Home Retrofit and Decarbonisation Case Study

FUTURE PROOF CUMBRIA

CENTRE for LEADERSHIP PERFORMANCE

DREAM PLACEMENT

Overview

- Background to the house
- Retrofit process & Futureproof Cumbria (CAfS)
- Measures implemented
- Heat pump
- Solar PV
- Batteries
- Tariff
- Comparisons
- Interview
- Conclusion

Background to the house

- Traditional farmhouse
- Built ~ 1740
- Construction: mix of older random rubble and new cavity masonry walls, solid floors, slate roof
- 4 bedroom, detached with additions
- Mix of single and double-glazed windows
- Floor area 210m^2
- Oil central heating (20+ years old) ~ 70% efficient
- No mains gas available

Retrofit Process & Futureproof Cumbria (CAfS)

- Two stages: **Home Retrofit Scenario Report** (21/08/22) and **Scope of Works** (09/01/23).
- First report gave 3 scenarios from which the homeowners could pick different suggested measures
- For example, not choosing to insulate the external walls or have mechanical extract ventilation but having a substantially larger heat pump and more solar panels
- **Scope of Works** gave detailed costing for selected measures

Measures Implemented

12/2021 - Insulated downstairs walls with lime/hemp, insulated hard floors, put in underfloor heating (Shire Homes)

As suggest by **Futureproof Cumbria's** reports:

11/2022 - Installed draught-proofing measures (DIY)

11/2023 - Replaced remaining single-glazed windows with double-glazed (Shire Homes) or secondary (DIY)

03/2024 - Installed air-source heat pump (ASHP) (Logic)

09/2024 - Installed solar PV and batteries (Eden Solar)

