Smart Solar in Barnsley – an evaluation of 75 Alpha ESS battery installations

Paul Rogers and Michael Hamer

October 2023

Background

National Energy Action is the national fuel poverty charity working across England, Wales and Northern Ireland, and with sister charity Energy Action Scotland (EAS), to ensure that everyone can afford to live in a warm, dry home. In partnership with central and local government, fuel utilities, housing providers, consumer groups and voluntary organisations, NEA undertakes a range of activities to address the causes and treat the symptoms of fuel poverty. Its work encompasses all aspects of fuel poverty, but in particular emphasises the importance of greater investment in domestic energy efficiency.

This evaluation was carried out by the Innovation and Technical Evaluation team at NEA:

Paul Rogers, Innovation and Technical Evaluation Coordinator
Michael Hamer, Innovation and Technical Evaluation Manager
Chris Rogers, Innovation and Technical Evaluation Consultant

October 2023
National Energy Action
Level 6 (Elswick)
West One
Forth Banks
Newcastle upon Tyne
NE1 3PA
www.nea.org.uk

Acknowledgements

Funding for this project was provided by the Energy Industry Voluntary Redress Scheme

With grateful thanks to our project partners:

Age UK Barnsley, Berneslai Homes and Energise Barnsley

and

Andy Heald, Innovation Director, Energise Barnsley
Bethan Wynton, Society Secretary, Energise Barnsley
Faye Lawson, Information & Advice Manager Age UK Barnsley
Julie Shipley, Information & Advice Officer, Age UK Barnsley
Rachel Hutchinson, Project Delivery Manager, Berneslai Homes
Louise Wood, Project Liaison Officer, Berneslai Homes

Table of contents

Executive Summary

Project Overview

Smart Solar in Barnsley was an innovation project funded by the Energy Industry Voluntary Redress scheme which installed 75 batteries in homes with solar PV in the Metropolitan Borough of Barnsley. The project was led by Age UK Barnsley who also provided advice visits. Project management was provided by Energise Barnsley. The homes receiving installations were managed by Berneslai Homes and their in-house electrical team installed the batteries. Evaluation of the project was carried out by National Energy Action (NEA).

The batteries installed were Alpha ESS SMILE-B3 which had a storage capacity of 2.9kWh (usable capacity of 2.8kWh) and a maximum power output of 3kW. The installations were kept online and their performance analysed using the Alpha ESS monitoring portal. Berneslai Homes and Energise Barnsley had installed Moixa and sonnen batteries in previous projects, but these had lower maximum power outputs of 430W and 2.5kW respectively.

Project Timeline

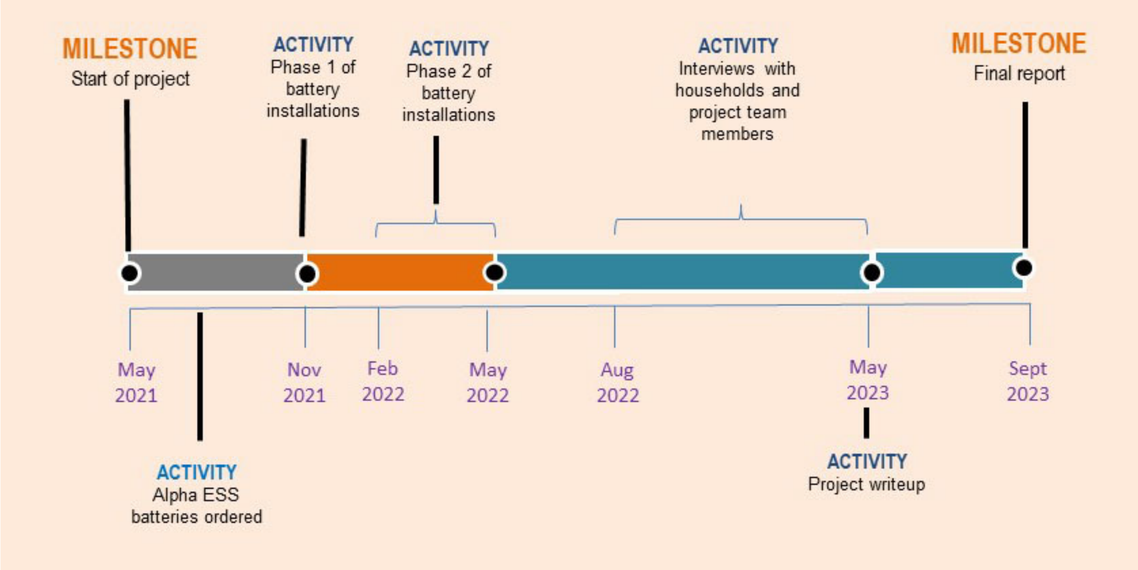


Figure ES1 Timeline for Smart Solar in Barnsley project

The project started at the beginning of May 2021. In the summer of 2021, the Alpha ESS SMILE-B3 battery was selected and ordered. Clusters of suitable bungalows with solar PV were also identified. These households were sent recruitment letters and follow-up telephone calls were made to bring the total households recruited for installations to 75.

The first phase of 15 installations took place in November 2021. The second phase with the remaining 60 installations was from 23 February 2022 and 5 May 2022. There were 30 households in a monitored group who were interviewed by NEA between August 2022 and May 2023. Project team members were also interviewed in the Spring of 2023.

Installation programme

The properties receiving installations were either 1- or 2-bedroom bungalows that were reserved for residents over 50 years of age. 48 of the bungalows were heated by gas boilers and 22 were heated by a biomass heat network. The remaining 5 had an air source heat pump (ASHP).

Among the 30 residents interviewed, 24 were retired and 6 were carers or not working due to a health condition or disability. As a result, these households were likely to spend larger amounts of time at home during the day. 19 of the households were typically at home all day and 11 usually at home half of the day.

40 of the bungalows receiving batteries had their solar PV system funded through Energise Barnsley while the remaining 35 had been funded through Berneslai Homes. The size of the solar PV systems ranged from 1kW to 3.78kW, with 27 of the homes having a 2.7kW system and 20 having a 3.43kW solar PV installation. The 5 households with ASHPs all had a 1.07kW solar PV system.

The Alpha ESS SMILE-B3 battery used was IP65 outdoor rated. The batteries were installed by Berneslai Homes electricians with the assistance of the project liaison officer who was trained to connect the batteries online. 45 of the batteries were installed inside the house, while the remaining 30 were fitted in an outhouse that had previously been used to store coal. The batteries cost about £1,200+VAT. An indoor installation was on average £304, while the average cost of an installation in an outhouse was £637.

The battery needed to be connected to the internet for monitoring and warranty purposes. There were 57 installations connected to the internet through the tenant's broadband while 18 had a separate mobile router. Using the household broadband had the advantage of no additional installation or running costs but a visit could be required to reconnect the battery to the internet if the tenant changed broadband router. Using a wireless router with the installation had additional costs due to the extra equipment and annual data charges for the 3G SIM card. However, there were fewer maintenance visits such as having to reconnect the battery to the internet.

Figure ES2 SMILE-B3 installation

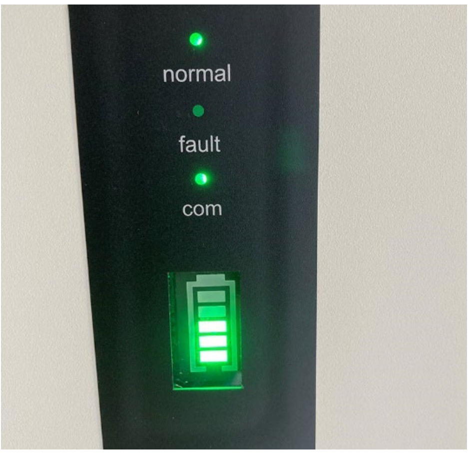


Figure ES3 SMILE-B3 battery display

Social analysis

Households could monitor the level of charge in the battery using the battery display (figure ES3) or the Alpha ESS monitoring app. Among the 30 households interviewed, all 30 were aware of the battery display and 24 of the households made use of it. This could be to check the battery was working or if it was a good time to use appliances. Most of those who did not use the display had the battery fitted in an outhouse where it was less accessible.

25 of the 30 households interviewed had the Alpha ESS monitoring app installed on a smart phone with 17 using the app and 12 finding it helpful or interesting. Some households said they were not very technically minded and so did not tend to use the app. Others used it extensively to monitor the solar PV, electricity use and how much was coming from the battery. They also used it as a guide for behaviour change, using appliances when they were likely to be powered for free.

In addition to having the battery display and app and being able to perceive changes in their electricity costs, households also received a visit from Age UK Barnsley. During these visits, residents were shown data from the battery portal illustrating savings provided by the solar PV and the battery.

All 30 households interviewed thought they were making savings from the battery. 25 out of the 29 households that responded said they were more aware of how they used electricity after the battery was installed and 21 of the 29 households who responded said they had changed the way they used electricity. Comments included:

"I don't put the dishwasher on until I know there is some free electricity. I use appliances when there is free solar or battery available."

"I used to cook in the evening and the 5 bars on the battery went down quickly. I have since switched to cooking in the afternoon. Every day I will check there is 5 bars on the battery at 7pm, then I know I will not be charged for anything overnight."

There were high levels of satisfaction with the battery installations, with 27 of 29 households who responded saying the overall installation was very good while the remaining 2 households thought it was good. All 30 of the households were happy with the battery installation and the 29 that responded said they would recommend a similar installation to their friends. There were many positive comments about the project from the interviewed households. These included:

"I am over the moon with the battery. It is discrete, silent, it is out of the way. If I could have another one, I would have two!"

"I think the Government should fit solar panels and storage batteries in every home to help with the cost of electricity. They should install them for all pensioners and also the poorest families. The systems are a big help. I am thrilled to pieces and ecstatic with the battery system."

Technical analysis

The performance of the battery and solar PV systems were analysed using data from the Alpha ESS monitoring portal. This was compared with data from smart generation meters and household smart meters for the 30 monitored households.

Households on the biomass heat network

There were 22 battery installations for households on the biomass heat network. Out of these, 9 of the batteries were noted to have issues over the monitoring period (40%). This included 3 where the CT clamp was reversed. One installation was offline for over 7 months while the solar generation for another was not recorded on the portal for 3.5 months of the analysis period.

The battery discharge over a 12-month period for the homes on the biomass heat network ranged from 567kWh to 974kWh. This included 19 households where there was a significant amount of data for analysis. The percentage PV self-consumption ranged from 32.2% for a low electricity user to 80.2% for a household with higher electricity consumption. Most households had a level of PV generated electricity self-consumption between 40 and 60%.

Estimates of the electricity cost and savings were made using data from the Alpha ESS portal and a unit rate of 30p/kWh for 18 households with batteries on the biomass heat network. This excluded the standing charge and ignored periods offline. The electricity cost for households was between £43.60 and £666.13 with an average of £245.89. The savings from the solar PV ranged from £151.01 to £360.66 with an average of £258.09. The savings from the battery were between £170.22 and £292.20 with an average of £229.34. The average total saving for solar and battery for the heat network households was £487.43.

Based on the cost of the battery, the installation cost and the annual battery savings, it was possible to make a simple estimate of the payback time for the battery. For an indoor installation the payback time was on average 7.6 years and ranged between 6.0 and 10.3 years. If the battery was fitted in an outhouse, the payback time was between 7.1 and 12.2 years with an average of 9.05 years.

Households with gas boilers

There were 48 installations in homes with gas boilers. 20 had issues during the monitoring period (42%). These were mainly around connection of the battery to the internet, but there were also issues with CT clamps reversed and no solar generation. The issues meant there was no long-term data available to analyse for 2 of the installations. A few of the others had lower generation due to the issues.

The battery discharge among the homes with gas boilers ranged from 352kWh to 810kWh. The lower levels of discharge among some of these households were due to the batteries being offline for an extended period and a household having the smallest solar PV system.

The self-consumption of the solar generation for the households with gas heating ranged from 37.5% to 82.5%. 8 of the households had a self-consumption greater than 70%.

The average self-consumption was 57.0% for the gas heated households compared to 51.4% for the households on the heat network.

Costs and savings were estimated using the Alpha ESS portal for 39 out of the 48 households with gas boilers. The electricity cost excluding standing charge was between £26.10 and £830.51 with an average of £273.53. The average saving from the solar PV systems was £230.65 with savings ranging from £133.08 to £357.45. The saving from the battery was between £139.38 and £243.12, with an average of £203.03. The average total saving was £433.68 for the gas heated households.

For an indoor installation among the homes with gas boilers, the payback period was between 7.2 and 12.6 years with an average of 8.6 years. If the battery was fitted in an outhouse, the payback period was between 8.5 and 14.9 years with an average of 10.2 years.

Households with air source heat pumps

There were 5 installations in homes heated by ASHPs. The solar PV systems were all 1.07kW and the annual generation recorded by the Alpha ESS portal over the analysis period ranged from 867 to 1,083kWh. The grid consumption recorded on the Alpha ESS portal for the ASHP households ranged from 3,550kWh to 6,537kWh. This compared to a maximum annual grid consumption of 2,220kWh among the homes on the heat network and 2,768kWh for those heated by gas.

The battery discharge ranged from 88.5kWh to 388.6kWh, which was low compared to other installations in the study. There was limited excess solar generation available to charge the battery for the ASHP households as most of the generation was already being used in colder months by the heat pump. The solar self-consumption for the ASHP households was between 94.3% and 99.1%. The combination of low solar generation, high grid consumption and a battery meant that little of the solar generation was exported to the grid. The benefit of the battery was more limited for these households as there would already have been high levels of self-consumption of the solar generation, particularly between September and April.

The electricity cost estimated from the Alpha ESS portal for the households with ASHPs was between £1,065.09 and £1,961.11 with an average of £1,602.71. As a result of the electric heating, the electricity cost for these households was considerably more than for those heated by gas or the biomass heat network. The savings from the solar PV were between £182.75 and £242.12 with an average of £201.43. The battery savings for the ASHP households were low at between £26.55 and £116.58, with an average of £74.36. The ASHP household with the highest battery saving had a lower saving than all the households with batteries on the heat network or with gas boilers where savings were calculated.

The payback period for an indoor installation was between 15.0 and 65.9 years with an average of 23.5 years. The battery has a 5-year product warranty and a performance warranty that the battery will retain 80% of its usable capacity for 10 years. Based on these simple calculations for payback, it is unlikely that there will be a payback within the lifespan of the batteries fitted in the homes with ASHPs.

Comparison of Alpha ESS portal data with smart meter data

For the monitored group of 30 households, PV generation data was obtained from smart generation meters at the properties for the period 1 Jun 22 to 31 May 23. This was compared with solar generation data derived from the Alpha ESS portal.

For the 10 households analysed that were on the biomass heat network, the smart generation meter data was normally between 1.9 and 6.7% lower than the data from the Alpha ESS portal. There were however 2 exceptions. Household B-11 was offline for 26.8 days, which led the generation from the Alpha ESS portal to be nearly 10% lower than the smart generation meter data. For household B-10, the annual consumption from the smart generation meter was 2,266kWh lower than from the Alpha ESS portal. This was likely to have been due to the smart generation meter being associated with the wrong property.

With the 9 households with gas boilers that were analysed, the smart generation meter data was normally between 2.7 and 5.2% lower than the data from the Alpha ESS portal over the 12-month analysis period. The single exception was household G-46 which had many short periods offline. This meant the smart generation meter data was 6.6% higher than the data from the Alpha ESS portal.

When smart generation meter data was compared with generation data from the Alpha ESS portal for the 5 households with ASHPs, the smart generation meter data was between 3.3% and 10.1% lower.

The grid consumption recorded by smart meters was also compared to the grid consumption recorded by the Alpha ESS portal as an indication of the accuracy of savings made. The periods analysed had different dates and durations due to the limited smart meter data available.

For the 8 households analysed that were on the biomass heat network, the percentage difference between the smart meter and Alpha ESS portal data was ±4%. This was within the expected error for readings from a CT clamp.

There was suitable smart meter data available for comparisons for 7 households with gas boilers. For 5 of the 7 households, the difference between the grid consumption recorded by the smart meter and the Alpha portal was between 1.6 and 6.8%. For household G-33, the Alpha ESS portal recorded the grid consumption between 1 September 2022 and 30 June 2023 to be 85.4kWh while the smart meter recorded 607.9kWh over the same period. It is likely the Alpha ESS portal was not recording all the grid consumption from the household. This might be due to how well the CT clamp was fitted, or other electromagnetic interference. Other households where particularly low grid consumption was measured might have been similarly affected.

For one household on the biomass heat network, there was 6 years of smart meter readings available. This allowed approximately annual values to grid consumption to be calculated. Before the battery was fitted, the household was using on average between 3.82kWh/day and 4.65kWh/day. Over a period of about a year after the battery was installed, the grid consumption was 2.26kWh/day. This was a reduction of 47.2% on the average before the battery was installed.

The electricity consumption can significantly increase for households if the CT clamp for the battery is accidently reversed

The batteries installed used a CT clamp to measure the grid import/export. This can be fitted in the wrong orientation at the time of installation or can be moved during electrical work in the home such as replacing a consumer unit or when a smart meter is fitted.

During the project, there were 5 installations where the CT clamp was accidently reversed, with 3 of these occurring for extended periods. It was only possible to properly assess the increased consumption for one of these households where smart meter data was available.

Household G-15 had the CT clamp reversed between 15 March 2022 and 12 August 2022. The monthly electricity consumption during March – July 2022 was approximately in the range 355 to 390kWh. This compared to a maximum value of 291kWh in January 2019, before the battery was fitted and a minimum of 40.9kWh in June 2023 once the battery was operating as expected.

For the period 15 March 2022 to 12 August 2022, the electricity consumption was 1,766.8kWh compared to 325.5kWh between the same dates the following year. This suggests an increased electricity consumption of about 1,441kWh while the CT clamp was reversed with an extra electricity cost of about £432 using a unit rate of 30p/kWh

Households with smart meters are likely to be able detect the issue of increased electricity consumption more easily than those with non-smart meters on Direct Debit.

Conclusions and recommendations

- The in-house electrical team at Berneslai Homes successfully completed a project installing battery storage at scale with 75 Alpha ESS SMILE-B3 batteries
- The success of this project showed that in-house electrical teams for social landlords can be a suitable and cheaper alternative to using renewable contractors
- The Alpha ESS SMILE-B3 batteries had a 2.8kWh usable capacity and power output of up to 3kW
- The batteries were installed in 2 phases in November 2021 and between February and May 2022
- The installations took place in socially rented bungalows that were heated either by a biomass heat network, gas boilers or air source heat pumps (ASHPs)
- The solar PV system sizes ranged from 1kW to 3.78kW, with all the PV systems on the homes with ASHPs sized at 1.07kW
- There were high levels of satisfaction with the battery systems, with 30 households who were interviewed happy with the battery installation and believing they were making savings
- 24 of the 30 households interviewed made use of the battery display while 17 of the households were using the Alpha ESS app on their phone
- 25 of 29 households were more aware of how they used electricity and 21 had changed how they used electricity

- The battery discharge from households on the biomass heat network was between 567kWh and 974kWh which equated to a saving from the battery of between £170.22 and £292.20
- For the households with gas boilers, the battery discharge ranged from 352kWh to 810kWh. The battery savings for the systems analysed were £139.38 to £243.12
- The battery discharge for the households with ASHPs was lower due to having low solar generation and high grid consumption
- The battery discharge for these households was between 88.5kWh and 388.6kWh and equated to annual savings of between £26.55 and £116.58
- The average payback time for an indoor installation was 7.6 years for households on the biomass heat network, 8.6 years for those with a gas boiler and 23.5 years for the households with ASHPs (partly due to a small PV array)
- The main issues which occurred during the project were batteries going offline, CT clamps being reversed and faults with the solar PV system
- A major cause for the batteries going offline was due to households switching broadband router/supplier
- Installing a wireless router with 3G SIM card would increase installation and running costs, but reduce the number of maintenance visits required to reconnect batteries
- The grid CT clamp for the battery was reversed for 3 installations for extended periods and for at least 2 more installations for less than a month
- This can have serious consequences and cause an increase in bills for the resident
- An installation had the CT clamp reversed between 15 March 2022 and 12 August 2022 and the electricity consumption was 1,766.8kWh compared to 325.5kWh for the same period a year later; the estimated extra electricity cost was £432
- Using a meter instead of a CT clamp would increase installation costs, but reduce the risk of this problem during smart meter installations or electrical maintenance work
- Electricians working in homes with batteries with CT clamps should be warned about the risk of moving the clamp and fitting it back in an incorrect position or orientation
- Details of the battery and CT clamp should be included in records for the property
- Before starting a battery installation programme, it is important to assess the solar PV generation and likely electricity consumption at the site
- The households with ASHPs would have gained more benefit from a larger solar PV system and a larger battery and potentially also using a time of use electricity tariff
- Larger capacity batteries such as 5kWh could improve savings for many households
- Monitoring of a battery system is important for both the household and landlord
- Households are able to make greater savings through behaviour change if they can monitor the performance of the battery from a display, website or app
- Landlords need their portfolio of batteries to be regularly checked (every 2-4 weeks) by an internal or external energy team
- Batteries need to be kept online for warranty and monitoring purposes
- Monitoring can help quickly pick up faults with the battery or solar PV or situations where the CT clamp has been moved, causing higher bills for tenants

1. Project overview

1.1 Introduction

Smart Solar in Barnsley was an innovation project funded by the Energy Industry Voluntary Redress scheme which installed 75 batteries in homes with solar PV in the Metropolitan Borough of Barnsley. The project was led by Age UK Barnsley with project management by Energise Barnsley. The homes receiving batteries were managed by Berneslai Homes and evaluation of the project was carried out by National Energy Action (NEA). The project was awarded a grant of £228,203 and there was additional match funding provided by Berneslai Homes of £50,000.

The project enabled battery storage installation to be trialled at scale by the Berneslai Homes in-house electrical team. The batteries stored spare electricity from the solar panels which would otherwise be exported to the grid and allowed residents to use it later in the day.

Resident engagement by the Berneslai Homes project team and through advice visits and calls by Age UK Barnsley aimed to ensure households understood how to maximise the benefit from the solar and battery systems and increase their level of solar self-consumption which in turn reduces their electricity bills.

The batteries installed were Alpha ESS SMILE-B3 which had a storage capacity of 2.9kWh (usable capacity of 2.8kWh) and a maximum power output of 3kW. The installations were kept online and assessed via the Alpha ESS monitoring portal.

1.2 Project partners

Age UK Barnsley

Age UK is the country's leading charity dedicated to helping everyone make the most of later life. The Age UK network comprises over 125 local Age UKs across England. Age UK Barnsley is the local charity supporting older people across the Metropolitan Borough of Barnsley. They were the lead in the Smart Solar in Barnsley project and provided support to the residents receiving batteries through home visits and telephone calls. This included advice on the savings provided by the battery and the solar PV as well as more general advice on benefits the households were eligible for.

Berneslai Homes

Berneslai Homes is an arms-length management organisation (ALMO) responsible for managing over 18,000 homes on behalf of Barnsley Metropolitan Borough Council. Berneslai Homes staff recruited 75 households to have battery installations and their in-house electrical team installed the Alpha ESS batteries. A project liaison officer provided advice at the time of commissioning and assisted in setting up the app for the households.

Energise Barnsley

Energise Barnsley is a Community Benefit Society that was set up to deliver community owned renewable energy and heating projects across the Metropolitan Borough of Barnsley. The society raised £800k through the Barnsley Solar Bond in 2016 and domestic solar PV systems were installed on 321 council owned homes managed by Berneslai Homes. The tenants in these homes were able to use the electricity generated by the solar panels for free. Energise Barnsley provided project management for the Smart Solar in Barnsley project and 40 of the 75 properties had solar PV systems funded through Energise Barnsley. They also provided training for Age UK Barnsley staff and information on the savings provided by the battery and solar PV systems.

National Energy Action (NEA)

National Energy Action (NEA) is the leading national fuel poverty charity operating across England, Wales and Northern Ireland and with sister charity Energy Action Scotland, to ensure that everyone can afford to live in a warm, dry home. Established in 1981, NEA has spent the past 42 years working to lift people out of fuel poverty.

The Innovation and Technical Evaluation team at NEA completed the evaluation for the Smart Solar in Barnsley project. Their work included following progress of the project through attending progress meetings, interviewing team members and households and analysing the performance of the batteries.

1.3 Context

In 2020, there were about 108,289 households in the Barnsley Metropolitan Borough Council area and the proportion of fuel poor households was estimated to be 19.2%[1]. In the 2021 census, 19.7% of households were socially renting in Barnsley and 17.2% were privately renting. 19.4% of residents were aged 65 years or over[2].

The feed-in tariff encouraged installation of renewable technologies between 1 Apr 10 and 31 Mar 19. A total of 5,081 domestic solar PV installations were recorded in the Barnsley Metropolitan Borough Council area during the period of the feed-in tariff scheme[3].

Berneslai Homes manages over 18,000 homes and at the time of writing, 766 had solar PV. There were 4,639 bungalows and 400 of these had solar PV.

Energise Barnsley has been involved in several previous solar and/or battery projects with Berneslai Homes which provided the experience to help them develop and project manage the smart solar in Barnsley project. Their first project in 2015/16 was the installation solar PV systems on 321 homes managed by Berneslai Homes.

They were partners in a network innovation allowance project called Distributed Storage and Solar Study run by Northern Powergrid. Growing levels of PV installations were leading to issues with reverse power flows and voltage rises on the low voltage network. The project looked at battery storage which was considered a potential solution that might allow greater amounts of solar PV to be installed without network reinforcement and could assist in lowering the early evening local peak in electricity demand[4].

During the trial which ran from 2017 to 2019, 40 batteries were installed for 36 households, with 27 of them having solar PV. The properties were close to one another, on the same distribution substation in Oxspring, Barnsley.

The batteries fitted were manufactured by Moixa and had a total capacity of either 2 or 3kWh. Only 80% of this battery capacity could be discharged. The maximum power output from the battery was 0.4kW. There were 17 homes which had a single 2kWh battery and 15 homes with a single 3kWh battery. There was a further home with a pair of 2kWh batteries and 3 homes with a pair of 3kWh batteries.

Energise Barnsley was awarded a BEIS Domestic Demand-Side Response project in partnership with PassivSystems, Oxford Brookes University, Northern Powergrid and Berneslai Homes. The project was known as Project BREATHE, Bringing Renewable

---

[1] Department for Business, Energy and Industrial Strategy, Sub-regional Fuel Poverty England 2022 (2020 data) https://www.gov.uk/government/statistics/sub-regional-fuel-poverty-data-2022 (Accessed 20 Apr 23)

[2] How life has changed in Barnsley: Census 2021, https://www.ons.gov.uk/visualisations/censusareachanges/E08000016/ (Accessed 20 Apr 23)

[3] Sub-regional Feed-in Tariff Statistics, UK Government, https://www.gov.uk/government/statistical-data-sets/sub-regional-feed-in-tariffs-confirmed-on-the-cfr-statistics (Accessed 20 Apr 23)

[4] Distributed Storage & Solar Study (NIA_NPG_011), Northern Powergrid, https://www.northernpowergrid.com/innovation/projects/distributed-storage-solar-study-nia-npg-011 (Accessed 20 Apr 23)

Energy Automation to Homes Everywhere[5] and aimed to reduce peak time demand on the grid for homes with air source heat pumps (ASHPs), batteries, solar PV and smart controls.

A total of 28 sonnen 5kWh batteries were fitted by the Berneslai Homes electrical team. These had a charge and discharge rate of 2.5kW. All the properties had existing 5kW Mitsubishi Ecodan ASHPs which provided space and water heating. 23 of the properties had solar PV installations. A Passiv UK PassivLiving Hub smart control system was installed for each of the households. This aimed to optimise the operation of the heat pump and the battery to minimise costs for residents while avoiding thermal discomfort. 18 of the properties which had installations were modern, well-insulated and built in about 2014 to Code 4 Sustainable Homes. The majority of these were semi-detached properties.

Several different types of demand side response (DSR) trials were run by Oxford Brookes University with households on the project. There were ‘turn down’ interventions where the battery was discharged during peak demand periods, powering the appliances and/or the heat pump. There were also some ‘turn-up’ interventions, where the battery was charged primarily from the electricity grid in the early afternoon along with operation of the heat pump. This meant a greater reduction in demand was subsequently possible in the late afternoon/early evening[6] [7].

The smart solar in Barnsley project is the third battery storage project for Berneslai Homes and Energise Barnsley. The organisations were keen to investigate battery installation at scale by the in-house team and the savings it could provide the residents. 75 Alpha ESS batteries were installed by the electrical team at Berneslai Homes. These were the SMILE-B3 model which each had a total capacity of 2.9kWh and a usable capacity of 2.8kWh (96% maximum discharge). The maximum charge and discharge power for the battery was 3.0kW. This had a higher charge and discharge rate than the Moixa and sonnen batteries in the earlier projects. Further details about the SMILE-B3 battery are provided in Appendix 3.

The batteries were installed in clusters across the Metropolitan Borough of Barnsley in streets of properties managed by Berneslai Homes which had bungalows with solar PV. Among the statistics collected by the UK Government is electricity consumption at a postcode level (for multiple households)[8]. Among the streets having multiple battery installations was one in Dodworth. The heating was provided by a biomass district heating scheme and the median electricity consumption for homes in that postcode (with 20 households) in 2021 was 1,240kWh. Another street which had multiple battery installations was in Bolton upon Dearne. In this case, the homes were heated by gas and the median electricity consumption in 2021 was 1,211kWh for the 12 households in that postcode.

---

[5] Project BREATHE, https://www.project-breathe.org/ (Accessed 20 Apr 23)

[6] Gupta and Morey (2022), Empirical evaluation of demand side response trials in UK dwellings with smart low carbon technologies, Renewable Energy, Vol. 199, pp. 993-1004, https://www.sciencedirect.com/science/article/pii/S0960148122013441 (Accessed 10 May 23)

[7] Gupta and Morey (2023), Evaluation of residential demand response trials with smart heat pumps and batteries and their effect at substation feeder, Journal of Cleaner Production, Vol, 403, 136760, https://www.sciencedirect.com/science/article/pii/S0959652623009186 (Accessed 10 May 23)

[8] Postcode level electricity statistics: 2021 (experimental), UK Government official statistics, https://www.gov.uk/government/statistics/postcode-level-electricity-statistics-2021-experimental (Accessed 20 Apr 23)

For comparison, the electricity consumption of the typical household in Britain is estimated by Ofgem to be 2,900kWh in 2022. For a low energy use, typically in a flat or 1-bedroom house, the typical annual electricity use is about 1,800kWh[9]. The homes in Dodworth and Bolton upon Dearne in the postcodes mentioned were likely to be low electricity consumers because many were smaller bungalows with solar PV.

---

[9] Average gas and electricity use explained, Ofgem, https://www.ofgem.gov.uk/information-consumers/energy-advice-households/average-gas-and-electricity-use-explained (Accessed 20 Apr 2023)

1.4 Project timeline

The project started at the beginning of May 2021. The Alpha SMILE-B3 battery was selected and ordered through Immersa in the summer of 2021. Recruitment of households to receive the batteries began over the Summer and early Autumn of 2021 and the first phase of 15 installations took place between 15 and 25 Nov 21. The second phase with the remaining 60 installations was from 23 Feb 22 and 5 May 22.

The 30 households in the monitored group were interviewed by NEA staff between August 2022 and May 2023. Project team members were also interviewed in the Spring of 2023. The project was written up from May 2023.

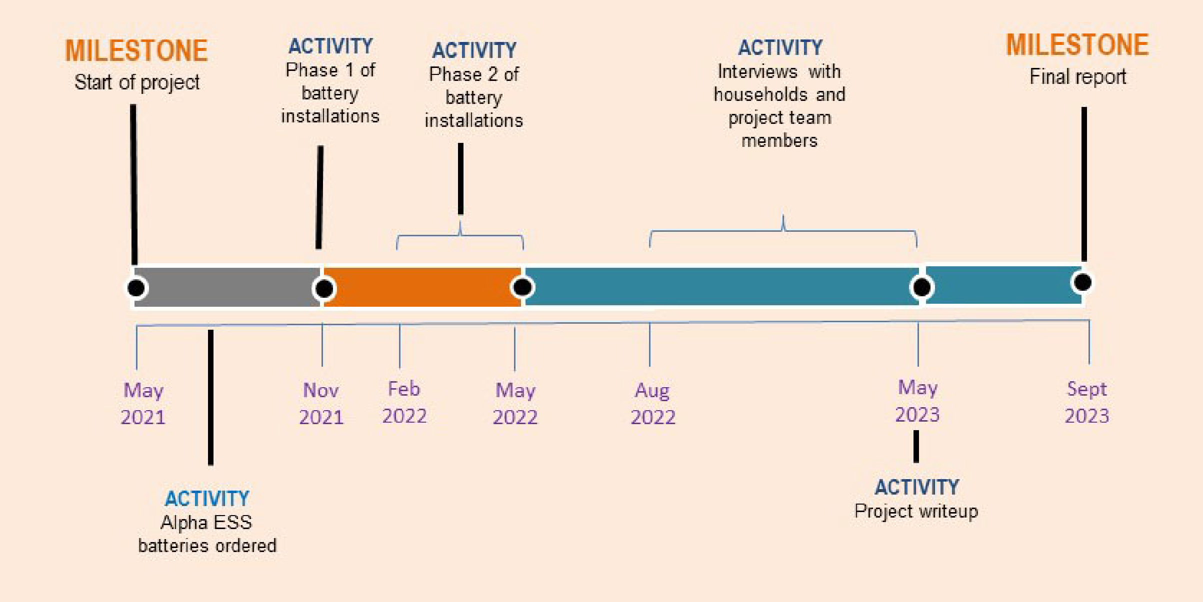


Figure 1.1 Timeline for Smart Solar in Barnsley project

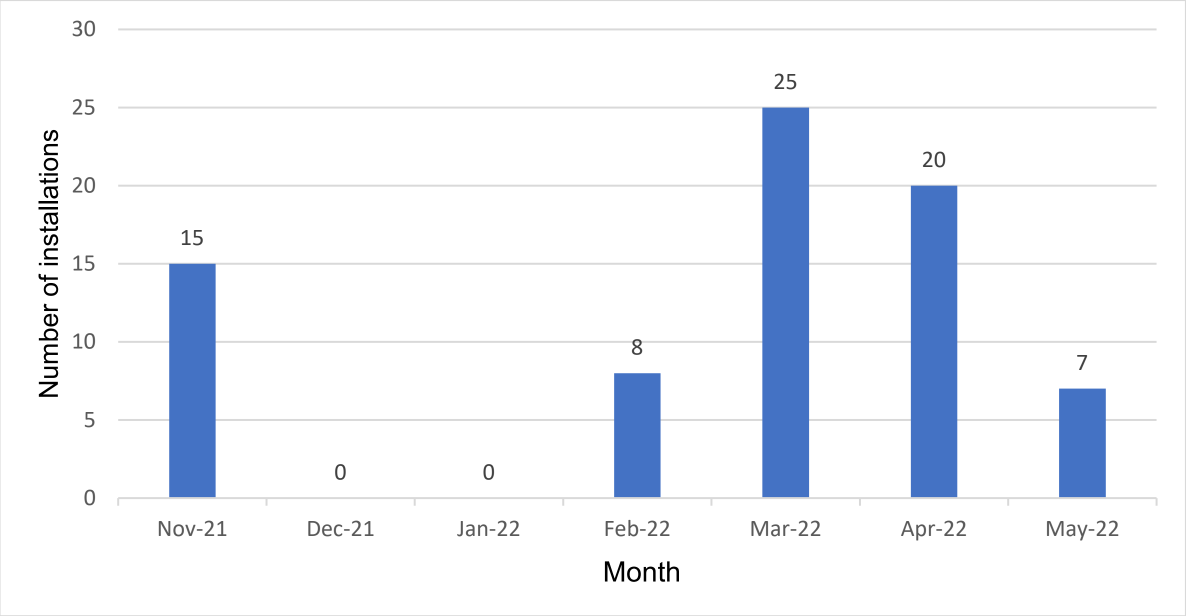


Figure 1.2 Dates of battery installations

1.5 Recruitment of households for installations and monitoring

- The selection of potential households was carried out by Berneslai Homes' Project Development Manager
- Clusters of bungalows with solar PV were identified which would make it easy to carry out groups of battery installations
- Berneslai Homes posted a project recruitment letter to the 200 households who were initially selected as being suitable (see Appendix 1)
- Households needed to respond to the letter by 8 Oct 21 and by that time, about 69 household had responded
- The Project Liaison Officer contacted some households who had not responded to the letter to encourage them to also have an installation, taking the total up to 75 households
- This often involved contacting neighbours of households who had already signed up
- Some households were interested in being part of the scheme but were unsure of the size of the battery. The Project Liaison Officer was able to bring the battery case on visits so residents could see the size of the unit
- In most cases seeing the battery size reassured residents, but there were 4 or 5 households who decided against an installation
- This engagement reduced the risk of households being surprised at the battery size on the day of installation and refusing to have the unit fitted
- Once phase 1 of the battery installations had started and word of mouth among the residents was positive it was easy to recruit the remaining households for phase 2

- 30 of the households having batteries were recruited to assist with the project evaluation
- The Project Liaison Officer recruited the initial households while doing home visits
- Households were provided with the NEA Project Information Sheet (see Appendix 2) and signed a project consent form and consent to provide meter readings for the project
- The households had to take part in at least one telephone interview and be willing for the performance of their battery to be analysed and for their electricity supplier to provide meter readings
- To reward households for taking part in the evaluation, NEA provided them with £50 in shopping vouchers at the end of the project
- There were some withdrawals from the monitored group during the project
- Additional households were recruited later in the project with the assistance of the Project Liaison Officer and Age UK Barnsley

1.6 Factors affecting the project plan

Issue	Description and mitigation
Consortium agreement	A project with multiple partners needed a legal agreement between the parties. The consortium agreement selected for the project was one that had been used by Energise Barnsley in their Demand Side Response project funded by the Department for Business, Energy and Industrial Strategy (BEIS). This had the advantage of including up to date GDPR details and coverage of intellectual property, but overall, this agreement proved to be too complex. Barnsley Metropolitan Borough Council had to sign the contract on behalf of Berneslai Homes. The consortium agreement was not signed for a number of months after the start of the project in part due to the complexity of the agreement. Due to the nature of the agreement and partner relationships within it, the project was deemed by HMRC as being “in scope of VAT” for NEA’s Evaluation element, and corresponding savings on delivery costs had to be made.
Selection of the battery and estimating costs	There were challenges developing the project and estimating the costs. Careful consideration was needed in selecting the right battery distributor, manufacturer, battery size and rating the chance of delivery. It was also important to produce close estimates for the costs associated with the batteries and their installation for the project budget. When selecting the battery to be installed, factors considered were: • Battery cost • Ease of installation • After sales service • Ability to monitor performance of all systems on a portal • A manufacturer with different battery capacities and outputs • An outdoor rated battery to allow flexibility given the small size of many socially rented homes in the UK
Use of in-house electrical team	There was a desire to keep the costs down for the project and retain the maximum benefit within the community. One of the benefits was to upskill staff among the Berneslai Homes electrical team who installed the 75 batteries. This provided them with useful experience to assist with maintenance and larger scale battery installation programmes in the future. The electrical team had an in-situ training course provided by Immersa who distributed the Alpha ESS batteries. There was also some online guidance, and they could contact Immersa/Alpha to discuss issues during installations.

Current clamps	During the first phase of installations, some of the CT clamps (current transformers) for the batteries were not fitted on either the correct wire or in the correct orientation. These were resolved after a few days. There were later issues where CT clamps were moved and not replaced in the correct orientation after smart meter installations or other electrical upgrade work in the home. When the CT clamps were in the wrong orientation it caused the electricity consumption to increase rather than decrease. It was therefore important to quickly detect when this problem occurred. There were however 3 installations where the CT clamp was reversed for several months. Estimates were made of the extra cost for the residents and compensation paid.
Time zone on battery portal and app	Some of the batteries were initially set to Beijing time. This was corrected, but there was a tendency to revert back to Beijing time after a power cut.
Method of connecting the battery to the internet	It is necessary to keep the batteries connected to the internet for warranty and monitoring purposes. For most households, the battery connected to the internet through the household broadband. This reduced costs, but if residents had a new Wi-Fi router, the battery would need to be reconnected to the internet on a home visit. The alternative to using the home broadband was to fit an alternative networking / comms solution. There were additional costs with this for the wireless router, adding a 13A socket during installation and the ongoing SIM card costs. Results from the study suggested that the wireless router was a more reliable option that reduced the number of maintenance visits needed for the battery.

2. Social evaluation

2.1 Details of the properties

2.1.1 Location of the installations

Figure 2.1 Map of the administrative area of Barnsley Metropolitan Borough Council[10]

Berneslai Homes is an arms-length management organisation (ALMO) which is responsible for managing around 18,000 socially rented homes on behalf of Barnsley Metropolitan Borough Council. The administrative area of the Council is shown in figure 2.1.

The properties which received battery installations were situated across the Barnsley Metropolitan Borough District, in areas such as Bolton upon Dearne, Brierley, Dodworth, Monk Bretton and Wombwell. Figure 2.2 shows the locations of the installations.

The batteries were fitted in bungalows with solar PV that were managed by Berneslai Homes. In some areas, up to 9 batteries were installed on a street and in others, it was either 1 or 2. Sometimes there were several nearby streets with bungalows with solar panels which received batteries. For example, in Dodworth, 19 properties in nearby streets received installations.

The bungalows had either 1 or 2 bedrooms and were reserved for residents over 50 years of age. They were either semi-detached, terraced (mid or end) or detached. Heating for the bungalows was provided by gas boilers, a biomass district heating network or air-source heat pumps.

