EAST LOTHIAN COUNCIL SOLAR PV AND BATTERY

Area Based Schemes - Special Project 2022-23
December 2023

CHANGEWORKS.

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About the project

East Lothian Council received funding through the Area Based Schemes, a grant fund managed through Scottish Government.

The funding was awarded for a Special Project which installed solar panels (PV) and battery systems in 17 properties. These were located in Prestonpans (12), Bolton (3), Morham (1) and Dunbar (1). The new energy systems were installed with the aim of allowing households to generate and store their own renewable energy, meaning they are less dependent on energy from the national grid.

The project focus

The overall aim of the project was to determine the extent to which solar PV and battery storage can reduce fuel consumption from the national grid, while allowing households in East Lothian to maintain a comfortable environment.

This aim was supported by the following specific project outcomes:

1. Household energy consumption annually is reduced.
2. Households adapt to the new energy system, allowing a comfortable home environment to be maintained.

This report

Changeworks were asked to evaluate the impact of the project in relation to these outcomes. Using a combination of battery data analysis, energy consumption analysis and environmental monitoring[1], the evaluation found that:

- Household energy consumption reduced as a result of the measures installed
  - The new energy systems had financial and environmental benefits to the householders
  - Generated solar energy contributed to the national grid, meaning a higher proportion of renewable energy in the supply
- Householders adapted to the new energy system
  - Householder energy use moved to primarily come from onsite solar generation
  - Householders benefited from the solar energy throughout the year

The following presents a summary of the evidence Changeworks collected and what this shows about the impact of the solar PV and battery installations. In line with the points of project focus, this is presented as it relates to energy consumption and householder behaviour, and identifies recommendations for future projects.

[1] More details on the data collection methods and limitations can be found in Appendix 1.

Findings

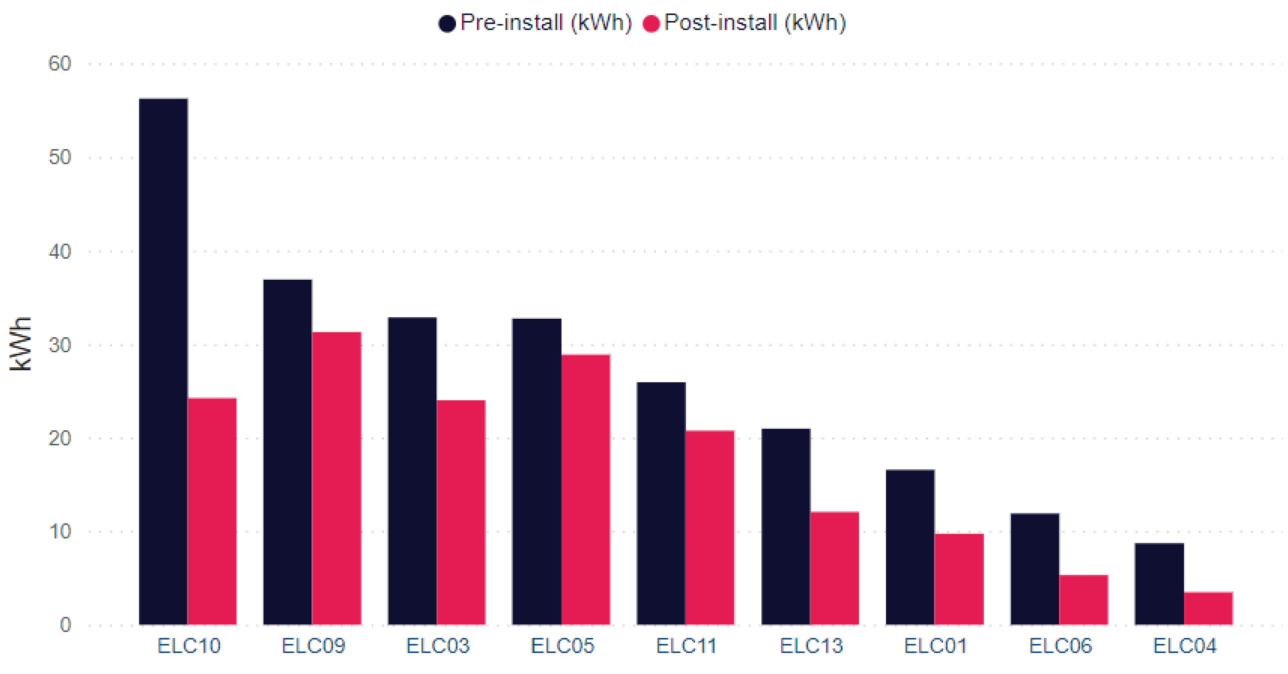
The findings presented here are based on battery data from 16 properties with annual data available. The installed solar PV panels ranged from 8 to 10 panels, with various roof aspects. Across all properties annual solar generation was between 2,495 kWh and 3,363 kWh. A full illustration of this information for each property can be found in Appendix 2, Table 3.

