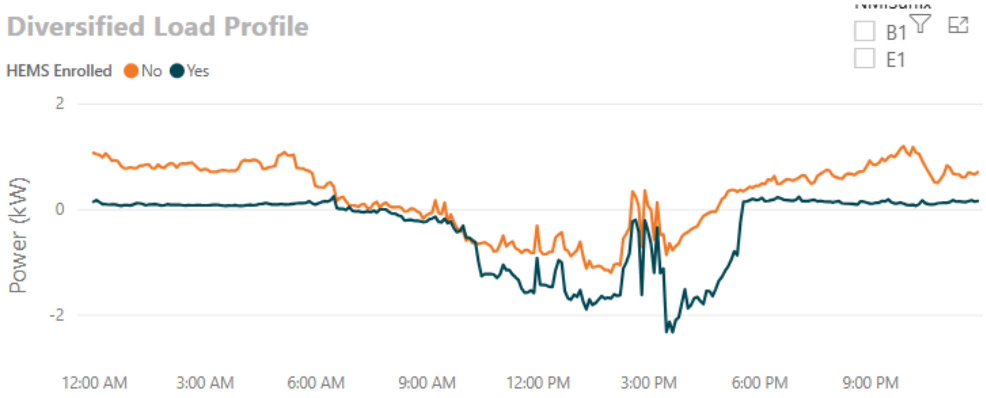
Peak Demand signalled event

Date: Thursday 16 January 2025, 24-hour lead time
Time: 15:30 – 17.30
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management

Weather day prior; plenty of broken cloud, mostly sunny, OK solar generation, 32.3^{0}C max (relatively warm with 60% humidity)
Weather day of; 32.9^{0}C max but humidity of 49% and light breeze
Weather day after; Max of 29.4^{0}C

For those HEMS enrolled customers, a significant contribution to reducing peak demand when requested to discharge is visible (Figure 27). Within 10 minutes however, the HEMS customer contribution to the peak event diminished rapidly and by the end of the event was seeing an export to the grid of 0.26kW.

Figure 27. Smart Meter data



The maximum, diversified impact on the peak was 2.33kW per HEMS customer.

By 1pm the BESS were on average fully charged by the solar (Figure 28), in comparison to event 5 where the full charge took longer (cloudy conditions) and needed augmentation by grid supply at 3pm, prior to the event commencing (Figure 29).

Figure 28. Evergen average battery charge

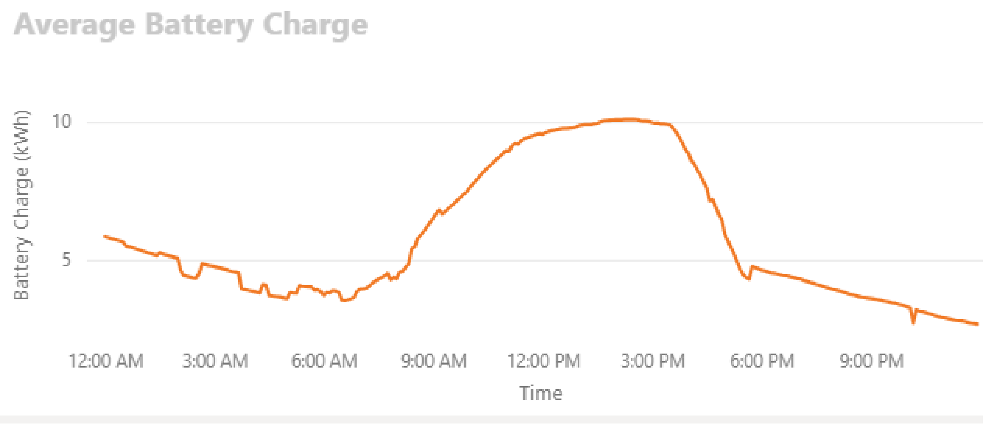
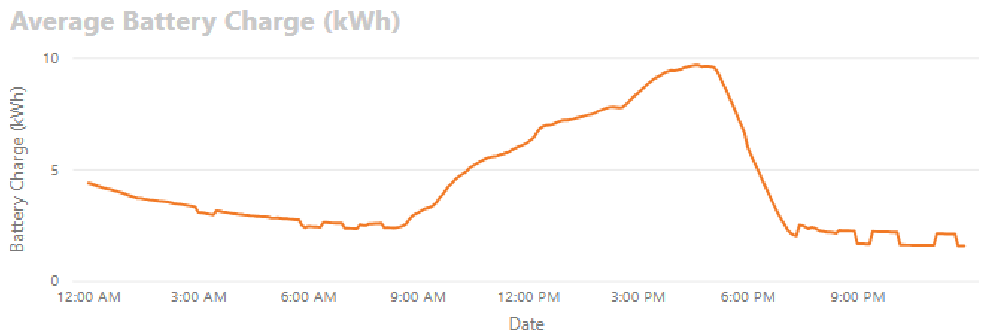
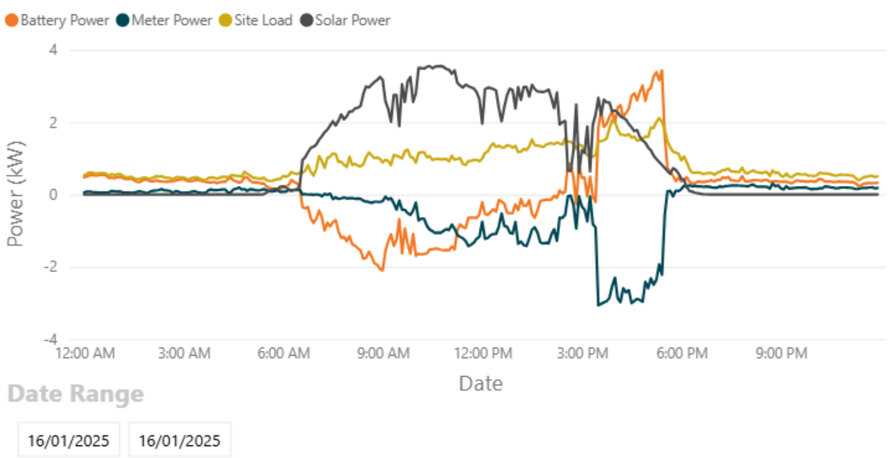