Insulative lime plaster

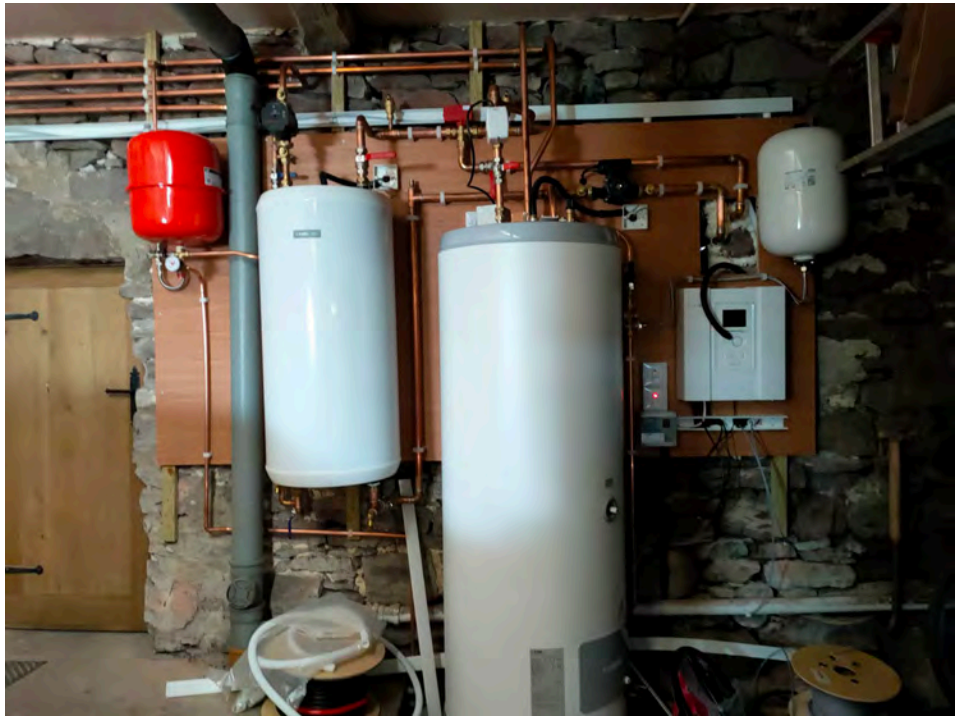
Underfloor heating

Heat Pump

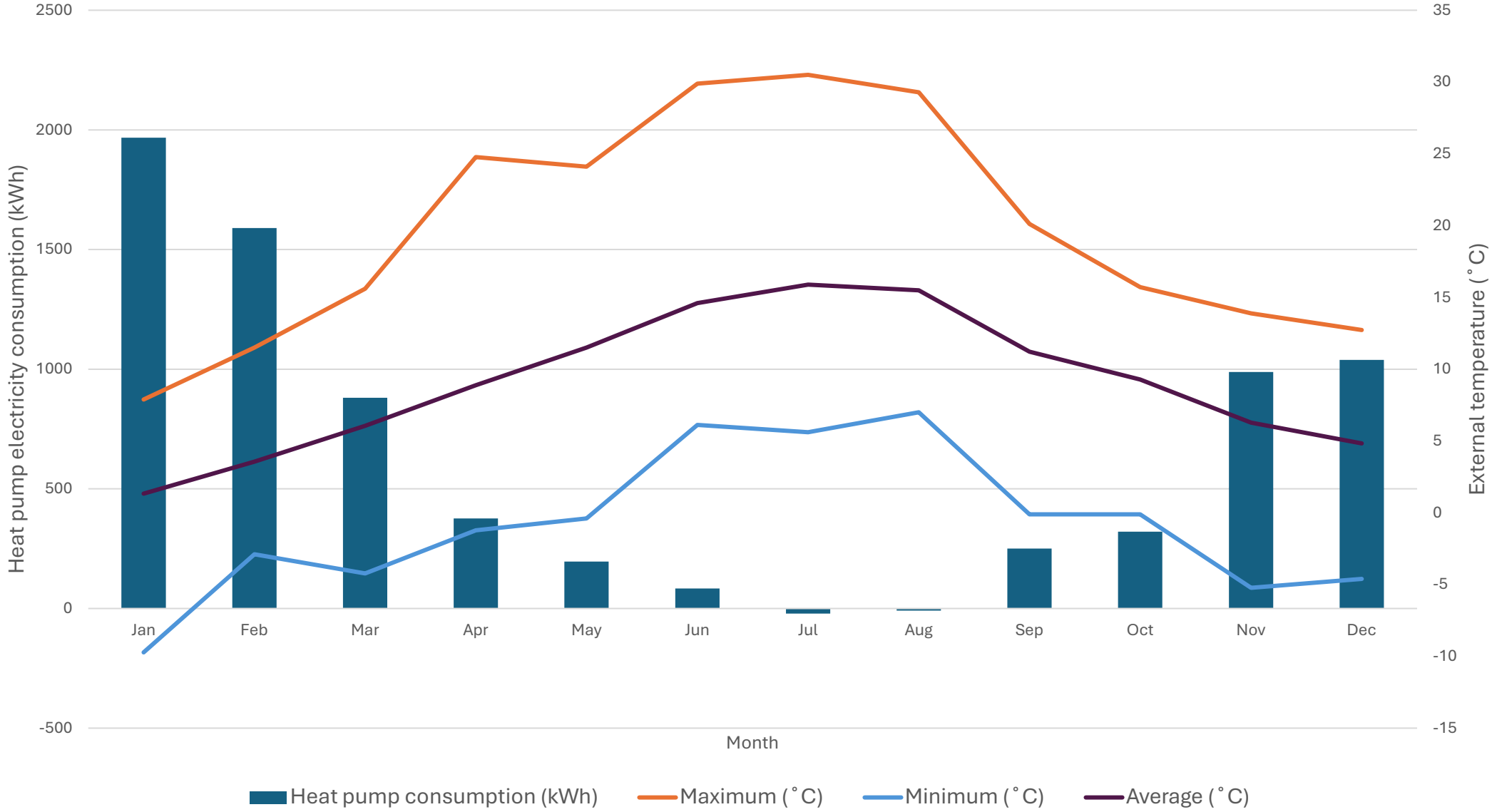
- Nibe 16kW ASHP with 300l hot water cylinder
- Underfloor heating downstairs and new (larger) radiators upstairs because larger surface area heat emitters are needed to maximise heat pump efficiency
- The heat pump was more expensive than average because of the house layout - £18.7K
- However, the boiler upgrade scheme allowed for a grant of £7.5K