1. Energy consumption is reduced

Energy consumption

Household energy consumption from the grid was reduced following the installation of the solar PV and battery storage systems. Average daily energy use from the national grid reduced by 88 kWh, from 271 kWh in the year prior to installations to 183 kWh in the year following (Figure 1). This change represents an 32% reduction and is equal to a saving of 31,122 kWh across the year.

Figure 1: Average daily grid energy consumption per household, before and after install



In that time, solar generation supplemented 28,474 kWh of the reduction. In 8 of the 10 properties with available consumption data, the solar power generated by the new systems was greater than the reduction in energy consumption from the national grid. This indicates that solar generation surpassed the amount that could be used or stored in the batteries. In these cases, larger battery sizes would have allowed households to fully utilise the renewable energy their systems produced.

Financial and environmental savings

The energy consumption savings had positive environmental and financial impacts for the households (Table 1). Overall financial savings across the 10 households was up to £6,041, ranging from £109 in ELC05 to £1,049 in ELC13[2]. Total CO_2 savings across the 10 households was up to 6,174 kg. This ranged from 143 kg in ELC05 to 2,360 kg in ELC10[3].

Table 1: Financial and CO_2 savings by property[4]

Property Code	Annual electricity change (kWh)	Annual gas change (kWh)	Total annual usage change (kWh)	Total Financial Savings (£)	Total CO_2 Savings (kg)
ELC05	-171	-545	-716	£109	143
ELC09	36	-2,023	-1,987	£186	401
ELC11	-1,014	-879	-1,893	£414	374
ELC14*	-1,681	-	-1,681	£543	325
ELC04*	-1,891	-	-1,891	£611	366
ELC03	-1,621	-1,564	-3,185	£677	629
ELC06	-2,238	-146	-2,384	£737	462
ELC01*	-2,492	-	-2,492	£811	485
ELC10	1,045	-12,689	-11,644	£905	2,360
ELC13*	-3,249	-	-3,249	£1,049	628
TOTAL	**-13,276**	**-17,846**	**-31,122**	**£6,041**	**6,174**

Supporting the national grid

In addition to the savings on household energy usage, there was an environmental benefit to the national grid. By exporting excess solar generation to the grid, households increased the proportion of renewable energy in the supply. This has potential financial benefits to households through Smart Export Guarantee (SEG) tariffs.

In the year following installation of the measures, all households exported solar generation to the grid. This varied from 215 kWh to 2,078 kWh. SEG tariff varies by supplier. As of October 2023, available SEG tariffs rates ranged from 29.3p to 1p per kWh[5]. Potential savings are outlined in Table 2.

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[2] Energy costs savings are calculated using regional figures for January to March 2023 in order to gain an average from across the year. These work out at £0.3230 for electricity and £0.0979 for gas (£/kWh ex VAT). These can be found at: Energy Price Guarantee: regional rates, January to March 2023 - GOV.UK (www.gov.uk)
[3] Carbon factors are calculated using the most recent government numbers from 2022. These are 0.19338 for electricity and 0.20188 for gas (kg CO_2/unit). These can be found at: Greenhouse gas reporting: conversion factors 2022 - GOV.UK (www.gov.uk)
[4] Property codes marked with * do not include any gas usage data in the savings calculations. Other properties usage was provided from energy suppliers as electricity only.
[5] The Best Smart Export Guarantee Rates 2023 (theecoexperts.co.uk)

Table 2: Potential savings from SEG tariffs

	Exported Energy (kWh/yr)	Financial benefits		
		Highest rate 29.3p/kWh	Lowest rate 1p/kWh	Average rate 9.6p/kWh
Maximum export	2,079	£609	£21	£200
Minimum export	215	£63	£2	£21
Average export	866	£254	£9	£83