---

[10] Barnsley Metropolitan Borough Council Preliminary Flood Risk Assessment Report, July 2011 https://www.barnsley.gov.uk/media/16269/barnsley-pfra-report.pdf (Accessed 16 May 23)

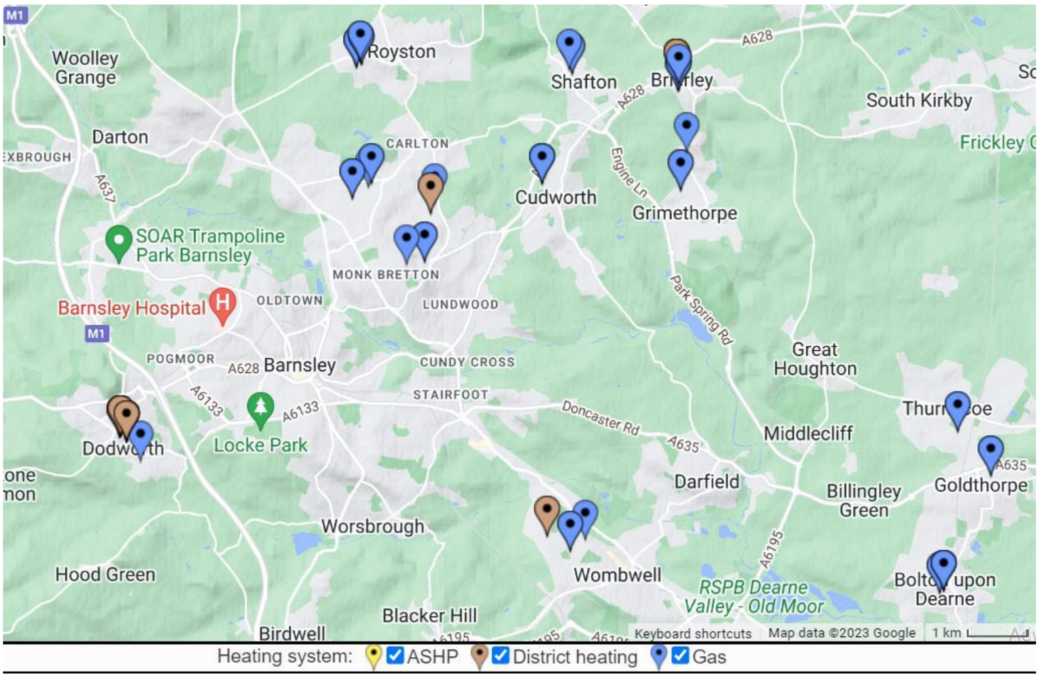


Figure 2.2 Alpha SMILE-B3 battery installations in the Barnsley Metropolitan Borough District

Out of the 75 households who received battery installations, 30 of these were recruited to be a monitored group for this evaluation. These households took part in telephone interviews and the performance of the systems was studied in more depth.

2.1.2. Building types and characteristics

Figure 2.3 Example of terraced bungalows with installations (image from Google Earth)

The bungalows typically date from the 1970s onwards with the most recent being built in 2011. Figure 2.4 shows the mix of bungalow types. 48 of the 75 bungalows were semi-detached, with a further 24 terraced (mid and end) and just 3 detached bungalows.

There was a mix of 1- and 2-bedroom bungalows. Figure 2.5 shows the floor area for the bungalows that received installations based on information from the Energy Performance Certificates. The values ranged from 25m^2 up to 63m^2. Properties on the same street or with the same design typically had the same or similar floor areas recorded. For example, there were 13 properties that were 62m^2 and 10 properties that were 49m^2.

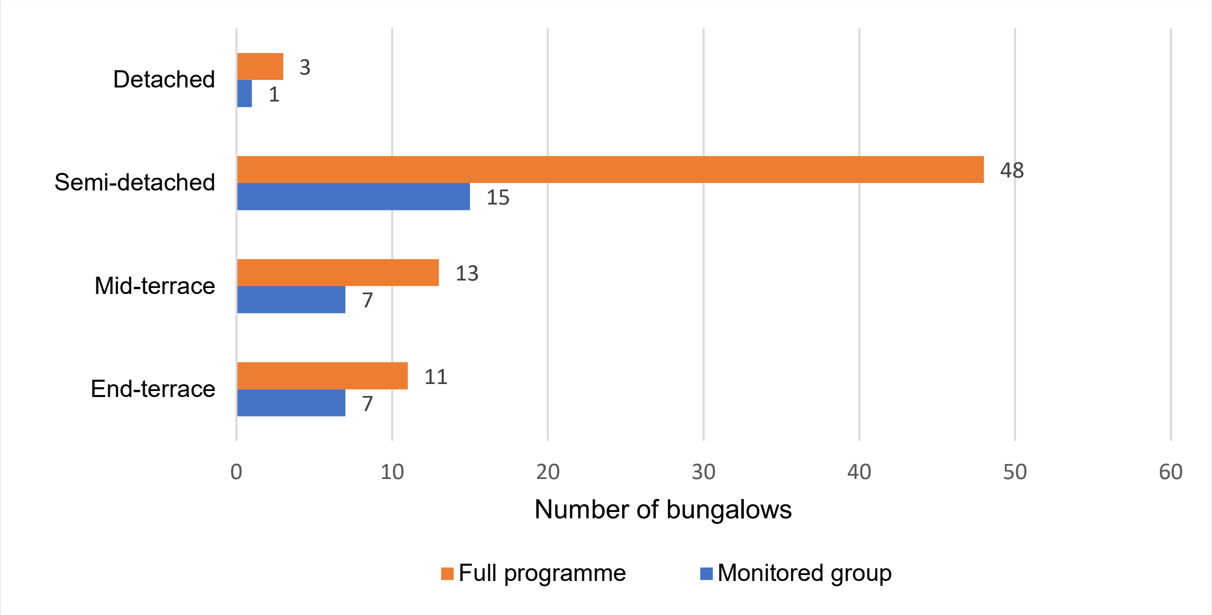


Figure 2.4 Type of bungalows which received batteries and were in the monitored group

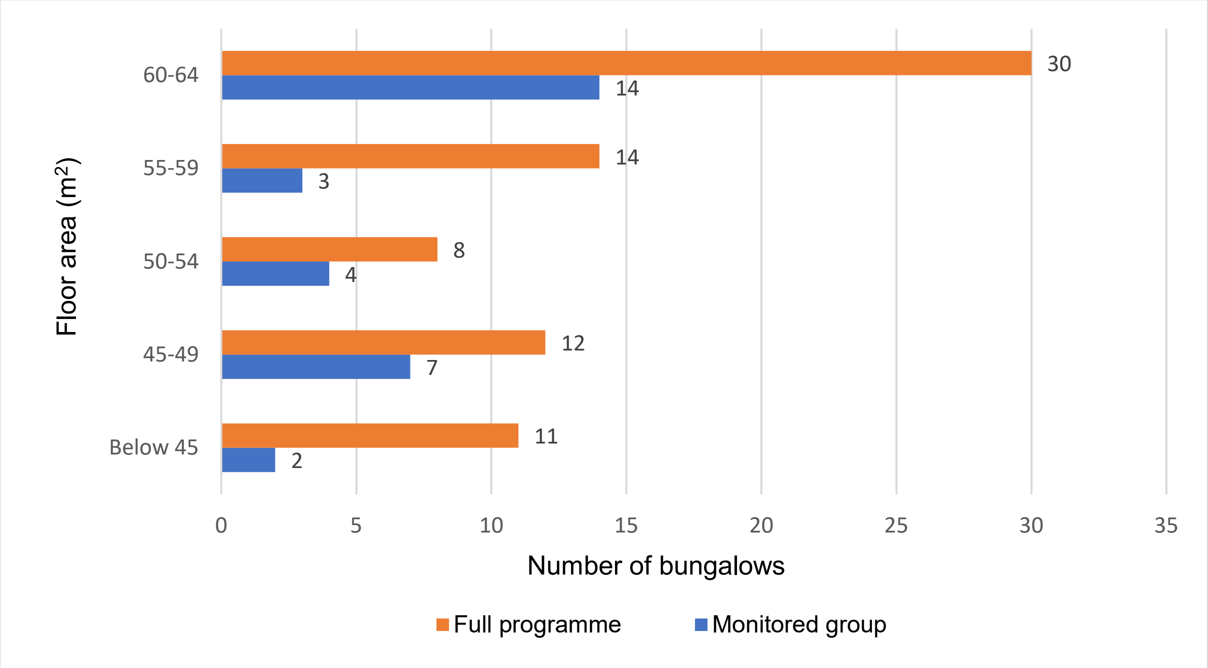


Figure 2.5 Floor area of bungalows that received battery installations

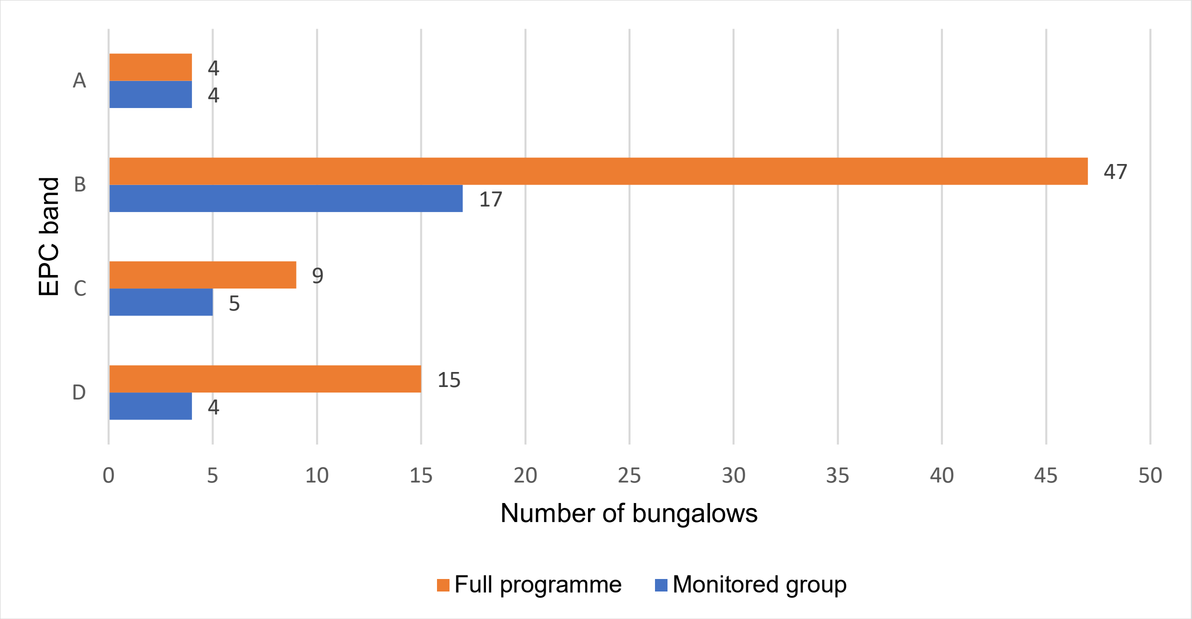


Figure 2.6 Energy Performance Certificate band for the bungalows that received batteries

Figure 2.6 shows the Energy Performance Certificate (EPC) bands for the properties that received batteries. The average energy score for the EPC was 80.4 and the range was from 60 up to 92. A band A property has an energy score of 92 or above. For band B the energy score is between 81 and 91, band C between 69 and 80 and band D between 55 and 68.

There were 4 band A properties which had the EPC lodged in either 2021 or 2022. These all had solar PV systems of between 3 and 3.5kW. A larger solar PV system improves the energy score. 3 of the properties were heated by a biomass district heating scheme while the other property was heated by gas.

Almost two thirds of the properties were in EPC band B with 47 out of the 75. There were 9 properties in EPC band C and 15 properties in EPC band D.

55 out of the 75 properties had EPCs lodged between 2020 and 2023. Among the 15 band D properties, only 5 had recent EPCs lodged between 2020 and 2023. Out of the remaining band D properties, 8 of the 10 had the EPC lodged in 2014 or 2015 before the solar PV system was installed. An updated EPC including the solar PV system is likely to lead to a higher energy score and EPC band for these properties.

The software used to produce nearly all the EPCs was RdSAP 2012. This does not take into account the benefits of battery storage and adding a battery does not increase the energy score. However, an update to RdSAP is expected in 2023/24 and this is likely to see an improved an energy score with battery installations.

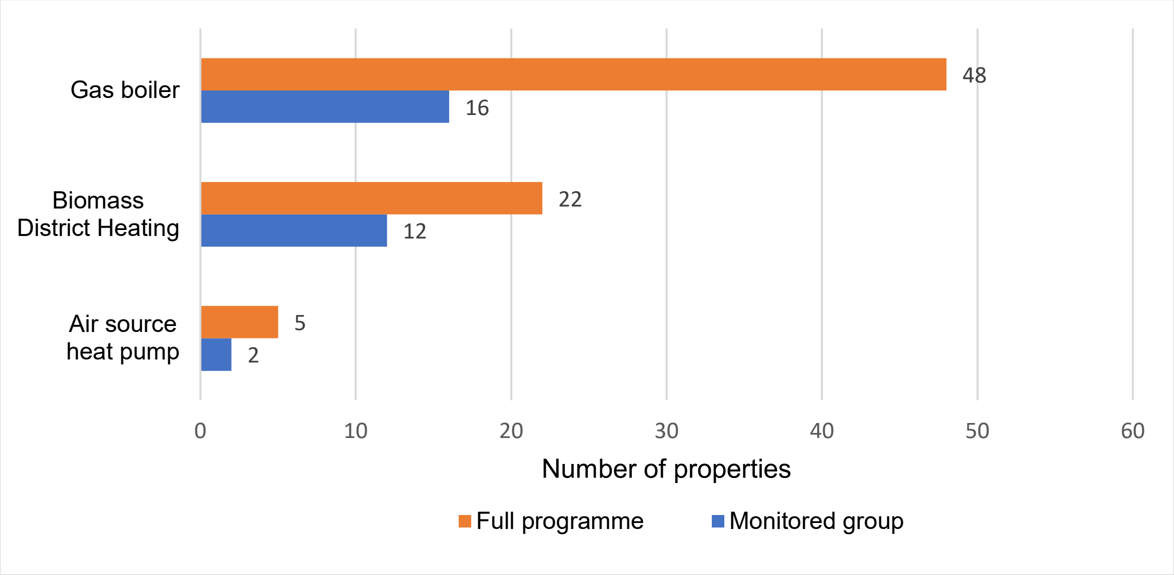


Figure 2.7 Method of heating for the bungalows

Almost two thirds of the bungalows that received battery installations were heated by combi gas boilers with 48 out of the 75 properties. There were 22 bungalows where space and water heating were provided by a biomass district heating scheme. The remaining 5 bungalows were built in 2011 and had air source heat pumps with underfloor heating.

Berneslai Homes had a programme of installing solar PV systems on the properties they manage during the early stages of the feed-in tariff scheme in 2011/12. Energise Barnsley had their programme to install 321 solar PV systems on Berneslai Homes properties in 2015/16. Figure 2.8 shows that 40 of the bungalows receiving battery installations had solar PV systems managed by Energise Barnsley while 35 were managed by Berneslai Homes. In the monitored group, there was a higher proportion of PV systems managed by Berneslai Homes with 18 compared to 12 managed by Energise Barnsley.

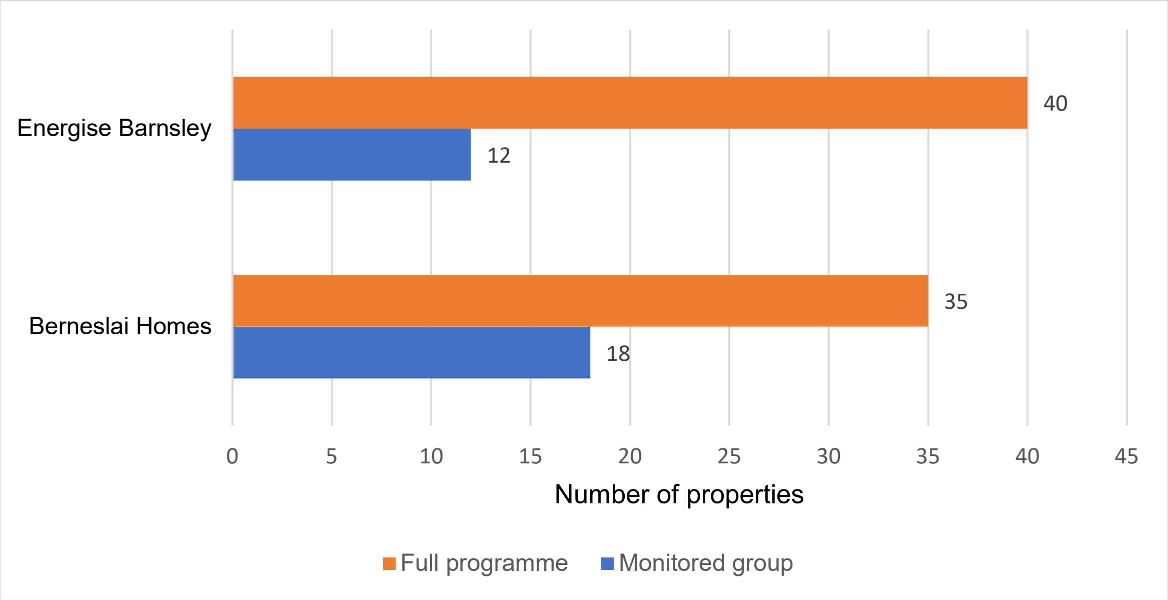


Figure 2.8 Organisation managing the solar PV system

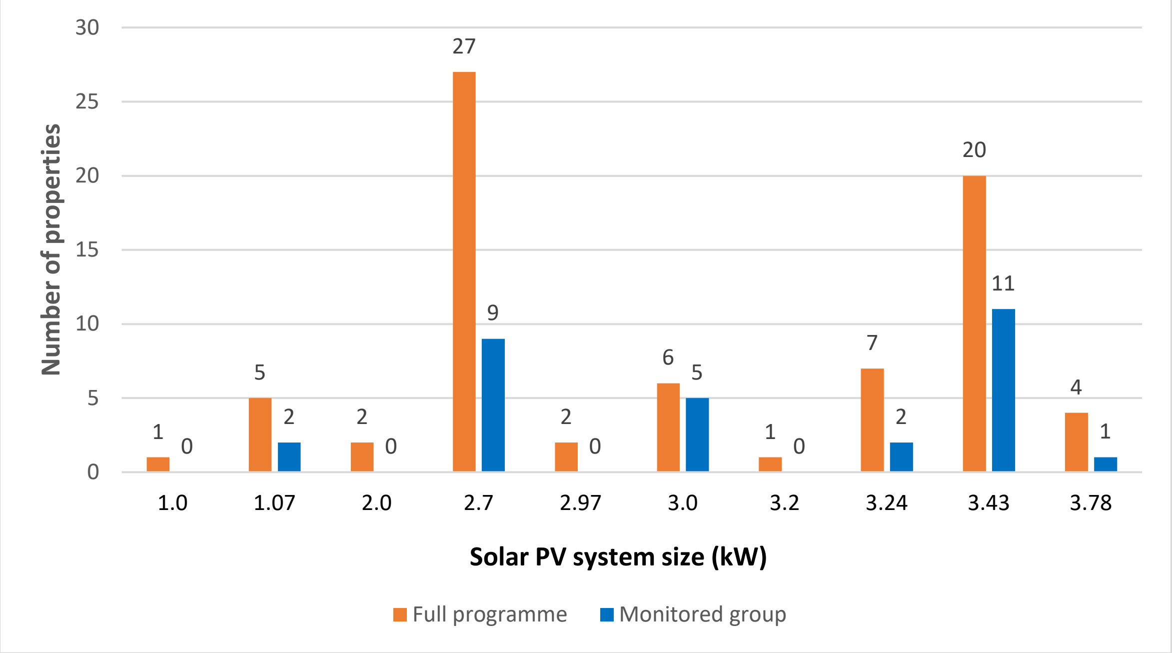


Figure 2.9 Size of solar PV systems on the bungalows which received battery storage

Figure 2.9 shows that 20 of the properties receiving batteries had a 3.43kW solar PV system. Berneslai Homes records indicated that 7 of these were 3kW installations. However, the number of panels and annual generation indicated they were 3.43kW installations as for neighbouring properties. Over one third of the properties had 2.7kW solar PV systems. Only 8 of the properties had solar PV systems sized at 2.0kW or smaller. Out of these, the 5 with 1.07kW PV systems were in properties that had air-source heat pumps.

The batteries were fitted either inside the bungalow or in outhouses that had previously been used to store coal. Overall, there were 45 batteries fitted inside and 30 in outhouses. In the monitored group, 20 of the batteries were inside and 10 in outhouses.

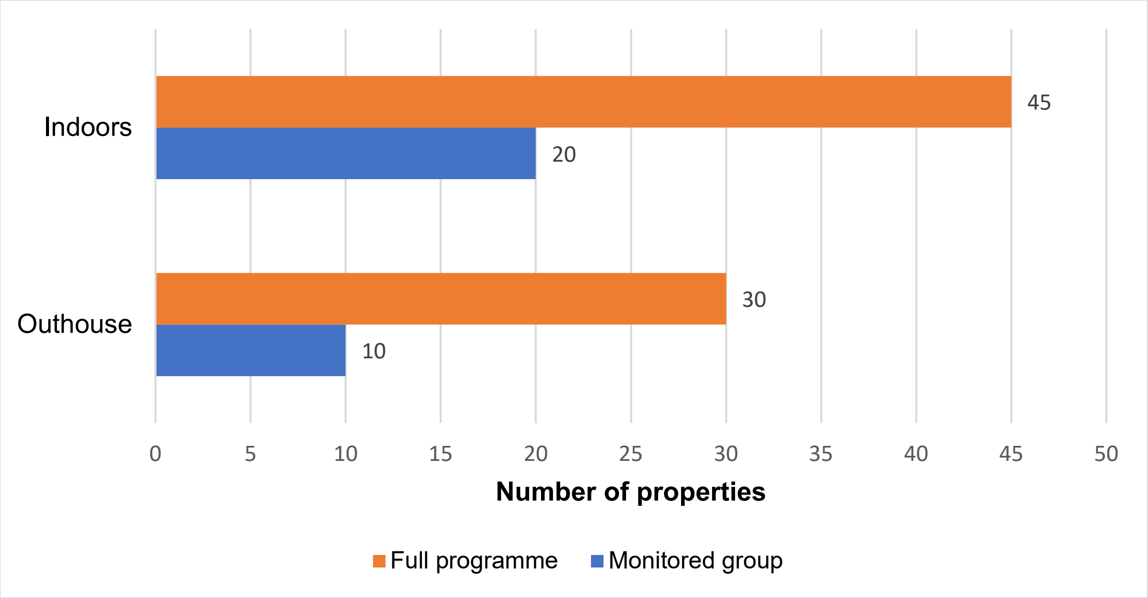


Figure 2.10 Location of the battery storage installation

2.2 Details of monitored households

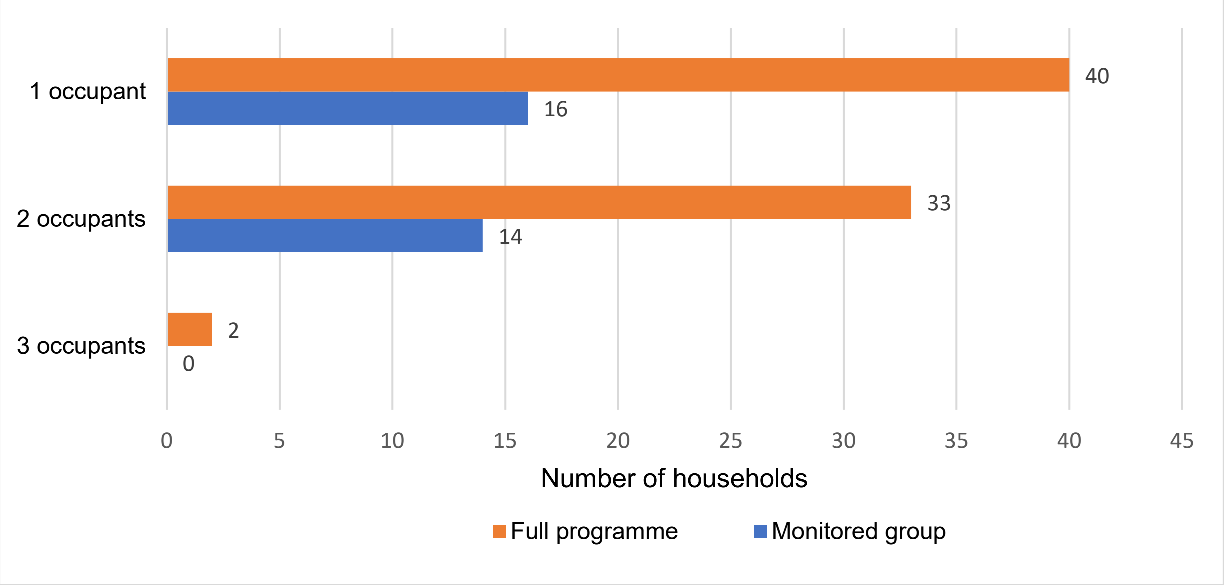


Figure 2.11 Number of occupants per household

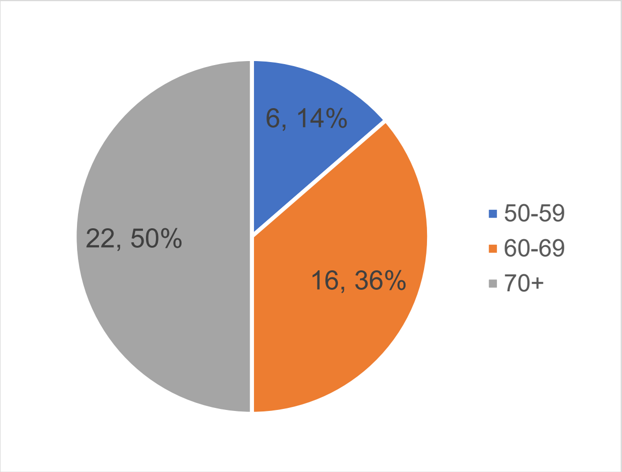


Figure 2.12 Age band of residents in the monitored group

Among the households receiving batteries, 40 had a single occupant, 33 had 2 occupants and 2 households had 3 occupants.

In the monitored group there were 16 single person households and 14 households with 2 occupants.

There were 6 residents in the monitored group who were in the age band 50-59 and 16 in the band 60-69. There were 22 residents who were over 70 years old.

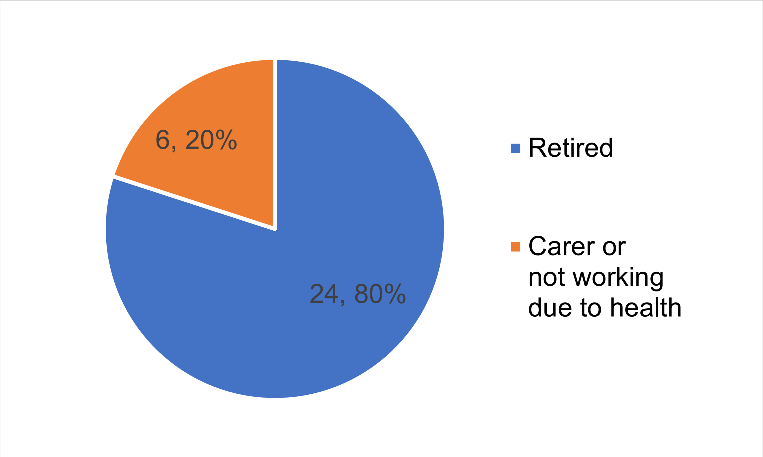


Figure 2.13 Occupational status of residents interviewed

Given the age profile of the households, it is understandable that 24 or 80% of the residents interviewed were retired.

The remaining 6 residents were carers or not working due to health or a disability. As a result, these households were likely to spend larger amounts of time at home during the day.

As part of the interview for the monitored group, residents were asked how much of the day they were typically at home. Figure 2.14 shows that 19 of the residents said they were typically at home all day, while 11 said they were usually at home for half of the day.

The amount of time the resident is at home is used along with the annual electricity consumption and annual solar generation to estimate the level of solar PV self-consumption. Where a battery is included, the capacity of the battery is also included[11].

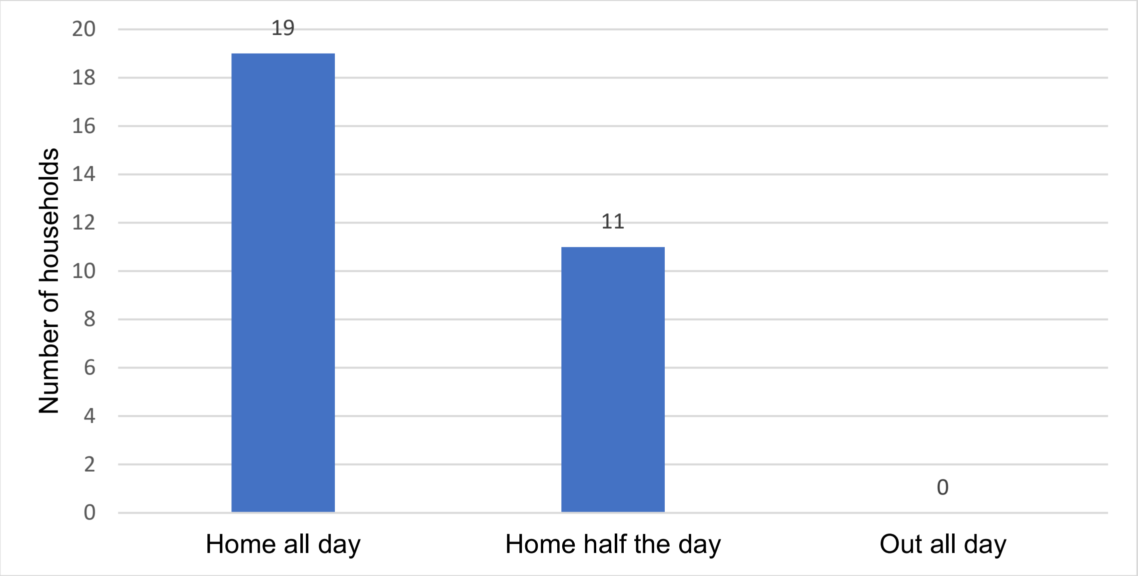


Figure 2.14 Times when residents were typically at home

During the interviews, households were asked about their electrical appliances and the times of day they were used (see figure 2.15). 25 of the 30 households had an electric cooker, with the others having a gas cooker. There were 22 households interviewed who had an electric shower. Among the 7 who said they did not have electric showers, 2 households had air source heat pumps, 3 were on a biomass heat network and 2 had gas boilers. Not having electric cookers or showers should have reduced the household electricity demand.

Only 3 of the 30 households had dishwashers, while 13 had tumble driers. It should be noted that most of those with tumble driers only used them in winter/wet weather. Other high power electrical appliances used by households included: electric wheelchairs/scooters, other electrical medical equipment, kettles, toasters and air fryers.

Households were also asked about whether they had home broadband or a smart phone. Among the 30 households interviewed, 26 had home broadband and a Wi-Fi router, 3 had no broadband and a further household had mobile broadband. There were 23 households who left the Wi-Fi router switched on overnight and when they were out. The remaining 3 households had been turning the Wi-Fi router off but were advised against this during the interview due to the need to keep the battery online. A total of 26 of the 30 households had smart phones which were capable of using phone apps.

---

[11] Solar PV Self-Consumption: A method to determine the Electrical Self-Consumption of Domestic Solar PV installations with and without Storage, https://mcscertified.com/wp-content/uploads/2022/04/MGD-003-Solar-PV-Self-Consumption-Issue-2.0-Final.pdf (Accessed 18 May 2023)

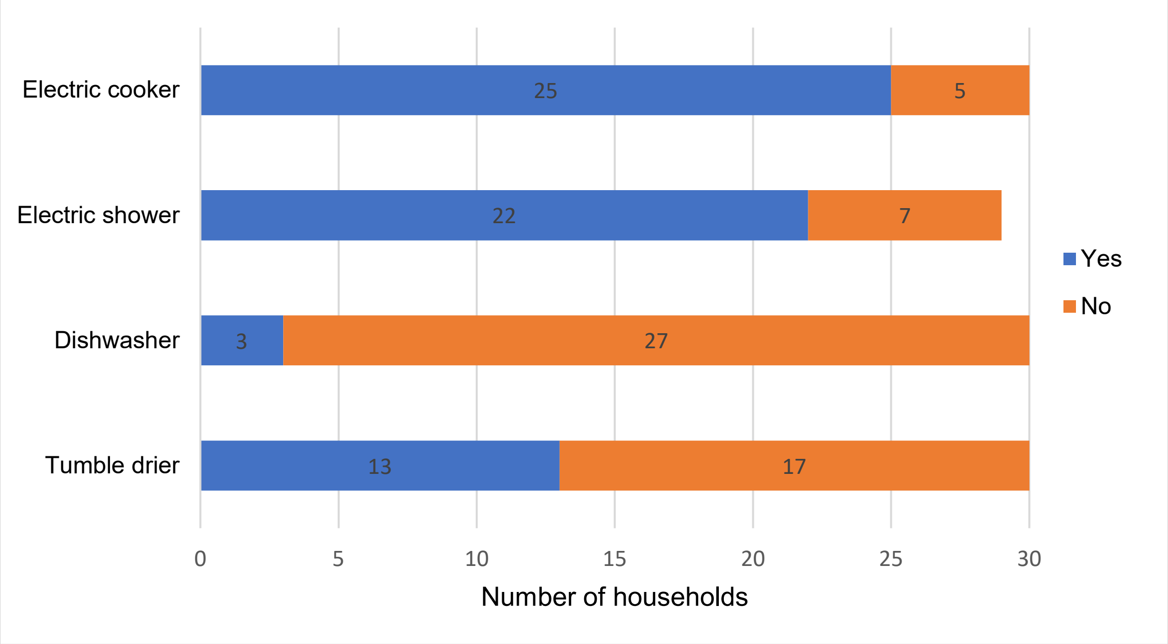


Figure 2.15 Household electrical appliances

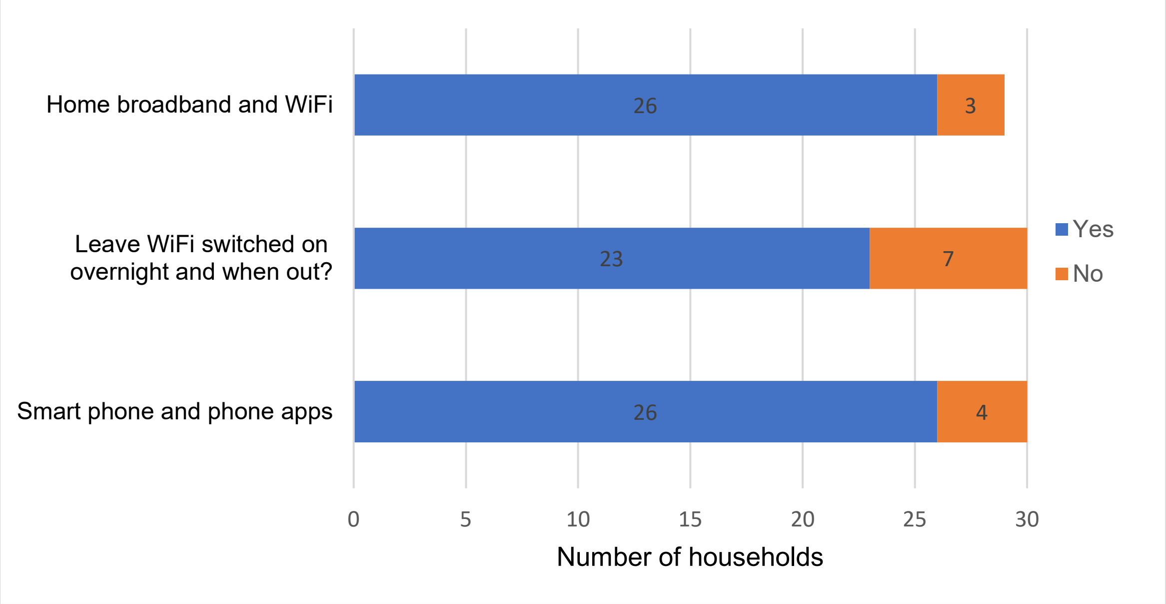


Figure 2.16 Household broadband and smart phones

2.3 Age UK Barnsley advice

As part of the project, the households receiving batteries were provided with advice and support from Age UK Barnsley. The aim was to provide each household with a home visit while some households had additional support by telephone.

The home visits began in August 2022 and were completed by the end of March 2023. Residents received a telephone call to book the home visit. In some cases, there were follow up telephone calls after the home visits. In total, 66 households received 1 home visit and 6 households received 2 home visits. There were 3 households where it was not possible to arrange visits.

There were 49 households who had a single phone call, with 15 households having 2 calls and 7 having 3 phone calls. There were 4 households who had 4, 5 or 6 phone calls.

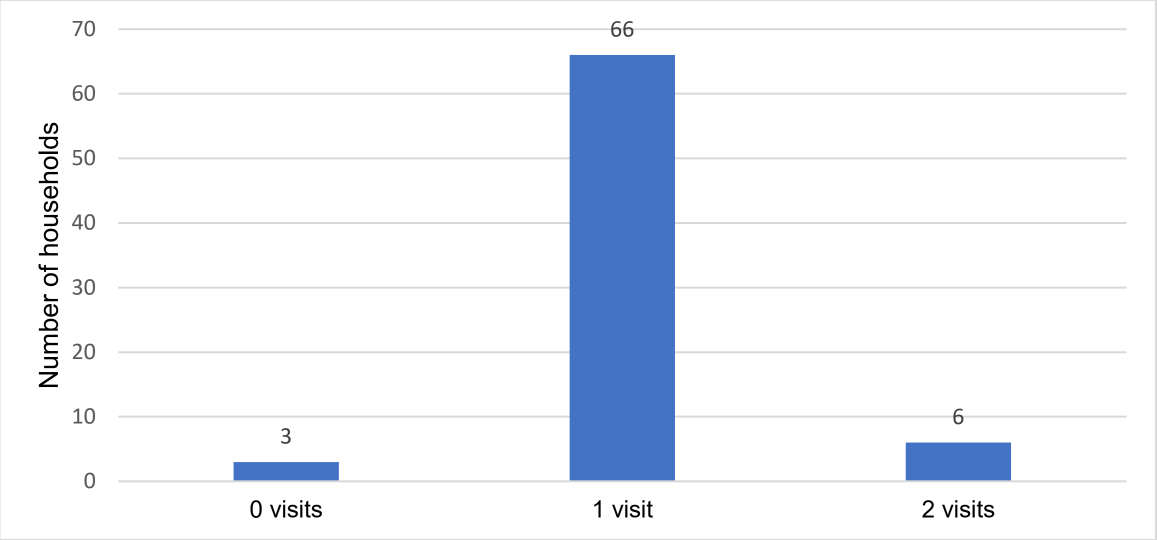


Figure 2.17 Number of home visits per household carried out by Age UK Barnsley

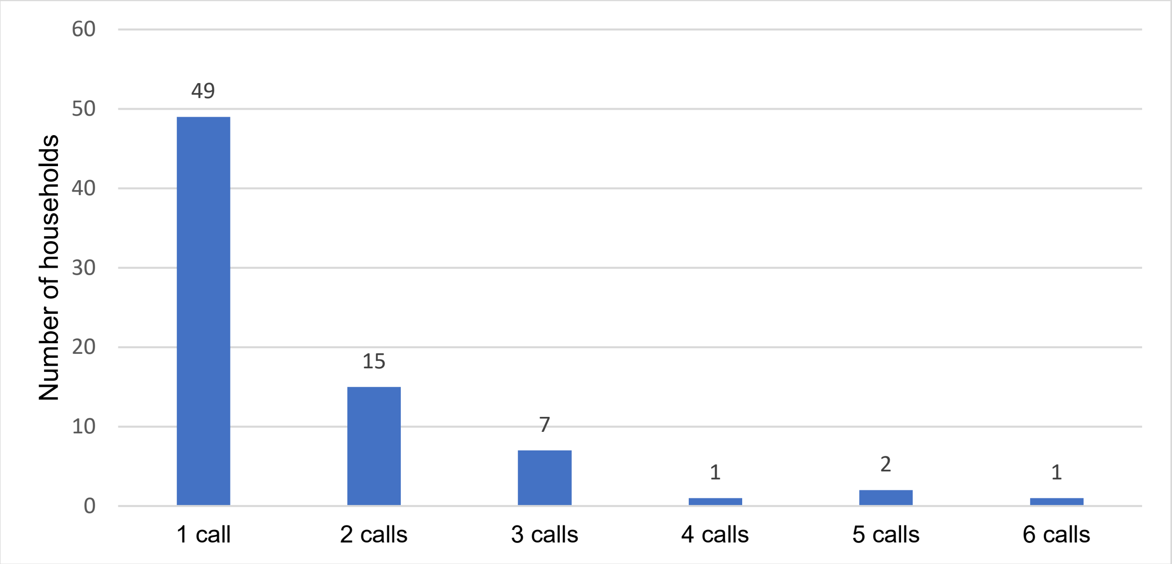


Figure 2.18 Number of phone calls per household carried out by Age UK Barnsley

The Age UK Barnsley advisor typically carried out 4 home visits per day. During a visit she provided the household with a copy of a solar PV advice leaflet produced by NEA through another project[12]. This was used to explain the solar PV system and discuss the best times to use appliances. The residents were also shown information on the savings they had achieved with the battery system. This was based on a spreadsheet downloaded from the battery monitoring portal. It calculated the savings in kWh from the solar PV and from the battery. An electricity unit rate of 28p/kWh was used to calculate the savings in £. This was based on the default electricity price cap for the period 1 Apr 22 to 30 Sep 22.

The advisor also discussed how residents could see information on the phone app for the battery and see when the best time was to use appliances. 20 of the households were using the battery phone app. There were 22 households also provided with additional benefits advice. If there were any questions the advisor could not answer on the day, she consulted with other project team members and got back to the household.