Outside (1.28m high)

In out building (300l tank is 1.58m high)



ASHP Consumption vs External Temperature



Temperature data is from “Weather History for ICUMBRIA41” wunderground.com.
Heat pump energy consumption is calculated from total energy consumption – EV energy consumption – average appliance energy consumption. This means the heat pump heating water for non-space heating use is not included in these figures.

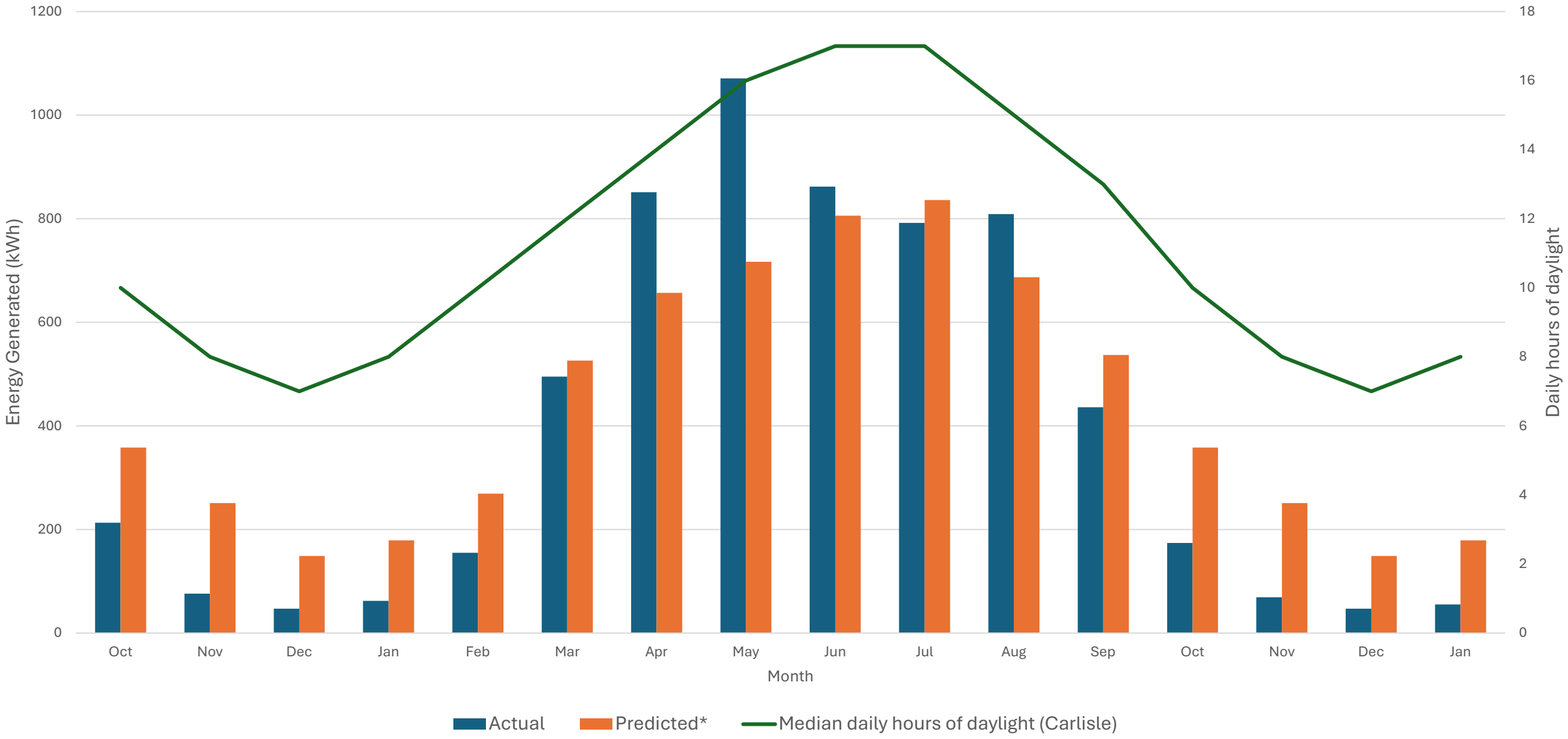
Solar PV