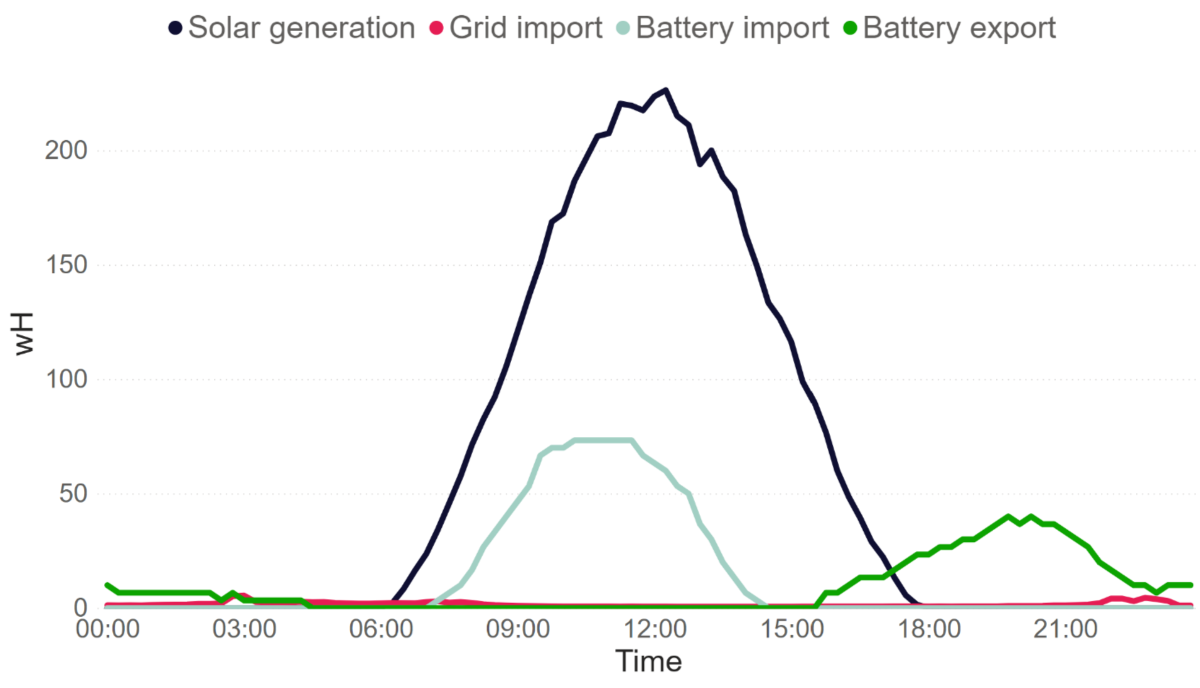
The range of possible savings emphasises the importance of ensuring householders are aware of these benefits and know how to switch their energy suppliers and tariffs once installations are complete.

2. Households adapt to new systems

Energy Usage Patterns

Energy usage patterns shows that average daily energy consumption across the first year was primarily supported through on-site solar-generated energy. This was true throughout the day. Solar generation supplied the property and charged the battery from 6am to 6pm and stored energy from the battery was used to supplement solar from approximately 3:30pm, remaining the primary source of energy into the evening and overnight (Figure 2). Although some householders may have taken advantage of cheaper unit rates to charge their batteries, the majority of householders appeared to primarily charge the batteries using solar generation.

Figure 2: Average daily energy profile for solar generation, battery use and grid usage