Figure 29. Evergen average battery charge – event 5 comparison



It needs to be noted that the early start to the event also means that there was still significant PV generation at the beginning of the event (Figure 30). This meant that combined the PV and BESS delivery was significant, with the BESS discharging more as the PV generation declined into the evening

Figure 30. Evergen aggregate data



It is important to note that compared to event 5 where at the event finishing the BESS Soc was 1.99kWh, the BESS SoC at the end of event 10 was 4.47kWh.
Events 11 – 13 were called due to a forecast three-day heatwave. The weather conditions forecast for those 3 days were over 32^{0}C each day culminating at 36^{0}C on the Friday.

Wednesday 22 January; 35.8^{0}C max with a humidity of 52% and light breeze (network peak demand day).
Thursday 23 January; 29.9^{0}C max, humidity of 55% and light wind (lower than forecast).
Friday 24 January; 35.4^{0}C max but humidity of 54% and light breeze.

Event 11

Peak Demand signalled event

Date: Wednesday 22 January 2025, 8-hour lead time
Time: 17:30 – 19:30
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management

Event 12

Peak Demand signalled event

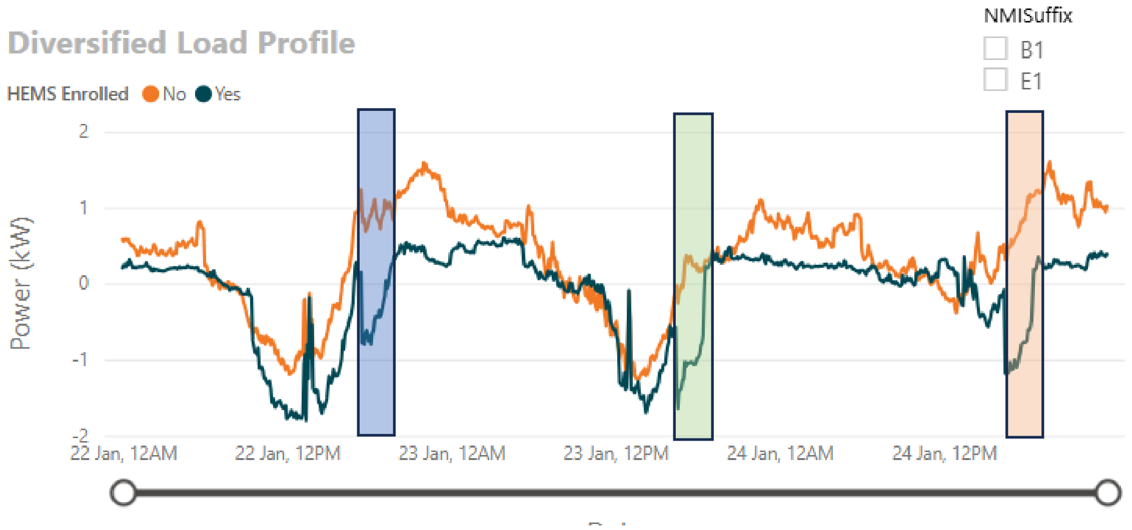
Date: Thursday 23 January 2025, 8-hour lead time
Time: 16:30 – 18:30
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management