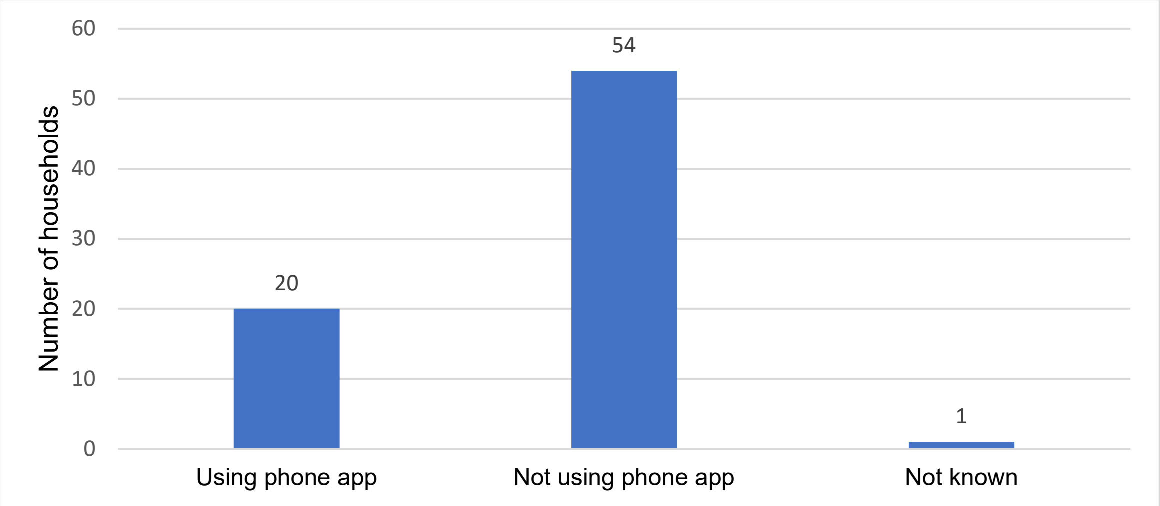


Figure 2.19 Number of households visited by Age UK Barnsley using the battery phone app

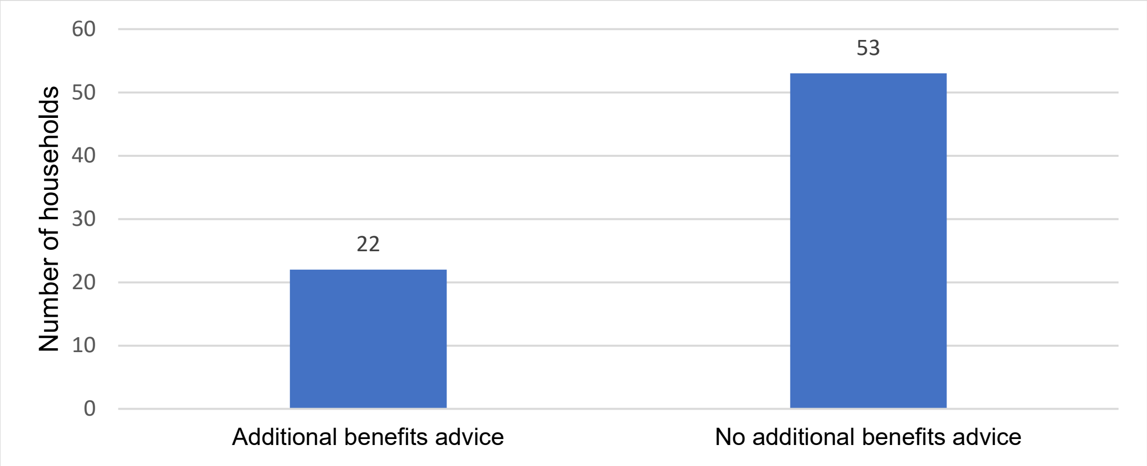


Figure 2.20 Number of households receiving additional benefits advice

---

[12] Understanding solar PV and maximising the benefits, National Energy Action (2020), https://www.nea.org.uk/wp-content/uploads/2020/11/SOLAR_PV_2020_final.pdf (Accessed 22 May 2023)

3. Installations, technologies and monitoring

3.1 Overview of the technology

3.1.1. Electrical battery

The SMILE-B3 battery manufactured by Alpha ESS was selected for the installations. The battery had a capacity of 2.9kWh with a usable capacity of 2.8kWh (with a 96% depth of discharge). The battery had a maximum charge and discharge rate of 3kW. The lifespan of the battery under test conditions is 10,000 cycles. It has a 5-year product warranty and 10-year battery performance warranty. Further details of the system are available from the battery datasheet in Appendix 3, with a summary of the warranty in Appendix 4.

The SMILE-B3 was available in an IP65-rated version suitable for outdoor use. This was chosen as it allowed greater flexibility in where the battery could be fitted.

The dimensions of the SMILE-B3 were 610 x 236 x 625mm. During the initial resident engagement, the Berneslai Homes project liaison officer had a SMILE-B3 battery case which was shown to households during recruitment to ensure they were comfortable with the size of the battery.

The SMILE-B3 is a modular battery, and the size of the system can be expanded. Up to 5 further 2.9kWh modules could be added, taking the capacity to 17.4kWh.

The battery is AC-coupled which means there was no need to change the inverter for the solar PV system. Figure 3.1 shows a schematic diagram for an installation. There are 2 current transformers (CT clamps) required by the battery for monitoring the solar generation and the household electricity consumption. The battery is able to charge from either a solar PV system or the electricity grid with a time of use tariff.

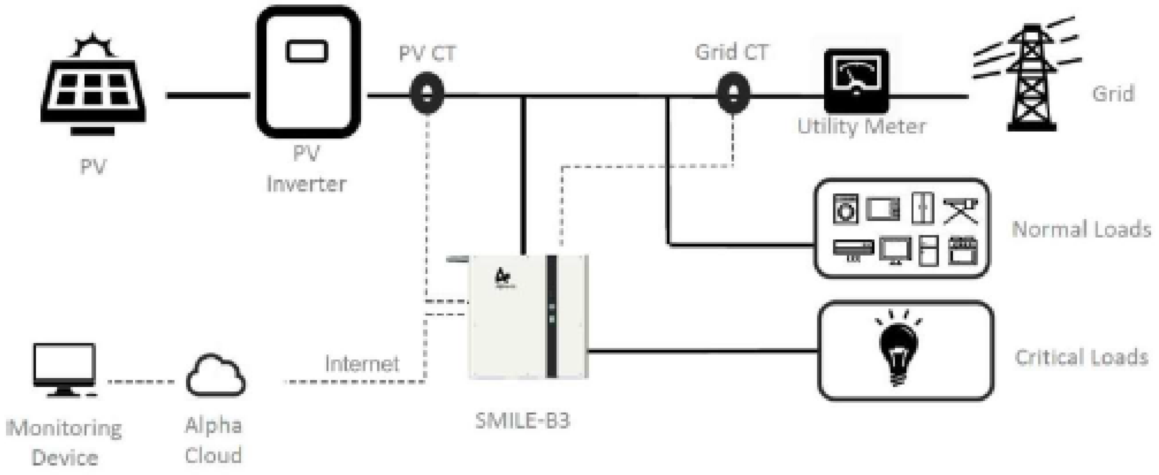


Figure 3.1 Schematic diagram of an Alpha ESS SMILE-B3 battery installation with solar PV[13]

---

[13] Alpha ESS, Installation & Operation Manual Energy Storage System (ESS) Storian-SMILE-B3 V08

Figure 3.2(a) SMILE-B3 installation

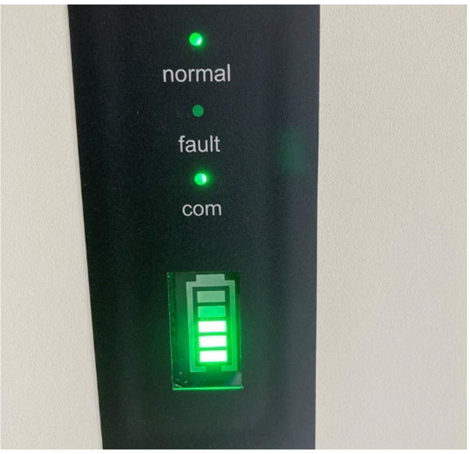


Figure 3.2(b) SMILE-B3 battery display

An example of a SMILE-B3 battery installed on the project is shown in figure 3.2(a) where it was located in the storage area of one of the bungalows.

The battery has 3 small green LEDs which indicate the operating status of the battery:

- Normal
    - LED on indicates normal system operation
    - LED flickering – system on standby or in self-inspection
    - LED off – system out of order
- Fault
    - LED off – fault-free
    - LED on – out of order
- Com
    - LED on – has normal network connection
    - LED flickering – connecting to the server
    - LED off – the battery is not connected to the network

The display also has a battery symbol with 5 green LEDs showing the state of charge (SOC) of the battery.

- 0 bars on battery
    - Less than 5% state of charge
- 1 bar on battery
    - Between 5 and 25% state of charge
- 2 bars on battery
    - Between 25 and 50% state of charge
- 3 bars on battery
    - Between 50 and 75% state of charge
- 4 bars on battery
    - Between 75 and 95% state of charge
- 5 bars on battery
    - Greater than 95% state of charge

Figure 3.3(a) Isolator installed by engineer Figure 3.3(b) SMILE-B3 battery breaker and switch

The communication ports are on the left-hand side of the SMILE-B3 battery. A Wi-Fi dongle can be used or an ethernet communication cable. These can be used to connect the battery to the internet. There is also the battery switch and breaker on this side of the battery.

Occasionally the communications for the battery can go offline and all that may be required is a system reboot. The procedure for this is as follows:

Power Down

- Turn off the isolator switch which was fitted by the engineer (figure 3.3(a))
    - This will isolate the battery from the mains grid
- Flick all the power switches within the 'Battery Breaker' unit to off, after undoing the two screws by hand and pushing the lever whilst opening the box
- Push and hold down the 'Battery Switch' for 30 seconds (figure 3.3(b))
- Check that all the LED lights on the front are off (figure 3.2(a)) and wait a minute

Power Up

- Turn the isolator switch back on
- Turn the 'Battery Breaker' switches back on
- Power the 'Battery Switch', press and hold for 30 seconds
- Observe the LED lights on the front of the battery
    - Give them time to settle down and the 3 green LEDs to stay on constantly
- Check the Wi-Fi dongle is showing red and green

With a fleet of 75 batteries communication faults might be expected to occur every now and then. This procedure was a method that tenant liaison officers or perhaps some residents could use to check if it was a communications fault rather than the battery having stopped working.

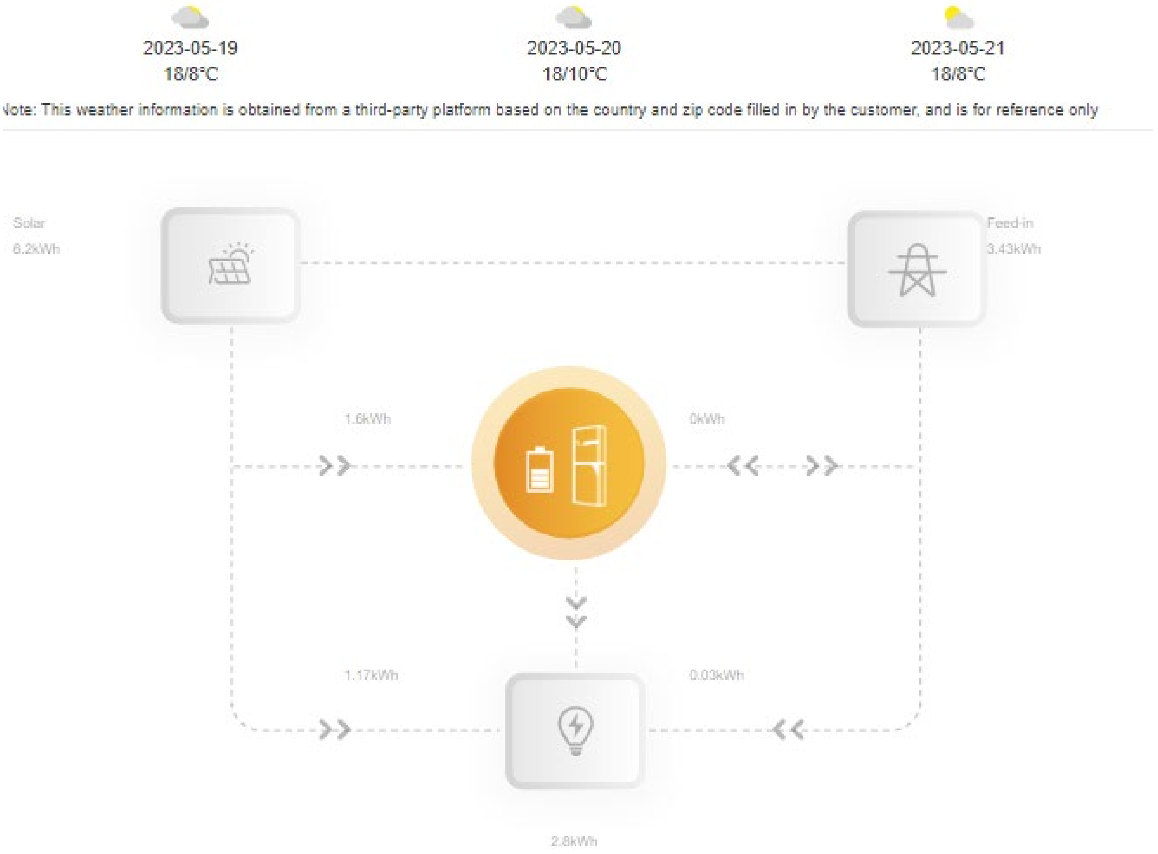
3.1.2. Alpha Cloud monitoring portal

Alpha ESS provides customers with access to free monitoring via the Alpha Cloud monitoring portal and the Alpha ESS app. The 75 batteries installed on the project were connected to the internet and setup on a single account with the same login for the Alpha Cloud portal. The batteries are listed on the portal by serial number and it is possible to find a particular installation by searching for the battery serial number.

The main use the project team made of the portal was for monitoring system performance and noting if a system had lost connection with the internet. It was also possible to use the portal to change settings on the batteries and notify Alpha of faults with batteries.

The portal produces a number of different graphs and charts which are useful in understanding the performance of the battery system.

The first 2 are under the system information tab and are the Energy Diagram and Real-time Power Graph which illustrate performance of the battery-solar system that day. Figure 3.4 shows the Energy Diagram on 19 May 23 for one of the installations. This shows the energy flows on the day in kWh up until the time the image was taken. On that day, there had been 6.2kWh generated by the solar panels and 3.43kWh had been exported to the grid (described as feed-in). 1.6kWh of the solar generation had been stored by the battery and 1.17kWh of the generation had been used by household appliances. Only 0.03kWh had been imported from the grid.



Note: This weather information is obtained from a third-party platform based on the country and zip code filled in by the customer, and is for reference only

Figure 3.4 Energy Diagram from the Alpha Cloud portal on 19 May 2023 for a SMILE-B3 battery

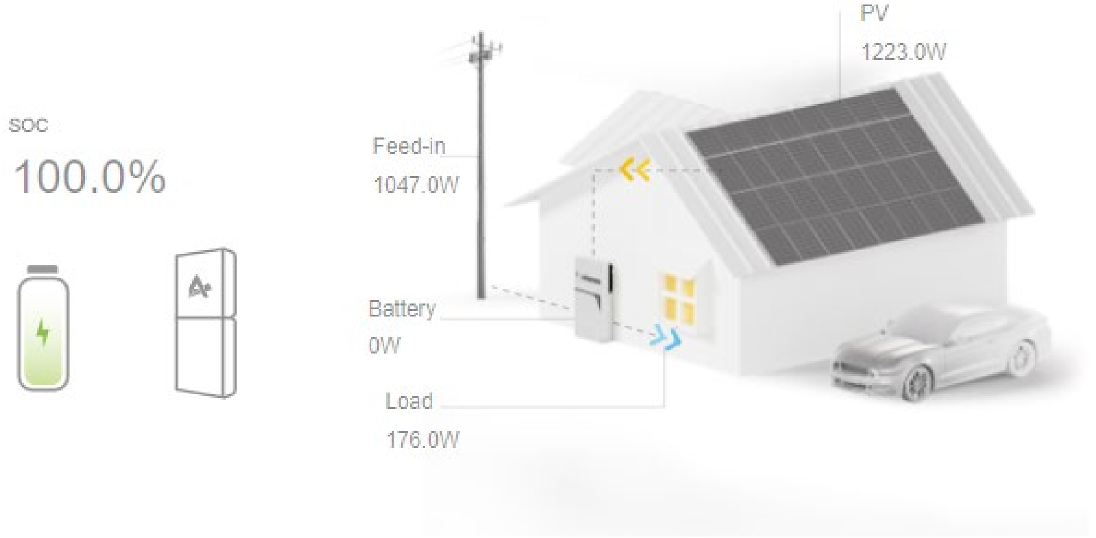


Figure 3.5 Real-time Power Graph from the Alpha Cloud portal on 19 May 2023 for a SMILE-B3 battery installed in the Smart Solar in Barnsley project

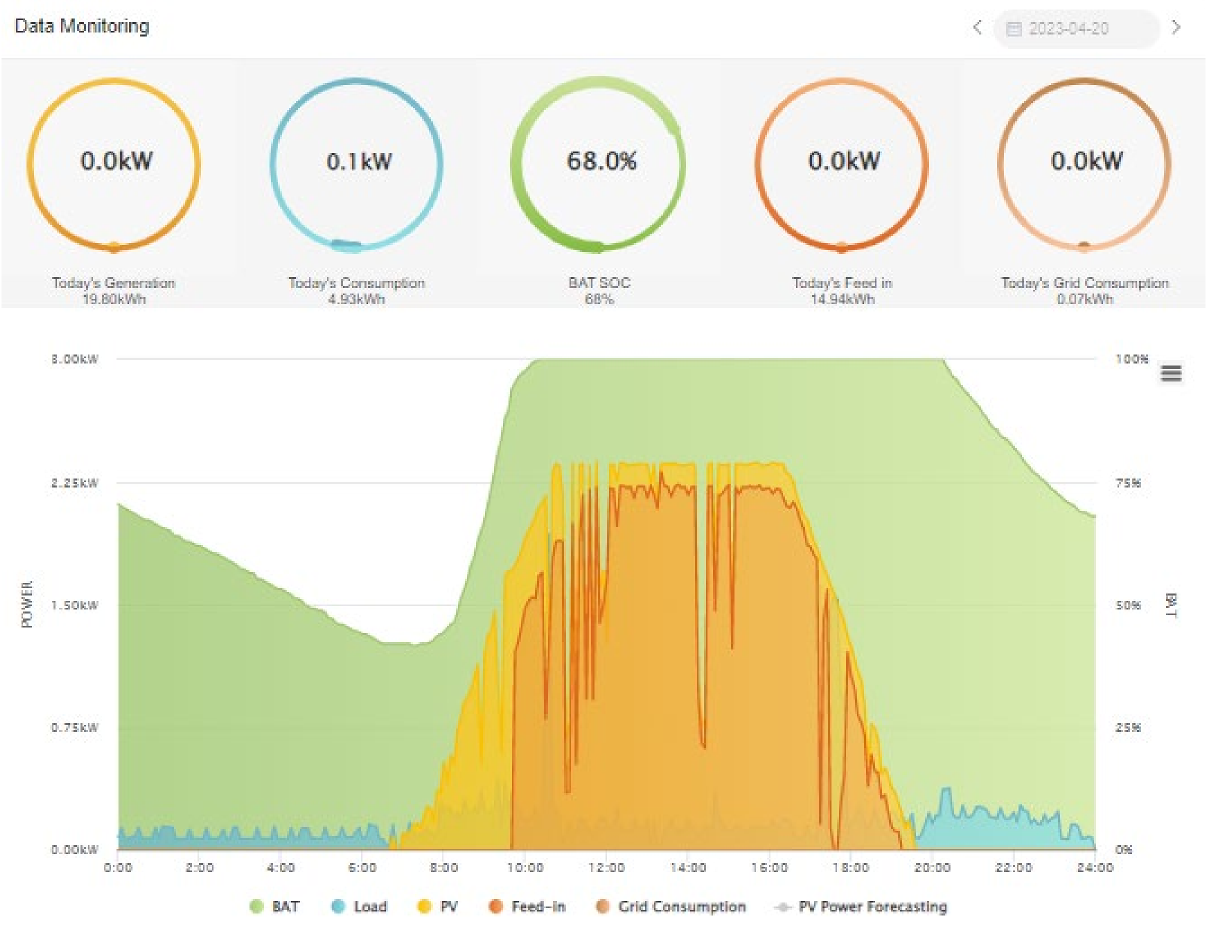
The Real-time Power Graph in figure 3.5 shows the instantaneous power flows for the battery-solar installation. At the time the image was taken, the solar PV system was generating 1,223W and the battery was fully charged (100% state of charge). This meant that apart from the 176W being used by the household load, the remaining 1,047W of electricity was being exported to the grid (feed-in).

The Power Diagram plots a graph of generation, consumption and battery charge on a selected day. Figure 3.7 shows an example Power Diagram for a SMILE-B3 battery installation with a 3.0kW solar PV system on 20 Apr 23. At the top of the chart is a summary of key statistics for that day. On 20 Apr 23, the solar panels generated 19.8kWh and 14.94kWh was exported to the grid (feed-in). The household used 4.93kWh of electricity that day, with most of it coming from the solar PV and battery and only 0.07kWh being imported from the electricity grid (grid consumption).

The colours used on the Power Diagram are explained in table 3.6.

Colour	Summary	Explanation
Green	BAT	Percentage battery charge
Blue	Load	Household load – electricity used in home
Yellow	PV	Solar PV generation
Orange	Feed-in	Electricity exported to the grid
Brown	Grid consumption	Electricity used by the home from the grid

Table 3.6 Colour coding used on the Alpha Cloud Power Diagram



Data Monitoring

2023-04-20

0.0kW
Today's Generation
19.80kWh

0.1kW
Today's Consumption
4.93kWh

68.0%
BAT SOC
68%

0.0kW
Today's Feed in
14.94kWh

0.0kW
Today's Grid Consumption
0.07kWh

Figure 3.7 Power Diagram from the Alpha Cloud portal for an installation on 20 April 2023

Overnight on 20 Apr 23, the household had an electricity consumption of 70 to 140W (shown in blue) and this was provided by the battery. The charge level of the battery (shown in green) dropped from 70% at midnight down to 42% at 07:25 when the solar generation (in yellow) exceeded the household consumption and allowed the battery to charge. The battery had reached 95% charge by 09:45 and excess solar generation began to be exported to the grid (in orange). The solar generation exceeded the household consumption until 19:30. The battery then powered the household consumption (load) until midnight and the battery charge by that stage had fallen to 68%. During the day, the portal suggested the household only used 0.07kWh from the electricity grid and so no grid consumption (in brown) was apparent on the graph.

It is possible to download a spreadsheet with data for the graph by clicking the 3 horizontal lines on the top right of the chart of the Power Diagram. The spreadsheet provides 5-minute interval data in kW for the Load, PV generation, Export (Feed-in) and Grid Consumption. The spreadsheet also includes the percentage charge of the battery.

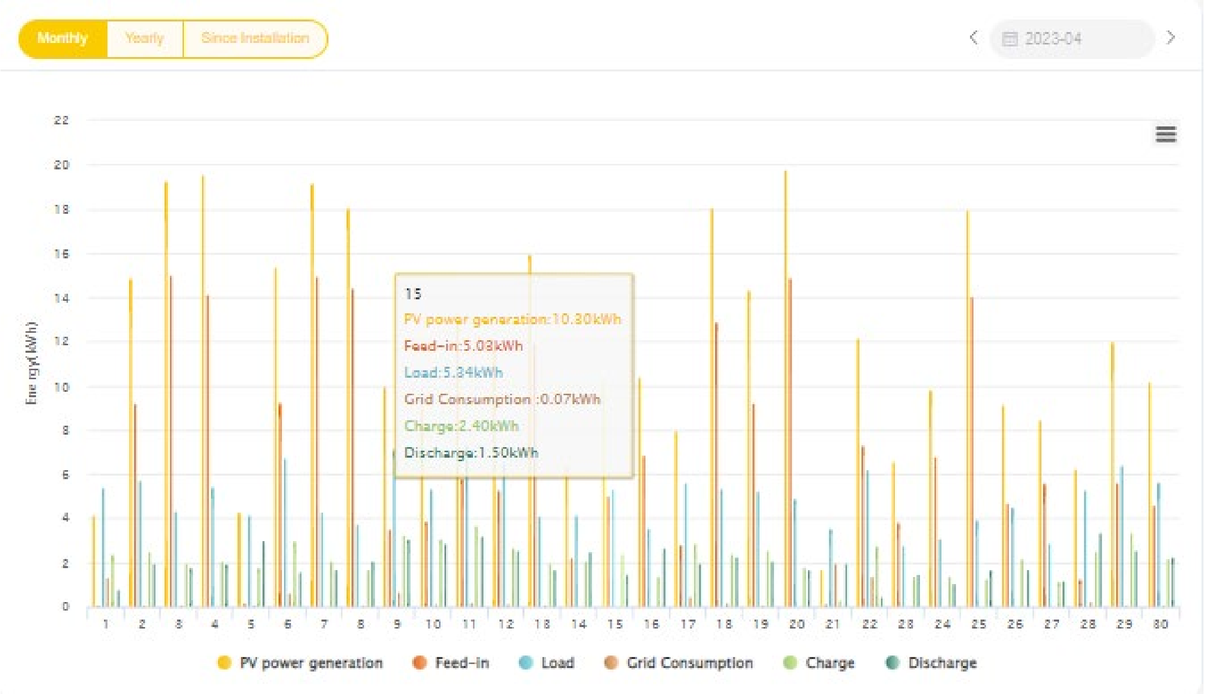


Figure 3.8 Statistical diagram from the Alpha Cloud portal for a battery installed on the project

The other chart on the Alpha Cloud portal which is useful for analysis of the performance of the battery system is the Statistical Diagram. This plots a bar-chart showing in different colours the values of:

- PV power generation
- PV export to the grid (Feed-in)
- Household electricity consumption (Load)
- Household grid consumption
- Battery charge
- Battery discharge

It is possible to choose a Statistical Diagram for a particular month which will show values for each day in that month. Likewise, it is possible to select the Yearly Statistical Diagram which will show values for each month in that year.

The numerical values can be displayed by hovering over part of the diagram. A spreadsheet can also be downloaded by clicking on the 3 horizontal bars to the top right of the statistical diagram.

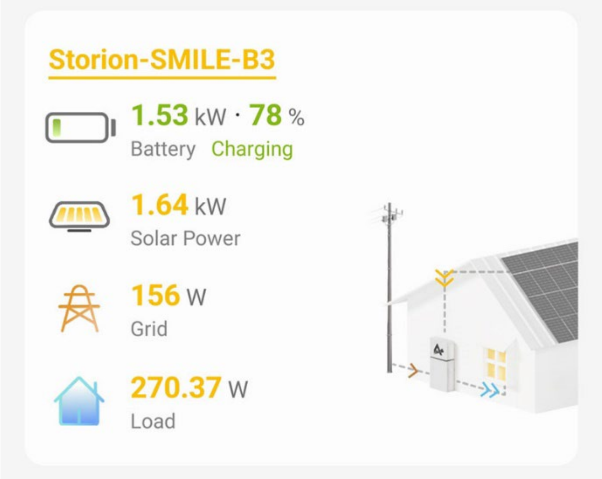
Energise Barnsley downloaded data from the statistical diagram for each of the households prior to advice visits from Age UK Barnsley. This was used to calculate the savings in kWh from the solar PV and from the battery storage. The savings in £ were calculated by multiplying the kWh by the typical unit rate for the Default Energy Price Cap for 1 Apr 22 to 30 Sep 22 of 28p/kWh.

Savings from solar PV = (PV generation – PV export – Battery Charge) x electricity unit rate

Savings from battery = Battery discharge x electricity unit rate

3.1.3. Alpha ESS monitoring app

The Alpha ESS app is able to show users similar information to the Cloud monitoring portal.



Storion-SMILE-B3

1.53 kW · 78 %
Battery Charging

1.64 kW
Solar Power

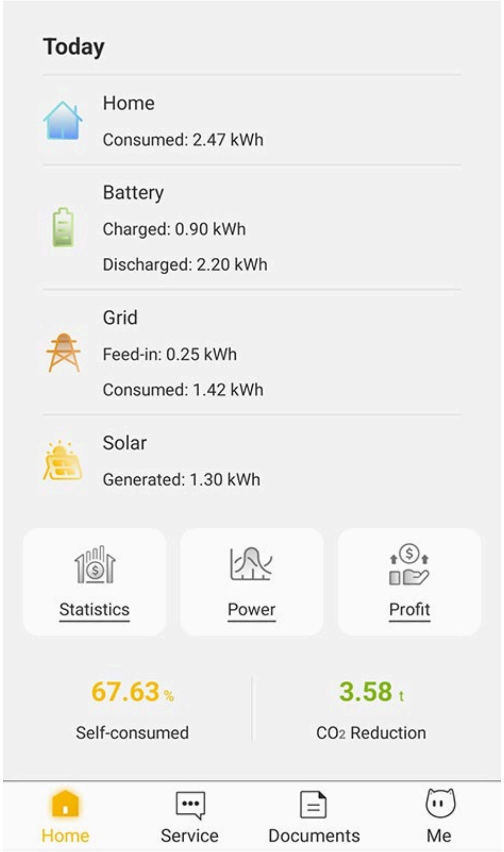
156 W
Grid

270.37 W
Load

Figure 3.9 Real-time power graph on app

The diagram in figure 3.9 is from the home screen of the app, showing the equivalent of the Real-time power graph on the Alpha Cloud portal. This provides the current values of the battery charge (and the rate of charge or discharge), solar power, the import from or export to the grid and the load in the home.

These values could be updated every few minutes. The batteries which were connected to the internet with a wireless router collected data every 5 minutes.



Today

Home
Consumed: 2.47 kWh

Battery
Charged: 0.90 kWh
Discharged: 2.20 kWh

Grid
Feed-in: 0.25 kWh
Consumed: 1.42 kWh

Solar
Generated: 1.30 kWh

67.63 % Self-consumed

3.58 t CO2 Reduction

Figure 3.10 Energy summary for today

On the home screen, below the summary of the current performance or Real-time power graph is an energy summary for that day as shown in figure 3.10. This provides details of the household consumption that day to that time, the charge and discharge of the battery, the consumption and export (feed-in) to the grid and the solar generation.

There are 3 buttons on the screen which can be clicked for additional performance information. These are ‘Statistics’, ‘Power’ and ‘Profit’.

There are also a further 4 buttons at the bottom of the screen. Normally households would only use the ‘Home’ section. The ‘Service’ section is used for notifying Alpha if there is an issue with the battery. The documents section provides the opportunity to access information such as a user manual. The Me section includes settings such as the language and can be used to set-up with Wi-Fi for the battery. This should generally not be used by tenants.

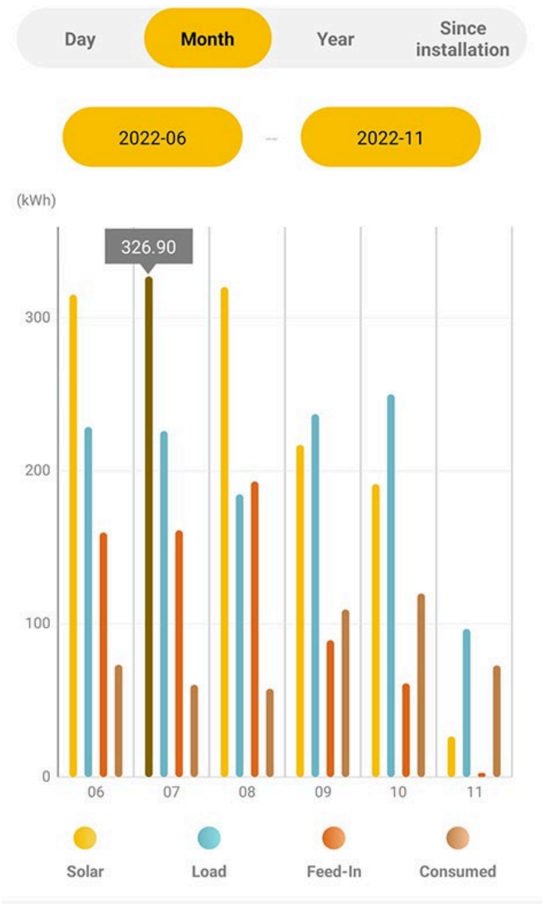


Figure 3.11 Alpha ESS app Statistics

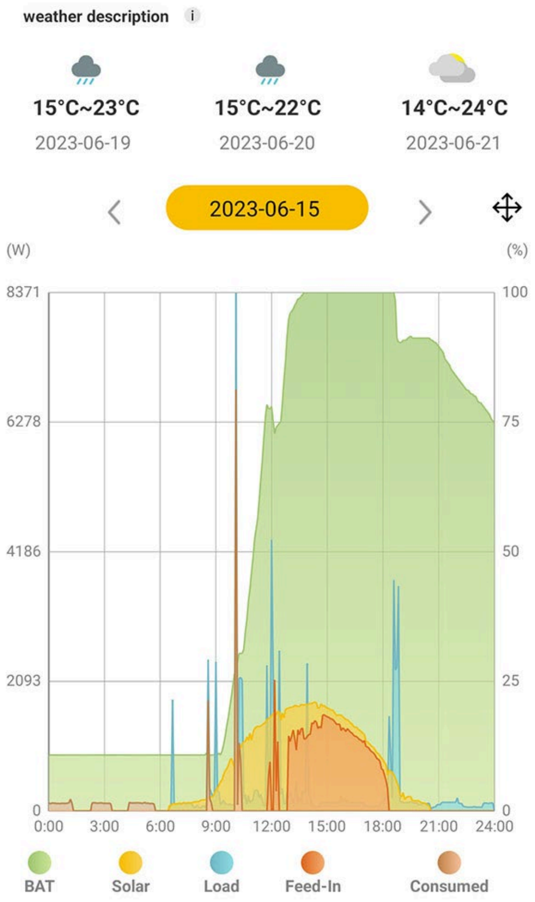


Figure 3.12 Alpha ESS app Power

Figure 3.11 shows the Statistics section of the Alpha ESS app. In this case it was set to month and showed values of solar generation, household load, export (feed-in) and (grid) consumption between June 2022 and November 2022. Values can be obtained by clicking on individual bars on the chart which are then highlighted in black, with the number at the top. The Statistics section can also show bar charts of the days in a month and different years.

A graph from the Power section is shown in figure 3.12. This illustrates how the battery charge, solar generation, load (household consumption), feed-in (export to the grid) and consumed (grid consumption) varies over a particular day. It is possible to select another day by clicking on the orange date button or using the “<” and “>” characters. The app will display values for the different parameters if the user clicks on the graph.

The battery charge was at 11% overnight on 15 Jun 23 and the battery started charging from just after 09:00 and reached 95% charge by about 13:00. There was sustained export of electricity to the grid from 13:00 until about 18:00 until the household load exceeded the solar generation, most likely from cooking the evening meal. The battery started to discharge from that point and by midnight had fallen to a charge level of 75%.

Residents who had smart phones had the Alpha ESS app set up on their phone by the Project Support Officer for Berneslai Homes.

3.2 Installation programme of the 75 batteries

The battery installation programme was carried out by Berneslai Homes electricians with the assistance of the project liaison officer who was trained to connect the batteries online.

The wholesale cost of the Alpha ESS SMILE-B3 battery was about £1,200 + VAT. 45 of the batteries were fitted inside the bungalow and the average indoor installation cost was £304. The remaining 30 batteries were fitted in outhouses. These could be directly connected to the bungalow or a short distance away from the bungalow. The average price for the installations in the outhouses was £637.

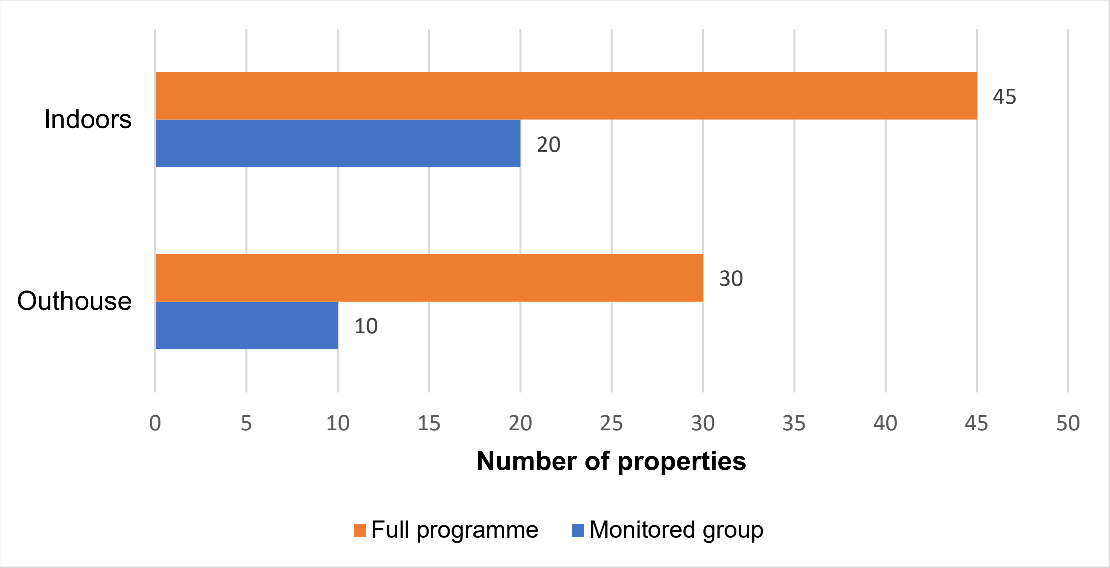


Figure 3.13 Location of the Alpha ESS SMILE-B3 batteries

The electrical team had been provided with in-situ training by Alpha/Immersa. The lead electrician for the project later trained 2 further electricians on his team and an apprentice to complete the later installations. The electricians worked in teams of 2 as the battery was too heavy for a single person to fit. It was possible for a team to install 2 batteries in a day.

Residents were advised the power would be off in their home for around a couple hours. The installers made the final choice for the location of the battery and fitted the brackets for the battery onto the wall. The battery was connected to the consumer unit with appropriate changes and labelling required.

The batteries needed to be connected to the internet to provide monitoring and for warranty purposes. Out of the installations, 57 used the household Wi-Fi broadband to connect the battery to the internet (figure 3.14). This had the advantage of no additional installation or running costs for Berneslai Homes. However, if the resident changes broadband router, the battery loses internet connection and a visit to reconnect the battery would be required.

The other 18 installations had a wireless router fitted which had its own SIM card. This was typically used for households who did not have the internet. For these installations, a new 13A socket was fitted near the battery for the wireless router. Figure 3.15 shows a battery installation in an outhouse with a wireless router. While fitting a wireless router avoids issues with the battery connection being lost due to changes of the broadband router, there are the additional costs associated with the mobile router and annual data charges.

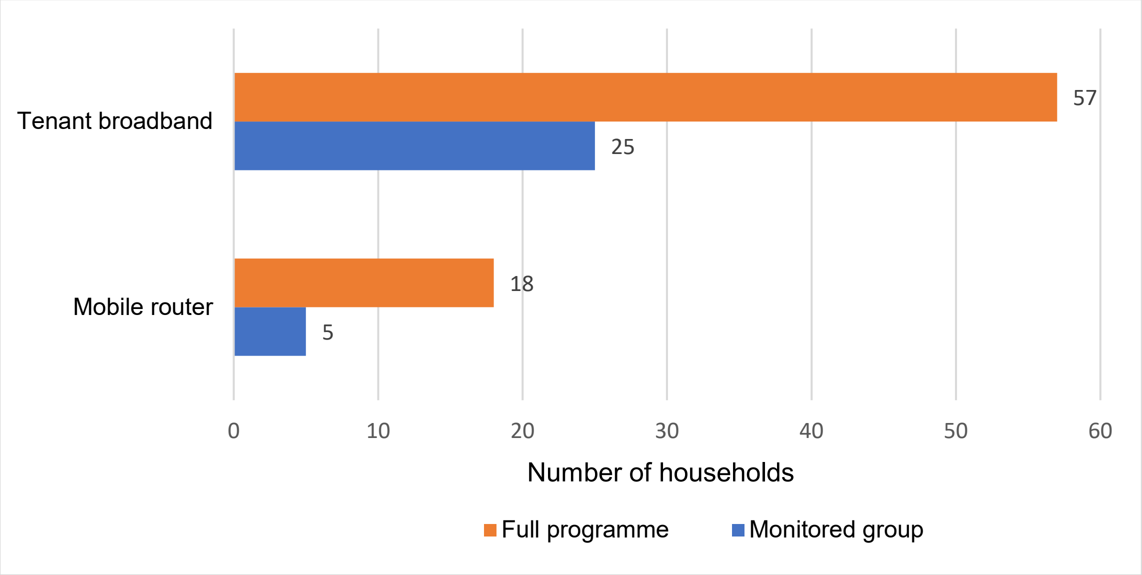


Figure 3.14 Method of connecting the Alpha ESS SMILE-B3 batteries to the internet

Figure 3.15 Installation of an Alpha ESS SMILE-B3 battery in an outhouse with a mobile router

The project liaison officer was provided with an afternoon of training by the lead electrician on how to connect the batteries to the internet and carry out the commissioning process. Additional support was also provided by telephone from the lead electrician, Immersa and Energise Barnsley.

About 50 of the households had the Alpha ESS monitoring app installed and set up on a smart phone by the project liaison officer to enable monitoring of the system by residents. She also explained how the system worked and how best to make savings. An advice leaflet explaining the solar and battery system was left in a clear wallet stuck on the front of the battery. A copy of this leaflet is available in Appendix 5.

The first phase of 15 installations ran from 15 Nov 21 until 25 Nov 21. Phase 2 of the installations ran from 23 Feb 22 until 5 May 22 (see figure 3.16). These later battery installations included all those in the outhouses. There were some issues during phase 1 of the installations with CT clamps being fitted in the wrong location or orientation. These were picked up during the commissioning process. For some of the early installations, this took a few days to resolve, but subsequently, issues were sometimes dealt with on the same day.