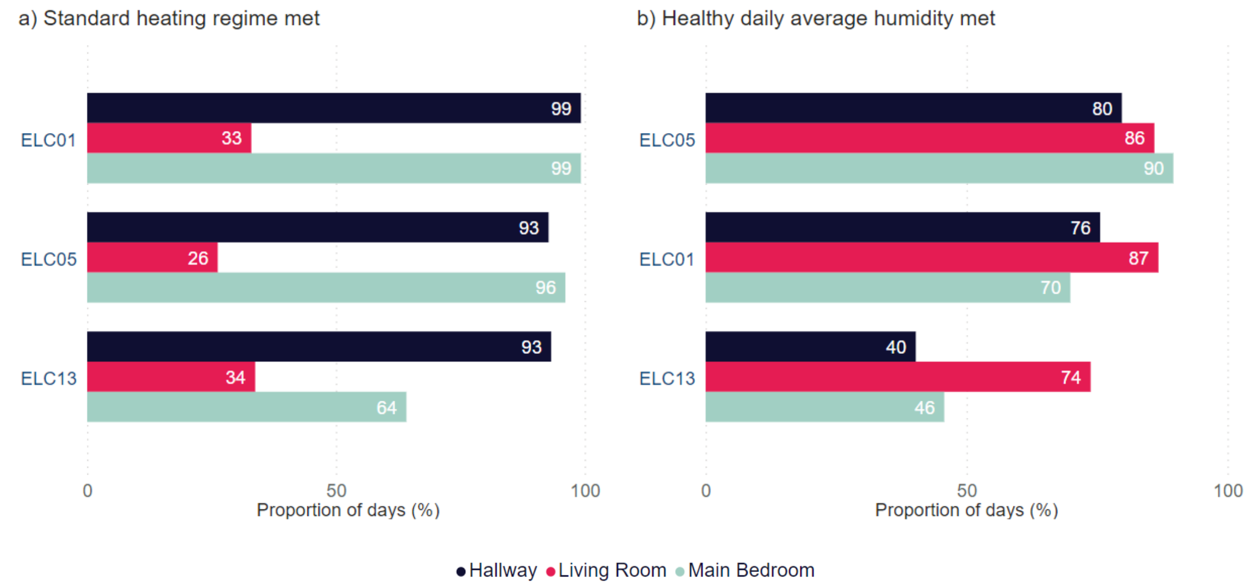
There were variations in usage across the year, with summer months seeing greater and more prolonged solar generation periods. However, householders benefited all year round. Average sunlight hours varied from 65 per month in October to December 2022 to 170 per month in April to June 2023. Only January to March 2023 showed households relying on a substantial mix of solar and grid energy, with solar genertion contributing only between 10:30am and 2:30pm (Appendix 2, Figure 4).

Householder Comfort

Householder comfort was measured through temperature and relative humidity data in three of the project properties. These showed that in the year following installations, a standard heating regime[6] was met 71% of the time, with an average property temperature of 20.5ºC. Healthy levels of relative humidity[7] were met 72% of the time, with average relative humidity being 54%.

Figure 3 illustrates the proportion of days that standard heating regimes (a) and healthy relative humidity levels (b) were met, across the monitored rooms. The standard heating regime requires a higher temperature to be met in living rooms, which partly explains the lower proportion of days this was met in the living room compared to the other rooms.

Figure 3: Proportion of days that standard heating regimes and healthy humidity achieved



Additional data on the lived experience of householders would be needed to fully align levels of home comfort to the solar PV and battery systems. This was out of scope of this evaluation, however in future projects qualitative data would provide context and evidence of any connection to energy efficiency measures installed.

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[6] To meet the standard heating regime, temperature must be at least 18ºC in hallways and bedrooms, and 21ºC in living rooms. This must be maintained for at least 9 hours on weekdays and 16 hours on weekends. Full details can be found in the [Scottish Governments Fuel Poverty Strategy – Analytical Annex.]
[7] Healthy levels of Relative Humidity are between 40-60%

3. Recommendations

The evidence detailed in this report highlights a number of ways in which delivery could be improved in future projects. These include:

Size batteries to individual properties

In future projects which install solar PV and battery systems, it may be appropriate to size the batteries more specifically to the properties receiving installations. Energy monitoring of usage patterns across a year would allow for the home energy demand to be taken into account. Combined with data on average sunlight hours in the area, the potential solar generation could be analysed alongside usage data to ensure battery sizes maximise benefits to the householders.

Include post-install support on energy tariffs and supplier changes in project planning

The variations in available SEG tariffs highlight a need to engage and support households to explore the best options for them. Export of solar energy to the grid has environmental benefits and the personal financial gain from SEG tariffs make it appealing to householders. The more households engage in these tariffs and the export of solar energy, the greater the environmental benefits.

Carry out qualitative data collection and analysis

Gathering data on the lived experience of householders give a more holistic view of the impact of installed energy efficiency measures. By collecting this data, the technical evidence can be contextualised with behaviour changes and impacts on householders' physical and mental health and wellbeing. It would also capture any unintended impacts not shown in the quantitative technical data. Having this fuller picture supports improved project planning in the future.