Event 13

Peak Demand signalled event

Date: Friday 24 January 2025, 8-hour lead time
Time: 16:30 – 18:30
Request: Provide network support
Aggregate Quantity: Maximum available from all energy under management

Figure 31. Smart Meter data



For each called event in Figure 31:

22 January, 5.30 – 7.30pm (light blue); the initial net impact of the BESS discharge was 0.93kW, but by 7.30pm the load on the network was the same at the beginning of the event. This suggests that while maximum export was almost 1kW, other loads in the home were using the BESS reserves first.

23 January, 4.30 – 6.30pm (light green); this cooler day meant that the electricity demand within the household were less and by the time the event was called, the HEMS homes were still net exporting (0.57kW). At the initiation of the event, export rose to 1.65kW but quickly dropped to 1kW within 40 minutes which was sustained for the remainder of the event (1 hour and 20 minutes).

24 January, 4.30 – 6.30pm (light orange); while being a hotter day than for events 11 and 12, and the third in a heatwave, the HEMS households were marginally net exporting for a couple of hours prior to the event being called. At the event commencing, export increased by 1.10kW from (0.08kW). This export stayed level for the first hour of the event but, as with event 11, the export quickly faded as other loads in the home took precedence to direct network support.

Figure 32. Evergen aggregate data

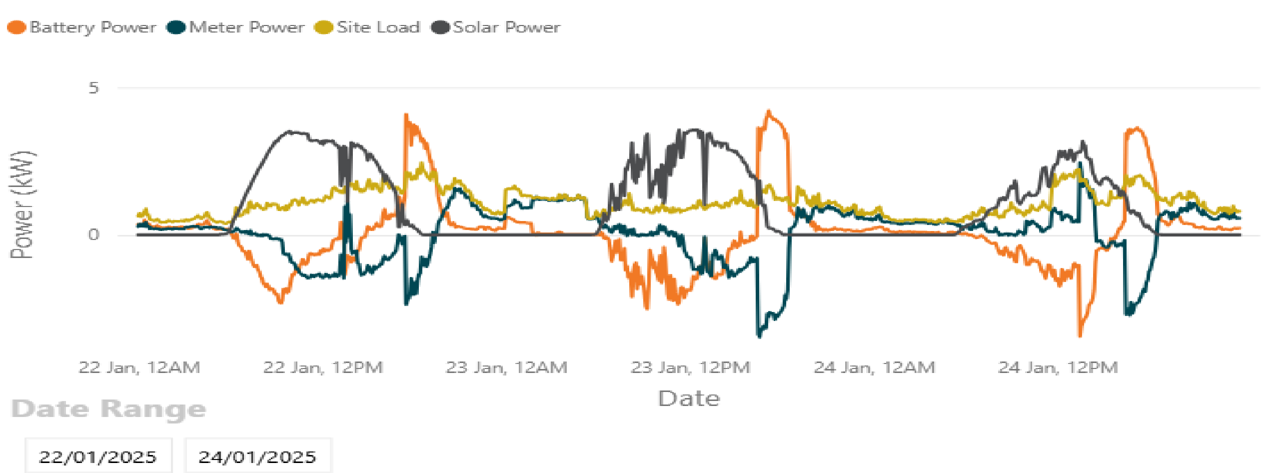


Figure 33. Evergen aggregate battery charge

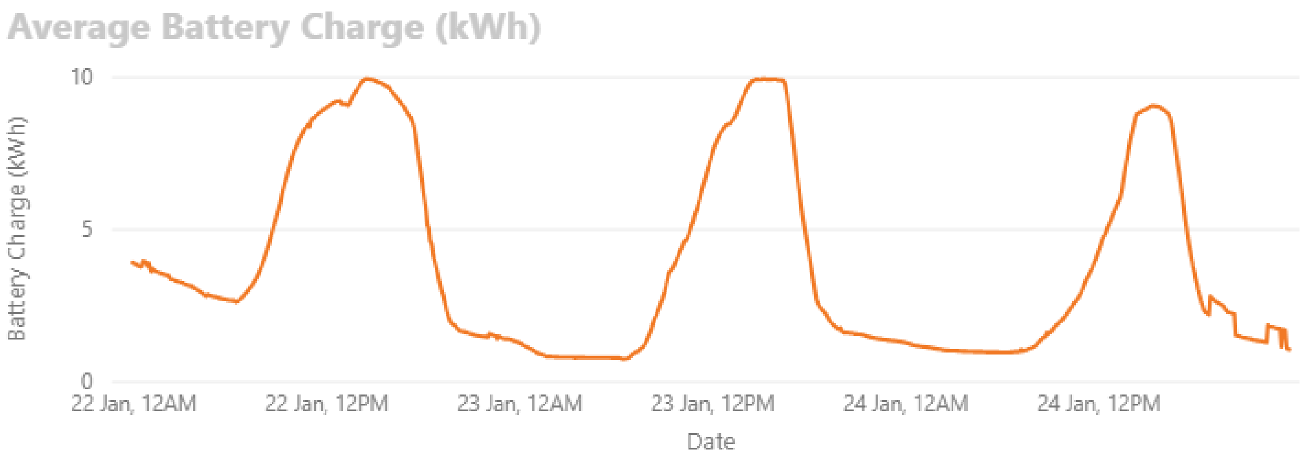


Table 4. HEMS battery state of charge over three-day event program

Date	Start of battery charge SoC	When battery SoC full*
22-Jan	6.35am, SoC 2.62kW (26%)	2.35pm, SoC 9.91kW (99%)
23-Jan	6.35am, SoC 0.72kW (7%)	2.50pm, SoC 9.91kW (99%)