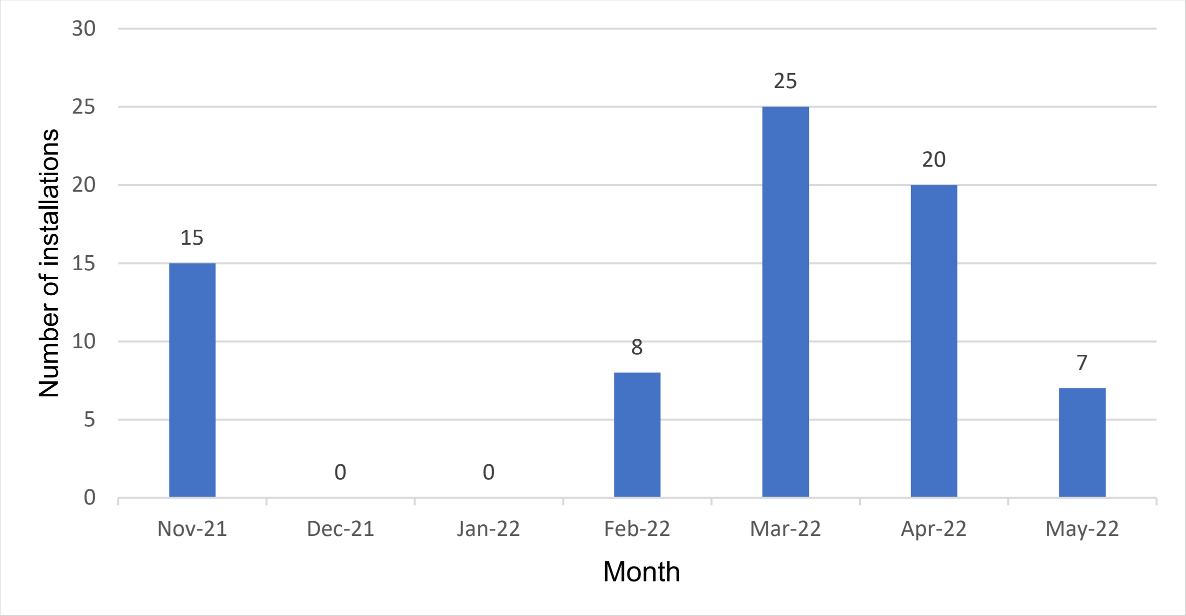


Figure 3.16 Dates of Alpha ESS SMILE-B3 battery installations

Figure 3.17
Alpha ESS SMILE-B3 battery with the cover off

Figure 3.18
Battery installed in an outhouse with a boiler

3.3 Resident satisfaction with the battery installations

A group of 30 of the households that received batteries were recruited to assist with the project evaluation. This monitored group completed a telephone interview and the performance of their battery and solar PV system was investigated in greater depth. The interview for a resident in the monitored group who was deaf was completed by a friend. In this case, not every question was answered.

As part of the telephone interview, households were asked about their satisfaction with the battery installation programme. They were asked to rate different aspects of the installation as either: Very Good, Good, Average, Poor or Very Poor.

Households were asked how they rated communications leading up to installation of the battery and 26 of them thought it was very good while 3 households thought it was good. When asked how they rated the courtesy of the staff installing the battery, 27 said it was very good and 2 said it was good. There were also 27 households who rated the tidiness of the work as very good and a further 2 saying it was good.

When asked about rating the overall workmanship of the installation of the battery, 28 households thought it was very good and a further household said it was good. The residents were also asked to rate the explanation of the battery. In this case, 20 households described it as very good, 5 households as good and 4 households as average. Residents were also asked to rate the overall installation of the battery with 27 describing it as very good and 2 households as being good.

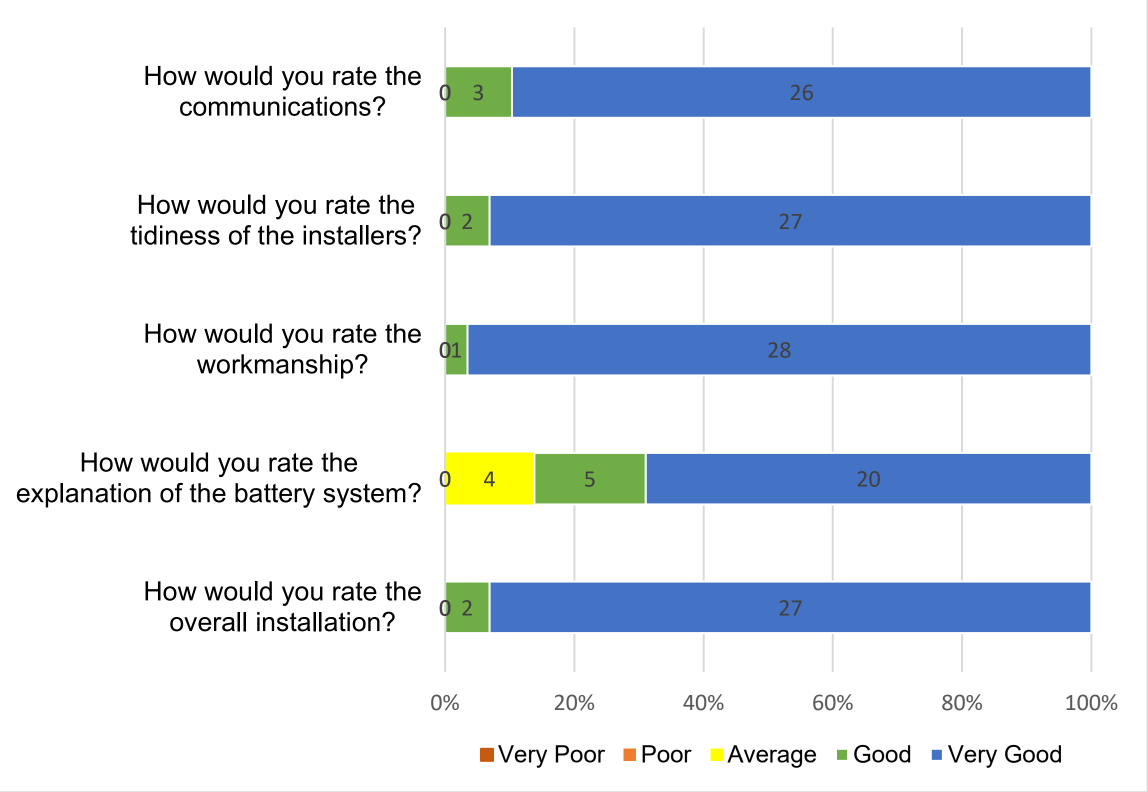


Figure 3.19 Resident satisfaction with the battery installation programme

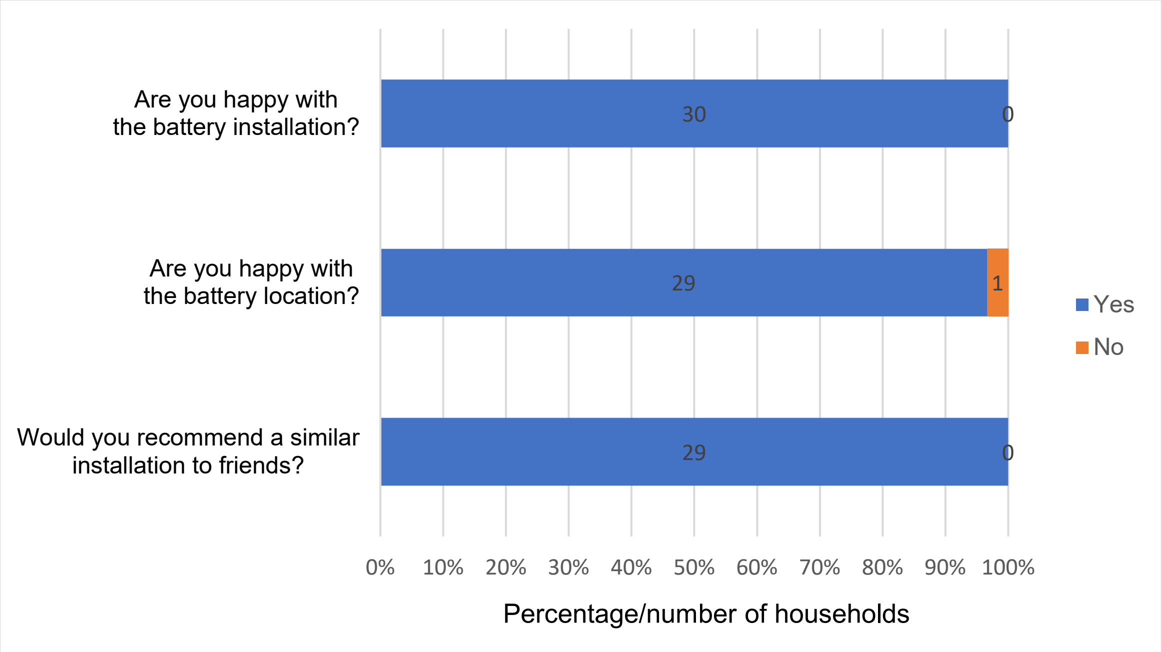


Figure 3.20 Satisfaction with the Alpha ESS SMILE-B3 battery

Households were asked some yes/no questions to determine their satisfaction with the battery. When asked if they were happy with the battery installation, 30 of the households said yes. Only a single household was unhappy with the location of the battery. It had been fitted in a cupboard in the bedroom. At the time the resident was happy with the location, but a neighbour later had an installation in an outhouse which would have been preferable. All 29 of the households that responded would recommend a similar installation to their friends.

The resident satisfaction survey results were extremely positive and compare favourably with other projects. The question where responses were less positive was on explanation of the battery system. It can be a challenge to explain how a battery and solar system works. It can also be harder for some older residents who have a less good understanding of technology and might have memory issues to fully understand and retain the explanation. This may be a factor in the responses to this question.

3.4. Monitoring and understanding of the battery by the residents

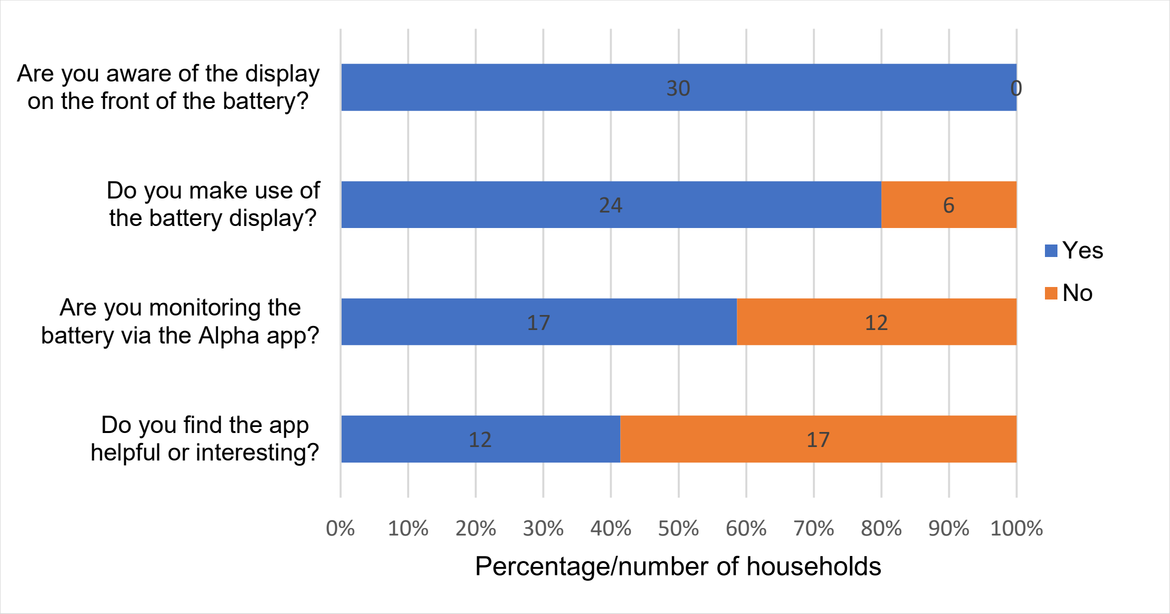


Figure 3.21 Monitoring of the battery by residents

Section 3.1.1 showed the Alpha ESS SMILE-B3 battery has an LED display which shows the charge level of the battery. The number of these LEDs on the battery which are lit rises and falls each day as the battery charges and discharges.

During the interview with the 30 monitored households, residents were asked about the display showing the level of charge on the battery. All 30 of the households were aware of the battery display and 24 of the households made use of it. This could be to check the battery was working or to know when it might be a good time to use appliances. In some cases, residents looked at the display 2 or 3 times a day. Most of those who did not use the display had the battery installed in an outhouse and so did not regularly see the display. A household with an indoor installation in the hallway had covered the display because the green light flashing was distracting.

There were 25 out of the 30 monitored households who had the Alpha ESS app installed on a smart phone. When interviewed, 17 out of the 30 households said they were monitoring the battery via the Alpha ESS app and 12 of these said they found the app helpful or interesting. Some households said they were not very technically minded and so did not tend to use the app. Others used it extensively to monitor the solar PV, electricity use and how much was coming from the battery. They also used it as a guide for behaviour change, using appliances when they were likely to be powered for free.

A full list of comments residents made on how they used the battery display and the Alpha ESS phone app is provided in Appendix 6.

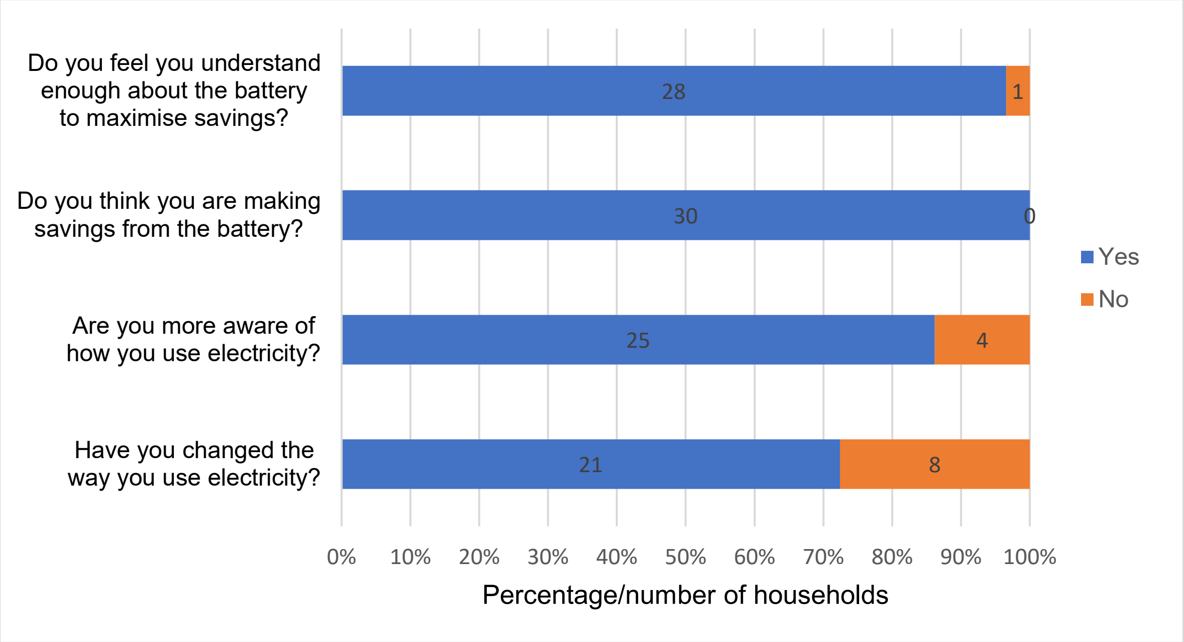


Figure 3.22 Understanding the performance of the battery and awareness of electricity use

The households that were interviewed were asked further questions on their understanding of savings from the battery and their electricity use which are shown in figure 3.22. Out of the 29 households that responded, 28 felt they understood enough about the battery to maximise savings. All 30 households thought they were making savings from the battery.

In addition to having the battery display and app and being able to perceive changes in their electricity costs, households also received a visit from Age UK Barnsley. During these visits, residents were shown data from the battery portal illustrating savings provided by the solar PV and the battery. Some of the interviews took place before the Age UK visits and some after.

Households were asked whether they were more aware of how they used electricity after the battery installation, with 25 saying yes and 4 saying no. When asked if they had changed the way they had used electricity, 21 of the households said yes and 8 of the households no. The residents also elaborated on these responses with comments:

- I don't put the dishwasher on until I know there is some free electricity. I use appliances when there is free solar or battery available
- You try to use appliances so that they don't cost much to run thanks to the battery. When the battery was fitted they told us to use it when it was full
- I am more aware of trying to reduce energy use and to minimise use from the grid
- I will not put two high power appliances on together
- I used to cook in the evening and the 5 bars on the battery went down quickly. I have since switched to cooking in the afternoon. Every day I will check there is 5 bars on the battery at 7pm, then I know I will not be charged for anything overnight
- I turn off things which are not being used like lights and the TV. I think more about energy saving, partly due to the battery and partly due to price rises

- I wait until it is a sunny day knowing that the battery will power the washing machine. We bought an air fryer after getting the battery as another way of making savings. The battery should be able to power the air fryer on its own if it is full
- We tend to be careful when using appliances so we are not using too much power and are more careful since the battery was fitted
- I am more aware of using electricity, but have always been economical with it and would turn things off

Figure 3.23 John Healey, MP for Wentworth and Deane visiting a resident who received one of the batteries along with staff from Age UK Barnsley and Berneslai Homes

After the battery installation programme had been completed, one of the local Members of Parliament was invited to visit some of the installations and talk to residents. Figure 3.23 shows a photograph taken at the beginning of July 2022 with John Healey MP and members of staff from Age UK Barnsley and Berneslai Homes visiting a resident who received a battery.

During the interviews with the residents there were many positive comments about the project. These can be seen in Appendix 8. Comments included:

“I am over the moon with the battery. It is discrete, silent, it is out of the way. If I could have another one, I would have two.”

“I think the Government should fit solar panels and storage batteries in every home to help with the cost of electricity. They should install them for all pensioners and also the poorest families. The systems are a big help. I am thrilled to pieces and ecstatic with the battery system.”

4. Technical evaluation and results

4.1. Introduction

The technical evaluation carried out a basic assessment of the performance of all 75 batteries along with a more detailed assessment of 30 batteries where the households were in a monitored group.

This primarily used the Alpha ESS monitoring portal. Any issues with the installations were identified using the portal. These could include the system going offline due to a change of broadband router, a fault with the solar PV system or problems due to a current transformer (CT clamp) being accidently reversed.

The installations were carried out between 15 Nov 21 and 5 May 22. The annual performance was assessed for most installations between 1 Jun 22 and 31 May 23. This should have allowed a full year of data to be analysed for all the batteries. In practice, a number of the batteries had periods offline due to changing broadband router or some other issue. Where necessary, the dates for the analysis period were changed if it meant there was a longer period when the system was online and performing as expected.

In the initial analysis, values for the annual generation, grid consumption and battery discharge were determined from the Alpha ESS portal. The self-consumption of the solar generation was calculated using the formula:

$$Self\ consumption\ (\%) = \frac{Solar\ PV\ generation\ consumed\ in\ property(kWh)}{Solar\ PV\ electricity\ generated\ (kWh)}$$

$$= \frac{Solar\ PV\ generation - \ Solar\ PV\ export}{Solar\ PV\ generation}$$

The time the battery was offline was also estimated. Days when there was no, or very limited generation or consumption were checked using the Statistical Diagram on the Alpha ESS portal. This helped in determining start and end date and times when a system was offline due to a change of broadband account. There were also occasionally single days with large gaps in the data or periodic small gaps. These were harder to assess and could require looking at individual days using a Power Diagram or the data from a Power Diagram.

A more in-depth assessment of the performance was carried out of some of the 30 batteries in the monitored group. This used data from electricity meter readings, smart generation meters and from interviews with the residents.

4.2. Overview of the performance of the battery systems

Ref No	PV system (kW)	Dates	Generation (kWh)	Grid consumption (kWh)	Battery Discharge (kWh)	Self consumption (%)	Time offline (days)	Issues
B-01	2.7	1 Jun 22 - 31 May 23	2641	804.2	628.8	47.0%	1.6	-
B-02	3.43	1 Jun 22 - 31 May 23	3465				-	Y
B-03	3.43	1 Jun 22 - 31 May 23	3285	390.6	747.6	48.0%	-	-
B-04	3.43	1 Jun 22 - 31 May 23	3260	1313.0	849.7	64.2%	1.6	-
B-05	3.43	1 Jun 22 - 31 May 23	3422	942.2	805.9	53.9%	-	-
B-06	3.43	1 Dec 21 - 30 Nov 22	3636	704.2	853.7	53.3%	3.0	Y
B-07	3.43 *	1 Apr 22 - 31 Mar 23	3136	833.6	770.8	52.9%	0.9	Y
B-08	3.43							Y
B-09	3.43 *						237.6	Y
B-10	3.43	1 Jun 22 - 31 May 23	3389	457.4	771.7	49.6%	0.9	-
B-11	3.43	1 Jun 22 - 31 May 23	2876	1259.9	704.1	58.6%	26.8	Y
B-12	3.43	1 Jun 22 - 31 May 23	3563	1079.0	950.9	57.6%	0.8	-
B-13	3.43 *	1 Jun 22 - 31 May 23	3406	359.3	718.9	42.1%	-	-
B-14	3.43 *	1 Jun 22 - 31 May 23	3441	1202.2	974.0	61.4%	0.8	-
B-15	3.43 *	1 Jun 22 - 31 May 23	3517	313.5	689.4	41.8%	0.9	-
B-16	3.43	1 Dec 21 - 30 Nov 22	3555	483.0	790.6	45.8%	-	Y
B-17	3.43	1 Jun 22 - 31 May 23	3483	145.3	577.1	32.2%	-	-
B-18	3.43 *	1 Jun 22 - 31 May 23	3449	414.9	741.4	40.0%	-	-
B-19	3.43	1 Jun 22 - 31 May 23	3443	500.1	768.5	42.4%	-	-
B-20	3.43 *	1 Jun 22 - 31 May 23	3517	1330.5	849.8	53.8%	-	-
B-21	2.7	1 Jul 22 - 30 Jun 23	1390	380.2	594.7		9.6	Y
B-22	2.7	1 Apr 22 - 31 Mar 23	2102	2220.4	567.4	80.2%	3.0	Y
		Average	**3199**	**796.5**	**755.5**	**51.38%**		
		Maximum	**3636**	**2220.4**	**974.0**	**80.20%**		
		Minimum	**1390**	**145.3**	**567.4**	**32.20%**		

Table 4.1 Overview of the performance of the systems installed in homes heated by a Biomass Heat Network. * Installations recorded as 3kW in Berneslai Homes records.

An overview of the performance of the solar and battery systems that were fitted in homes that were on a biomass heat network is shown in table 4.1. There was a total of 22 batteries installed in bungalows which had solar PV systems which were either 2.7kW or 3.43kW in size. Installations B-02 to B-20 were in the same area and all had 14 panels. In the records held by Berneslai Homes, systems with a * were recorded as 3kW. However, the level of generation and number of panels make it likely they were in fact all 3.43kW.

9 of the installations were noted as having issues over the monitoring period. For some, the data was sufficiently limited that it was not included in the table. More details of the issues are provided in Appendix 7. Installation B-02 had the CT clamp for the electricity grid reversed between 21 Sep 22 and 30 Jun 23, which led to greater electricity consumption rather than reduced consumption. The value of the consumption while the CT clamp was reversed could not easily be determined from the Alpha ESS portal. The CT clamp was also reversed for households B-06 and B-16. This only occurred for a few days for B-06 and for B-16 it was possible to select an analysis period avoiding the time when the CT clamp was reversed.

For household B-08, the Alpha ESS monitoring system was not recording solar generation until 26 Oct 22 and no charging and discharging of the battery until 18 Jan 23. Household B-09 was offline for over 7 months which meant there was limited data to analyse. The solar generation was not properly recorded on the battery portal for household B-21 until 17 Oct 22. This meant the generation was lower than might be expected for a 2.7kW system.

The self-consumption of the solar generation was typically between about 40% and 60% for the households with batteries that were on the heat network. Household B-17 had a self-consumption of 32.2%. This household had a gas cooker and the lowest grid consumption of all the households on the heat network. The other household significantly outside the range of 40 to 60% self-consumption was B-22 where it was 80.2%. This was likely to be due to having the highest grid consumption of all those households with batteries on the heat network. Households B-04 and B-14 had a self-consumption slightly greater than the 40-60% range with values of 64.2% and 61.4% respectively. These households had higher values of grid consumption (1,313kWh and 1,202kWh) than most of the other households on the heat network.

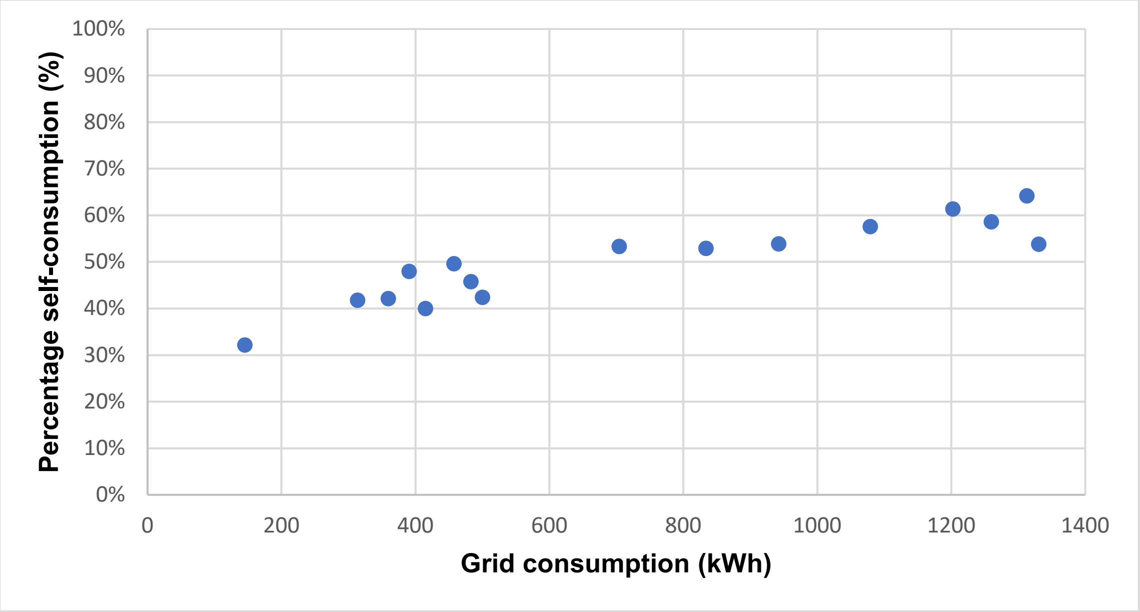


Figure 4.2 Graph of percentage self-consumption of the solar generation against grid consumption recorded by the Alpha ESS portal for biomass households with 3.43kW PV installations

Figure 4.2 shows a graph of percentage self-consumption against grid consumption for the 3.43kW PV installations on the biomass heat network which did not have extended periods offline or other issues. The graph showed an approximately linear relationship between the percentage self-consumption of the solar generation and the grid consumption.

MCS has published a guidance document which enables installers to estimate the percentage self-consumption of the solar generation for a new solar installation (with or without a battery)[14]. Factors which affect the percentage self-consumption include the

---

[14] MGD 003, Solar PV Self-Consumption – A method to determine the Electrical Self-Consumption of Domestic Solar PV Installations with and without Storage, (MCS, 2022), https://mcscertified.com/wp-content/uploads/2022/04/MGD-003-Solar-PV-Self-Consumption-Issue-2.0-Final.pdf (Accessed 22 Aug 23)

annual solar generation, the annual electricity consumption, the capacity of the battery and the amount of time the resident spends at home.

The battery discharge ranged from 567kWh to 974kWh. The 2 households with the lowest battery charge were B-22 and B-17. For household B-22, the lower battery discharge (567kWh) may have been due to the household load being sufficiently high that there was insufficient excess solar generation to as regularly fully charge the battery. However, for B-17, the household load was likely to be often too low to fully discharge the battery.

Household B-14 had the greatest level of battery discharge of 974kWh. B-14 often had a fairly high daytime household load and this meant the battery could go through more than one partial charge/discharge cycles in a day. This led to a higher level of battery discharge than other households with an average of 2.67kWh discharge per day over the year.

Table 4.3 summarises the performance of the battery and solar systems for the households with gas boilers. Out of the 48 installations in homes with gas boilers, 20 had issues that were noted over the period the systems were monitored. These were again mainly issues around the connection of the battery to the internet, but there were also some issues with CT clamps being reversed or no solar generation.

Household G-01 was offline from 18 Mar 23, most likely due to changing broadband router. As a result, the analysis period for this household was changed to 1 Apr 22 to 31 Mar 23. There was a solar PV fault for household G-10 from 18 Apr 23 which meant the battery was no longer charging or discharging. As a result, the analysis period used was from 1 May 22 to 30 Apr 23.

No data is shown for household G-13. There were initially issues with monitoring of the solar PV and for some of the time there may have been a solar PV fault. The system was operating correctly with the solar PV also monitored from 14 Oct 22. The CT clamp for the grid was reversed on 1 Jun 23 which caused greater grid consumption. This was rectified on 21 Jul 23 by Alpha ESS reversing the polarity of the CT after they were notified of the issue.

The monitoring for household G-14 was offline for multiple short periods in a day which could vary from 10 to 190 minutes. These periods mainly occurred overnight. The system was connected via the household broadband and not a wireless router. The issues could have been due to Wi-Fi connectivity. As there was no wireless router, it was not due to an issue with reception for a 3G signal.

Data is not included for household G-15. Here, the CT clamp on the grid supply was reversed from the time of installation on 15 Mar 22 until 12 Aug 22, leading to greater electricity consumption as a result. Household G-19 had multiple short periods with the battery offline in January 2023. The battery was connected to the household broadband, so this was not due to the loss of a 3G signal with a wireless router. The system was also offline from 28 Feb 23 to 3 Apr 23, due to the household changing broadband router. As a result of the password change, the project liaison officer had to setup the Wi-Fi dongle for the battery again.

Ref No	PV system (kW)	Dates	Generation (kWh)	Grid consumption (kWh)	Battery Discharge (kWh)	Self consumption (%)	Time offline (days)	Issues
G-01	2.7	1 Apr 22 - 31 Mar 23	2614	2166.9	733.0	74.9%	14.4	Y
G-02	2.7	1 Jun 22 - 31 May 23	2564.1	1598.3	740.0	67.0%	1.7	-
G-03	2.7	1 Jun 22 - 31 May 23	2560.1	2080.3	734.8	75.2%	1.7	-
G-04	3.24	1 Jun 22 - 31 May 23	2678.5	996.7	642.9	56.4%	7.1	Y
G-05	2.7	1 Jun 22 - 31 May 23	2563.4	364.0	631.6	48.7%	2.5	-
G-06	2.7	1 Jun 22 - 31 May 23	2286.2	343.2	610.3	51.9%	0.6	-
G-07	2.7	1 Jun 22 - 31 May 23	2379.7	2160.1	755.7	78.7%	0.9	-
G-08	2.7	1 Jun 22 - 31 May 23	1993	614.8	594.7	63.3%	2.3	-
G-09	2	1 Jun 22 - 31 May 23	1754.2	753.0	619.3	65.3%	1.7	-
G-10	2	1 May 22 - 30 Apr 23	1832.6	496.9	545.6	55.8%	-	Y
G-11	3.78	1 Jun 22 - 31 May 23	3302	639.9	732.3	52.5%	3.2	-
G-12	3.78	1 Jun 22 - 31 May 23	3348.4	979.2	781.8	58.4%	0.6	-
G-13	2.97							Y
G-14	2.97	1 Jun 22 - 31 May 23	2418.9	1283.6	674.0	68.9%	>9.83	Y
G-16	2.7	1 Jun 22 - 31 May 23	2572.6	822.7	595.9	55.7%	0.8	-
G-17	3.78	1 Jun 22 - 31 May 23	3668.9	774.3	803.1	44.8%	0.5	-
G-18	2.7	1 Jun 22 - 31 May 23	2571.6	544.6	598.8	50.3%	0.7	-
G-19	3.78	1 Jun 22 - 31 May 23	3104.9	1167.1	658.8	57.5%	37.0	Y
G-20	3.43	1 Jun 22 - 31 May 23	2970.9	364.5	650.8	40.8%	0.7	-
G-21	3.2	1 Jun 22 - 31 May 23	3052.9	1168.7	810.4	48.6%	-	-
G-22	2.7	1 Jun 22 - 31 May 23	2177.3	598.8	654.0	52.1%	39.2	-
G-23	2.7	1 Jun 22 - 31 May 23	2528	1126.5	754.7	56.5%	-	-
G-24	3	1 Jun 22 - 31 May 23	2114.6	456.8	614.0	50.3%	91.2	Y
G-25	1	1 Jun 22 - 31 May 23	1282	1068.7	480.8	76.9%	-	-
G-26	3	1 May 22 - 30 Apr 23	2341	112.4	396.3	37.5%	160.1	Y
G-27	3	1 Jun 22 - 31 May 23	3077	350.3	699.2	47.1%	2.7	-
G-28	3	1 Jun 22 - 31 May 23	3143	433.8	729.5	51.4%	3.2	-
G-29	3	1 Jun 22 - 31 May 23	2771	282.9	697.9	47.3%	95.0	Y
G-30	3	1 Jun 22 - 31 May 23	2848	445.4	649.3	46.8%	0.8	-
G-31	2.7	1 Jun 22 - 31 May 23	2660	973.1	803.0	59.4%	1.0	-
G-32	2.7	1 Jun 22 - 31 May 23	2593	903.7	727.2	55.5%	12.3	Y
G-33	2.7	1 Jun 22 - 31 May 23	2432	95.9	765.2	70.5%	10.5	Y
G-34	3.24	1 Jun 22 - 31 May 23	3034	520.0	673.4	46.2%	0.6	-
G-35	3.24	1 Jun 22 - 31 May 23	2985	87.0	539.9	41.7%	2.7	-
G-36	2.7	1 Jun 22 - 31 May 23	2768	1351.3	769.3	70.3%	-	-
G-37	2.7	1 Jun 22 - 31 May 23	2692	429.5	630.3	45.8%	>3.7	-
G-38	2.7	1 Jul 22 - 30 Jun 23	1814	252.1	436.3	45.2%	105.4	Y
G-39	2.7	1 Jun 22 - 31 May 23	2658	30.7	506.0	65.4%	0.9	-
G-40	2.7	1 Jun 22 - 31 May 23	2173	2768.4	607.7	80.1%	1.7	-
G-41	3.24	1 May 22 - 30 Apr 23	2234	653.9	464.6	48.1%	1.5	Y
G-42	2.7	1 May 22 - 30 Apr 23	2474	1445.6	777.3	65.7%	5.4	Y
G-43	2.7	1 Apr 22 - 31 Mar 23	2270	999.7	668.3	63.0%	1.7	Y
G-44	2.7	1 Jun 22 - 31 May 23	2370	278.0	798.6	82.5%	1.9	-
G-45	3.24	1 Jul 22 - 30 Jun 23	2631	1307.0	598.0	49.4%	0.8	Y
G-46	3.24	1 Jun 22 - 31 May 23	2952	404.3	689.4	41.5%	>1.72	Y
G-47	2.7	1 Jun 22 - 31 May 23	1955	323.6	535.1	57.7%	125.7	Y
G-48	2.7	1 Jun 22 - 31 May 23	1577	1337.6	352.2	51.3%	72.1	Y
		Average	**2538.9**	**833.8**	**650.7**	**57.0%**		
		Maximum	**3668.9**	**2768.4**	**810.4**	**82.5%**		
		Minimum	**1282.0**	**30.7**	**352.2**	**37.5%**		

Table 4.3 Overview of the performance of the systems installed in homes with gas boilers

The battery system for household G-24 was offline between 2 hours and most of the day for a number of days between July and November 2022. The system was fully offline from 10 Nov 22 until 6 Feb 23. The extended period offline might have been due to a communications issue that required the battery to be rebooted.

Households G-26 and G-29 are on the same street. Both batteries went offline on 27 Oct 22 at the same time, which suggests either a grid or broadband issue in that area caused the system to go offline, requiring a reboot of the battery system. Household G-29 was back online on 31 Jan 23 and G-26 on 21 Feb 23. The battery system for G-29 had previously also been offline between 13 Aug 22 and 28 Aug 22.

The battery system for household G-32 was offline for multiple short periods of the day for many days during the analysis period. This mostly occurred overnight but could take place during the day and the period offline could vary from 30 to 600 minutes. This was likely to be a communications issue between the battery and the household broadband.

For 9 days in August 2022, the battery for household G-33 was offline from midnight for most of the day. There were 3 similar days in May 2022 and a further 3 in November 2022. It seems likely that this was due to an issue with the battery such as battery updates. Many of the battery installations showed similar behaviour for a couple days in November 2022.

There were 2 extended periods with the battery offline for household G-38. These were from 19 Jun 22 to 24 Aug 22 and 1 Jan 23 to 21 Feb 23. After coming back online, the system was not showing the level of battery charge until 21 Mar 23.

Household G-41 had a periodic fault with the solar PV system from 12 Mar 23. The battery system for household G-45 was installed on 29 Apr 22, but there was no solar PV and battery charge recorded until 28 Jun 22. This may have been due to either a solar PV fault or the PV system being left switched off at an isolator switch.

The battery systems were offline for household G-42 from 2 May 23 and for G-43 from 22 Apr 23. These may have been due to the households switching broadband router or the battery requiring a reboot.

There were many short periods offline for the battery system for household G-46. These were mainly between March and June 2022. This may have been due to connection issues between the Wi-Fi dongle and the home broadband.

The battery system for household G-47 was offline from 1 Nov 22 to 6 Mar 23. This may have been due to the household changing broadband router or a communications issue which caused the system to go offline.

For household G-48, the battery system went offline between 1 Nov 22 and 13 Dec 22 and again from 15 Feb 22 to 15 Mar 22. After coming back online the second time, there was no solar generation, which suggested there was a solar PV fault. This explains the particularly low solar generation for the PV system size.

The solar generation over the analysis period for the systems in homes with gas boilers ranged from 1,282kWh to 3,669kWh. Household G-25 had the lowest generation and this was due to having the smallest solar PV system (recorded as 1kW). Others with solar generation under 2,000kWh were households G-08, G-09, G-10, G-38, G-47 and G-48. Household G-08 was in the same road as households G-06 and G-07 and had the same solar PV system size. The lower generation was likely to be due to the PV system being offline between 8 and 23 Aug 22. This might have been due to an isolator switch being left off after electrical work. Households G-09 and G-10 had 2kW PV systems, so generation under 2,000kWh is not unexpected. The solar PV system for G-10 was also offline for 12 days in April 2023, at the end of the analysis period. Households G-38, G-47 and G-48 were offline for extended periods which accounted for the low solar generation.

The grid consumption recorded by the Alpha ESS monitoring portal ranged from 30.7kWh for household G-39 to 2,768kWh for household G-40. While household G-39 was a low electricity user, it appeared that the Alpha ESS monitoring portal may have been under recording the grid consumption. There is usually a baseload electricity consumption for a household and figure 4.4 shows neither ‘Load’ nor ‘Consumed’ (grid consumption) when the battery was fully discharged. There might be a threshold before the system was recording grid consumption which could account for the issue.

Only 3 of the gas households recorded less than 100kWh grid consumption over the year, while 4 had a grid consumption greater than 2,000kWh.

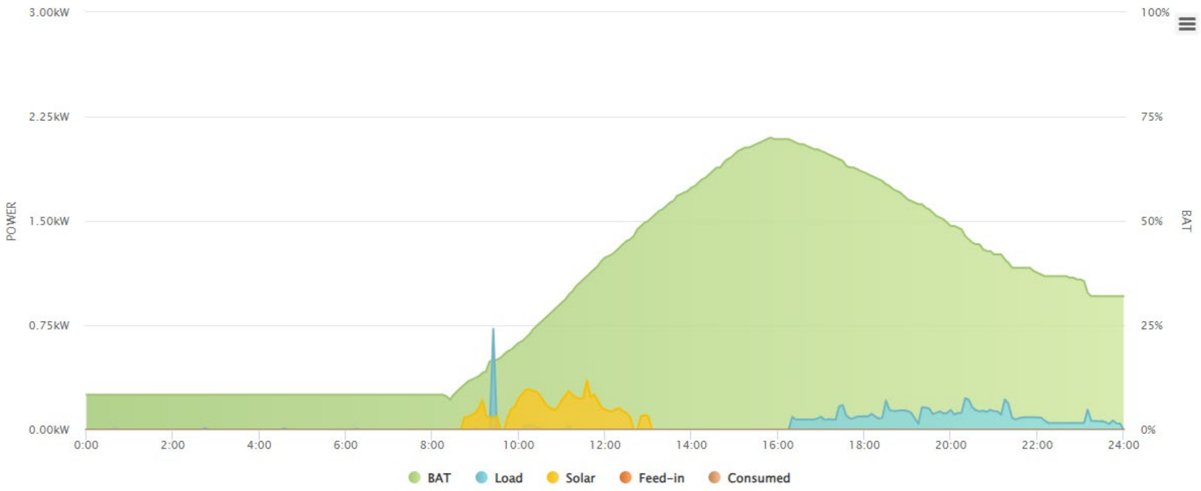


Figure 4.4 Power Diagram from the Alpha ESS battery portal for Household G-39 on 10 Dec 22

The battery discharge for the households with gas boilers ranged from 352kWh to 810kWh. There were 5 households with higher battery discharge among the households heated by the biomass heat network, where the highest level of annual discharge was 974kWh. The households heated by the heat network had a higher average solar generation (3,199kWh) compared to the those heated by gas (2,539kWh). The higher solar generation was a factor in there being more households with higher battery discharge among those on the heat network.

The battery system in a gas heated household that had the lowest discharge was G-48. This was offline for 72 days and after coming back online the second time had a solar PV fault.

Households G-25, G-26, G-38 and G-41 all had levels of battery discharge under 500kWh. The battery discharge for G-25 was 481kWh. The lower level of discharge was due to having the smallest solar PV system. This meant there was less excess solar generation available to charge the battery. Households G-26 and G38 were both offline for more than 100 days in the year, significantly limiting the time that the battery discharge was recorded.

The solar PV system for household G-41 had a periodic fault from 12 Mar 23. The PV system size was 3.24kW and the annual generation of 2,234kWh was several hundred kWh lower than might be expected for the PV system size. There was no battery charging on the days with no solar generation, which was the main cause of the low annual battery discharge of 465kWh. Figure 4.5 shows a Statistical Diagram from the Alpha ESS battery portal for household G-41 in March 2023. There was solar generation from 1 Mar 23 to 12 Mar 23 after which the PV generation cut out. There was no solar generation for the rest of the month apart from on 24 Mar 23. In April 2023, the solar PV system operated for 3 days out of the 30.