Conclusion

The project set out to determine the extent to which solar PV and battery can reduce fuel consumption. The evidence presented above shows that the aim was achieved in the following ways:

Household energy consumption reduced as a result of the measures installed

Following the installations of the new energy systems there was a 32% reduction in energy usage from the national grid. Across the 10 properties with usage data, average daily energy consumption decreased from 271 kWh to 183 kWh. When comparing annual grid usage reductions to solar generation, eight properties had greater solar generation. This indicated generation was higher than could be used or stored in the batteries on site.

The reduced consumption resulted in financial and environmental savings for the households receiving measures. Usage data from ten of the sixteen properties showed an overall financial saving of up to £6,000 in the year following the installations. The savings ranged by property, however even the lowest savings were over £100. Those same properties made carbon savings of 6,173kg CO_2 in the year following the installation of the new energy systems, with even the lowest saving reaching nearly 150kg CO_2 across the year.

The on-site generation of solar energy also has the potential to support the national grid, increasing the proportion of renewable energy in the supply. On average, the 16 properties exported 866 kWh across the year. SEG tariffs mean that this could have resulted in each household earning an average of £83 per year. This financial benefit is only available if householders are on an SEG tariff, highlighting the importance of engagement following installations to ensure they are switching.

Householders adapted to the new energy system

Due to the inclusion of the battery alongside the installed solar PV, limited behaviour changes were required from the householders to adapt to the new energy system. Average daily energy patterns show that the primary energy source moved to solar, either through direct generation during the day or via battery stored energy in the evening and overnight. Additionally, battery charging mainly occurred during periods of solar generation.

Households also benefitted from the solar PV generation throughout the year, with only January to March showing a substantial mix in solar and grid energy supporting average daily energy use.

Appendix

1. Methodology

This section outlines the data collection methodology used on this project and any limitations of the data gathered using each method.

Data used to evidence the impact on this project includes:

- Battery data
- Energy consumption
- Technical Temperature and Relative Humidity data

Battery data analysis

Tesla batteries record data automatically on the Tesla PowerHub platform. Access to the platform was obtained, allowing data to be downloaded for analysis and visualisation.

The following data was collected, at 15 minute intervals:

- Electrical consumption from the grid.
- Electrical production from the solar PV array.
- Battery electrical import.
- Battery electrical export.

This data was used in evidence of Outcome 1 and 2.

The data was available for all properties that received measures through this project. Only 16 of the 17 properties data was used, as one was vacant from January 2023 and so that data would not be representative.

Energy consumption analysis

Permission was gathered from all households receiving measures through this project which granted power for Changeworks to contact and request energy data from their suppliers.

Annual electricity and gas usage was requested for the year prior to the installations and the year following. This information was used to show changes in consumption and calculate financial and CO_2 savings.

This data was used in evidence of Outcome 1.

Although permissions were gathered from, and request for, all households only 10 households' data was available for analysis. Reasons for this included:

- Changes in energy suppliers causing breaks in the data and incomplete data sets.
- Energy suppliers being taken over (e.g., Bulb being taken over by Octopus) and the historic data from the original company not being available.
- Data provided by energy suppliers varied from meter readings, estimated usage figures or only one year of the requested data.

Property environment monitoring

It was a requirement of the special project ABS funding to monitor the temperature and humidity effects of any installed measures.

Technical monitors were used to measure temperature and relative humidity in three points: The hallway, this living room and the main bedroom. These were placed and left in the properties for one year following the measure installations.

Analysis of the recorded data was analysed to show any fluctuations on temperature, the ability of households to achieve standard heating regimes and maintain healthy levels of humidity.

Monitors were place in four properties on the project. Only three properties data is included in the report analysis as one was vacant from January 2023 and so that data would not be representative.