24-Jan	6.50am, SoC 0.94 (9%)	3.20pm, SoC 9.2kW (92%)

*Usable battery power

Over the period of the three-day event the batteries performed well in delivering relief to the network, certainly for the first hour of each event. On the second day recovery of state of charge means starting from a significantly lower base but good solar irradiation supported a full charge well in advance of the event itself (1 hour 30 mins). Day three saw lower solar generation and as such was not able to bring the battery to full charge by the time of the event (some grid support was needed at midday to get it to 92% SoC ready for the event). This is represented in Table 4 above.

Appendix 3 - PeakSmart Event analysis

All homes in Stage 1 were included into the PeakSmart program at time of build. Table A shows WattWatcher data to illustrate the individual air conditioner response to the PeakSmart signal. Table B shows the overall impact to the network of initiating a PeakSmart event when other loads will also be at play.

Table A

PeakSmart Event				HEMS customer WattWatcher Data air conditioner (kW)		
Date	Time	Duration (hrs)	DRM	event start (ave.)	end of event (ave.)	Comments
22-Jan-24	4.20pm	2.5	2	0.81	0.3	Steady decline over duration of event greater than a 50% DRM 2 called
27-Jan-24	4.20pm	2.5	2	0.47	0.27	Data gaps, but definite drop compared to kW at event start.
27-Dec-24	5.20pm	2	2	0.18	0.13	At event start, load rose to 0.28kW at 5.35pm prior to falling to 0.13
28-Dec-24	4.20pm	2.5	2	0.5	0.25	Marginal load decline until 5.35pm when it dropped to a steady 0.25kW
22-Jan-25	4.20pm	2.5	2	1	0.7	Dropped to 0.7kW to 5.45pm, rising to 0.89kW at 6.35pm and dropping to 0.7kW
23-Jan-25	4.20pm	2.5	2	0.4	0.35	Fluctuated between the start and end kW.
24-Jan-25	4.20pm	2.5	2	0.48	0.52	Fluctuated between the start and end kW, but between 6.10-6.45pm was at 0.56kW.