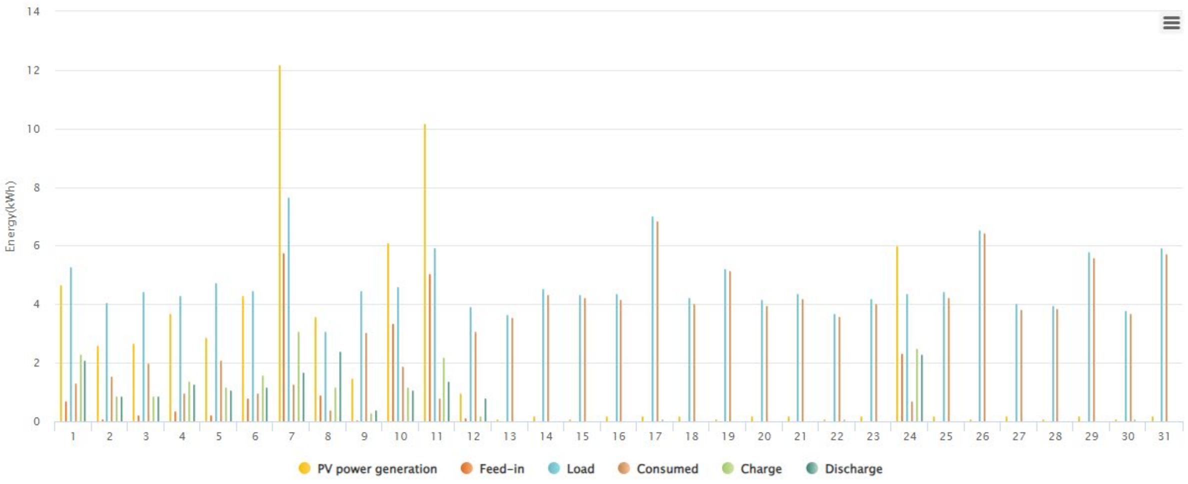


Figure 4.5 Statistical Diagram from the Alpha ESS battery portal showing daily PV generation, export, household load, grid consumption, charge and discharge for Household G-41 in March 2023

The self-consumption of the solar generation for the households with gas heating ranged from 37.5% to 82.5%. The average self-consumption was 57.0% for the gas heated households compared to 51.4% for the households on the heat network. There were 8 gas heated households with a self-consumption greater than 70%. There was a single gas heated household with a level of solar self-consumption under 40%. Household G-26 had a self-consumption of 37.5%. The analysis period was from 1 May 22 to 30 Apr 23. The battery was offline from 27 Oct 22 to 21 Feb 23 which was a period of lower generation and normally higher self-consumption. Had the battery been online for the full analysis period, it is likely the self-consumption would have been higher.

A plot of percentage self-consumption of the solar generation against the grid consumption recorded by the Alpha ESS portal is shown in figure 4.6 for the gas heated households with 2.7kW solar PV systems which were not offline for extended periods.

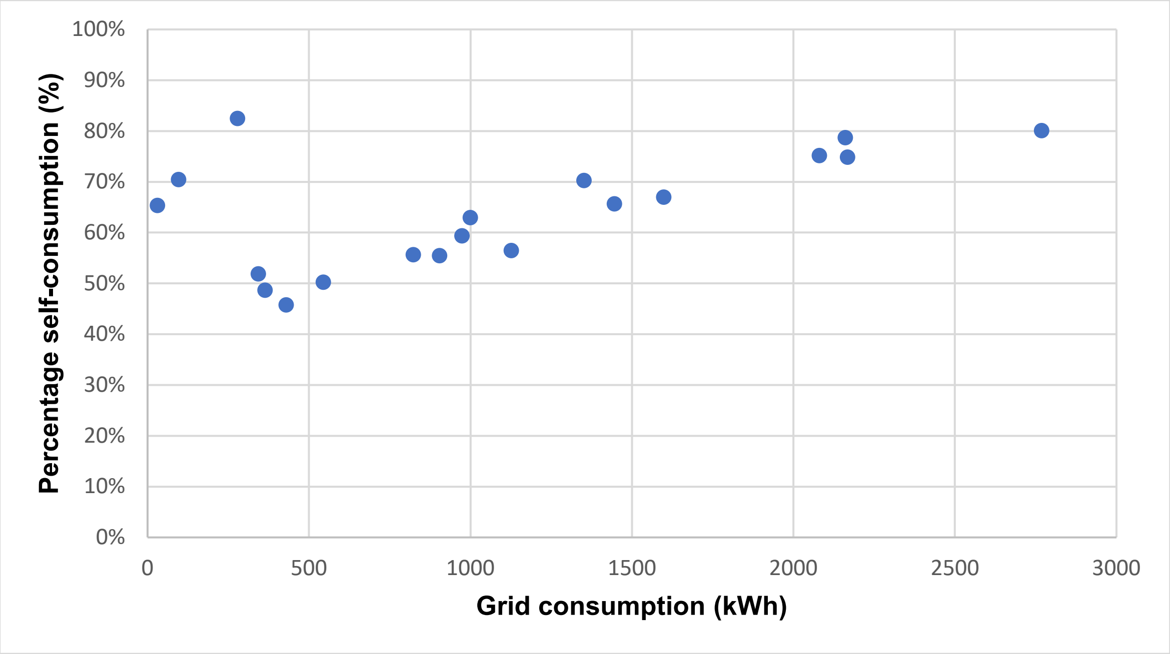


Figure 4.6 Graph of percentage self-consumption of solar generation against grid consumption recorded by the Alpha ESS portal for gas heated households with 2.7kW PV installations

The relationship between the data for self-consumption and grid consumption was approximately linear apart from for 3 anomalous data points at low grid consumption. It was noted earlier that the Alpha ESS portal seemed to be under recording the consumption for household G-39, which had the lowest grid consumption. It is likely that households G-33 with 95.9kWh grid consumption and 70.5% self-consumption along with G-44 with 278kWh grid consumption and 82.5% self-consumption similarly under-recorded the grid consumption. The problems with these 3 installations were likely to be due to issues with the grid CT clamps and how they were fitted.

5 of the Alpha ESS battery systems were fitted in homes heated by Air Source Heat Pumps (ASHPs). The properties were all semi-detached bungalows with a floor area of about 60m^2 and had a 1.07kW solar PV system. Table 4.7 provides an overview of the performance of the systems.

The battery system for household A-04 was offline from 13 Apr 23 to 26 May 23. This might have been due to a communications issue or the household switching broadband supplier. To minimise the days offline, an analysis period of 1 May 22 to 30 Apr 23 was used.

Household A-05 had the battery system offline between 17 Mar 23 and 22 Mar 23. During the month before the system went offline, there was no solar generation. After the system was running again on 22 Mar 23, there was generation from the solar PV system once again. It is possible a fault had developed with the solar PV system in February 2023 and the system went offline on 17 Mar 23 while the solar PV system was repaired.

Ref No	PV system (kW)	Dates	Generation (kWh)	Grid consumption (kWh)	Battery Discharge (kWh)	Self consumption (%)	Time offline (days)	Issues
A-01	1.07	1 Jun 22 - 31 May 23	925	5243	272.4	97.3%	1.4	-
A-02	1.07	1 Jun 22 - 31 May 23	1031	4878	293.7	96.6%	-	-
A-03	1.07	1 Jun 22 - 31 May 23	1083	3550	388.6	94.3%	0.7	-
A-04	1.07	1 May 22 - 30 Apr 23	912	6503	88.5	99.1%	17.1	Y
A-05	1.07	1 Jun 22 - 31 May 23	867	6537	196.2	98.1%	8.4	Y
		Average	**964**	**5342**	**247.9**	**97.1%**		
		Maximum	**1083**	**6537**	**388.6**	**99.1%**		
		Minimum	**867**	**3550**	**88.5**	**94.3%**		

Table 4.7 Overview of the performance of the systems installed in homes with ASHPs

The available roof space on the bungalows limited the number of solar panels which could be fitted to only 5. As a result of the 1.07kW PV systems, the annual solar generation was low and was between 867 and 1,083kWh. There was lower generation recorded for household A-04 due to the 17 days when the battery system was offline. Household A-05 had the lowest annual solar generation (867kWh). A factor in the lower generation was the solar PV system not generating between 17 Feb 23 and 22 Mar 23.

The grid consumption for the households heated by ASHPs ranged from 3,550kWh to 6,537kWh. The majority of this consumption was due to the electricity consumption of the heat pump. For comparison, the maximum annual grid consumption among the properties heated by the biomass heat network was 2,220kWh and it was 2,768kWh for the gas heated households.

The battery discharge was between 88.5kWh and 388.6kWh. This was much lower than for the other households with between 567 and 974kWh for those heated by the biomass heat network and between 352 and 810kWh for the households with gas boilers. The low battery discharge for the ASHP households was due to a combination of low solar generation and high grid consumption. There was limited excess solar generation available to charge the battery as most of the generation was already being used in colder months by the heat pump.

The self-consumption of the solar generation was between 94.3% and 99.1%. This was higher than the maximum value for the households on the heat network (80.2%) and for those with gas boilers (82.5%). The combination of low solar generation, high grid consumption and a battery meant that little of the solar generation was exported to the grid. The benefit of the battery for these households was more limited as there would have already been high levels of self-consumption of the solar generation, particularly between September and April.

Figure 4.8 shows a Power Diagram for household A-04 on 4 Apr 23. Between midnight and 08:00, the grid consumption (Consumed, shown in brown) was between 140 and 430W. The battery charge (shown in green) was at 6% and so the battery was unable to supply power to the home. From 09:30, the household load (shown in blue) increased to about 900W, most likely to due to the ASHP and this broadly continued through the day until about 19:20. At this time there was a peak in consumption of approximately 4kW for about 35 minutes. This increase in consumption might have been due to cooking.

There was solar generation from 09:15 until 18:45, with a peak of 815W at 14:05. The solar generation was able to partially (or for a short period fully) power the household load during this period. There was however no excess solar generation to charge the battery and the level of battery charge did not increase above 6% during the day.

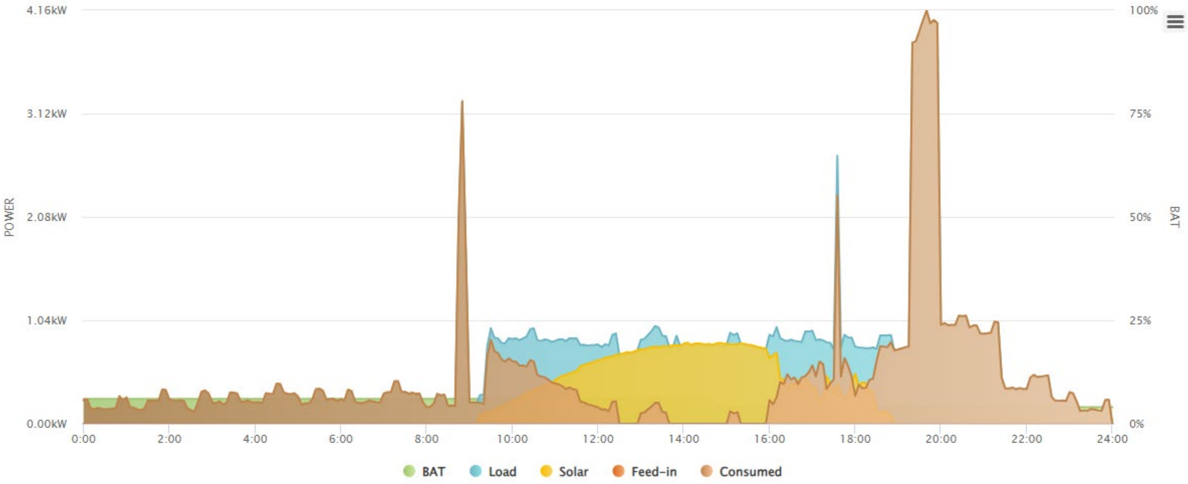


Figure 4.8 Power Diagram from the Alpha ESS battery portal for Household A-04 on 4 Apr 23

4.3. Savings from the solar and battery systems

Where sufficient data was available, estimates were made of the savings from the solar PV system and the battery. These used an electricity unit rate of £0.30/kWh and the following equations:

$$Electricity\ cost\ (£) = Grid\ consumption\ (kWh) \times electricity\ unit\ rate\ (£/kWh)$$

$$Solar\ savings\ (£) = (Generation - PV\ Export\ - Battery\ charge\ ) \times unit\ rate$$

$$Battery\ savings\ (£) = Battery\ discharge\ (kWh) \times electricity\ unit\ rate\ (£/kWh)$$

Ref No	PV system (kW)	Dates	Electricity cost (£)	Solar PV savings (£)	Battery savings (£)	Total savings (£)	Time offline (days)	Issues
B-01	2.7	1 Jun 22 - 31 May 23	£ 241.25	£ 171.16	£ 188.64	£ 359.80	1.6	-
B-03	3.43	1 Jun 22 - 31 May 23	£ 117.19	£ 237.87	£ 224.28	£ 462.15	-	-
B-04	3.43	1 Jun 22 - 31 May 23	£ 393.89	£ 360.66	£ 254.91	£ 615.57	1.6	-
B-05	3.43	1 Jun 22 - 31 May 23	£ 282.67	£ 301.01	£ 241.77	£ 542.78	-	-
B-06	3.43	1 Dec 21 - 30 Nov 22	£ 211.26	£ 313.45	£ 256.11	£ 569.56	3.0	Y
B-07	3.43 *	1 Apr 22 - 31 Mar 23	£ 250.09	£ 254.89	£ 231.24	£ 486.13	0.9	Y
B-10	3.43	1 Jun 22 - 31 May 23	£ 137.21	£ 259.82	£ 231.51	£ 491.33	0.9	-
B-11	3.43	1 Jun 22 - 31 May 23	£ 377.96	£ 283.10	£ 211.23	£ 494.33	26.8	Y
B-12	3.43	1 Jun 22 - 31 May 23	£ 323.69	£ 316.54	£ 285.27	£ 601.81	0.8	-
B-13	3.43 *	1 Jun 22 - 31 May 23	£ 107.79	£ 202.82	£ 215.67	£ 418.49	-	-
B-14	3.43 *	1 Jun 22 - 31 May 23	£ 360.67	£ 328.24	£ 292.20	£ 620.44	0.8	-
B-15	3.43 *	1 Jun 22 - 31 May 23	£ 94.05	£ 223.25	£ 206.82	£ 430.07	0.9	-
B-16	3.43	1 Dec 21 - 30 Nov 22	£ 144.89	£ 239.14	£ 237.18	£ 476.32	-	Y
B-17	3.43	1 Jun 22 - 31 May 23	£ 43.60	£ 151.01	£ 173.13	£ 324.14	-	-
B-18	3.43 *	1 Jun 22 - 31 May 23	£ 124.46	£ 179.97	£ 222.42	£ 402.39	-	-
B-19	3.43	1 Jun 22 - 31 May 23	£ 150.02	£ 194.08	£ 230.55	£ 424.63	-	-
B-20	3.43 *	1 Jun 22 - 31 May 23	£ 399.14	£ 300.92	£ 254.94	£ 555.86	-	-
B-22	2.7	1 Apr 22 - 31 Mar 23	£ 666.13	£ 327.79	£ 170.22	£ 498.01	3.0	Y
		Average	**£ 245.89**	**£ 258.09**	**£ 229.34**	**£ 487.43**		
		Maximum	**£ 666.13**	**£ 360.66**	**£ 292.20**	**£ 620.44**		
		Minimum	**£ 43.60**	**£ 151.01**	**£ 170.22**	**£ 324.14**		

Table 4.9 Overview of the electricity cost and savings for the households heated by a Biomass Heat Network. * Installations recorded as 3kW in Berneslai Homes records.

The costs and savings for the households on the heat network are shown in table 4.9. The electricity cost over a 12-month period, ignoring the standing charge and periods offline was estimated to range between £43.60 and £666.13 with an average of £245.89.

Household B-17 had the lowest solar PV savings (£151.01) and close to the lowest battery savings (£173.13). This was due to having the lowest grid consumption and electricity cost. The solar savings ranged from £151.01 to £360.66, with an average of £258.09. The average saving from the battery was lower than for the solar PV at £229.34. The range of savings between £170.22 and £292.20 was narrower than for the solar PV. Overall, the average total saving was £487.43, with the lowest saving £324.14 and greatest saving £620.44 among the households on heat networks that were analysed.

Ref No	PV system (kW)	Dates	Electricity cost (£)	Solar PV savings (£)	Battery savings (£)	Total savings (£)	Time offline (days)	Issues
G-01	2.7	1 Apr 22 - 31 Mar 23	£ 650.06	£ 357.45	£ 219.90	£ 577.35	14.4	Y
G-02	2.7	1 Jun 22 - 31 May 23	£ 479.49	£ 282.47	£ 222.00	£ 504.47	1.7	-
G-03	2.7	1 Jun 22 - 31 May 23	£ 624.10	£ 347.19	£ 220.44	£ 567.63	1.7	-
G-04	3.24	1 Jun 22 - 31 May 23	£ 299.01	£ 249.38	£ 192.87	£ 442.25	7.1	Y
G-05	2.7	1 Jun 22 - 31 May 23	£ 109.19	£ 173.03	£ 189.48	£ 362.51	2.5	-
G-06	2.7	1 Jun 22 - 31 May 23	£ 102.96	£ 161.59	£ 183.09	£ 344.68	0.6	-
G-07	2.7	1 Jun 22 - 31 May 23	£ 648.04	£ 323.15	£ 226.71	£ 549.86	0.9	-
G-08	2.7	1 Jun 22 - 31 May 23	£ 184.43	£ 188.22	£ 178.41	£ 366.63	2.3	-
G-09	2	1 Jun 22 - 31 May 23	£ 225.90	£ 147.09	£ 185.79	£ 332.88	1.7	-
G-10	2	1 May 22 - 30 Apr 23	£ 149.06	£ 133.27	£ 163.68	£ 296.95	-	Y
G-11	3.78	1 Jun 22 - 31 May 23	£ 191.96	£ 289.13	£ 219.69	£ 508.82	3.2	-
G-12	3.78	1 Jun 22 - 31 May 23	£ 293.77	£ 338.61	£ 234.54	£ 573.15	0.6	-
G-14	2.97	1 Jun 22 - 31 May 23	£ 385.09	£ 285.33	£ 202.20	£ 487.53	>9.83	Y
G-16	2.7	1 Jun 22 - 31 May 23	£ 246.80	£ 240.80	£ 178.77	£ 419.57	0.8	-
G-17	3.78	1 Jun 22 - 31 May 23	£ 232.29	£ 237.39	£ 240.93	£ 478.32	0.5	-
G-18	2.7	1 Jun 22 - 31 May 23	£ 163.39	£ 196.72	£ 179.64	£ 376.36	0.7	-
G-19	3.78	1 Jun 22 - 31 May 23	£ 350.12	£ 328.31	£ 197.64	£ 525.95	37.0	Y
G-20	3.43	1 Jun 22 - 31 May 23	£ 109.35	£ 155.06	£ 195.24	£ 350.30	0.7	-
G-21	3.2	1 Jun 22 - 31 May 23	£ 350.60	£ 188.81	£ 243.12	£ 431.93	-	-
G-22	2.7	1 Jun 22 - 31 May 23	£ 179.63	£ 133.08	£ 196.20	£ 329.28	39.2	-
G-23	2.7	1 Jun 22 - 31 May 23	£ 337.95	£ 189.93	£ 226.41	£ 416.34	-	-
G-25	1	1 Jun 22 - 31 May 23	£ 320.61	£ 142.74	£ 144.24	£ 286.98	-	-
G-27	3	1 Jun 22 - 31 May 23	£ 105.08	£ 211.44	£ 209.76	£ 421.20	2.7	-
G-28	3	1 Jun 22 - 31 May 23	£ 130.13	£ 251.94	£ 218.85	£ 470.79	3.2	-
G-30	3	1 Jun 22 - 31 May 23	£ 133.62	£ 189.93	£ 194.79	£ 384.72	0.8	-
G-31	2.7	1 Jun 22 - 31 May 23	£ 291.92	£ 219.98	£ 240.90	£ 460.88	1.0	-
G-32	2.7	1 Jun 22 - 31 May 23	£ 271.10	£ 200.69	£ 218.16	£ 418.85	12.3	Y
G-33	2.7	1 Jun 22 - 31 May 23	£ 28.77	£ 271.38	£ 229.56	£ 500.94	10.5	Y
G-34	3.24	1 Jun 22 - 31 May 23	£ 156.00	£ 205.95	£ 202.02	£ 407.97	0.6	-
G-35	3.24	1 Jun 22 - 31 May 23	£ 26.10	£ 201.10	£ 161.97	£ 363.07	2.7	-
G-36	2.7	1 Jun 22 - 31 May 23	£ 405.39	£ 340.20	£ 230.79	£ 570.99	-	-
G-37	2.7	1 Jun 22 - 31 May 23	£ 128.85	£ 170.33	£ 189.09	£ 359.42	>3.7	-
G-40	2.7	1 Jun 22 - 31 May 23	£ 830.51	£ 330.53	£ 182.31	£ 512.84	1.7	-
G-41	3.24	1 May 22 - 30 Apr 23	£ 196.18	£ 173.57	£ 139.38	£ 312.95	1.5	Y
G-42	2.7	1 May 22 - 30 Apr 23	£ 433.68	£ 242.09	£ 233.19	£ 475.28	5.4	Y
G-43	2.7	1 Apr 22 - 31 Mar 23	£ 299.92	£ 217.68	£ 200.49	£ 418.17	1.7	Y
G-44	2.7	1 Jun 22 - 31 May 23	£ 83.39	£ 332.93	£ 239.58	£ 572.51	1.9	-
G-45	3.24	1 Jul 22 - 30 Jun 23	£ 392.09	£ 198.64	£ 179.40	£ 378.04	0.8	Y
G-46	3.24	1 Jun 22 - 31 May 23	£ 121.30	£ 148.44	£ 206.82	£ 355.26	>1.72	Y
		Average	**£ 273.53**	**£ 230.65**	**£ 203.03**	**£ 433.68**		
		Maximum	**£ 830.51**	**£ 357.45**	**£ 243.12**	**£ 577.35**		
		Minimum	**£ 26.10**	**£ 133.08**	**£ 139.38**	**£ 286.98**		

Table 4.10 Overview of the electricity cost and savings for the households with gas boilers

An overview of the electricity cost and savings from the solar PV and battery is shown in table 4.10 for the households with gas boilers. The households with major issues or where the battery system was offline for more than 50 days were not included in this analysis.

Annual electricity costs ignoring the standing charge ranged from £26.10 to £830.51 with an average of £273.53. The average electricity cost of £245.89 for the households on the heat network was slightly lower. Note that the electricity costs of £26.10 for household G-35 and £28.77 for household G-33 are not likely to be accurate due to an issue with measurement of grid consumption with the Alpha ESS monitoring portal at those sites.

The savings from the solar PV systems for the households with gas boilers were between £133.08 and £357.45, with an average of £230.65. This compared to an average saving of £258.09 from the solar PV for the households on the heat network.

The average battery saving for the gas heated households was £203.03. This was lower than the average saving from the solar PV and lower than the average battery saving of £229.34 for the households on the heat network. The battery savings ranged from £139.38 to £243.12 for the households with gas boilers.

The average total savings was £433.68 for the gas heated households. This compares to £487.43 for the households on the heat network. The range in total savings for the gas heated households was between £286.98 and £577.35.

A factor in the higher average savings for the households on the heat network was likely to be the higher average solar PV system size, leading to greater solar generation.

Ref No	**PV system (kW)**	**Dates**	**Electricity cost (£)**	**Solar PV savings (£)**	**Battery savings (£)**	**Total savings (£)**	**Time offline (days)**	**Issues**
A-01	1.07	1 Jun 22 - 31 May 23	£1,572.85	£ 183.35	£ 81.72	£ 265.07	1.4	-
A-02	1.07	1 Jun 22 - 31 May 23	£1,463.54	£ 206.17	£ 88.11	£ 294.28	-	-
A-03	1.07	1 Jun 22 - 31 May 23	£1,065.09	£ 182.75	£ 116.58	£ 299.33	0.7	-
A-04	1.07	1 May 22 - 30 Apr 23	£1,950.99	£ 242.12	£ 26.55	£ 268.67	17.1	Y
A-05	1.07	1 Jun 22 - 31 May 23	£1,961.11	£ 192.76	£ 58.86	£ 251.62	8.4	Y
		Average	**£1,602.71**	**£ 201.43**	**£ 74.36**	**£ 275.79**		
		Maximum	**£1,961.11**	**£ 242.12**	**£ 116.58**	**£ 299.33**		
		Minimum	**£1,065.09**	**£ 182.75**	**£ 26.55**	**£ 251.62**		

Table 4.11 Overview of the electricity cost and savings for the households heated by ASHPs

Table 4.11 shows an overview of the electricity cost and savings for the households that used an ASHP for their heating. As a result of the electric heating, the electricity cost for these households was considerably more than for those heated by gas or the biomass heat network. The average electricity cost was £1,602.71, while even the minimum electricity cost of £1,065.09 was higher than the maximum for the gas heated (£830.51) and the households on the heat network (£666.13). Note that this analysis does not take into account additional heating costs the households with gas boilers or on the biomass heat network would also pay.

The savings from the solar PV systems on the ASHP heated homes ranged from £182.75 to £242.12, with an average of £201.43. For comparison the average solar PV saving was £230.65 for the gas heated households and £258.09 for those on the heat network. The only other property that had a similarly sized solar PV system was G-25. Here the saving from the solar PV was £142.74. This was lower than for the households with the heat pumps as the daytime electricity consumption was lower.

The average battery saving was £74.36 for the households with heat pumps and the savings ranged from only £26.55 to £116.58. The average battery saving for the households heated by gas was £203.03 and for the households on the heat network it was £229.34. The saving from the battery from household G-25 with a similar sized solar system was £144.24.

The reason for the poor battery savings from the households with ASHPs was due to a combination of small solar PV system size and high electricity demand from the ASHP. Most days from October to April, there was likely to be a high electricity demand throughout the day from the heat pump which would have consumed nearly all the solar generation. Only in the summer months, when the heat pump only provided water heating, was the household electricity demand likely to be consistently lower than the solar generation, allowing the battery to charge.

There was little charge and discharge of the battery in winter. It is possible to charge a battery on a time of use tariff, where the battery charges during a low cost, off-peak period and discharges during a higher cost peak rate period. However, the SMILE-B3 battery has too small a capacity for it to be beneficial to operate using a time of use tariff. With limited benefit from the battery charging during the off-peak period, electricity consumption during the peak rate period could lead to higher costs for residents.

There can however be benefits if the battery has sufficient capacity. A project with North Devon Homes used 7kW Vaillant aroTHERM plus ASHPs combined with a 10 to 11kWh Alpha ESS battery. These installations did not have solar PV and the battery charged during off-peak Economy 7 and discharged during the peak rate period[15].

---

[15] Paul Rogers and Michael Hamer (NEA, 2023), Making heat cheaper, smarter and greener, https://www.nea.org.uk/wp-content/uploads/2023/06/CP1438-Boxergy-NDH-full-report-16-Jan-22.pdf (Accessed 1 Aug 2023)

4.4. Estimates of payback time for the battery

Method of heating	Average battery saving (£)	Maximum battery saving (£)	Minimum battery saving (£)	Average Payback (years)	Minimum Payback (years)	Maximum Payback (years)
Heat Network (Indoor installation)	£ 229.34	£ 292.20	£ 170.22	7.63	5.99	10.28
Heat Network (Outhouse installation)	£ 229.34	£ 292.20	£ 170.22	9.05	7.10	12.19
Gas boiler (Indoor installation)	£ 203.03	£ 243.12	£ 139.38	8.62	7.20	12.56
Gas boiler (Outhouse installation)	£ 203.03	£ 243.12	£ 139.38	10.22	8.53	14.89
ASHP (Indoor installation)	£ 74.36	£ 116.58	£ 26.55	23.53	15.01	65.91
ASHP (Outhouse installation)	£ 74.36	£ 116.58	£ 26.55	27.90	17.80	78.15

Table 4.12 Battery savings and estimated payback times

The average savings from the batteries in Section 4.3 were used to make rough estimates of the payback times for the batteries, which are shown in table 4.12. The estimates assume a unit cost for electricity of 30p/kWh and the same level of battery saving each year throughout the period. It was assumed that the battery and installation cost for an indoor system was £1,750 and where the battery was fitted in an outhouse it was £2,075. The battery had cost £1,200+VAT with installation by the Berneslai Homes electrical team an additional cost. The savings analysis covered the savings from both indoor and outhouse installations.

For the households on the heat network, the average payback was about 7.6 years for an indoor installation and ranged between a minimum of 6 years and maximum of 10.3 years. The payback time was longer if the battery was fitted in an outhouse, with an average of 9.1 years for households on the heat network and ranging between 7.1 and 12.2 years.

The payback times for the gas heated households were longer than for those on the heat network. Here the payback time for an indoor installation was between 7.2 and 12.6 years, with an average of 8.6 years. If the battery was fitted in an outhouse, the average payback time was 10.2 years and ranged from 8.5 to 14.9 years.

Appendix 4 provides a summary of key points of the warranty for the Alpha ESS battery system. There is a 5-year product warranty. Alpha ESS also provides a performance warranty that the battery will retain at least 80% of its usable capacity for 10 years. The performance warranty is only valid if the battery is operated under normal use. This includes the battery operating at a temperature between -10ºC and 50ºC and a through output energy per kWh usable capacity less than 2.92MWh. The latter is effectively a single full capacity discharge per day for 8 years. The battery should also maintain an internet connection.

It is likely that there will be a payback within the lifespan of the batteries for the systems installed in homes on the heat network and those with gas heating. This is most likely where the batteries were fitted indoors.

The batteries fitted in the homes with the ASHPs made low savings. This was due to having small solar PV systems and high daytime electricity consumption so there was limited charging of the battery. The shape of the roof of the properties limited the PV system to only 5 panels. At the time of the PV installations in 2011, solar panels had a lower output, with these rated at only 214W. There could be potential to replace the PV system with higher power output panels. However, if these systems were eligible for the Feed-in tariff (FiT), this could be an issue as the FiT is associated with the panels.

For the households with ASHPs, the average payback time for a battery fitted indoors was 23.5 years and the range of payback times among indoor installations was between 15 and 65.9 years. The payback times were even worse if the batteries had been fitted in an outhouse. For these systems, it was unlikely there would be any payback within the lifespan of the battery.

In situations with a small solar PV system and high daytime electrical demand, it could be better to fit a larger battery and charge this from the grid using a time of use tariff like Economy 7 or Cosy Octopus with some extra charging from the solar in summer.

The payback time for batteries has improved since installations in 2016[16]. This is due to increased electricity prices and improved batteries, with a higher power output and lower cost per kWh of storage. Batteries are continuing to develop, with larger capacities becoming more common and the price per kWh of storage continuing to fall. There are additional ways battery storage can provide savings for households such as through demand flexibility services or time of use tariffs which also allow grid charging.

National Grid ESO (Electricity System Operator) along with electricity suppliers and aggregators ran a Demand Flexibility Service for winter 2022/23 which aimed to encourage consumers to reduce their power consumption at times of high demand. During the demonstration tests, there was a guaranteed minimum price of £3/kWh. They noted that a typical household could save about £100 if they took part in the maximum 12 demonstration tests[17]. The Alpha ESS system is able to act as a virtual power plant, where many batteries can be controlled together. This could provide a simple way for willing households to participate in flexibility services and receive additional savings.

Future installation programmes could have better payback times due to new models of battery with better performance and a lower cost per kWh of storage. Time of use tariffs and flexibility services could improve the benefits for households and the payback time. However, it is important that an assessment of the solar generation and household consumption is made to ensure the site is appropriate for installing the battery selected.

---

[16] Paul Rogers and Michael Hamer (NEA, 2019), 24/7 Solar, London Borough of Camden, https://www.nea.org.uk/wp-content/uploads/2020/10/CP745-TIF-REPORT-Final-02-01-2019-v2.pdf (Accessed 2 Aug 23)

[17] The ESO's Demand Flexibility Service, https://www.nationalgrideso.com/electricity-explained/electricity-and-me/esos-demand-flexibility-service (Accessed 2 Aug 23)

4.5. The financial impact of a reversed CT clamp

Figure 4.13 Power Diagram from the Alpha ESS battery portal for Household B-02 on 13 Jun 23 Property with CT clamp reversed resulting in unstable charge/discharge cycles

The battery installations monitored the electricity import or export with a CT clamp that was fitted around the cable of the mains supply. The CT clamp was reversed for an extended period for 3 installations and for about 1 and 7 weeks respectively for 2 further installations. The CT clamp can become reversed after being taken off during a smart meter installation or during general electrical work in the home, such as replacing a consumer unit. It can also be fitted incorrectly at the time of the installation.

If the CT clamp is fitted the wrong way around, the system regards electricity import as export and electricity export as import. Normally the battery will charge when there is export to the grid and discharge when electricity is being imported from the grid. When the CT clamp is reversed, the battery will charge when it should be discharging and discharge when it should be charging. This leads to increased electricity consumption from the grid rather than savings.

Although Alpha ESS can change the polarity of the CT clamp remotely, the system does not currently have an alarm which is able to detect when a CT clamp has been reversed and alert system administrators. This issue is common to most batteries which use a CT clamp for monitoring the import from or export to the grid.

Figure 4.13 shows an example of a Power Diagram from the Alpha ESS battery portal for household B-02 on 13 Jun 23. This was on a day which was sunny and where the CT clamp on the mains supply was in the wrong orientation. The multiple short charge and discharge cycles are typical of the performance of a battery when the CT clamp is reversed.

During the period while the CT clamp was reversed, the value of Consumed (or grid consumption) on the Alpha portal became Feed-in (or export to grid). Likewise, Feed-in became Consumed. It appeared from the Power Diagrams that the Feed-in shown was the amount of forced charging of the battery.

Household B-16 had the grid CT reversed from 24 Dec 22 until 13 Jun 23. During this period, the portal recorded a feed-in (potentially the forced grid charging) of 1,696kWh. For household B-03, the grid CT was reversed from 21 Sep 22 to 30 Jun 23. While the grid CT was reversed, the feed-in recorded by the portal was 3,508kWh.

There was an installation issue with household G-15 and the grid CT was reversed from 15 Mar 22 until 12 Aug 22. The feed-in recorded over this period was 1,640kWh.

There were 2 households with shorter periods with the grid CT reversed following electrical work in the homes. For household B-06, the CT was reversed for between 12 and 17 Aug 22 and the feed-in recorded over this period was 44.2kWh. For household G-13, the grid CT was reversed between 1 Jun 23 and 21 Jul 23. Over this period, the feed-in recorded on the portal was 578kWh.

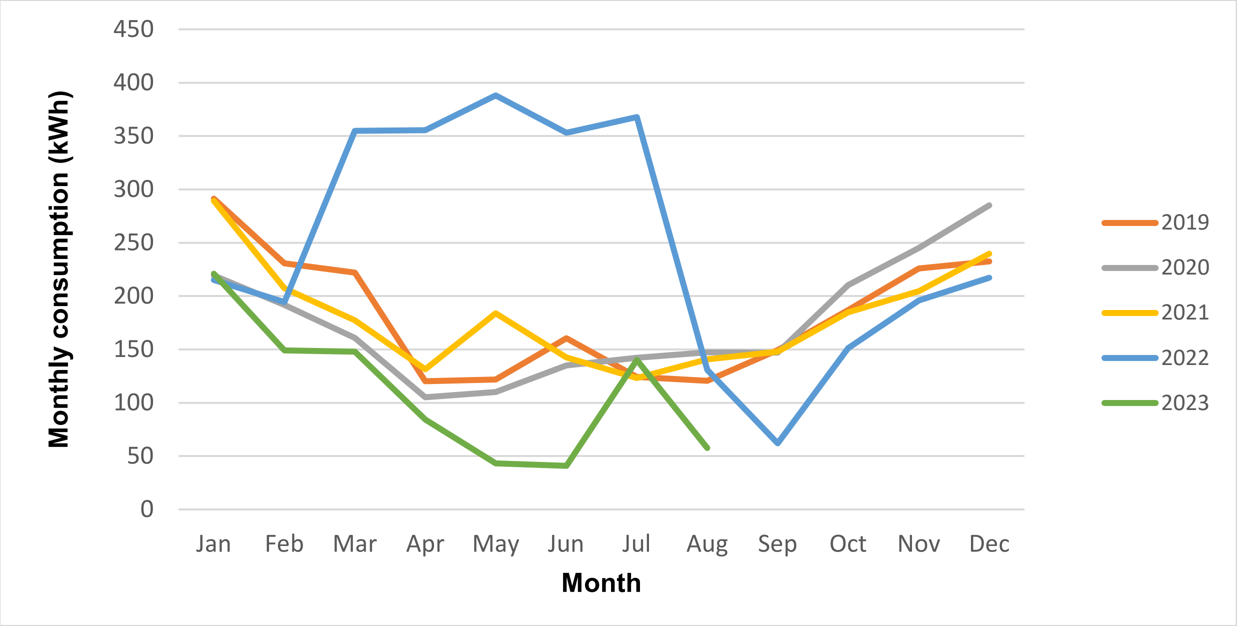


Figure 4.14 Plot of monthly electricity consumption for household G-15 between 2019 and 2023

The only way to accurately assess the impact of the reversed CT clamps was to analyse smart meter data. This was only available for household G-15 and a plot of monthly electricity consumption based on the smart meter data is shown in Figure 4.14. The consumption in the years 2019 to 2021 followed a similar trend, with higher consumption in the winter, when there was less sunshine and lower consumption in summer. There were months with slightly higher consumption than normal such as March 2019 and May 2021, which might be due to less sunny months and/or greater household consumption.

The consumption during the period with the reversed CT was higher than for any month without the battery system. Between March 2022 and July 2022, the monthly consumption was between about 355kWh and 390kWh. Previously, the highest monthly consumption was 291.2kWh in January 2019.

For the period 15 Mar 22 to 12 Aug 22 where the CT clamp was reversed, the electricity consumption was 1,766.75kWh. Over the same dates in 2023 with the battery running correctly, the consumption was 325.5kWh. This suggests the electricity consumption was about 1,441kWh higher during the period with the reversed CT clamp. Using a unit rate of 30p/kWh, the extra cost was £432.38. It should be noted that in July 2023, the electricity consumption was higher than might be expected. This may be due to behaviour change by the household. Had this change not occurred, the excess consumption calculated when the CT clamp was reversed was likely to have been higher.

If households have a smart meter with an in-home display, they would be more likely to notice if there has been a significant increase in electricity consumption due to the CT clamp for the battery being reversed.

4.6. Assessment of solar generation with smart generation meter data

Ref No	PV system (kW)	Dates	Generation from Alpha portal (kWh)	Generation from smart generation meter (kWh)	Percentage difference	Time offline (days)	Issues
B-01	2.7	1 Jun 22 - 31 May 23	2641	2533.8	4.05%	1.6	-
B-03	3.43	1 Jun 22 - 31 May 23	3285	3152.8	4.04%	-	-
B-04	3.43	1 Jun 22 - 31 May 23	3260	3197.7	1.91%	1.6	-
B-05	3.43	1 Jun 22 - 31 May 23	3422	3259.5	4.76%	-	-
B-10	3.43	1 Jun 22 - 31 May 23	3389	1123.4	66.85%	0.9	-
B-11	3.43	1 Jun 22 - 31 May 23	2876	3151.4	-9.58%	26.8	Y
B-14	3.43 *	1 Jun 22 - 31 May 23	3441	3209.1	6.74%	0.8	-
B-18	3.43 *	1 Jun 22 - 31 May 23	3449	3356.6	2.69%	-	-
B-19	3.43	1 Jun 22 - 31 May 23	3443	3365.7	2.26%	-	-
B-20	3.43 *	1 Jun 22 - 31 May 23	3517	3306.1	6.00%	-	-

Table 4.15 Comparison of PV generation recorded on the Alpha ESS portal with PV generation recorded with smart generation meters for households on the biomass heat network. * Installations recorded as 3kW in Berneslai Homes records.

For the monitored group of 30 households, PV generation data was obtained from the smart generation meters at the properties for the period 1 Jun 22 to 31 May 23. This was compared with solar generation data derived from the Alpha ESS portal. The smart generation meters were used for recording readings for the feed-in tariff. They are MID approved meters, but there can occasionally be issues with loss of reception or failure.

Table 4.15 shows this data for the households on the biomass heat network. The annual PV generation readings from the Alpha ESS portal were higher than those for the smart generation meter for all installations apart from B-11. In this case, the battery was offline for 26.8 days which resulted in missed PV generation.

The PV generation readings from the smart generation meters were normally 1.9 to 6.7% lower than the readings from the Alpha ESS portal. This is the type of error which is typical with CT clamp monitoring. However, the generation for household B-10 was only 1,123kWh with the smart generation meter and 3,389kWh on the Alpha ESS portal. The generation recorded by the smart generation meter was about 2,000kWh lower than for similar sized and orientated installations in Table 4.15. It was not due to shading or a PV fault as the data from the Alpha ESS portal would have been similarly affected. A smart generation meter fault was less likely as the generation each month was slightly higher than the installations with ASHPs. It is likely that the issue was due to the serial number for the generation meter being recorded incorrectly at that site with the data coming from about a 1.2kW PV system.

A similar comparison of solar generation data from the Alpha ESS portal and smart generation meters is provided in table 4.16 for the homes with gas boilers. Again, the smart generation meter data was normally lower than the data from the Alpha ESS portal. The one exception was household G-46. This battery had many short periods offline, probably due to communications issues between the Wi-Fi dongle and the broadband router. As a result of periods of data loss, less solar generation was recorded. The values of annual PV generation from the smart generation meters were normally between 2.7 and 5.2% lower than the values from the Alpha ESS portal.