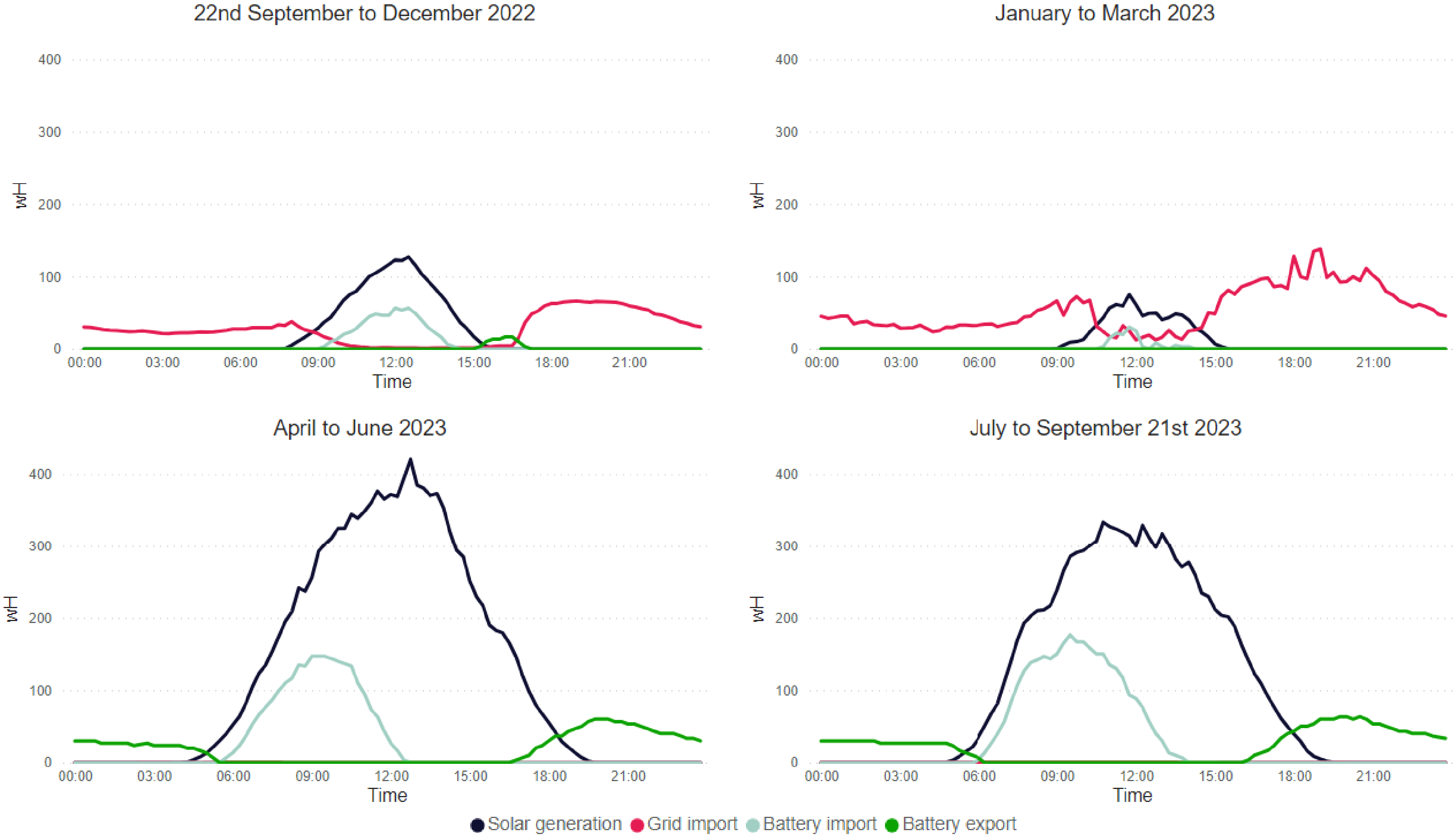
2. Property installation and generation

Table 3: Property solar PV installation and annual generation

Property	No. of panels	Roof Aspect	Annual solar generation (kWh)
ELC13	10	North & South	2,495
ELC01	10	North & South	2,511
ELC07	8	South & West	2,595
ELC10	10	South & West	2,649
ELC11	8	South & West	2,718
ELC02	10	South & West	2,794
ELC05	10	South & West	2,800
ELC09	10	South & West	2,813
ELC15	10	North & South	2,866
ELC14	10	South	2,929
ELC16	8	South	2,935
ELC06	10	South & West	2,952
ELC12	9	South & West	2,956
ELC03	10	South & West	3,244
ELC08	10	South & West	3,352
ELC04	10	South & West	3,363

3. Quarterly energy profile

Figure 4: Average household energy profile for solar generation, battery use and grid usage[8]



[8] Averages start from September 22nd 2022 to account for installation dates and ensure annual averages for all properties are accounted for in analysis.

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Get in touch with the team to discuss how we can help you.

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