- Quotes obtained using the “solar made easy” questionnaire (from Futureproof Cumbria)
- Installed by Eden Solar
- Panels are on two roofs of different orientation (one South-facing, one West-facing)
- Total of 17 x 430W all-black mono panels – total capacity of 7.3kW
- 2 x 5.8kWh batteries
- Total cost of solar PV and batteries = £12.3K

64cm tall batteries and inverter (in out-building)

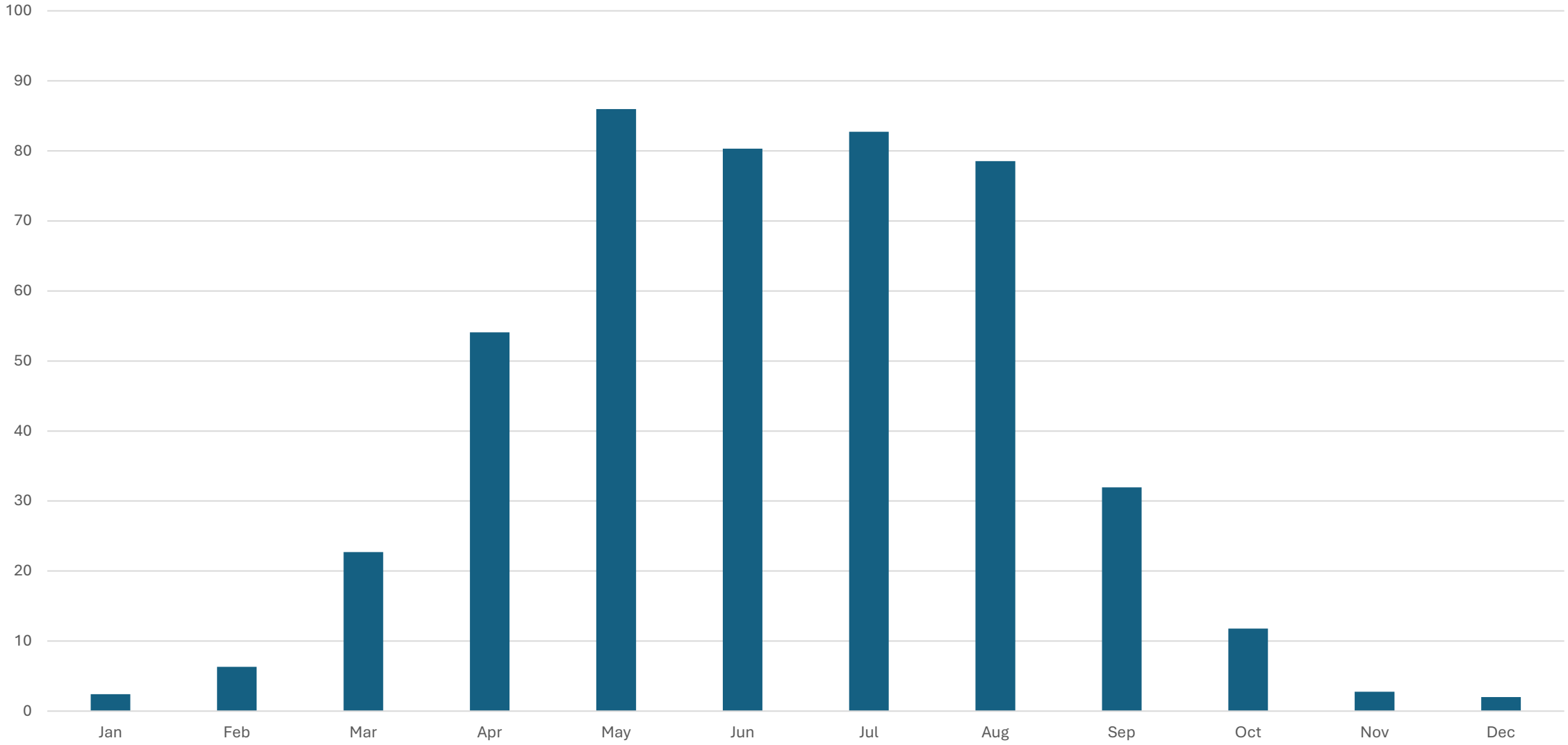
10 panels on South-facing roof and 7 on the West-facing roof