Ref No	PV system (kW)	Dates	Generation from Alpha portal (kWh)	Generation from smart generation meter (kWh)	Percentage difference	Time offline (days)	Issues
G-04	3.24	1 Jun 22 - 31 May 23	2678.5	2584.4	3.51%	7.1	Y
G-05	2.7	1 Jun 22 - 31 May 23	2563.4	2481.6	3.19%	2.5	-
G-16	2.7	1 Jun 22 - 31 May 23	2572.6	2503.3	2.69%	0.8	-
G-23	2.7	1 Jun 22 - 31 May 23	2528	2459.2	2.72%	-	-
G-27	3	1 Jun 22 - 31 May 23	3077	2939.0	4.49%	2.7	-
G-28	3	1 Jun 22 - 31 May 23	3143	2980.8	5.16%	3.2	-
G-30	3	1 Jun 22 - 31 May 23	2848	2720.8	4.47%	0.8	-
G-31	2.7	1 Jun 22 - 31 May 23	2660	2547.3	4.23%	1.0	-
G-46	3.24	1 Jun 22 - 31 May 23	2952	3147.6	-6.63%	>1.72	Y

Table 4.16 Comparison of PV generation recorded on the Alpha ESS portal with PV generation recorded with smart generation meters for households with gas boilers.

Ref No	PV system (kW)	Dates	Generation from Alpha portal (kWh)	Generation from smart generation meter (kWh)	Percentage difference	Time offline (days)	Issues
A-01	1.07	1 Jun 22 - 31 May 23	925	866.2	6.36%	1.4	-
A-02	1.07	1 Jun 22 - 31 May 23	1031	964.9	6.45%	-	-
A-03	1.07	1 Jun 22 - 31 May 23	1083	973.3	10.11%	0.7	-
A-04	1.07	1 May 22 - 30 Apr 23	912	872.9	4.29%	17.1	Y
A-05	1.07	1 Jun 22 - 31 May 23	867	839.0	3.23%	8.4	Y

Table 4.17 Comparison of PV generation recorded on the Alpha ESS portal with PV generation recorded with smart generation meters for households heated by ASHPs.

Smart generation meter data was compared with PV generation data from the Alpha ESS portal for the 5 households heated by ASHPs. The smart generation meter data was again lower than for the data from the Alpha ESS portal.

The percentage difference ranged from 3.2% to 10.1%. The difference was lowest for households A-04 and A-05 which were offline for 8.4 and 17.1 days respectively. Had they been offline for a less time, the generation recorded by the Alpha ESS portal would have been higher and the percentage difference greater. The percentage difference of 6.4% to 10.1% was more reflective of the measuring error when the portal had little or no time offline.

4.7. Assessment of grid consumption with smart meter data

Ref No	PV system (kW)	Dates	Consumption from Alpha portal (kWh)	Grid consumption from electricity meter (kWh)	Percentage difference	Time offline (days)	Issues
B-01	2.7	31 Mar 22 - 31 Mar 23	798.6	811.0	-1.55%	1.6	-
B-03	3.43	1 Oct 22 - 31 May 23	366.8	361.1	1.58%	-	-
B-07	3.43*	20 Nov 21 - 19 Nov 22	948	912.0	3.80%	0.9	Y
B-10	3.43	1 May 22 - 30 Apr 23	464.7	457.5	1.53%	0.9	-
B-14	3.43 *	1 Jun 22 - 31 May 23	1202	1227.9	-2.13%	0.8	-
B-18	3.43 *	18 Dec 21 - 17 Dec 22	419	436.0	-3.95%	-	-
B-20	3.43 *	12 Dec 21 - 22 Nov 22	1299	1275.0	1.85%	-	-
B-22	2.7	1 Apr 22 - 31 Mar 23	2220	2231.4	-0.50%	3.0	Y

Table 4.18 Comparison of grid consumption recorded on the Alpha ESS portal with grid consumption recorded with smart meters for households on the heat network. * Installations recorded as 3kW in Berneslai Homes records.

It was also possible to compare the grid consumption recorded by the Alpha ESS portal with the electricity import recorded by the electricity supplier's smart meter. Data from the Alpha ESS portal was derived from downloads of data from the Statistical Diagram. The battery could be offline at a site for a short or longer period. The Alpha system did not record the grid consumption for the periods while the battery was offline.

Smart meter data from the electricity meter was obtained from the electricity supplier. This was in the form of either 30-minute or daily consumption data or meter readings used for billing which could be on an approximately monthly or quarterly basis. The analysis period was typically about a year, but for some households, limited data was available and so the period assessed was under a year.

For the households on a heat network where electricity import data was available for about a year, table 4.18 shows that household B-18 had the lowest consumption of 436kWh from the smart meter and 419kWh on the Alpha portal. The grid consumption from the smart meter for household B-03 was lower at 361.1kWh, but this only covered 8-months.

Household B-22 had the highest grid consumption among those on the heat network where suitable smart meter data was available for analysis. Here the smart meter recorded 2,231kWh compared to 2,220kWh on the Alpha ESS portal. The battery system was offline for 3 days which would have lowered the consumption reading. Factors which contributed to the high grid consumption included having an electric shower each day, washing clothes every other day and drying clothes with a tumble drier in poorer weather, charging an electric scooter once a week and having a chest freezer as well as a fridge freezer.

The grid consumption from the electricity meter was between 3.80% lower than and 3.95% higher than the reading from the Alpha ESS portal. The periods where the battery was offline for households B-01, B-14 and B-22 would have contributed to the grid consumption being higher for the electricity meter. Overall, the error in the reading from the Alpha battery portal was within the expected measurement error from a CT clamp.

Ref No	PV system (kW)	Start Date	End Date	Days	Grid consumption from smart meter (kWh)	Grid consumption from smart meter (kWh/day)
B-07	3.43 *	26-May-17	25-May-18	364	1,635	4.49
		25-May-18	26-May-19	366	1,529	4.18
		26-May-19	22-May-20	362	1,383	3.82
		22-May-20	24-May-21	367	1,706	4.65
		24-May-21	25-May-22	366	1,320	3.61
		25-May-22	27-May-23	367	830	2.26

Table 4.19 Grid consumption recorded by a smart meter for household B-07 on the heat network. * Installation recorded as 3kW in Berneslai Homes records.

Smart meter data was obtained for household B-07 dating back to 2016. This allowed approximately annual values of consumption to be calculated over 6 years. The Alpha SMILE-B3 battery was installed on 18 Nov 21.

The period from 26 May 17 to 24 May 21 without the battery had an approximately annual grid consumption of between 1,383kWh and 1,706kWh or 3.82kWh/day to 4.65kWh/day. For the year 24 May 21 to 25 May 22, there was just over 6 months with the battery operating. The battery was operational for the full year from 25 May 22 to 27 May 22 and the grid consumption measured by the smart meter was 830kWh or 2.26kWh/day.

The average grid consumption for the years prior to the battery installation was 4.28kWh/day. For year from 25 May 22 to 27 May 23 with the battery running during the whole period, the grid consumption was 47.2% lower than pre-installation average.

Ref No	PV system (kW)	Dates	Consumption from Alpha portal (kWh)	Grid consumption from electricity meter (kWh)	Percentage difference	Time offline (days)	Issues
G-04	3.24	1 May 22 - 30 Apr 23	997.5	1013.0	-1.55%	7.1	Y
G-16	2.7	1 May 22 - 1 Feb 22	633.6	653.0	-3.06%	0.8	-
G-22	2.7	1 Feb 23 - 31 May 23	167.0	173.0	-3.56%	0.0	Y
G-27	3	1 Apr 22 - 5 Mar 23	339.6	385.0	-13.39%	2.7	-
G-30	3	1 Jun 22 - 31 May 23	445.4	464.2	-4.21%	0.8	-
G-33	2.7	1 Sep 22 - 30 Jun 23	85.4	607.9	-611.71%		
G-43	2.7	12 Apr 22 - 12 Apr 23	1007.2	1076.0	-6.83%		-

Table 4.20 Comparison of grid consumption recorded on the Alpha ESS portal with grid consumption recorded with smart meters for households with gas boilers.

A comparison between the grid consumption recorded by smart meters and the Alpha ESS portal is provided in table 4.20 for households with gas boilers. This includes households who were in the monitored group of 30, had smart meters and there was a suitable period where a comparison could be made.

The grid consumption recorded by the smart meters ranged from 173kWh to 1,076kWh. The analysis period for household G-22 was only 4 months and this explained the particularly low consumption at that site. There was grid consumption of under 500kWh recorded by the smart meter for households G-27 (385kWh) and G-30 (464kWh) over a period of 11 or 12 months.

Households G-04 and G-43 both recorded between 1,000 and 1,100kWh grid consumption with the smart meter over a year. When considering all the households with gas boilers in table 4.3, Alpha ESS portal data indicated 4 households had a grid consumption above 2,000kWh.

Household G-16 had a grid consumption of 653kWh over a 9-month period from 1 May 22 to 1 Feb 22 with the battery operational. For the year 1 Apr 21 to 1 Apr 22, before the battery was installed, the grid consumption recorded by the smart meter was 1,417kWh.

For 5 of the 7 households with gas boilers, the difference between the grid consumption recorded by the smart meter and the Alpha portal was under 7%. There was a significant difference between the values of grid consumption recorded for household G-33 by the 2 methods. The Alpha ESS portal indicated a consumption of only 85.4kWh while the smart meter showed a value of 607.9kWh. Data from this household made up one of the anomalous points in figure 4.6, where the self-consumption of the solar generation was abnormally high for the level of grid consumption recorded.

Figure 4.21 shows an Alpha ESS portal Power Diagram for household G-33 on 29 Dec 22. Here the battery charge was at 3.6% between midnight and 09:15. During this period, the household load recorded in 5-minute interval data was zero apart from at 03:25, 05:10 and 05:55 when it was between 0.002kW and 0.008kW. The load was also zero between 15:10 and 16:35, while the battery was 100% charged. There is normally a baseload electricity consumption for a property. The load between 18:00 and midnight in figure 4.21 is typical of the baseload consumption, with some small peaks due to the fridge-freezer compressor turning on periodically. This is normally seen throughout the 24-hour period and suggests that the Alpha ESS portal may have not been recording the full consumption for this household. Although no grid consumption was apparent in the 5-minute interval data, the portal recorded a grid consumption of 0.42kWh that day. There was a similar issue noted in figure 4.4 for household G-39, where the annual grid consumption recorded by the Alpha ESS portal was only 30.7kWh. The accuracy of the grid consumption measurement might have been affected by how well the CT clamp was fitted. Other households where particularly low grid consumption was recorded might have the same issue.

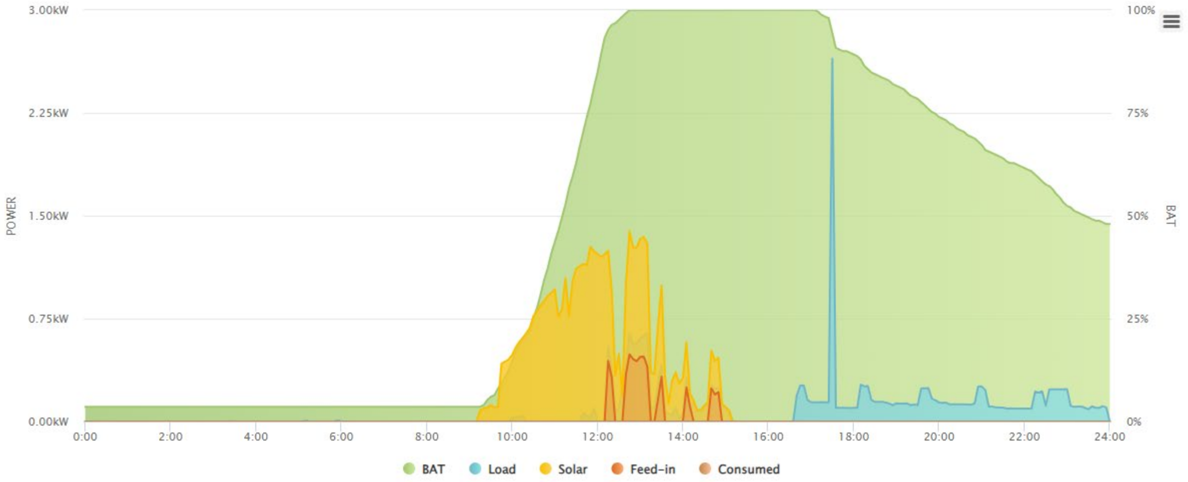


Figure 4.21 Power Diagram from the Alpha ESS battery portal for Household G-33 on 29 Dec 22

4.8. Assessing how battery charge varies over the day

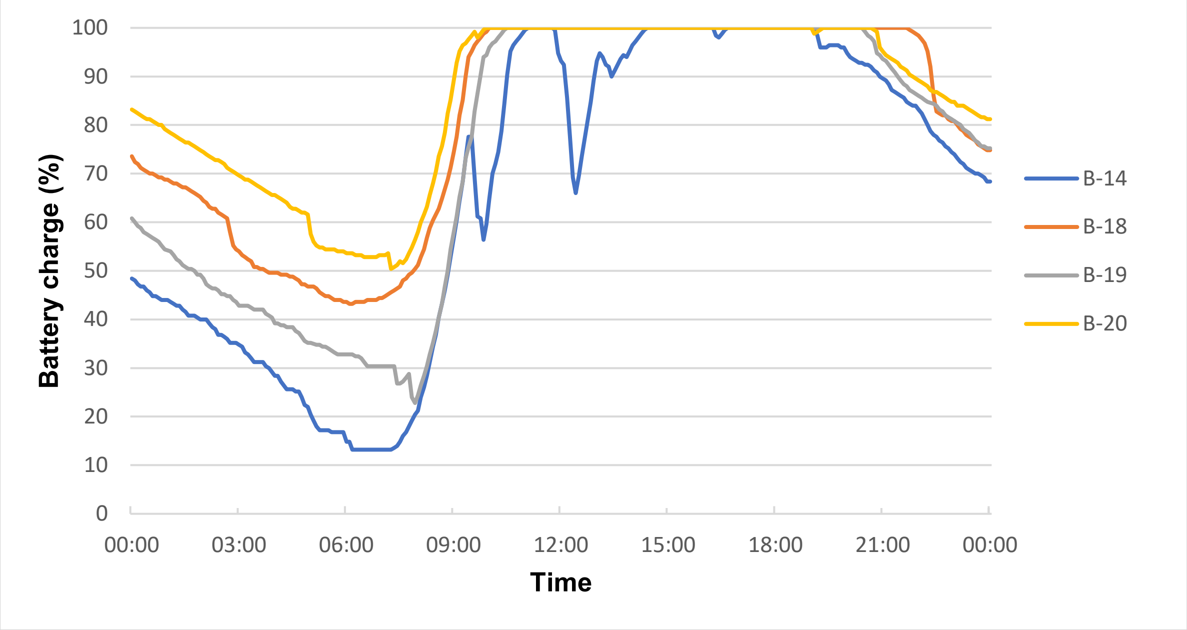


Figure 4.22 Graph showing the variation in battery charge with time on 21 May 23 for 4 households on the biomass heat network with 3.43kW solar PV systems

Section 4.8 considers how the battery charge varies across a day for 4 households on the biomass heat network and for 4 households with ASHPs on a sunny day in summer and a sunny day in winter. The 4 households on the biomass heat network all had 3.43kW solar PV systems and were on the same street. This meant the solar irradiance at the properties varied in a similar way over the day.

Figure 4.22 shows the change in battery charge over the day for the 4 households. At midnight at the start of the day, the battery charge level ranged from 48.4% for household B-14 to 83.2% for household B-20. Overnight, the battery charge fell as the baseload electricity consumption of fridges, freezers and other constantly on appliances were powered by the battery. Minimum charge was at between 06:10 and 07:30 and ranged from 13.2% charge for household B-14 to 50.4% for household B-20.

As the sun rose and the solar generation became greater than the household consumption, the batteries started to charge. The batteries for households B-18 and B-20 both reached 100% charge at about 10:00, with B-19 fully charged at 10:30. The charge level for B-14 decreased to a minimum at 09:50 and 12:25. This was due to the household using the electric shower at these times. Household B-14 is included in a case study in the next section and a Power Diagram for household B-14 is shown in figure 4.27 for 21 May 23.

In the evening as the solar generation decreased, the battery started to provide power to the home. By midnight at the end of the day, the battery charge had fallen to 80.2% for household B-20, while it was about 75% for both households B-18 and B-19 and had dropped to 68.4% for the higher consuming household B-14.

Figure 4.23 shows another graph plotting the variation in battery charge for the 4 households on the biomass heat network on 30 Jan 23, a sunny winter day. At midnight at the start of the day, the batteries for households B-14, B-19 and B-20 were all fully discharged and were at a charge level of 8%, 2.8% and 10.8% respectively.

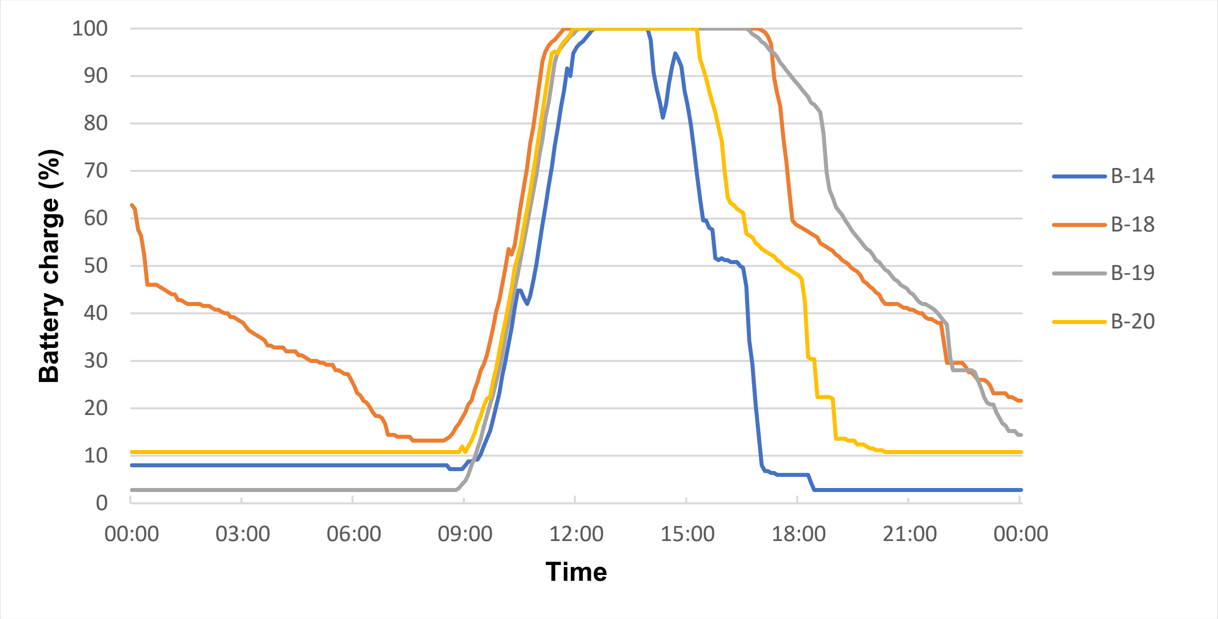


Figure 4.23 Graph showing the variation in battery charge with time on 30 Jan 23 for 4 households on the biomass heat network with 3.43kW solar PV systems

There was still 62.8% battery charge for household B-18 at midnight and the battery provided power during the night, falling to 13.2% by 08:00. From 08:30 to 09:00, the batteries started to charge, reaching 100% charge by between 11:40 and 12:30.

The rate of battery discharge depended on the level of household electricity consumption. The daytime consumption of household B-14 was the highest and the battery charge fell to 6% by 17:25 and dropped further to 2.8% at 18:25 and remained at that level overnight.

The battery for household B-20 started discharging after 15:15 and fell to 13.6% at 19:00 and subsequently 10.8% at 20:20 and stayed at that level of charge overnight.

The discharge rates for households B-18 and B-19 were lower and the batteries provided power over the evening. For household B-18, the battery began discharging at 17:00 and fell to 21.6% charge by midnight at the end of the evening. The battery for household B-19 began discharging at 16:40. Initially the discharge rate was lower than for B-18, however the battery discharge level dropped below B-18 at 22:10 and the charge level was 14.4% at midnight. The electricity consumption of household B-19 was likely to be higher than for B-18 later in the evening.

The households with gas boilers showed broadly similar variations in battery charge over the day to those on the biomass heat network. Factors affecting the variation were the size of the solar PV system which affected the rate of battery charge and the household electricity consumption which influenced the rate of battery discharge.

The behaviour of the households with ASHPs was noticeably different due to the small 1.07kW solar PV systems and the high daytime electricity consumption from the heat pump during the heating season. Figure 4.24 shows a graph of battery charge over the day for 4 of the households with ASHPs on 21 May 23. This was the same sunny summer day as for the households on the biomass heat network in figure 4.22.

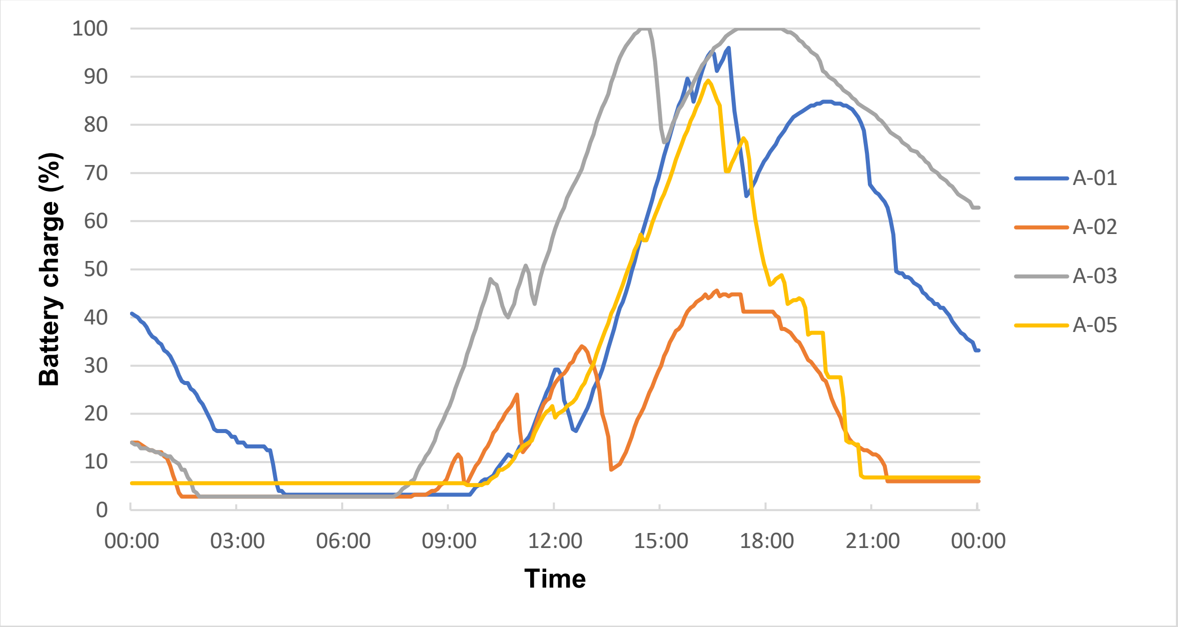


Figure 4.24 Graph showing the variation in battery charge with time on 21 May 23 for 4 households with air source heat pumps (ASHPs) and 1.07kW solar PV systems

Household A-01 still had 40.8% charge at midnight and this fell to 3.2% at 04:20 as the battery powered the baseload electricity consumption. Households A-02 and A-03 both had 14% battery charge at midnight, and this fell to 2.8% before 02:00 for both households. The battery for household A-05 had fully discharged to 5.6% before midnight and remained at that level overnight.

The batteries for the ASHP households charged more slowly than those on the heat network and reached their maximum charge later in the day. Use of appliances during the day led the batteries to discharge for each of the households.

Household A-03 had the lowest annual electricity consumption of the 5 households with ASHPs. It was the only one of the 4 ASHPs households to have the battery fully charge on 21 May 23. It initially reached 100% charge at 14:25, but subsequently discharged to 76.4% due to electricity consumption in the home. The battery became fully charged again at 17:10 and began to discharge at 18:30, falling to 62.8% charge at midnight at the end of the evening. There is a more detailed case study for household A-03 in section 4.9.3.

The battery for household A-01 achieved a maximum charge level of 96% at 16:55. The charge level dropped quickly to 66% by 17:30, perhaps due to preparing an evening meal. Late sunshine and low electricity consumption meant the battery could recharge to 84.8% at 19:30. By the end of the day, the charge level had fallen to 33.2%

There was a more straightforward charge and discharge cycle for household A-05. The maximum charge of 89.2% was achieved at 16:20 and the battery fully discharged to 6.8% by 20:45. The battery for household A-02 reached an initial peak in charge of 34% at 12:45, but following consumption in the home, the charge dropped to 8.4% at 13:35. The battery subsequently recharged and by 16:35 the maximum charge level for the day of 45.6% was achieved. Over the evening, the battery charge level fell and fully discharged to 6% at 21:25.

The batteries in the homes with the ASHPs in many respects performed less well on 21 May 23 than the batteries in the homes on the biomass heat network on 30 Jan 23.

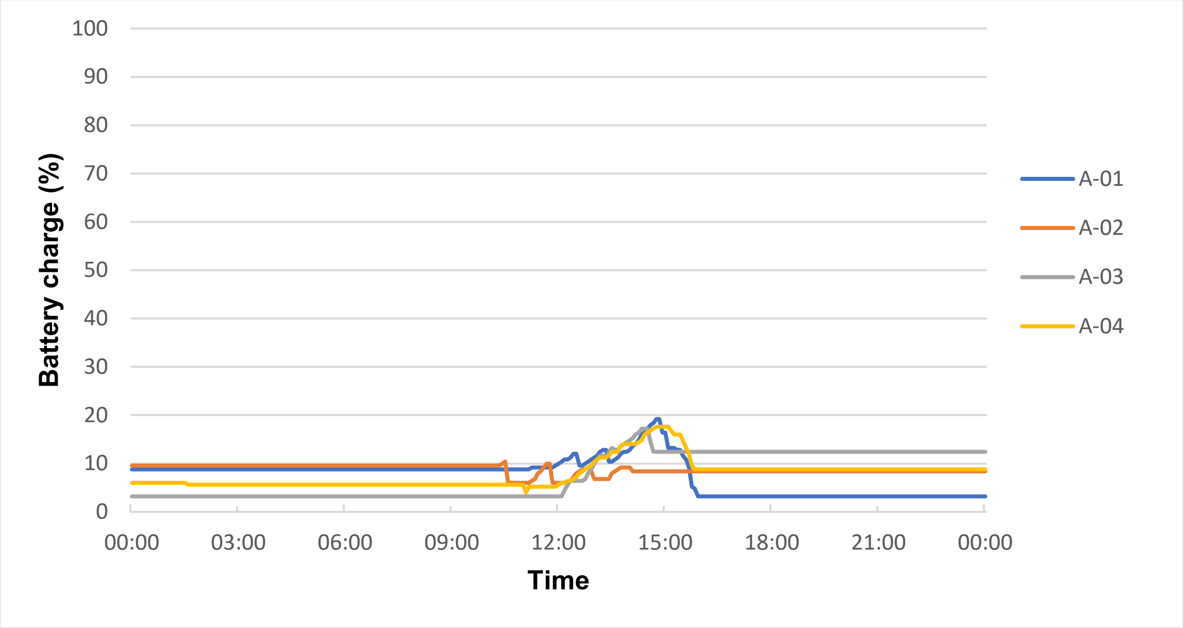


Figure 4.25 Graph showing the variation in battery charge with time on 30 Jan 23 for 4 households with air source heat pumps (ASHPs) and 1.07kW solar PV systems

Figure 4.25 shows a graph of battery charge over the day on 30 Jan 23 for 4 households with ASHPs. These were not the same 4 households as in figure 4.24 as a full day of data was not available for A-05 on 30 Jan 23 and no data was available for A-04 on 21 May 23.

The graph is for the same sunny winter day as for the 4 households on the biomass heat network in figure 4.23.

Due to high household consumption and low solar generation in winter, most of the solar generation was used to help power the ASHP. There was little excess generation available as a result to charge the battery and none of the batteries charged above 20% on the day.

Overnight, each of the batteries was fully discharged at a level of charge between 3.2 and 9.6%. There was some additional discharge of the battery for A-02 from 9.6% to 6% at 10:30 followed by a couple minor grid charge/discharge cycles until the charge level stabilised at 8.4% at 14:00.

The battery for household A-01 started charging from the solar PV at 11:15 and went from 8.8% charge to 19.2% at 14:50. However, this quickly discharged to 3.2% before 16:00.

For household A-03, the battery was at its overnight discharge level of 3.2% until it began charging at 12:10 and reached a charge level of 17.2% at 14:20. This quickly dropped to 12.4% at 14:40 and remained at this level of discharge for the rest of the day.

The battery for household A-04 was initially at a charge level of 5.6%. Following a minor dip in charge, the battery began to charge at 12:00 reaching a peak of 17.6% at 14:45. This fell to 8.8% by 15:50 and remained at that level for the rest of the day.

It was apparent that for the battery installations at the sites with ASHPs and small solar PV systems, there was only limited charging of the battery on a sunny day in winter and on other winter days no charging.

4.9. Case Studies

4.9.1. Household B-14

	Alpha ESS portal						Smart Meter	
Month	Generation (kWh)	Export (kWh)	Household consumption (kWh)	Grid consumption (kWh)	Battery charge (kWh)	Battery discharge (kWh)	Generation (kWh)	Grid import (kWh)
Jun-22	435.1	209.6	262.4	36.9	102.1	99.2	419.5	41.7
Jul-22	415.0	192.9	259.0	36.9	105.0	99.7	402.0	36.6
Aug-22	439.6	210.2	267.8	38.4	106.7	103.9	424.5	39.6
Sep-22	295.5	96.4	276.9	77.8	102.7	98.6	279.7	79.5
Oct-22	250.3	74.1	283.2	106.9	87.9	84.0	234.0	108.7
Nov-22	104.9	17.6	272.7	185.4	39.2	36.9	92.0	191.8
Dec-22	116.1	26.6	289.0	199.5	43.1	40.7	100.4	201.6
Jan-23	164.7	36.7	317.7	189.7	62.9	59.5	106.2	191.5
Feb-23	182.1	42.2	260.4	120.5	73.5	70.2	167.7	122.6
Mar-23	244.4	77.5	274.8	107.8	82.4	78.4	227.4	109.7
Apr-23	349.9	140.0	274.3	64.4	105.0	99.0	332.1	65.3
May-23	443.4	205.5	276.0	38.0	107.3	103.9	423.6	39.2
Total	**3441.0**	**1329.1**	**3314.2**	**1202.2**	**1017.8**	**974.0**	**3209.1**	**1227.9**

Table 4.26 Monthly energy data for Household B-14 with an Alpha ESS SMILE-B3 battery and a 3.43kW PV system. Note in Berneslai Homes data it was recorded as a 3kW system.

Household B-14 lived in a 2-bedroom bungalow which was heated by a biomass heat network. The 2 residents were retired and were in half of the day. They tended to use most electricity in the morning when washing clothes and after 5pm when cooking an evening meal, although on a Sunday they would cook in the middle of the day. About 4 loads of clothes were washed a week and a tumble drier was used when it was raining and not possible to dry the clothes outside. They would typically use the electric shower in the afternoons for about 10-15 minutes per shower. There was a separate under-counter fridge and an under-counter freezer. The residents did not use the Alpha ESS app but looked at the display on the battery. When it was fully charged, they tended to use appliances like the washing machine so they could use it for free.

Table 4.26 shows monthly energy data for household B-14 from the Alpha ESS portal and smart meter data. Each month, the Alpha ESS portal recorded higher generation that the smart generation meter at the site. Over the year, the generation recorded by the smart meter was 6.7% lower than the value from the Alpha ESS portal. The total generation over the year was 3,209kWh. For comparison, the predicted value using PVGIS[18] for a 3.43kW PV system facing south at the location of the installation was 3,249kWh. The solar PV generation recorded by the smart meter ranged from 424.5kWh in August 2022 to 92kWh in November 2022.

A total of 1,329kWh of export of the solar generation to the grid was recorded by the Alpha ESS portal over the year. Monthly values ranged from 17.6kWh in November 2022 to 210.1kWh in August 2022. The level of self-consumption of the solar generation over the

---

[18] Photovoltaic Geographical Information System (PVGIS), EU Science Hub, https://re.jrc.ec.europa.eu/pvg_tools/en/ (Accessed 11 Aug 23)

year was 61.38%, but the monthly self-consumption ranged from 51.8% in June 2022 to 83.2% in November 2022.

The household consumption over the year recorded by the Alpha ESS portal was 3,314kWh. For comparison the typical domestic consumption value (TCDV) for a medium electricity user in 2022 was 2,900kWh[19]. The monthly household consumption was greater in the winter months due to factors like increased use of lighting and of appliances like the tumble drier. The monthly values ranged from 259kWh in July 2022 to 318kWh in January 2023.

The grid consumption over the year was 1,202kWh from the Alpha ESS portal and 1,228kWh from the utility smart meter. The grid consumption was 36.3% of the household consumption, with the rest of the household consumption supplier by the solar PV and battery. The monthly grid consumption ranged from 36.9kWh (36.6kWh from the smart meter) in July 2022 to 199.5kWh (201.6kWh from the smart meter) in December 2022. This was a much more significant variation over the year than for the household consumption.

The annual battery charge recorded by the Alpha ESS portal was 1,018kWh and the annual battery discharge was 974kWh. This corresponds to a round trip efficiency for the battery of 95.68%. With an electricity cost of 30p/kWh, the annual electricity saving from the battery was £292.20.

Figure 4.27 shows a Power Diagram for household B-14 on 21 May 23. At midnight on the far left of the graph, the battery charge (BAT in green) was at 48.4%. The overnight baseload of electricity (Load – shown in blue) ranged from 70W to 275W as the fridge and freezer compressors turned on and off. By 06:30, there was initial solar generation and the battery charge had dropped to 13.2%. After the solar generation increased above the household load, the battery began to charge. By 09:30, the battery charge had increased to 77.6% and the electric shower was used.

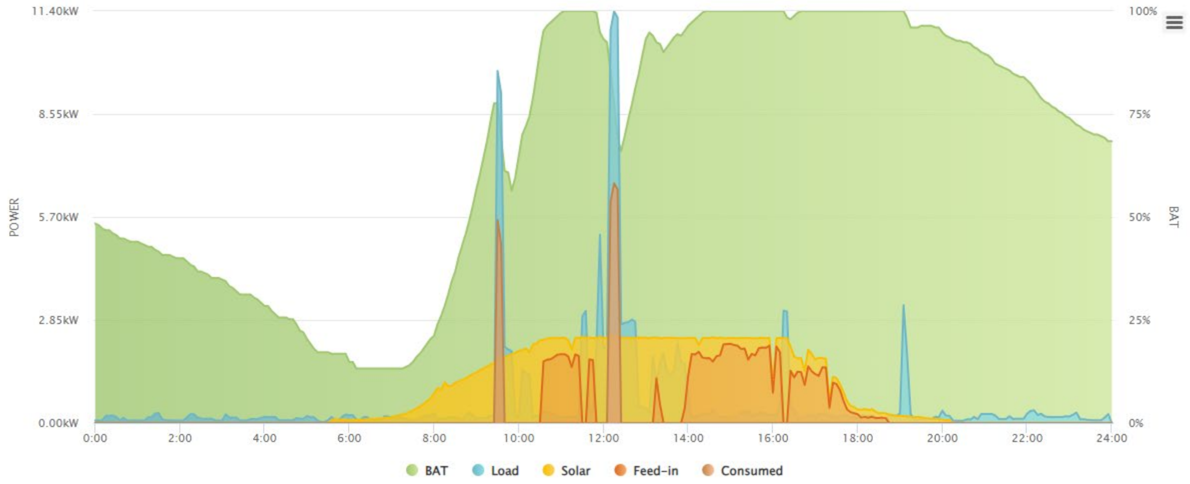


Figure 4.27 Power Diagram from the Alpha ESS battery portal for Household B-14 on 21 May 23

---

[19] Average gas and electricity use explained, Ofgem, https://www.ofgem.gov.uk/information-consumers/energy-advice-households/average-gas-and-electricity-use-explained#:~:text=Ofgem%20estimates%20the%20typical%20household,of%20gas%20in%20a%20year. (Accessed 11 Aug 23)

The household load while the electric shower was used was about 9.5kW, with about 5.3kW coming from the grid (Consumed shown in brown) and the rest from the solar PV and battery. By the end of the shower, the battery charge level had fallen to about 60%.

The battery then continued to charge from the solar and once it reached 95% charge at 10:35, excess solar generation was exported to the grid (Feed-in). The battery reached 100% charge at 11:05.

The household load increased above 2kW at 11:50 and the electric shower was used again at 12:10. The household load increased to 11.3kW with 6.5kW imported from the grid and 2.4kW provided by the solar PV, with a further 2.4kW from the Alpha ESS battery. After the shower, the battery charge dropped to 66%, but with further solar generation, the level of charge returned to 100% by 14:25. Excess solar generation was exported to the grid from 13:55 once the battery was 95% charged.

A 3kW appliance like a kettle was used at 16:15 and 19:05 and this was fully powered by the battery and the solar PV. Over the evening, the battery fully powered the appliances used and the battery charge dropped to 68%.

On 21 May 23, the solar panels generated about 21kWh, with 8.6kWh exported to the grid. The household load was about 14.9kWh, with about 2.5 - 3kWh of the grid consumption due to the electric shower. The shower could only be partially powered by the battery and solar panels. The battery charge was 4.7kWh and the discharge was 4.0kWh. This was greater than for a single charge and discharge cycle.

The solar generation in winter is much lower than in summer. For example, in January 2023, the daily solar generation ranged from 1.1kWh to 10.4kWh. Figure 4.28 shows a Power Diagram for household B-14 on 11 Jan 23. The solar generation that day was 3.3kWh, with only 1.1kWh generated the day before. Overnight, the battery was fully discharged, and the household load was supplied from the grid. The small peaks in consumption overnight were due to variation in the consumption by the fridge and freezer. Electricity was generated by the solar PV system from 08:45 and this started to power the household load. From 09:15, the PV generation was greater than the household load and the battery began to charge.

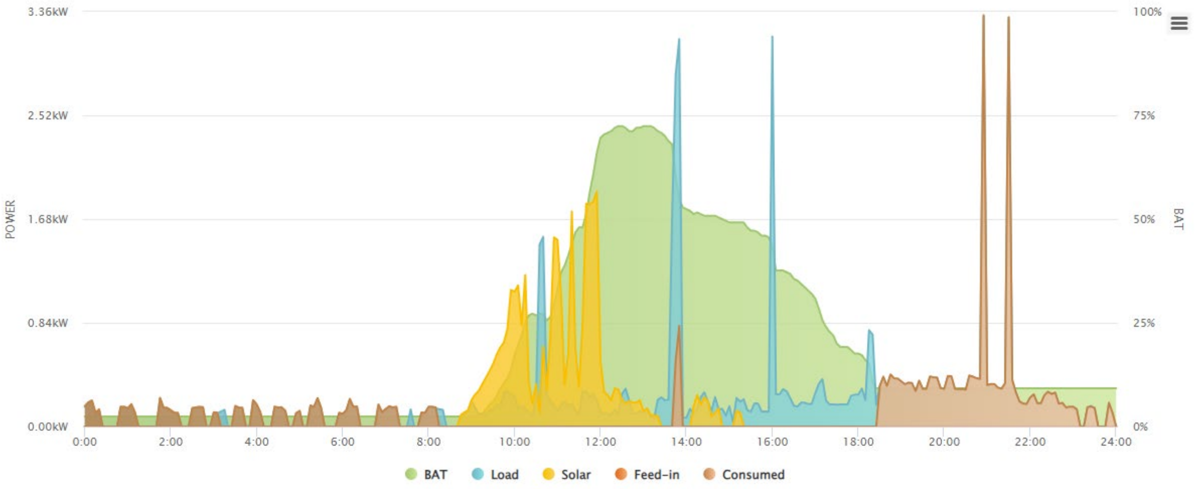


Figure 4.28 Power Diagram from the Alpha ESS battery portal for Household B-14 on 11 Jan 23

There was a load of about 1.5kW at 10:35 for 5-10 minutes. The battery had sufficiently charged so that this could be fully powered by the battery. Over the morning and into the afternoon, the battery continued to charge until it reached 72.4% at 12:30 and 13:00. The level of solar generation dropped from a maximum of 1.9kW at 11:55 to under 250W after 12:30 due to a change in the weather.

Over the rest of the day, there were 4 periods of about 5 minutes with consumption peaks of 3kW which may have been due to use of a kettle. The battery provided power to the household until 18:30 when the battery was depleted, and the charge had fallen to 9.2%.

Over the day, the solar generation was 3.3kWh, with only 0.12kWh exported to the grid. The household consumption was 6.33kWh with 3.15kWh imported from the grid. There was limited solar generation in the afternoon, but the battery was able to largely supply the household consumption until 18:30. The battery charge was 1.9kWh and the discharge was 1.7kWh.

4.9.2. Household G-30

	Alpha ESS portal						Smart Meter	
Month	**Generation (kWh)**	**Export (kWh)**	**Household consumption (kWh)**	**Grid consumption (kWh)**	**Battery charge (kWh)**	**Battery discharge (kWh)**	**Generation (kWh)**	**Grid import (kWh)**
Jun-22	380.2	238.5	148.4	6.8	64.4	60.3	367.2	7.6
Jul-22	354.4	214.7	146.7	7.0	65.6	60.9	341.8	7.8
Aug-22	379.1	241.4	142.1	4.4	69.2	64.4	366.2	4.8
Sep-22	239.5	114.8	134.9	10.2	70.7	67.2	228.6	11.2
Oct-22	193.7	87.9	131.8	25.9	61.0	56.5	182.3	27.1
Nov-22	73.3	15.5	124.7	66.9	31.9	29.6	66.4	70.7
Dec-22	74.0	15.0	141.8	82.8	33.4	30.7	65.9	85.5
Jan-23	117.6	33.5	154.3	70.1	49.8	45.7	108.6	72.4
Feb-23	138.2	48.4	133.6	43.7	53.3	49.8	129.7	45.2
Mar-23	209.1	93.0	148.5	32.3	64.8	60.3	198.8	34.2
Apr-23	305.4	175.9	172.5	43.0	66.7	60.5	294.0	43.6
May-23	383.6	237.1	198.8	52.3	68.5	63.4	371.3	54.0
Total	**2848.1**	**1515.7**	**1777.8**	**445.4**	**699.3**	**649.3**	**2720.8**	**464.2**

Table 4.29 Monthly energy data for Household G-30 with an Alpha ESS SMILE-B3 battery and a 3.0kW PV system. The property was heated by a gas boiler.