While WattWatcher data shows some PeakSmart events have had an impact on the average load from the main living room air conditioners, there are load fluctuations during events. This can most likely be accounted for by air conditioners being turned on during the event

Table B

PeakSmart Event				Smart Meter Data (diversified kW)				
				HEMS		Non-HEMS		
Date	Time	Duration (hrs)	DRM	event start	end of event	event start	end of event	Comments
22-Jan-24	4.20pm	2.5	2	-0.16	0.59	0.55	0.59	Steady increase (both groups), with non-HEMS peaking at 1.29kW (5.40pm) before dropping
27-Jan-24	4.20pm	2.5	2	-0.01	0.2	0.62	0.93	Steady but fluctuating increase (both groups). Control group sees similar growth (1.26 - 1.73kW)
27-Dec-24	5.20pm	2	2	-0.24	0.04	0.2	0.44	Steady increase (both groups) to 6.15pm plateau. Control group from 1.26-1.73kW
28-Dec-24	4.20pm	2.5	2	-0.7	0.04	-0.1	0.58	Steady increase (both groups). Control group from 1.48-1.69kW
22-Jan-25	4.20pm	2.5	2	N/A due to Carseldine Village Events 11-12		0.14	0.72	Steady increase to 5.25pm, then plateaus. Control group from 1.26-1.73kW
23-Jan-25	4.20pm	2.5	2			-0.18	0.31	Steady increase to 5.10pm, then plateaus. Control group from 1.26-1.72kW
24-Jan-25	4.20pm	2.5	2			0.5	1.22	Steady increase to 5.10pm, then plateaus. Control group from 1.26-1.73kW

When looking at the Smart Meter data and the diversified impact the network sees from a PeakSmart event when other loads are also present, the effect is not so clear. Comparison to the Control Group is also not conclusive as it is not known how many of the control group customers are also enrolled on the PeakSmart program. The average growth in load for the control group over a PeakSmart event is circa. 0.5kW. The HEMS group predominantly see smaller growth than this, but non-HEMS customers see average growth in load similar to the control group, albeit starting from a far lower base.

Appendix 4 – Market-Delivered Demand Response Pilot (2020 – 2022)

The market-delivered demand response program had a participation of 28 active customers. Their respective loads and generation are shown in Table C.

Table C

Having established the deemed kW and dollar value of individual loads and generation for the pilot it was possible to establish group participants into homogenous cohorts: non-solar (2), EV (2), small (8 defined as up to 3kW under management), medium (5 defined as 3 to 3.5kW under management) and large users (11 defined as >3.5kW under management).

Participant Group	Solar~	Pool Pumps*	Electric HW	Air Con	EV	Total cohort	Ave load under mgt (deemed kW)
Non-solar	2	2	1	2		2	2.27
EV	2	1	2	1	2	2	3.43
Small	7	7	6	7		8	2.54
Medium	4	3	4	5		5	3.21
Large	11	9	10	11		11	4.29
Total	26	22	23	26	2	28	3.4

~ Solar PV was deemed as having a value of 1kW for peak demand management for this pilot

*4 customers with pools have 2.4kW pool heaters (these were not included in deemed load under management for this pilot.

A summary of the results from the events that we run are provided in Table D.

Table D

HEMS fleet event outcomes (diversified across the cohort/customer)

Peak reduction range (5-7pm weekdays)	Between 0.90 and 1.2kW

Minimum Demand events	
Solar export reduction (direct inverter management)	1.7kW (3.1kW by signal respondents[1])
Solar export reduction (load increase)	2.3kW (3.3kW by signal respondents)
Solar generation stop	4kW
Solar generation stop/maximum load increase	5.79kW

Directly managing solar generation is very effective. Increasing loads to "solar soak" is also effective, but is less reliable as a mitigant to minimum demand.

Customer energy and bill impacts from having HEMS[2]	Reduces evening peaks by approximately 30% (potentially greater for actual peak demand days – these were unable to be tested).
	Reduced overall grid-supplied kWh by approximately 14%. Two participants without rooftop solar achieved reductions in grid-supplied kWh of 8% and 37% respectively.
	On average reduce customer bills by 19%[3].

[1] Not all households were signalled to respond to the events. The lower number reflects the diversified value across the cohort, the larger number reflects the diversified response of those households that did respond.
[2] Retrospective baselining is only indicative of the value of HEMS and, in this pilot, conservatives that value.
[3] All primary tariff grid-supplied energy was rated at Ergon Energy Tariff 11 gazetted rates.

Appendix 5 – IPDRS Functional Proposal v7

IPDRS Functional Proposal (v7) July 19

Appendix 6 – Basic funding from Energex DMIAM funding

Energex DMIAM Funding for Carseldine Village Project

Incentive Funding	$20,000
Additional Evergen funding	$20,000
WattWatcher support costs	$3,900
TOTAL DMIAM funding	**$43,900**