Solar Generation in 2025



*Based on In2gr8ed Solutions predicted energy generated – uses daily hours of sunlight in **Southern** England

% of Total Household Energy Consumption from Solar Panels



Of all household energy consumption in 2025, **24%** was from the solar panels

Solar PV

- The solar PV and batteries will together save £1.6K every year
- This means they will **pay for themselves in ~ 8 years**
- The predicted time for net cashflow was 7 years

Batteries

- 2 x SolaX T58 triple power HV
- Used for storing excess solar energy
- Can store 9.6kWh in total (nominally 5.8kWh per battery)
- If electricity is on a variable tariff, batteries could be used strategically to store electricity when it is cheapest and feed back into the grid in the day
- We could not do this due to smart meter connectivity issues so we are on a fixed tariff

Batteries

- In 2025, the batteries stored 1992kWh of electricity that would other wise go to the grid (no tariff so this is “lost”)
  - This is equivalent to £498
- There is some cost to charging and discharging the batteries due to energy loss
  - I.e. the batteries lost 12.7% of all energy stored (in charge – discharge cycles)
- Nominally, 5% is expected to be lost
- This brings the savings from the batteries to £435 per year meaning they will **repay themselves in ~ 6 years time**

Tariff benefits

- If a time-of-use tariff (a variable import tariff) was available, would be able to charge the battery overnight at ~ 7.5p per kWh
  - Saving of £1.47 per day
- The energy exported to the grid – 1143kWh last year - would have an export tariff of ~ 15p per kWh, saving ~ £171 (£0.47 per day)
- This totals at **£708 per year**
- Energy market-based buying and selling not taken into account as is extremely variable so hard to calculate

Energy Use Comparison

Year (April-March)	Oil (kWh)*	Electricity from National Grid (kWh)**	Solar energy to home (kWh)	Energy use (kWh)
2021/2	31500	n/a	0	>31500
2022/3	18200	n/a	0	>18200
2023/4	16100	9328	0	24528
2024/5	0	10904	1021	11925

*Assuming 1l=7kWh because boiler works at 70% efficiency & a litre of oil contains ~ 10kWh of energy.
**Ignoring electricity used for charging the EV. n/a is because no figures were available.

- Oil use reduced over time as retrofit measures were implemented & thermostat was turned down (from 21C to 18C)
- When the boiler was replaced with the heat pump, the total energy use roughly halved
- From over 86kWh consumption per day to 32.67kWh
- The solar panels only became operational for half of 2025 (in the Winter)

Carbon Comparison

Retrofit Stage	Emissions under standard carbon intensity (kg of CO_2)	Emissions with green supplier (kg of CO_2)
Before (2021/2)	>79380	79380
Fabric-only (2022/3)	>45864	45864
Fabric-only (2023/4)	42038	40572
After ASHP and solar (2024/5)	1363	0

Assumptions:
1l of oil produces 2.52kg of CO_2
Standard carbon intensity refers to the reported national grid data for that year
Green supplier has reported carbon intensity of 0kg/kWh

Cost Comparison

Underfloor heating, draught-proofing & lime-plastering

Window glazing, ASHP and solar panels

Before (2021/2) - **£5694**

Based on 4500l of oil at a rate of 68.5p per litre and (assuming) 9328kWh of electricity at 28.0p per kWh