Household G-30 had a single resident aged over 70 years who was at home all day. The resident washed clothes 2-3 times a week with a quick 15-minute wash at 30ºC. Although there was a tumble drier it was hardly ever used with clothes normally dried outside on a line or inside on a clothes horse. The electric shower was typically used twice a week in the evening. There was an undercounter fridge and 2 undercounter freezers. The stove was used 3 times a day for porridge and coffee. It could be used for tea at about 5pm. The resident frequently did not cook and often had sandwiches at lunchtime and in the evening.

The resident did not change behaviour to use the free electricity from the solar but was aware of when electricity was exported to the grid due to the in-home display for the smart meter. The battery was in an outbuilding and the resident did not check the display showing the level of charge on the battery. The resident struggled to do more than make calls and text messages with her phone and so did not use the Alpha ESS phone app.

Monthly energy data is shown in table 4.29 for household G-30 using data from the Alpha ESS portal and smart meters. The monthly generation from the smart generation meter ranged from 65.9kWh in December 2022 to 371.3kWh in May 2023. Over the analysis period, the annual solar generation recorded by the smart generation meter was 2720.8kWh compared to 2,848.1kWh using data from the Alpha ESS portal. Over this period, the smart generation meter data was 4.5% lower than the data from the Alpha ESS portal.

The monthly export recorded by the Alpha ESS portal ranged from 15.0kWh in December 2022 to 241.4kWh in August 2022. Over the 12-month analysis period the export was 1,515.7kWh. Using the export and annual generation from the Alpha ESS portal, it is possible to calculate the percentage self-consumption of the solar generation. This ranged from 36.3% in August 2022 to 79.7% in December 2022, with an average of 46.8% over the year.

The household consumption was highest in April and May 2023. This was because the resident bought an electric car in mid-April. In other months, the household consumption ranged from 124.7kWh in November 2022 to 154.3kWh in January 2023. The electric car was not heavily used and was charged on 3 occasions during the May 2023, taking the household consumption up to 198.8kWh.

The grid import recorded by the household smart meter ranged from 4.8kWh in August 2022 to 85.5kWh in December 2022. The values of grid consumption recorded by the Alpha ESS portal were lower than for the smart meter for each month. Over the 12-month period analysed, the grid consumption recorded by the Alpha ESS portal was 445.4kWh compared to 464.2kWh by the household smart meter. The household smart meter reading was 4.2% higher than the value from the Alpha ESS portal.

The battery discharge over the 12-month period was 649.3kWh, which was worth £194.79 for electricity at 30p/kWh. The discharge per month ranged from 29.6kWh in November 2022 to 67.2kWh in September 2022.

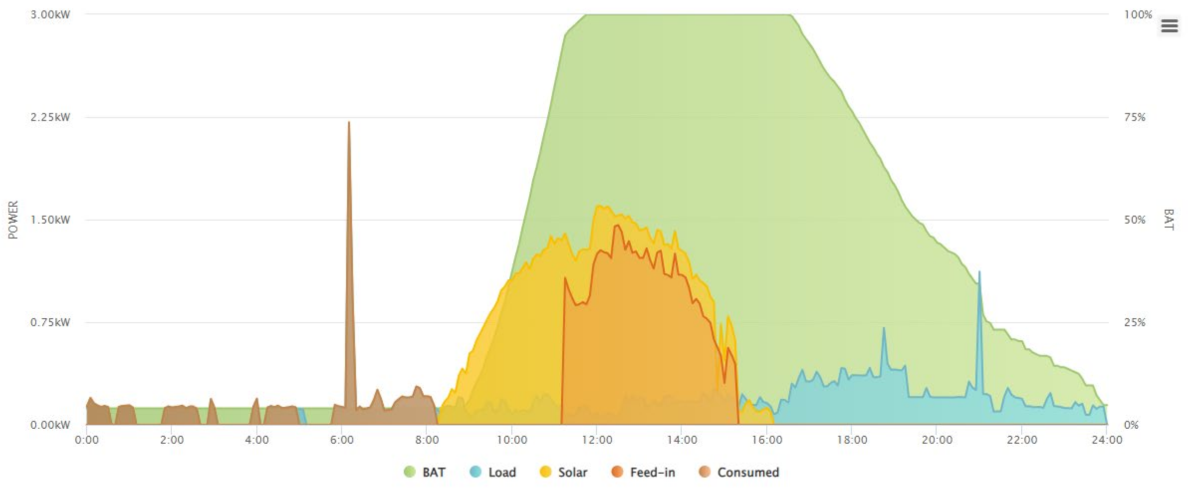


Figure 4.30 Power Diagram from the Alpha ESS battery portal for Household G-30 on 30 Jan 23

Figure 4.30 shows a Power Diagram for household G-30 on 30 Jan 23. Overnight, the battery was depleted and the charge had fallen to 4%, so the household baseload consumption of about 140W was imported from the grid.

There was a short 2.2kW peak of electricity consumption at 06:10 as the resident used an appliance after getting up in the morning. There was sufficient light by 08:20 that the solar generation was greater than the household consumption. The battery started charging from 08:55 and reached 95% charge by 11:15. Excess solar generation was exported to the grid from this time and the battery charged more slowly, becoming fully charged at 11:45.

It was a sunny January day and excess solar generation continued to be exported to the grid until 15:15. Subsequently, there was a fall in solar generation and the PV system stopped generating electricity at about 16:00.

The battery supplied all the household load after 16:00, with the load increasing to 200-400W in the early evening. By midnight, the battery charge had fallen to 4.8%. The solar and battery system had fully powered the household from 08:20 to midnight on this sunny day in January. Over the day there was 7.8kWh of solar generation with 4.17kWh exported to the grid. The household consumption was 4.89kWh with 1.26kWh imported from the grid. There was 2.3kWh of battery charge and 2.1kWh of discharge.

Another example from 9 May 23 is shown in figure 4.31. The battery was fully discharged overnight and power for the baseload household consumption came from the grid. There was solar generation from 06:30. The battery was charging from about 06:50 and was fully charged by 10:25. Although it was a day with limited direct sunshine, the solar and battery system supplied all the household load from about 06:30 to 15:45.

The electric car was put on charge at 15:50 and the load was initially about 4kW. The Alpha ESS battery supplied 2 to 3kW of the load and the Alpha ESS battery charge fell from 100% at 15:50 to 5.2% at 16:40. After this, the power charging the electric car was provided just from the solar panels and electricity imported from the grid. At 16:40 the electric car charger load increased from about 4kW to about 6.5kW and this continued until about 18:35. After this, the load from charging the electric car fell until it was fully charged at 20:00.

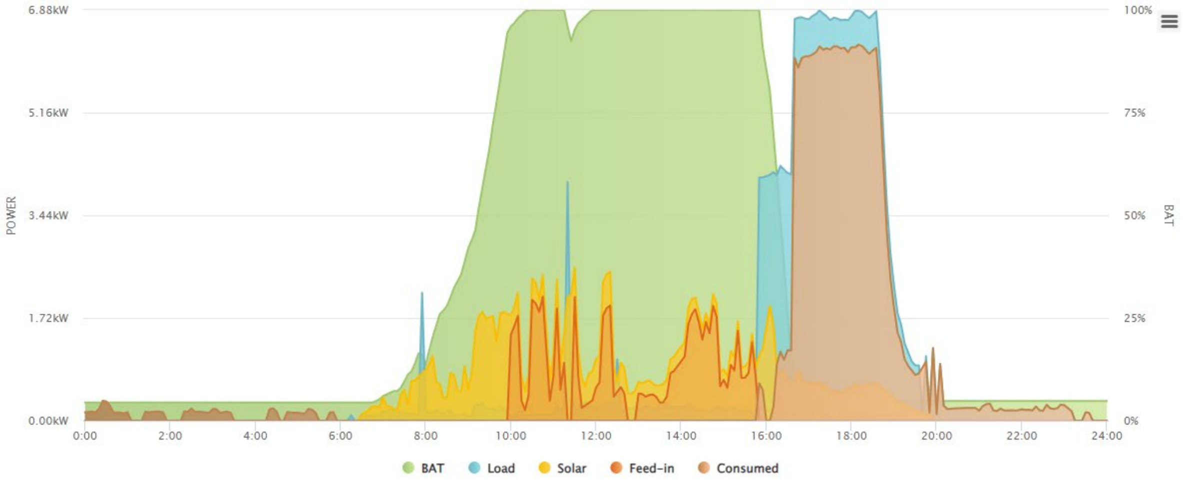


Figure 4.31 Power Diagram from the Alpha ESS battery portal for Household G-30 on 9 May 23

The Alpha ESS battery had fully discharged so the household load for the rest of the evening was supplied by import from the grid.

On 9 May 23, there was 12.4kWh of electricity generated by the solar panels with 5.06kW of this exported to the grid. The household consumption was 23.93kWh and the grid consumption was 16.59kWh. There was 2.8kWh of the solar generation charging the Alpha ESS battery and the discharge was 2.5kWh. It would have been more economical to charge the electric car earlier in the day when there was more excess solar generation to help charge the electric car.

4.9.3. Household A-03

	Alpha ESS portal						Smart Meter	
Month	**Generation (kWh)**	**Export (kWh)**	**Household consumption (kWh)**	**Grid consumption (kWh)**	**Battery charge (kWh)**	**Battery discharge (kWh)**	**Generation (kWh)**	**Grid import (kWh)**
Aug-22	146.8	9.8	219.7	82.7	71.4	68.0	135.7	
Sep-22	93.1	4.1	213.0	123.9	43.2	41.6	84.0	
Oct-22	72.7	2.3	227.9	157.5	34.5	32.4	63.4	
Nov-22	29.1	0.5	356.0	327.4	7.5	6.7	21.1	
Dec-22	30.9	0.1	747.1	716.3	1.6	0.8	23.2	
Jan-23	44.2	0.2	706.8	662.8	4.0	3.4	36.6	
Feb-23	50.8	0.9	478.6	428.7	10.2	9.2	43.6	415.4
Mar-23	71.3	1.3	533.8	463.8	16.4	15.1	62.9	454.0
Apr-23	114.2	2.7	415.6	304.1	36.6	34.6	104.9	290.2
May-23	147.3	12.6	251.1	116.4	63.0	59.3	135.5	112.3
Jun-23	151.6	18.6	202.0	69.0	65.8	62.8	141.1	64.8
Jul-23	121.5	6.4	211.1	96.0	50.0	47.8	111.7	93.8
Total	**1073.5**	**59.6**	**4562.6**	**3548.7**	**404.2**	**381.7**	**963.7**	**1430.5**

Table 4.32 Monthly energy data for Household A-03 with an Alpha ESS SMILE-B3 battery and a 1.07kW PV system. The property was heated by an Air Source Heat Pump (ASHP).

Household A-03 had a single resident aged over 60 years who was at home half of the day. The property was a modern semi-detached bungalow which was heated by an ASHP with underfloor heating and had a small 1.07kW solar PV system.

The water heating for the shower was provided by the ASHP. Clothes were washed once a week with them dried outside on a line. The resident had an electric cooker which he used 2 to 3 times a week between 16:00 and 18:00. He also had an air fryer which he used 3 to 4 times a week. There was a fridge-freezer and an additional under-counter fridge.

The battery was fitted in the hallway and the resident was able to make use of the battery display to see the level of charge in the battery. If there was plenty of charge, he knew he could use appliances for free as a result. He also made use of the Alpha ESS app which enabled him to see when there was free electricity to use and could use higher power appliances. He was already aware of his electricity use from his smart meter in-home display, but the information provided by the Alpha ESS app meant he could become even more engaged about his electricity consumption.

The Alpha ESS SMILE-B3 battery was installed on 15 Mar 22 and data was available on the Alpha ESS portal from 24 Mar 22. Daily electricity consumption data from the smart meter was available from 31 Jan 23. Using smart meter readings and other previous onsite readings, the annual electricity consumption between 7 Feb 22 and 7 Feb 23 was 3,497kWh.

Table 4.32 shows monthly energy data for household A-03 from the Alpha ESS portal and smart meter data. The solar generation recorded on the Alpha ESS portal was 1073.5kWh over the 12-months of the analysis period. This compares to 963.7kWh recorded by the smart generation meter, a value that was 10.2% lower. The monthly generation from the smart generation meter ranged from 21.1kWh in November 2022 to 141.1kWh in June 2023 compared to 29.1kWh to 151.6kWh for the Alpha ESS portal for the same months.

The solar generation exported to the grid recorded by the Alpha ESS portal was just 0.1kWh in December 2022 and rose to 18.6kWh in June 2023. Over the whole 12-month period it was 59.6kWh. The solar self-consumption was 94.45% for the 12-month period and ranged from 87.75% in June 2023 to 99.71% in December 2022.

The reason for the high level of self-consumption was the low level of generation from the small 1.07kW PV system along with the high household consumption due to electric heating with the heat pump.

The household consumption over the 12-month period was 4,563kWh and ranged from 202kWh in June 2023 to 747kWh in December 2022 during colder weather when the heat pump consumed more electricity. The monthly grid consumption recorded by the Alpha ESS portal was between 69kWh in June 2023 and 716kWh in December 2022. Limited monthly grid consumption data was available from the smart meter. Each of the monthly values of grid import from the smart meter was lower than the values of grid consumption recorded on the Alpha ESS portal. The opposite was the case for households B-14 and G-30. Between February and July 2023, the grid consumption recorded on the Alpha ESS portal was 1,478kWh. The grid import recorded by the smart meter was 1,430.5kWh, which was 3.2% lower than the value for the portal.

The battery charge over the 12-month analysis period was 404.2kWh and the battery discharge was 381.7kWh. The round-trip efficiency for the charge-discharge cycle over the year was 94.4%. The battery discharge ranged from 0.8kWh in December 2022 to 68kWh in August 2022. The battery discharge over a 12-month period for household A-03 was considerably lower than for households B-14 and G-30. The households in the earlier case studies had larger solar PV systems and lower household consumption. This meant there was more excess solar generation to charge the SMILE-B3 battery. It should be noted however that household A-03 had the highest battery discharge of the 5 households with ASHPs that had batteries installed.

Figure 4.33 shows a Power Diagram for household A-03 on 31 Jan 23. Overnight, the battery was discharged to a level of 12.4% and the baseload electricity consumption of 100 to 300W was imported from the grid. The electricity consumption rose from 05:30 due to operation of the heat pump, reaching a peak of 2.57kW at 06:20. The consumption decreased as the home heated, but there was a spike in consumption at 08:10, taking the grid import briefly to 4.37kW.

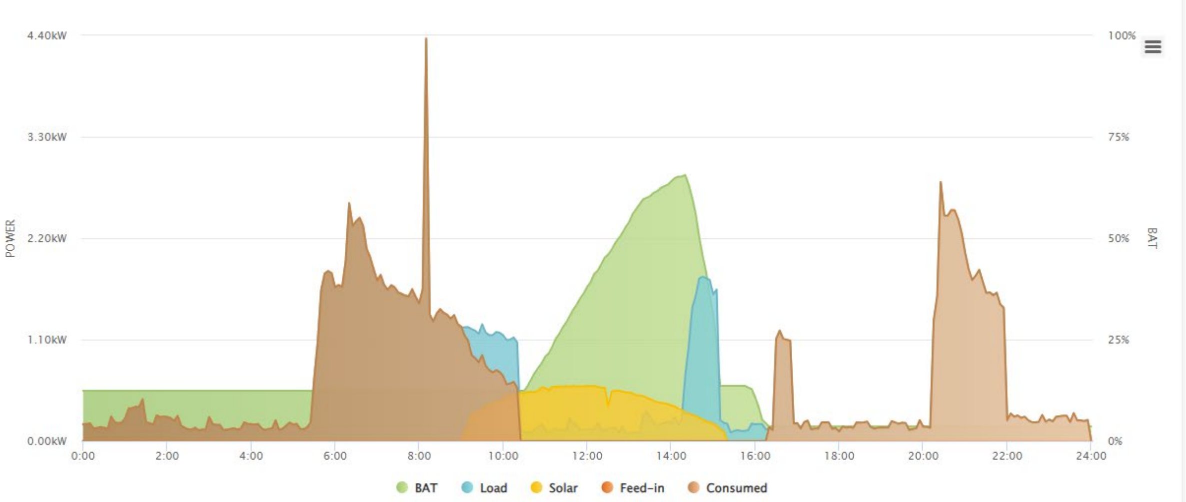


Figure 4.33 Power Diagram from the Alpha ESS battery portal for Household A-03 on 31 Jan 23

This was due to the resident using an appliance like a kettle or a toaster. It was a sunny January day, and the solar PV system began generating electricity from 09:00. This helped to power the heat pump and lowered the amount of electricity imported from the grid.

It is likely the heat pump was turned off at 10:30, reducing the household load to 100 to 200W. There was subsequently excess generation from the solar panels which enabled the battery to charge. The peak in solar generation was 0.60kW at 12:10 and the battery continued charging until 14:20 when it reached a charge level of 65.6%.

The household load increased to 1.78kW at 14:45 and the battery charge fell to 13.6% by 15:15 when the solar panels stopped generating. There was a further peak in consumption of 1.2kW at 16:35. By then, the battery had discharged to 3.6% and all the household load was provided by import from the grid. There was a consumption peak between 20:15 and 22:00, with a maximum value of consumption of 2.8kW. This was likely to be due the heating being scheduled to run during this period, with an initial high period of consumption which decreased as the home warmed and the heat pump had to work less hard.

Over the day, the solar panels generated 2.9kWh and 0.03kWh of this was exported to the grid. The household consumption was 15.8kWh and 12.93kWh was consumed from the grid. The battery charge and discharge on 31 Jan 23 was 1.3kWh.

During colder weather in December and January, the heating could be running from 05:30 until 22:00. For days like these, all the solar generation was used powering the heat pump and there was no excess generation to charge the battery. Figure 4.34 shows an example from 10 Jan 23 where the household consumption was 20kWh, the solar generation was 0.3kWh and the electricity imported from the grid was 19.7kWh. There was no charge or discharge of the battery.

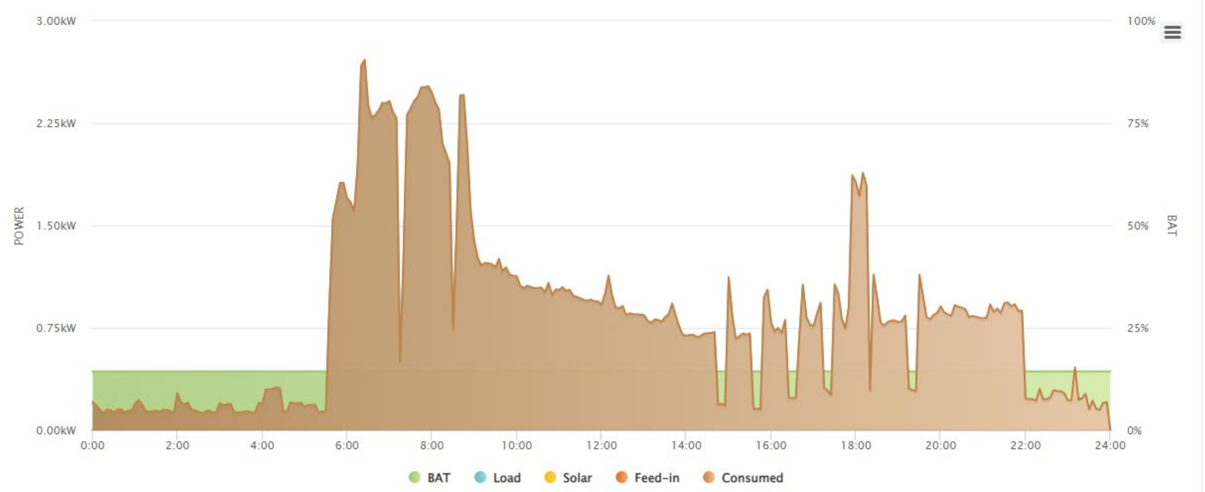


Figure 4.34 Power Diagram from the Alpha ESS battery portal for Household A-03 on 10 Jan 23

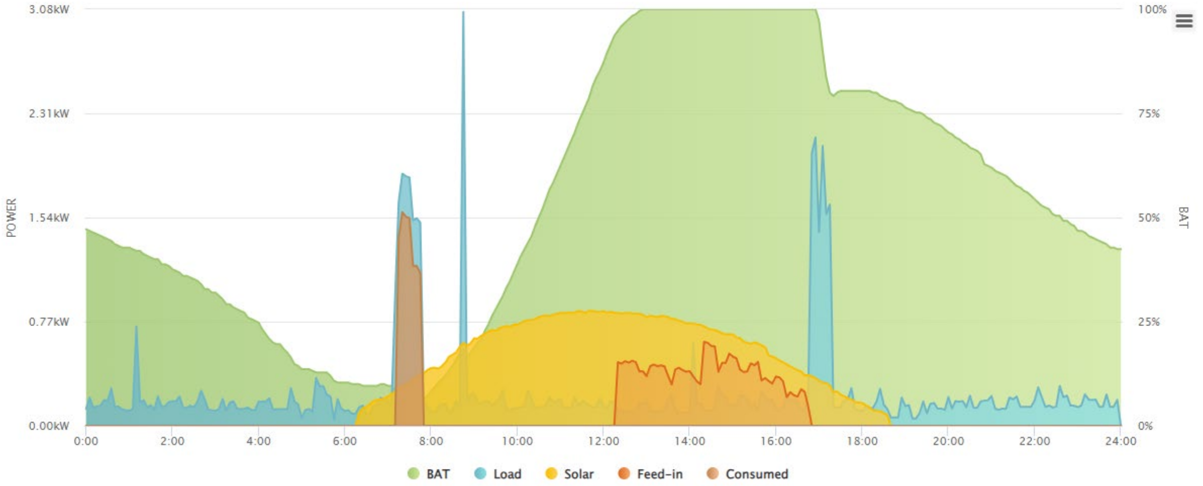


Figure 4.35 Power Diagram from the Alpha ESS battery portal for Household A-03 on 27 May 23

An example Power Diagram for household A-03 on a sunny day in summer is shown in figure 4.35. At midnight on 26/27 May 23, the battery charge was at 47%. The overnight baseload was typically 100 to 200W. By 06:30, the battery charge had fallen to 9.6%, but the solar PV system had started generating. There was a peak in consumption between 07:10 and 07:45 with a maximum load of 1.86kW where about 350W was supplied by the solar PV. The consumption peak was likely to be due to water heating by the ASHP. There was also a sharp peak in consumption of 3.1kW at 08:45, which was probably due to use of a kettle. This was fully powered by the battery and solar PV.

The peak in solar generation was 0.85kW at 11:45. The battery reached 95% charge at 12:20 and the rate of charging slowed so that electricity from the solar PV system started to be exported to the grid. The battery was 100% charged by 12:55.

There was higher consumption from 16:50 to 17:20 with a peak of 2.1kW that was fully powered by the battery and solar PV. The greater consumption might have been due to further water heating by the heat pump or cooking by the resident. By the end of this period, the battery charge had fallen to 80%. Over the course of the evening, the baseload consumption of 100 to 300W was fully powered by the battery. The battery charge had fallen to 42.4% by midnight.

On 27 May 23, the solar panels had generated 7.2kWh with 1.97kWh exported to the grid. The household consumption was 6.19kWh and 0.96kWh of this had been imported from the grid. The battery charge over the day was 2.9kWh and the discharge was 3.0kWh.

5. Conclusions, recommendations, and future work

5.1. Conclusions

The project successfully installed battery storage at scale with the Berneslai Homes in-house electrical team installing 75 Alpha ESS SMILE-B3 batteries

- The project was led by Age UK Barnsley who provided advice to residents, with project management by Energise Barnsley; the homes receiving installations were managed by Berneslai Homes and the project was evaluated by NEA
- The Alpha ESS SMILE-B3 battery was AC coupled and had a storage capacity of 2.9kWh (usable capacity of 2.8kWh) and a maximum power output of 3kW
- An initial phase of 15 installations took place in November 2021 with the remaining 60 installations taking place in a second phase between 23 Feb 22 and 5 May 22
- The battery installations took place in either 1- or 2-bedroom bungalows that were reserved for residents aged over 50 years and had existing solar PV systems
- There were 48 installations in homes with gas boilers, 22 in homes on a biomass heat network and 5 in homes with air source heat pumps (ASHPs)
- The solar PV systems ranged in size from 1kW to 3.78kW; all the homes with ASHPs had 1.07kW PV systems
- The batteries needed to be connected to the internet for warranty purposes, updates and monitoring
- 57 of the installations were connected to the internet using the tenant's household broadband via a Wi-Fi dongle
- The remaining 18 households had a wireless router connected to the battery which used a 3G SIM card; these were mainly households without home broadband
- 45 of the batteries were installed inside the home, while the remaining 30 were fitted in an outhouse which would previously have been used to store coal
- The battery had an LED display which showed the level of charge in the battery
- While connecting the battery online, the project liaison officer also installed the Alpha ESS monitoring app for residents who had smart phones
- The success of this project shows that in-house electrical teams for social landlords can be a suitable and cheaper alternative to using renewable contractors

There was a programme of advice visits by Age UK Barnsley

- As part of the project, home visits and telephone support was provided to households by Age UK Barnsley
- 66 of the households received a single visit while 6 households had 2 visits; it was not possible to visit 3 of the households
- There were 49 households who had a single phone call from Age UK Barnsley while the remaining 26 households had between 2 and 6 phone calls
- During the visits, the Age UK advisor showed them information about their savings from the solar PV and battery; this was produced by Energise Barnsley and used data from the Alpha ESS monitoring portal
- Households were also provided with an advice leaflet on solar PV and this was used to explain the solar PV system and discuss the best times to use appliances
- Age UK Barnsley also provided 22 of the households with additional benefits advice

30 of the households had telephone interviews with NEA

- Out of the 30 residents interviewed, 24 were retired and the remaining 6 were either carers or not working due to their health or a disability
- 19 of the households were normally in all day while the other 11 were typically in half the day; this meant they tended to use more of the solar generation
- There was a high level of satisfaction with the battery installations with 27 out of the 29 that responded saying it was very good, while the remaining 2 said it was good
- All the households that responded said they were happy with the battery installation and would recommend a similar installation to their friends
- All 30 of the households were aware of the display on the battery and 24 made use of it; those that didn't mainly had the battery less accessible in an outhouse
- 17 of the 30 households interviewed were monitoring the battery using the Alpha ESS app and 12 of these found it helpful or interesting
- All 30 of the residents interviewed thought they were making savings from the battery and 28 of the 29 that responded felt they understood enough to maximise savings
- 25 of the 29 that responded said they were more aware of how they used electricity after having the battery and 21 of these said they had changed how they used electricity after the battery was fitted
    - This included not using 2 high power appliances at once, not using the dishwasher until there was free solar and battery available, changing the time for cooking and waiting until it was a sunny day to use the washing machine
- There were many positive comments about the project from the residents including:
    - "I am over the moon with the battery. It is discrete, silent, it is out of the way. If I could have another one, I would have two."
    - "I think the Government should fit solar panels and storage batteries in every home to help with the cost of electricity. They should install them for all pensioners and also the poorest families. The systems are a big help. I am thrilled to pieces and ecstatic with the battery system."

There were issues with some of the installations which limited the data that was available for analysis

- Where possible, data over a full 12-month period was analysed, however there were several issues which could occur with installations; these included:
    - The battery going offline
        - This was often due to the household changing broadband router and the battery Wi-Fi dongle no longer having the correct password
        - There could be a communications error with the battery which required a system reboot
    - The battery CT clamp for the grid being reversed
        - This could happen at the time of installation or following installation of a smart meter or electrical work being carried out in the home
        - This confuses the battery system and leads to greater electricity consumption rather than savings
    - Issues with the solar PV system
        - If the solar PV system is not working the battery will not charge

        - This can happen due to a fault with the PV system or after electrical work in the home and the contractor forgets to turn the AC isolator back on

The performance of the battery systems was assessed using data from the Alpha ESS monitoring portal

Households on the biomass heat network

- The households with batteries on the biomass heat network all had solar PV systems which were either 2.7kW or 3.43kW (although some were wrongly recorded in Berneslai Homes records as 3kW)
- The battery discharge for the 19 households analysed on the heat network was between 567kWh and 974kWh over a 12-month period
- The self-consumption of the solar generation was between 32.2% and 80.2%
- Household B-17 had the lowest self-consumption and the second lowest battery discharge and this was probably due to having the lowest grid consumption
- Household B-22 had the highest grid consumption and self-consumption; this probably limited the amount of excess solar generation and so led to this household to have the lowest battery discharge among those on the heat network
- Savings from the battery were estimated using a unit rate of 30p/kWh
- There was suitable data to assess the savings of 18 of the 22 households on the biomass heat network; savings from the batteries were between £170.22 and £292.20 with an average of £229.34
- A simple estimate of the payback time for the battery was made using the battery savings as well as the battery and installation cost.
- The average payback time for an indoor battery installation among the households on the heat network was 7.6 years and this increased to 9.05 years if the battery was fitted in an outhouse

Households with gas boilers

- The solar PV system size ranged from 1kW to 3.78kW for the 48 households with gas boilers that received batteries
- There were a number of installations which were offline for extended periods, along with an installation where the CT clamp was reversed and 2 with solar PV issues
- The battery discharge ranged from 352kWh to 810kWh; out of the 5 installations which had a battery discharge under 500kWh, 3 were offline for extended periods, another had a PV fault while the last had the smallest PV system
- The self-consumption of the solar generation for the households with gas boilers was between 37.5% and 82.5%; the average self-consumption was 57.0% compared to 51.4% for those on the biomass heat network
- Savings were assessed for 39 of the 48 households which had suitable data
    - The savings from the batteries ranged from £139.38 to £243.12 with an average of £203.03
- Among the households with gas boilers, the average payback time for a battery with an indoor installation was 8.6 years and this rose to 10.2 years if fitted in an outhouse

Households with ASHPs

- There were batteries fitted in 5 modern bungalows with ASHPs and each of these had a 1.07kW solar PV system
- The electricity imported from the grid over a 12-month period for these households ranged from 3,550kWh to 6,537kWh
    - This consumption was higher than for all the households on the biomass heat network and with gas boilers due to the electric heating
- The discharge from the batteries was between 88.5kWh and 388.6kWh
    - The discharge levels were lower than for the households with other types of heating because there was limited excess solar generation to charge the battery during the heating season from September to April
- The self-consumption of the solar generation was between 94.3% and 99.1% for these households
    - The combination of low solar generation, high grid consumption and a battery meant that little of the solar generation was exported to the grid
- The savings from the battery were low and between £26.55 and £116.58 over a 12-month period with an average of £74.36
- The savings from the solar PV were better despite the low system size and were between £182.75 and £242.12 with an average of £201.43
- The average payback time for a battery installed indoors for one of the households with an ASHP was 23.5 years, which was not likely to be within the lifespan of the battery

Data from the Alpha ESS monitoring portal was compared with smart meter data from generation meters for the solar PV and household electricity meters

- The solar generation for 10 households on the biomass heat network was analysed over a 12-month period using the Alpha ESS portal and smart generation meter data
    - For 8 of the households, the solar generation recorded by the smart generation meter was between 1.9 and 6.7% lower than the data recorded by the Alpha ESS portal
    - The generation from the smart meter was about 10% higher for one household and this was mainly due to the battery being offline for 26.8 days
    - The generation recorded by the smart meter for one household was over 2,200kWh lower than for the Alpha ESS portal; this was likely to be due to the generation meter being associated with the wrong property in the records
- A comparison between data from the smart generation meter and the Alpha ESS portal was also made for 9 of the households which were heated by gas boilers
    - The smart generation meter data was between 2.7% and 5.2% lower than data from the portal for 8 of the 9 households
    - For the remaining household, the smart generation meter data was 6.6% higher than data from the portal; this was likely to be due to this system having many short periods offline
- Comparisons were also made for the solar generation recorded by the smart generation meter and the Alpha ESS portal for all the households with ASHPs
    - Here the smart generation meter data was between 3.3% and 10.1% lower than data from the Alpha ESS portal

- The grid consumption recorded by the household smart meters was compared with data from the Alpha ESS portal for 8 of the households on the biomass heat network
    - The periods covered and durations varied due to limitations in the smart meter data available
    - The percentage difference between the smart meter data and portal data was within ±4% for all these households
- A comparison of the grid consumption recorded was also made for 7 households which were heated by gas boilers
    - The grid consumption from the smart meter was between 1.6 and 6.8% higher than for the Alpha ESS portal for 5 of the 7 households
    - For one of the households, the smart meter grid consumption was 13.4% higher than the data from the portal
    - For household G-33, over a 10-month period, the consumption recorded by the Alpha ESS portal was 85.4kWh while the smart meter recorded 607.9kWh
        - This large difference in consumption was likely to be due to issues with how the CT clamp was fitted
        - Some other households where particularly low grid consumption was recorded on the Alpha ESS portal might have had the same issue
- For the majority of installations, the measuring error for the solar generation and grid consumption with under 10% and within the error normally expected for CT clamps
- There was 6 years of electricity smart meter data available for household B-07
    - The consumption for approximately 12-month periods was calculated
    - For 4 years prior to the battery installation, the average consumption was between 3.82kWh/day and 4.65kWh/day
    - Over an approximately 12-month period after the battery was installed, the average grid consumption had fallen to 2.26kWh/day; this corresponds to a reduction of about 47.2% on the pre-installation average grid consumption

The electricity consumption can significantly increase for households if the CT clamp for the battery is accidently reversed

- When the battery CT clamp which measures the grid import/export is accidently fitted in the wrong orientation, it causes the battery to go through forced cycles of charging and discharging
- This can significantly increase the monthly electricity consumption
- Household G-15 had the CT clamp reversed between 15 Mar 22 and 12 Aug 22; the monthly electricity consumption increased to approximately 355 to 390kWh during this period
    - The consumption while the CT clamp was reversed was 1,767.8kWh compared to 325.5kWh during the same period the following year
    - The extra electricity cost while the CT clamp was reversed was about £432

5.2. Recommendations and future work

- When choosing a battery manufacturer, it is worth considering one which has batteries which can have different power outputs and capacities which can all operate on the same monitoring portal
  - This could allow a landlord to have a wide portfolio of batteries for different types of properties on a single monitoring portal
- It is important to assess the suitability of a property prior to considering installing a battery – this should consider the annual solar generation and electricity consumption
- For properties where there is higher solar generation and higher electricity consumption, it is worth considering installing batteries with larger capacity and higher outputs than the Alpha ESS SMILE-B3 (2.9kWh) used in this project
  - Since the start of the project, the market has moved on to larger battery systems such as the Alpha ESS SMILE-B3 Plus (5.04kWh) and the Alpha ESS SMILE 5 hybrid inverter with a 5kW output which can use 5.7kWh or 10.1kWh batteries
- A battery which has a monitoring portal which allows detailed assessment of performance and analysis of issues with the system is important for a social landlord
  - Batteries need to be kept online for warranty and monitoring purposes
  - Having an in-house or external energy team to regularly check (every 2-4 weeks) the battery portfolio is important
  - This allows issues such as systems going offline or the battery/solar developing faults to be picked up early
- This project highlighted that monitoring is also important for residents to help them engage with the battery and solar PV system
  - A simple indicator such as an LCD display on the battery is very helpful for households who can regularly view the battery
  - An app which can be used on a phone or tablet computer can help households maximise their benefit from the system and encourage behaviour change
  - The app should be intuitive and easy to use while providing sufficient information
- It is important to have sufficient resident engagement during a battery installation project and this should include
  - A good explanation of the battery on the day of installation and advice on how to maximise the benefit from it
  - Providing an information leaflet to be stored with the battery in a self-adhesive pocket
  - Providing some form of monitoring, either with a display on the battery or an app
  - Follow up with the households after a maximum of a year to check their understanding and feedback information on their savings
- CT clamps are a vulnerability in a battery installation – if moved and replaced in the wrong orientation, they can cause electricity bills to increase rather than decrease
  - For social housing in particular, installers should use meters instead of CT clamps to monitor the grid consumption
  - While this will add to the installation cost, it could save households far more should the CT clamp be reversed and this is not be detected quickly
  - Alpha has a suitable meter which could be fitted on a DIN rail of a consumer unit
  - While it is apparent from the monitoring portal when a CT clamp has been fitted in the wrong orientation, most systems do not have alarms to detect this
  - With advanced processing and AI, it should be possible to quickly detect when a CT clamp has been fitted in reverse and send a notification to the user
  - Manufacturers can usually reverse the polarity remotely, saving a visit

- Relying on the household broadband to connect the battery to the internet saved money on the installation cost and running cost with the battery, however the battery was more prone to go offline which required a household visit to rectify
    - Connections with a wireless router and 3G SIM card were more reliable
    - An alternative where possible might be a wired connection between the battery and the broadband router, however, this can still get unplugged and not replaced, have a plug with a poor connection or the router can be turned off
- For households with electric heating such as heat pumps, it is important to have a larger sized solar PV system
    - The households with ASHPs in this project only had 5 panel, 1.07kW solar PV systems and there was insufficient excess solar generation to charge the battery for much of the year
    - It would be worth investigating whether larger solar panels could be fitted on these properties if the existing panels are not funded through the feed-in tariff
    - If a 7 to 10kWh battery had been fitted, these households could have switched to a time of use tariff and used grid charging as well as charging from the solar PV
    - The battery could then charge from the off-peak tariff and during the peak rate period, the lower cost electricity from the battery could help power the home and the heat pump
- Specialist battery tariffs are being introduced by some energy suppliers which may improve savings for households
    - The Octopus Flux tariff has a super cheap rate period between 02:00 and 05:00 which could be used to charge a battery from the grid – this would be of particular benefit in winter
    - However, the battery would need to have a sufficient power output and capacity to get households through a peak rate period between 16:00 and 19:00
- Further savings could be achieved through Demand Flexibility Services
    - During the winter of 2022/23 electricity suppliers offered customers payments to reduce their power consumption at times of high demand
    - Households might sign up to a service with their own supplier
    - This might be better done on a collective basis with households in the portfolio who are willing having their battery systems combined in a virtual power plant with pre-charging from the grid in advance of the event
- At the time of writing, there is no VAT paid on new battery installations if they are fitted at the same time as the solar PV system
    - Further savings could be made if a hybrid inverter is used for the solar PV and the battery system
    - It would be beneficial and stimulate the market if the VAT rate for retrofitting battery storage in homes with existing solar PV systems was reduced from 20% at the time of writing to 0% as for new solar and battery installations

6. Appendix

6.1. Appendix 1 – Berneslai Homes household recruitment letter

Dear Tenant

SMART SOLAR IN BARNSLEY

Berneslai Homes is working in partnership with Energise Barnsley (who installed your Solar PV system) and Age UK Barnsley. We have secured funding from the Ofgem Redress Fund to install 75 domestic smart batteries in homes with existing solar PV panels. The project is specifically targeted at residents over 50 years old.

This letter explains what participation in the project means, who is involved and the benefits to you. We also aim to answer some frequently asked questions about the project and provides contact information should you wish to discuss it.

Introduction

The Ofgem Redress Fund provides grants to organisations led by a charity who are seeking to deliver energy related projects which benefit consumers.

This project is designed to demonstrate how battery storage technology installed in homes can help residents use the energy generated from solar panels more effectively.

Typcially a home might use 30% of the energy generated by the solar panels. The rest of the energy generated (70%) ends up back in the grid. The battery aims to collect this lost energy, and retain it for use within the home.

How it Works

This is a 2 year research project. However the battery will remain with the homes for its' 10 year lifespan. The battery is a slim device which will be attached either to an outhouse, or to an inside wall in your property. It will be charged by your solar PV panels taking the surplus power generated. Typically on a sunny day the battery will be charged by the solar panels between 11am and 2pm, and then provide the power to your home in the evening period when the panels are not generating.

When you are using the battery power you will not be drawing electricity in from the mains, and this will reduce your electricity bill. When the battery becomes fully discharged in the evening, mains electricity will automatically take over.

The battery has an internal data chip which monitors battery usage and this data is collected via a broadband connection or SIM card equivalent and sent to Energise Barnsley. This data analysis is part of the project outcomes. All data is protected and no data is released which can identify indivdual persons connected to the household with the battery.

If you would like to be involved in this project, please contact [redacted] to register your interest before the 8th of October 2021.

Yours Sincerely,

Rachel Hutchinson

Project Delivery Manager

Investment & Regeneration Team

Berneslai Homes

Berneslai Homes has a Data Protection framework in place to ensure the effective and secure processing of your information. For details on how your information is used, how we maintain the security of this and your rights to access the information we hold about you, please refer to www.berneslaihomes.co.uk/information-and-privacy

Frequently Asked Questions

Why is the project called Smart Solar in Barnsley?

Solar generation is not always generated at the time when electricity demand from homes is at its' peak, and therefore a lot of the generation is wasted and is spilt back to the grid. The aim is for the battery to retain the power until your home needs it, reducing the spill back into the grid and reducing your electricity bills.

The other part of the project is for Age UK Barnsley to engage with tenants on how to get the most out of the solar generation, and what energy tariffs are best for your home

What is the timeframe for Smart Solar?

We aim to complete installations by the end of 2021. The project will run for two years, although the batteries last for 10 years.

How much of my time is this going to take?

The install process for the Smart Battery will take approximately 3 hours. We will contact you after the installation to hear how everything went. We expect you to make a commitment to talk to Age UK Barnsley on your energy use.

Will this affect my electricity supplier?

Smart Solar will not affect your electricity supplier. If you wish to change your supplier to get a better deal during the project, you are free to do so.

Is this compulsory and does it cost me anything?

It is not compulsory and there is no charge, apart from a commitment of time to cooperate with the project partners.

Will there be an interruption to my electricity supply?

There will be a brief interruption to your electricity supply during the installation of the Smart Battery. No further interruption is expected during the course of the project.

Why has my home been selected for this project?

We have undertaken a series of assessments to determine which households could take part in the project. Your home has been chosen because you have solar PV, and are over 50 years old.

What ongoing time commitment will be required?

We would like to hear your feedback throughout the project and we'll be looking for people who might be willing to speak about their experience. You do not have to answer questions or attend feedback events if you don't want to, but it will help us if you do.

What is the Northern Powergrid Priority Service Register (PSR)

The PSR is for customers who feel that they are particularly vulnerable and would benefit from receiving additional support during a power cut. It includes people who rely upon medical equipment such as a Home Kidney Dialysis Machine or Oxygen Concentrators, people recovering from a serious operation or illness who may have mobility issues, people with hearing or sight impairments and people who generally need additional advice and support by virtue of being elderly, having young children or those experiencing fuel poverty who may find a power cut more difficult to deal with. It is free to register and Berneslai Homes will provide advice and assistance if you feel you qualify.

6.2. Appendix 2 – NEA project information sheet

Project Information Sheet - Evaluation of Smart Solar in Barnsley

National Energy Action (NEA), the fuel poverty and energy efficiency charity are working with Energise Barnsley, Berneslai Homes and Age UK Barnsley on the Smart Solar in Barnsley project.

The role of NEA will be to carry out research, investigating the effectiveness of the community engagement programme for the project, the success of the battery installation programme and evaluate the savings achieved by households receiving batteries.

As part of this study, 30 of the 75 households receiving batteries will be invited to take part in this evaluation of the project.

What is involved in the research study?

A member of NEA's friendly Innovation and Technical Evaluation team will do a telephone interview with residents taking part in the evaluation in early 2023. This will cover issues like their satisfaction with the installation process, reliability of the battery system and the usefulness of the support and advice provided by Age UK Barnsley. A final interview will take place this summer. This will cover similar subjects to the first interview, but with a greater emphasis on perceived savings, household energy use and long-term reliability of the battery. These interviews will be agreed with you in advance and carried out either by telephone or face to face, depending on your preference.

There will also be a technical assessment of the battery. This will involve NEA analysing the performance of the battery, the amount of electricity generated by the solar PV and the electricity consumption in the home. This will mainly be achieved by use of the energy monitoring portal for the Alpha battery system. There may also be a need to obtain electricity meter readings from your energy supplier. It is likely we can obtain these on your behalf if you sign a consent form.

NEA will write a report in the summer of 2023 which evaluates the project. This will use information from the interviews and the performance of the battery. All data and details in our report will be anonymous so you or your property will not be identifiable in any way.

What are the benefits from taking part in the project?

The evaluation will present the benefits of the project to the funders at the Energy Industry Voluntary Redress scheme and could help build the evidence for further battery installations in the future.

NEA will analyse the available data from the batteries for each of the households taking part in the evaluation. This can be shared and explained to the household.

All households who take part in the NEA research study will receive **shopping vouchers worth £50** at the end of the project as a thank you for completing the questionnaires and providing access to electricity meter readings and data from the battery system.

Will information from the study be kept confidential?

YES, all information collected about you and your household during the study will remain strictly confidential. NEA complies with data protection regulations. Personal details will not be shared with anyone outside the team involved in this study. *You will not be personally identified in any report or publication*. Any quotes we use in the final report will be anonymous: no names of people or addresses will be used. NEA's full privacy policy can be viewed on their website at:

https://www.nea.org.uk/privacy-policy/

Do I have to take part?

It is up to you to decide whether or not to take part in the evaluation of the project. If you decide to take part, you will be asked to sign a consent form giving your permission for us to collect the data from the questionnaire and the battery monitoring system and formally indication they you are happy to take part in the research study.

You can withdraw from the evaluation at any time by contacting a member of staff at NEA or writing to their head office.

If you would like any further information on the research study, please contact:

NEA Innovation and Technical Evaluation Co-ordinator for the Smart Solar in Barnsley project:

Paul Rogers, telephone [redacted] and email paul.rogers@nea.org.uk

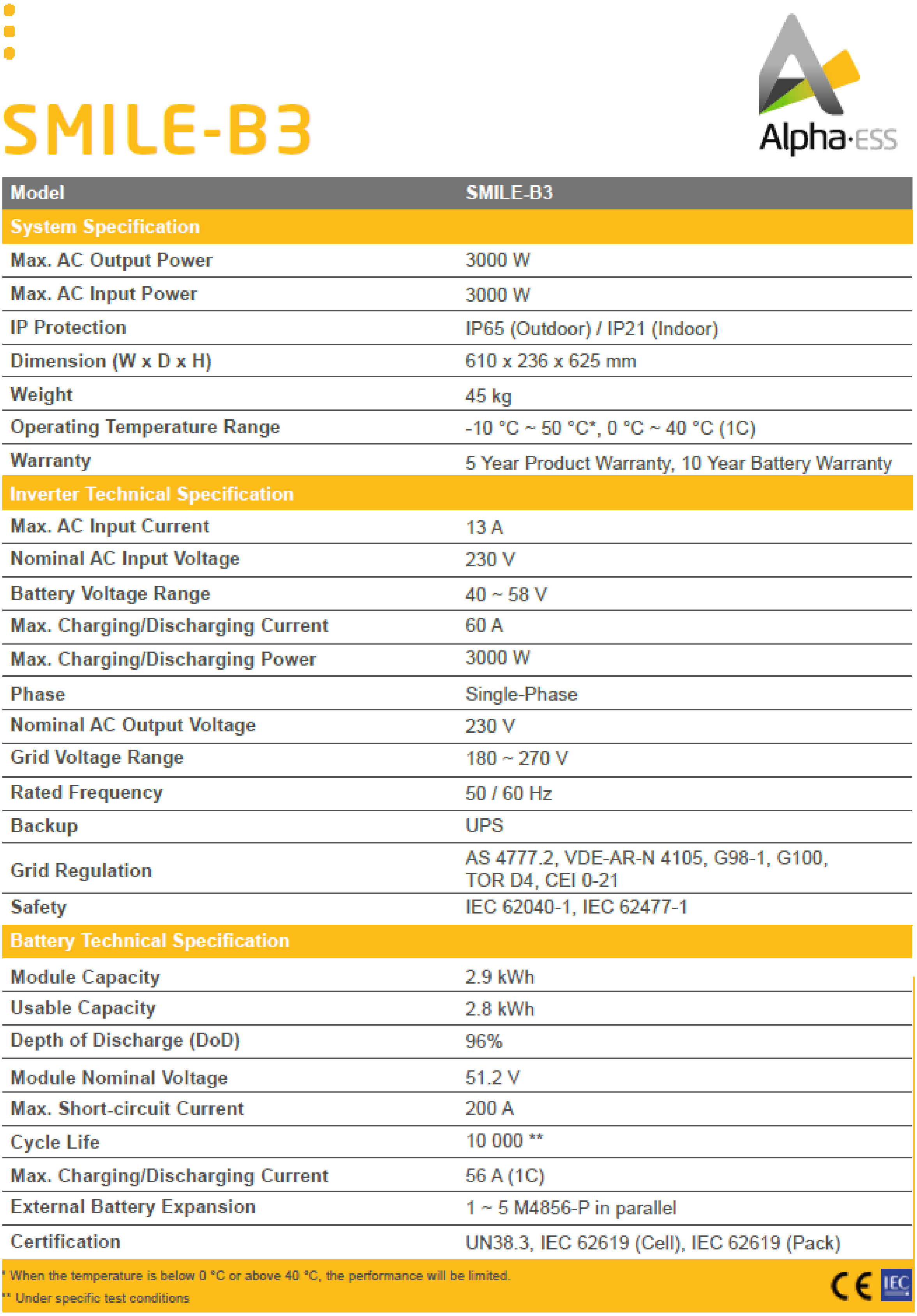
The head office address for NEA is:

National Energy Action (NEA), Level 6, West One, Forth Banks, Newcastle-upon-Tyne, NE1 3PA

Charity Registered Number 290511; Company Registered in England and Wales No. 01853927.

NEA is registered with the Information Commissioners Office – Registration Number Z847023X

6.3. Appendix 3 – Alpha ESS SMILE-B3 battery datasheet



SMILE-B3

Alpha·ESS

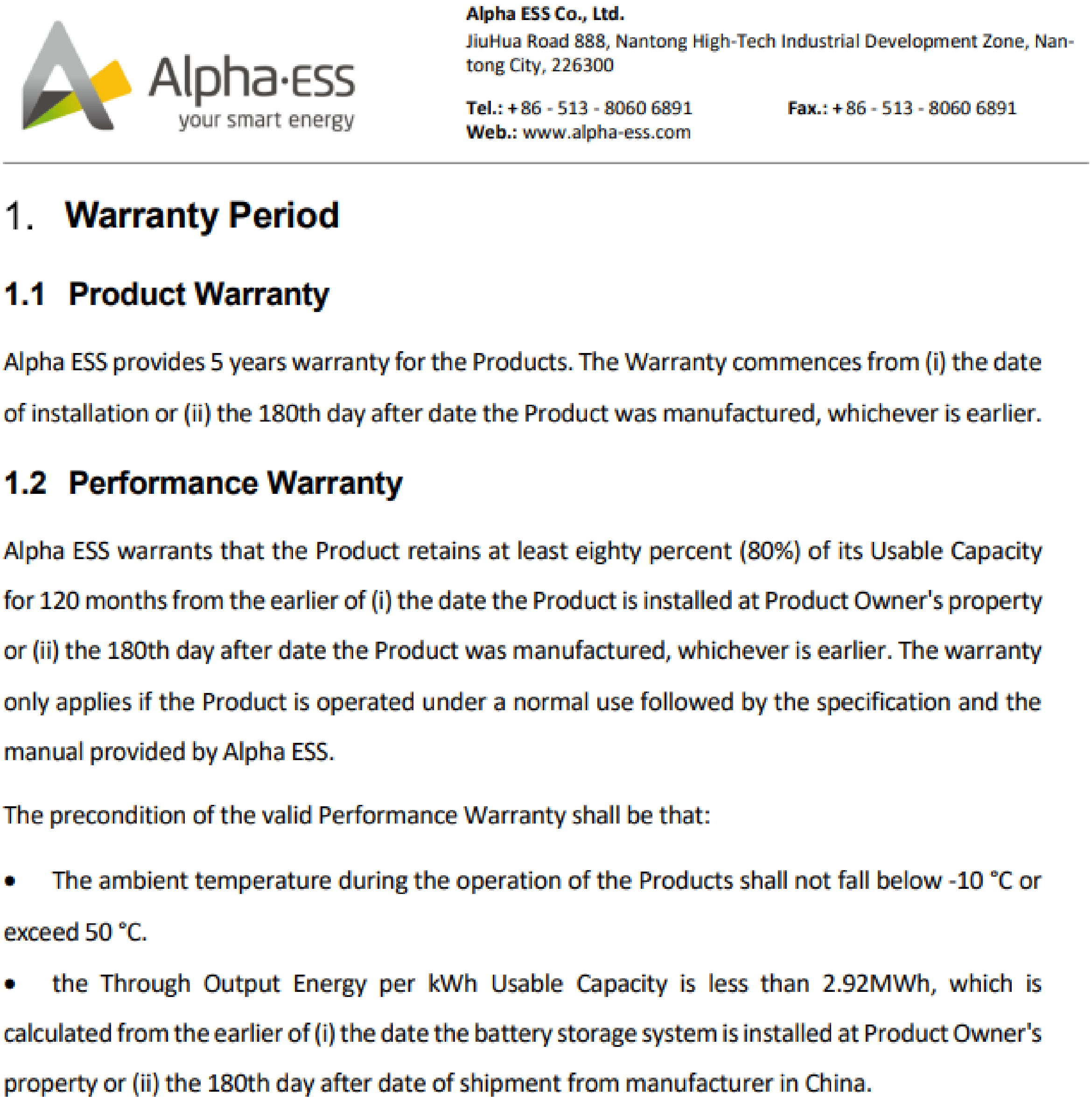
Model	SMILE-B3
System Specification	
Max. AC Output Power	3000 W
Max. AC Input Power	3000 W
IP Protection	IP65 (Outdoor) / IP21 (Indoor)
Dimension (W x D x H)	610 x 236 x 625 mm
Weight	45 kg
Operating Temperature Range	-10 °C ~ 50 °C*, 0 °C ~ 40 °C (1C)
Warranty	5 Year Product Warranty, 10 Year Battery Warranty
Inverter Technical Specification	
Max. AC Input Current	13 A
Nominal AC Input Voltage	230 V
Battery Voltage Range	40 ~ 58 V
Max. Charging/Discharging Current	60 A
Max. Charging/Discharging Power	3000 W
Phase	Single-Phase
Nominal AC Output Voltage	230 V
Grid Voltage Range	180 ~ 270 V
Rated Frequency	50 / 60 Hz
Backup	UPS
Grid Regulation	AS 4777.2, VDE-AR-N 4105, G98-1, G100, TOR D4, CEI 0-21
Safety	IEC 62040-1, IEC 62477-1
Battery Technical Specification	
Module Capacity	2.9 kWh
Usable Capacity	2.8 kWh
Depth of Discharge (DoD)	96%
Module Nominal Voltage	51.2 V
Max. Short-circuit Current	200 A
Cycle Life	10 000 **
Max. Charging/Discharging Current	56 A (1C)
External Battery Expansion	1 ~ 5 M4856-P in parallel
Certification	UN38.3, IEC 62619 (Cell), IEC 62619 (Pack)

* When the temperature is below 0 °C or above 40 °C, the performance will be limited.

** Under specific test conditions

CE IEC

6.4. Appendix 4 – Summary of Alpha ESS product and performance warranty



Alpha ESS Co., Ltd.
JiuHua Road 888, Nantong High-Tech Industrial Development Zone, Nantong City, 226300
Tel.: +86 - 513 - 8060 6891 **Fax.:** +86 - 513 - 8060 6891
Web.: www.alpha-ess.com

1. Warranty Period

1.1 Product Warranty

Alpha ESS provides 5 years warranty for the Products. The Warranty commences from (i) the date of installation or (ii) the 180th day after date the Product was manufactured, whichever is earlier.

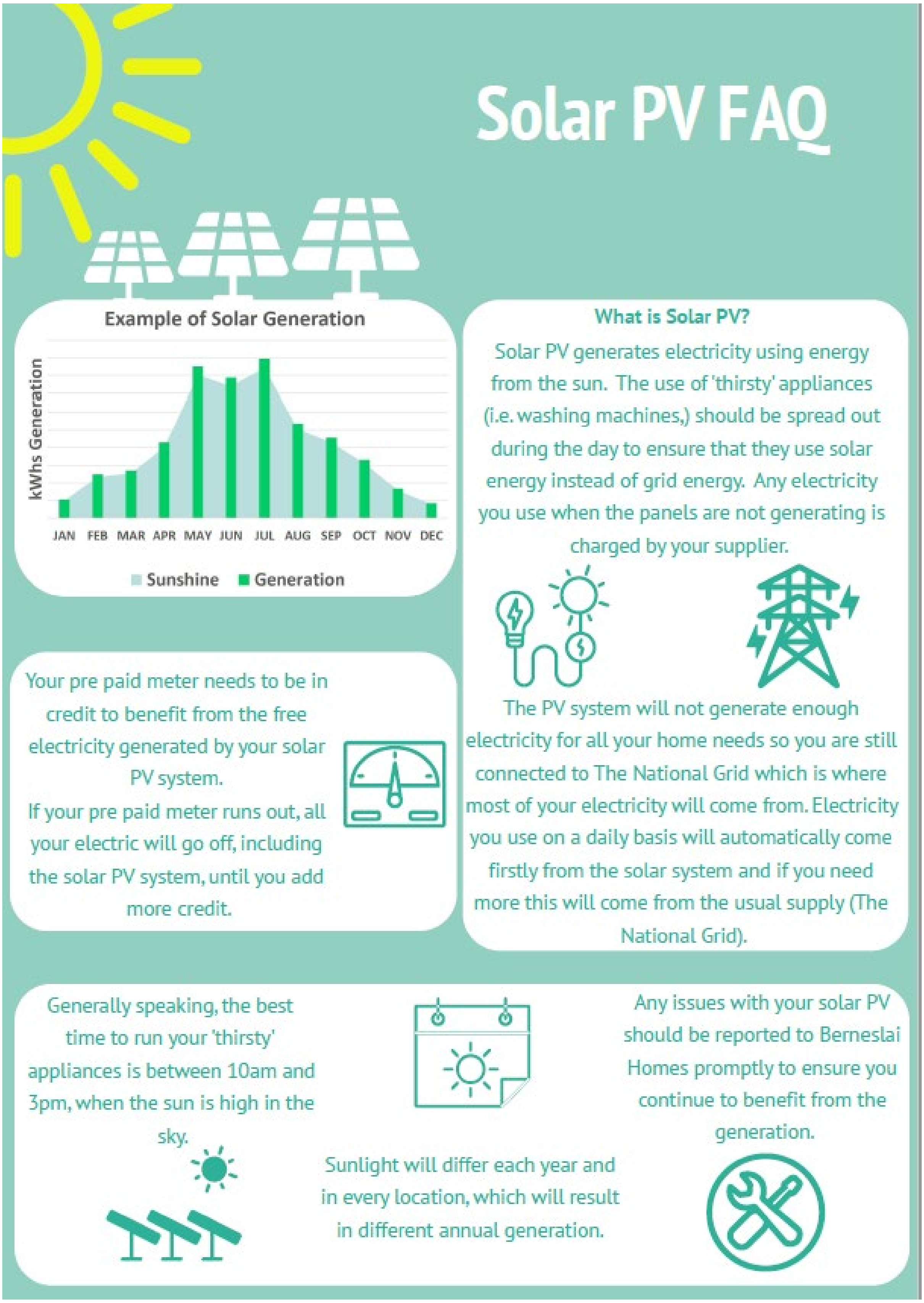
1.2 Performance Warranty

Alpha ESS warrants that the Product retains at least eighty percent (80%) of its Usable Capacity for 120 months from the earlier of (i) the date the Product is installed at Product Owner's property or (ii) the 180th day after date the Product was manufactured, whichever is earlier. The warranty only applies if the Product is operated under a normal use followed by the specification and the manual provided by Alpha ESS.

The precondition of the valid Performance Warranty shall be that:

- The ambient temperature during the operation of the Products shall not fall below -10 °C or exceed 50 °C.
- the Through Output Energy per kWh Usable Capacity is less than 2.92MWh, which is calculated from the earlier of (i) the date the battery storage system is installed at Product Owner's property or (ii) the 180th day after date of shipment from manufacturer in China.

6.5. Appendix 5 – Solar PV and battery advice leaflet attached to the battery



Solar PV FAQ

Example of Solar Generation

What is Solar PV?

Solar PV generates electricity using energy from the sun. The use of 'thirsty' appliances (i.e. washing machines,) should be spread out during the day to ensure that they use solar energy instead of grid energy. Any electricity you use when the panels are not generating is charged by your supplier.

Your pre paid meter needs to be in credit to benefit from the free electricity generated by your solar PV system.

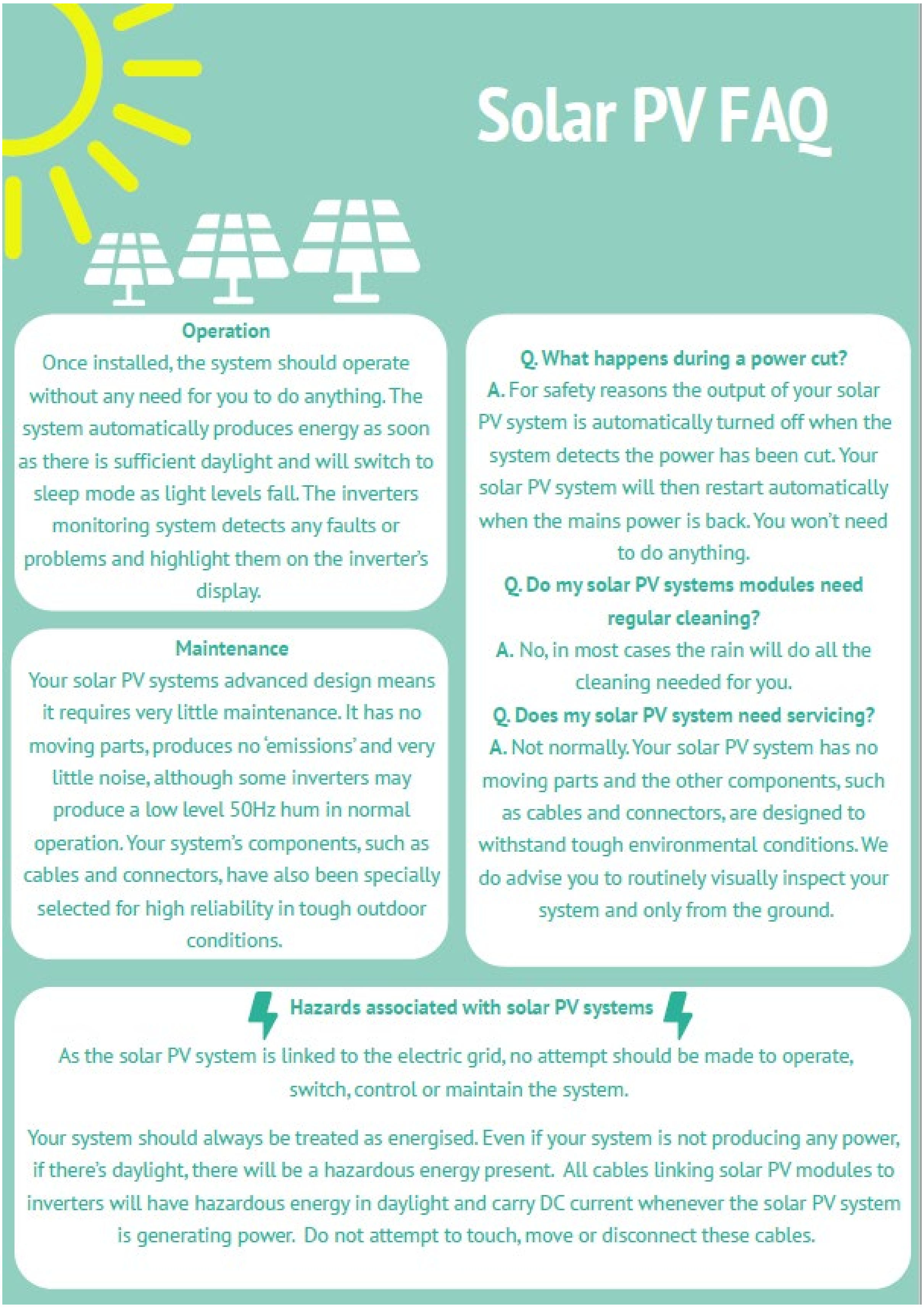
If your pre paid meter runs out, all your electric will go off, including the solar PV system, until you add more credit.

The PV system will not generate enough electricity for all your home needs so you are still connected to The National Grid which is where most of your electricity will come from. Electricity you use on a daily basis will automatically come firstly from the solar system and if you need more this will come from the usual supply (The National Grid).

Generally speaking, the best time to run your 'thirsty' appliances is between 10am and 3pm, when the sun is high in the sky.

Sunlight will differ each year and in every location, which will result in different annual generation.

Any issues with your solar PV should be reported to Berneslai Homes promptly to ensure you continue to benefit from the generation.



Solar PV FAQ

Operation

Once installed, the system should operate without any need for you to do anything. The system automatically produces energy as soon as there is sufficient daylight and will switch to sleep mode as light levels fall. The inverters monitoring system detects any faults or problems and highlight them on the inverter's display.

Maintenance

Your solar PV systems advanced design means it requires very little maintenance. It has no moving parts, produces no 'emissions' and very little noise, although some inverters may produce a low level 50Hz hum in normal operation. Your system's components, such as cables and connectors, have also been specially selected for high reliability in tough outdoor conditions.

Q. What happens during a power cut?

A. For safety reasons the output of your solar PV system is automatically turned off when the system detects the power has been cut. Your solar PV system will then restart automatically when the mains power is back. You won't need to do anything.

Q. Do my solar PV systems modules need regular cleaning?

A. No, in most cases the rain will do all the cleaning needed for you.

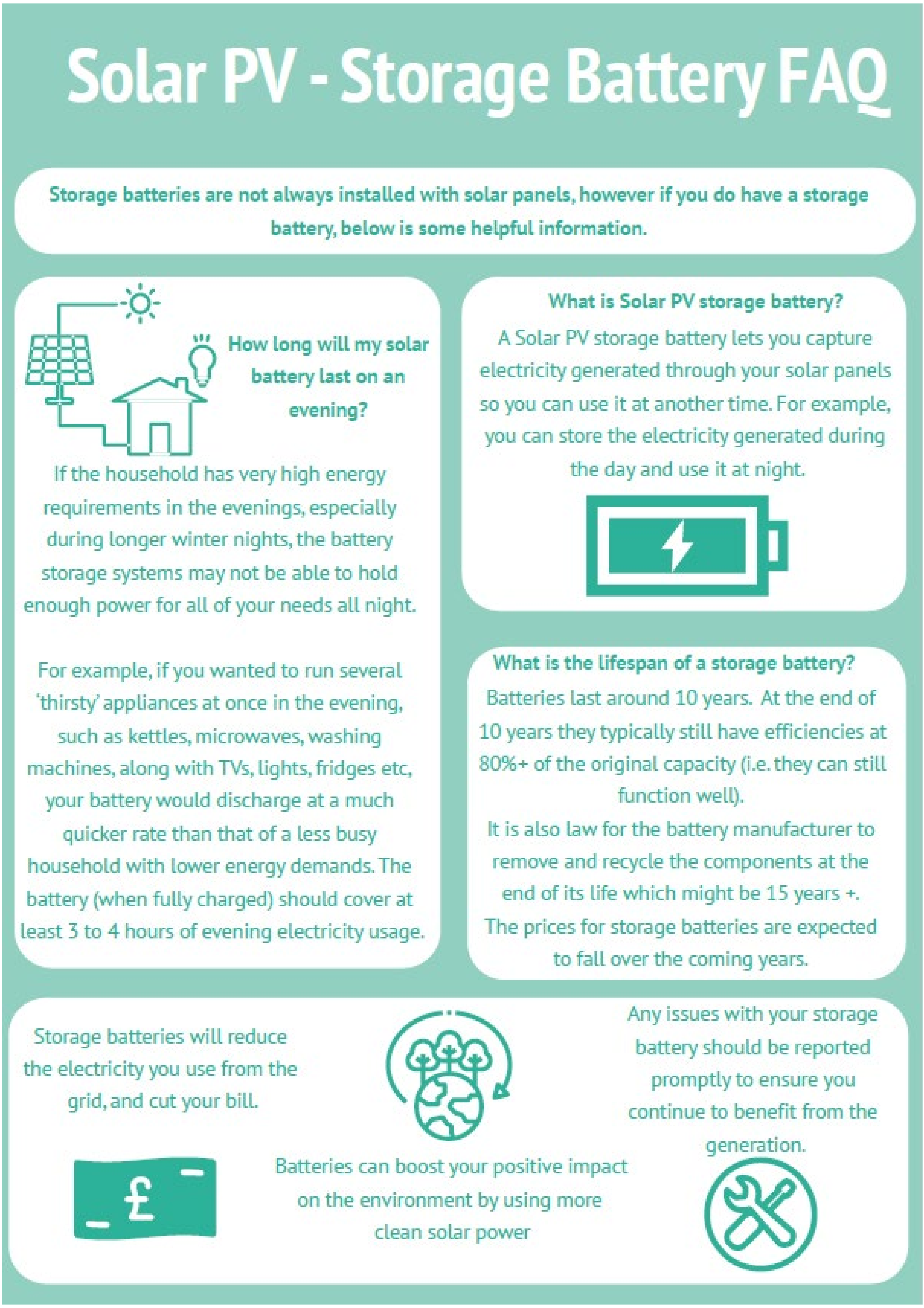
Q. Does my solar PV system need servicing?

A. Not normally. Your solar PV system has no moving parts and the other components, such as cables and connectors, are designed to withstand tough environmental conditions. We do advise you to routinely visually inspect your system and only from the ground.

Hazards associated with solar PV systems

As the solar PV system is linked to the electric grid, no attempt should be made to operate, switch, control or maintain the system.

Your system should always be treated as energised. Even if your system is not producing any power, if there's daylight, there will be a hazardous energy present. All cables linking solar PV modules to inverters will have hazardous energy in daylight and carry DC current whenever the solar PV system is generating power. Do not attempt to touch, move or disconnect these cables.



Solar PV - Storage Battery FAQ

Storage batteries are not always installed with solar panels, however if you do have a storage battery, below is some helpful information.

How long will my solar battery last on an evening?

If the household has very high energy requirements in the evenings, especially during longer winter nights, the battery storage systems may not be able to hold enough power for all of your needs all night.

For example, if you wanted to run several 'thirsty' appliances at once in the evening, such as kettles, microwaves, washing machines, along with TVs, lights, fridges etc, your battery would discharge at a much quicker rate than that of a less busy household with lower energy demands. The battery (when fully charged) should cover at least 3 to 4 hours of evening electricity usage.

What is Solar PV storage battery?

A Solar PV storage battery lets you capture electricity generated through your solar panels so you can use it at another time. For example, you can store the electricity generated during the day and use it at night.

What is the lifespan of a storage battery?

Batteries last around 10 years. At the end of 10 years they typically still have efficiencies at 80%+ of the original capacity (i.e. they can still function well).

It is also law for the battery manufacturer to remove and recycle the components at the end of its life which might be 15 years +.

The prices for storage batteries are expected to fall over the coming years.

Storage batteries will reduce the electricity you use from the grid, and cut your bill.

Batteries can boost your positive impact on the environment by using more clean solar power

Any issues with your storage battery should be reported promptly to ensure you continue to benefit from the generation.

6.6. Appendix 6 – Resident comments on use of battery monitoring

Resident comments of use of battery display	Comments on use of Alpha ESS phone app
Use to see the level of charge. Use more than the phone app.	Use occasionally to see the level of consumption
When it gets to the last bar, I know it will soon be needing electricity from the grid	Don’t use the phone app
Rarely use the display because the battery is in the old coal house. Tend to use the app instead	Use the app to check the solar generation, how much electricity is being used, how much electricity is in the battery. Learning what to do at certain times during the day. Am changing behaviour to minimise bills such as not tending to cook after 8pm in the evening
Keep an eye on the state of the battery during the day, but I cover the display up at night because the bright lights shine into the bedroom	Not very technically minded, so don’t tend to use the app.
Always look at the display first thing in the morning after getting up	Every night before going to bed I make a note of the readings from the app and note the solar, grid consumption and feed-in to know what savings have been made.
If the battery is full, I tend to do the washing at that time so it won’t cost any money	Don’t use the app
Look at it – if it is high, you can use electricity without worrying about the cost. If it is low, you know not to use so much electricity	Don’t use the app
Because it is in the outhouse which is locked I don't tend to go and see it	I ask my daughter to look at the phone app and see if the battery is running alright and she gives me advice
When it gets down to 1 bar, the battery is down to 10% and we will be using electricity from the grid. When there are more bars there is free electricity	See what is on during the day and usually the charge will power the home until the next day. Can check the level of charge on the battery.
Always look at in the morning to see if it is working and if it is full will tend to do an extra load of washing	Not monitoring the battery on the app as not technically minded. Didn't really have it explained. If someone explained it, I would make use of it if I could take the information in.
Don't tend to use the display because the battery is in the coal house. Is working perfectly and saving money so don't see the point	Don’t use the app
Look at it to see the level of charge. Use as a quick guide to state of battery	Don't use it that often - tend to look at the display on the battery more
Regularly check on the display to see the level of battery charge. Means I know how much charge is in the battery. If there is energy available in the battery, I can use more appliances	Haven’t used it due to being ill

Can see if there is any charge, but don't go into the room that often.	Only have a look when it is not a sunny day. Know it is alright with power to use when it is a bright sunny day
Don't use it as don't go into the room	Don't really understand how to use it. Struggle to do more than phone and text with phone.
Uses it to see when charge is in the battery. Check the charge at the end of the evening and tend to see still have two bars left at the end of the evening	Managing fine with the display on the battery. Don't think I need the app.
Look at it when I go in the cupboard to get my ironing board. If it is green, it is fine, if it is red you look to see what is wrong	My sister has the app on her phone
Wait to cut grass until it is a nice sunny day and the battery is full.	Can't understand the app and it doesn't tell me how much money I have saved.
Use the display all the time to check the level of charge in the battery. If it isn't charged, I wait until it is charged before using appliances	Don't tend to use it that often because it is a bit complicated. Tend to look at the battery instead. Can use it to check on the battery when away from the house
Use the display to see how quickly the charge is going down. Sometimes it might be full and by bedtime there are only 2 bars on the battery.	Look at it occasionally, to check what the battery is doing
Look at least 2 or 3 times a day at the display on the battery to know the level of battery charge	Don’t use the app
Don’t use the battery display. Has been covered due to green light flashing which was distracting	Don’t use the app
Look to see how much charge there is and can know if there is plenty of charge can use appliances for free as a result	It could tell you at any time of the day what the solar and battery was producing and could plan to use appliances accordingly
Can see when it is fully charged. Have been told when the battery is charged can use appliances for free. Don't tend to change behaviour such as using more	Not using the app. Think it would help if residents were provided with an information sheet on the Alpha battery app with screen shots showing how it worked and how to log in
Look to check it is working. Provides confidence it is working alright	Don’t use the app
Don’t use the display	Occasionally look at it, but don't really understand it. Don't think any explanation would help.
Use to see how much energy there is in the battery	Can uses the app to see the difference in performance with the weather such as when sunny, rainy and when snow on roof
When it is full, I know I can put appliances on like the washing machine. Can see the bars go down with appliance use and then for it to charge up again over time.	Don’t use the app

6.7. Appendix 7 – Issues with solar and battery systems

Ref No	Heating	Issue
B-02	Biomass Heat Network	The CT clamp for the grid was reversed on 21 Sep 22. This was switched back remotely on 30 Jun 23 by Alpha/Immersa.
B-06	Biomass Heat Network	The CT clamp was briefly reversed from 12 Aug 22 to 17 Aug 22 after consumer unit had been replaced. Offline from 27 Nov 22 to 15 Feb 23, due to some form of communications error.
B-07	Biomass Heat Network	Offline from 10 Apr 23, most likely due to changing broadband router
B-08	Biomass Heat Network	Battery installed on 4 Mar 22 and was working as expected until 10 Mar 22. Subsequently just the household load and grid were recorded. This was most likely due to a PV fault which was repaired on 26 Oct 22. The battery did not charge and discharge until 18 Jan 23 when the system was behaving as expected. The monitoring went offline after 3 Apr 23.
B-09	Biomass Heat Network	Offline from 15 Jun 22 to 7 Feb 23, most likely due to changing broadband router
B-11	Biomass Heat Network	Offline from 31 Jul 22 until 25 Aug 22, most likely due to changing broadband router. PV not working from 11 May 23 to 23 May 23.
B-16	Biomass Heat Network	The CT clamp for the grid was reversed between 24 Dec 22 and 13 Jun 23
B-21	Biomass Heat Network	Solar PV not recorded on the Alpha system until 17 Oct 22. Offline from 26 Jan 23 to 6 Feb 23, with a change of tenant.
B-22	Biomass Heat Network	System went offline for between a few minutes and most of the day with a total time offline of at least 8 days over the full period the system was monitored. Some of this might be due to Alpha battery system updates.
G-01	Gas boiler	Offline from 18 Mar 23, most likely due to changing broadband router.
G-04	Gas boiler	Offline from 1 Nov 22 until 8 Nov 22. Either a communications issue or due to switching broadband router.
G-10	Gas boiler	Solar PV fault from 18 Apr 23 which meant no charging and discharging of the battery.
G-13	Gas boiler	Monitoring was recording PV export and charge/discharge of the battery, but not generation from the time of installation. System stopped recording export and charge/discharge of the battery after 24 Aug 22, probably due to the solar PV system going offline or having a fault. The system was working with the solar included in the monitoring after 14 Oct 22. The CT clamp for the grid was reversed on 1 Jun 23 until 21 Jul 23, causing greater grid consumption.
G-14	Gas boiler	The Alpha ESS monitoring system was offline for multiple short periods in a day. The periods offline could vary from 10 minutes to 190 minutes in a day. This occurred mainly overnight. The system used the household broadband, so the issues were not due to use of a wireless router.

G-15	Gas boiler	The CT clamp on the grid supply was reversed from the time of installation on 15 Mar 22 until 12 Aug 22. This meant the household's electricity consumption increased rather than decreased during this period.
G-19	Gas boiler	Multiple short periods offline in January 2023. This site did not use a wireless router, so that was not the cause of the short periods offline. Offline from 28 Feb 23 to 3 Apr 23, due to a change in broadband router. This led to a password change and it was necessary for the project liaison officer to set up the Wi-Fi dongle for the battery again
G-24	Gas boiler	Offline for between 2 hours and most of a day for some days between July 22 and November 22. System was fully offline from 10 Nov 22 to 6 Feb 23. The later problem may have been due to a communications issue and may have required the battery to be rebooted.
G-26	Gas boiler	Battery system offline from 13 Aug 22 to 28 Aug 22 and 27 Oct 22 to 21 Feb 23. The system went offline in October at the same time as G-29, which suggests a grid or broadband issue affecting properties on the same street.
G-29	Gas boiler	Battery system offline from 27 Oct 22 to 31 Jan 23. This may have been due to a grid or broadband issue as G-26 went offline at the same time.
G-32	Gas boiler	System was offline for multiple short periods of the day for most days. These periods often occurred overnight but could take place during the day. The period offline in a day could vary between 30 and 600 minutes.
G-33	Gas boiler	Had 10 days in August 2022 where the battery system was offline for most of the day. System also offline for much of 3 days in November 2022, which might be due to system updates for the battery.
G-38	Gas boiler	Battery system offline for 2 extended periods: 19 Jun 22 – 24 Aug 22 and 1 Jan 23 – 21 Feb 23. The battery monitoring was not showing the level of charge after the system came back online on 21 Feb 23. This was not rectified until 21 Mar 23.
G-41	Gas boiler	Periodic fault with the solar PV system from 12 Mar 23.
G-42	Gas boiler	Battery system offline after 2 May 23. Likely to be due to the household switching broadband router.
G-43	Gas boiler	Battery system offline after 22 April 23. Likely to be due to the household switching broadband router.
G-45	Gas boiler	System was installed on 29 Apr 22 and there was no solar PV recorded until 28 Jun 22. This was either due to a solar PV fault or the PV system being left switched off at an isolator switch.
G-46	Gas boiler	Many short periods offline, particularly between March and June 2022. This was not due to having a wireless router. Might be connection issues between WiFi dongle and the home broadband.
G-47	Gas boiler	Battery system offline from 1 Nov 22 to 6 Mar 23. This was most likely due to the household switching broadband provider and the router.

G-48	Gas boiler	System went offline from 1 Nov 22 to 13 Dec 22. It then went offline again from 15 Feb 22 to 15 Mar 22. After it came back online the second time, there was no solar generation, suggesting a solar PV fault.
A-04	ASHP	Battery system offline from 13 Apr 23 to 26 May 23. This might be due to a communications error or the household switching broadband supplier
A-05	ASHP	Battery system offline from 17 Mar 23 to 22 Mar 23. Could be due to communications issue. Also offline for most of 3 days in November 2022. These might be associated with updates to the battery by Alpha.

6.8. Appendix 8 – Comments on the project by interviewed households

Comments
I think this is a brilliant project and idea
I am highly delighted with the battery system and I can’t thank those behind it enough
I think it is brilliant and would definitely recommend it to others. Others who had it are also very impressed while those who didn't get one now regret not having one.
If I went out during the day, I would not get any benefit from the solar. With the battery, it has reduced my electricity bill significantly. I can run the lights and television off the battery. If I was in a private dwelling with solar panels, I would add a battery or two. I wish the battery had been fitted several years ago.
I feel sorry that other people have not been able to have batteries as well. I think all houses and bungalows should be fitted with them. Electricity is getting so expensive that it is silly not to fit them. All new properties should be fitted with them. Was away 9-16 July and I was surprised by the amount of electricity used by the house while away (although little from the grid).
I thought it was really brilliant and there was lots of support. I know if we need someone (to help), they will support for you.
I want the battery to stay and I am very pleased that you had it fitted. It is the best thing I have had installed.
I think the battery project is good and I have learnt how to use it and when to use it - it is quite easy really.
I could have done with a bigger battery. A 6kWh battery would have been better and the solar panels would have charged it.
I didn't know much about the solar panels and how they worked before the project which installed the battery. I had moved in after the solar PV was installed
I think the Government should fit solar panels and storage batteries in every home to help with the cost of electricity. They should install them for all pensioners and also the poorest families. The systems are a big help. I am thrilled to pieces and ecstatic with the battery system.
I would ideally like someone to move the battery into the coal house.
I think is has been very good in terms of how it has been implemented. It makes you more in charge of what is happening and feel part of the country in which you are living. I would love the Government to support similar projects and take money from the companies who are making lots of money and ensure saving for households.

I am highly delighted that have got a battery.
I think it is a good idea and everyone should have one. I have seen the bills going down.
I think the battery storage project is absolutely brilliant and delighted to get it for nothing. Brilliant for older people on a fixed income. Anyone who does not take the opportunity to have one is foolish.
I think it is a good idea in helping with bills and at night I am using very little electricity as a result.
I have never found a fault and thought it was a good thing. Just the phone app has been confusing. Everything else has been fine. I am hardly using any electricity compared to what I could have been.
I am ecstatic with it and it is the best thing since sliced bread and it is saving me lots of money. I never realised the savings from the solar panels until the battery was installed.
I am happy with it and there have been no issues apart from the battery dropping down a couple bars overnight. I am very glad that I have the battery and am positive about the installation.
I am very happy with the installation and the solar panels. I would advise anyone to have a similar system installed as they will find a big difference in their energy bills.
From first discussions I have always praised the project. If it saves us money in any shape or form I was keen. Not had an ounce of problem with the entire scheme and battery. Everything you have done I can't praise it enough.
If anyone asks me and has the opportunity to have one, do take it, you will save money. You can see yourself saving money.
I would be very happy if everyone had solar panels on their houses. Solar panels are very reliable and government policy should involve everyone having solar panels and insulation so people can use their own energy. It is green efficient energy. The technology is a clear success story and will only get better. It will help save from importing fuel from abroad. We are doing our bit for environment
I like the battery very much and it would be great if more people were also able to have a battery installation.
I am glad I had a battery fitted and I would recommend a battery to other people. I have no complaints. The only issue is that it has gone off a couple times and I didn't notice it, so I was using more electricity. Apart from that I think it is good.

I was delighted when we moved in to have the solar panels. The battery is a very good system and I hope it keeps going on. It has been a good thing and I am very satisfied.
I am over the moon with the battery. It is discrete, silent, it is out of the way. If I could have another one, I would have two.