During (2023/4) - **£4140**

Based on 2300l of oil at a rate of 70.5p per litre and 9328kWh of electricity at 27.0p per kWh

After (2024/5) - **£2726**

Based on 10904kWh at 25.0p per kWh

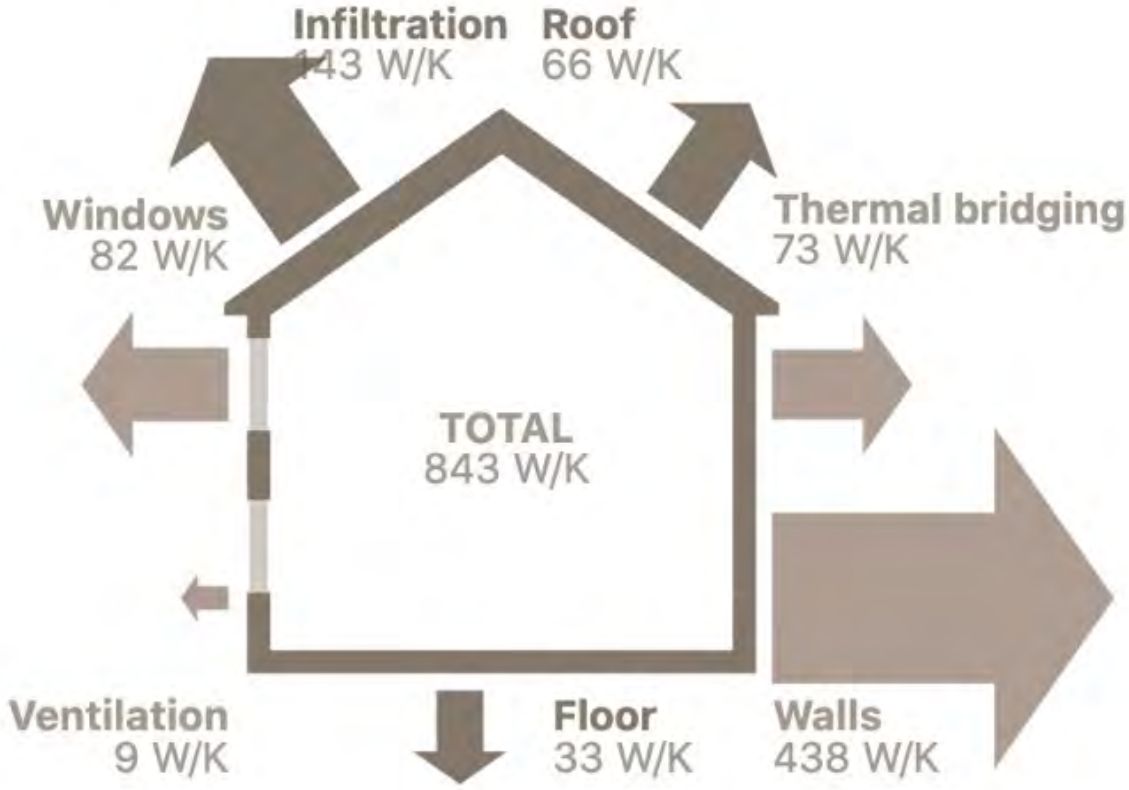
Total savings per year after <u>all</u> retrofit measures implemented = **£2968**
Full cost of measures ~ **£75000**
Time for system to have paid for itself ~ **25 years**
With variable import/export tariff, payback time ~ **20 years**
The figures above don't account for inflation – real time will (probably) be less
Subtracting the grant from the cost reduces the time for the system to pay for itself by 2 years

Heat Loss Comparison

The unit (W/K) represents the heat loss in Watts for every degree temperature difference between the interior and exterior

- Main heat loss areas were via walls and draughts (“infiltration”)
- Peak heat load at this point (the heating power necessary to maintain a comfortable temperature) was estimated at 21.1kW

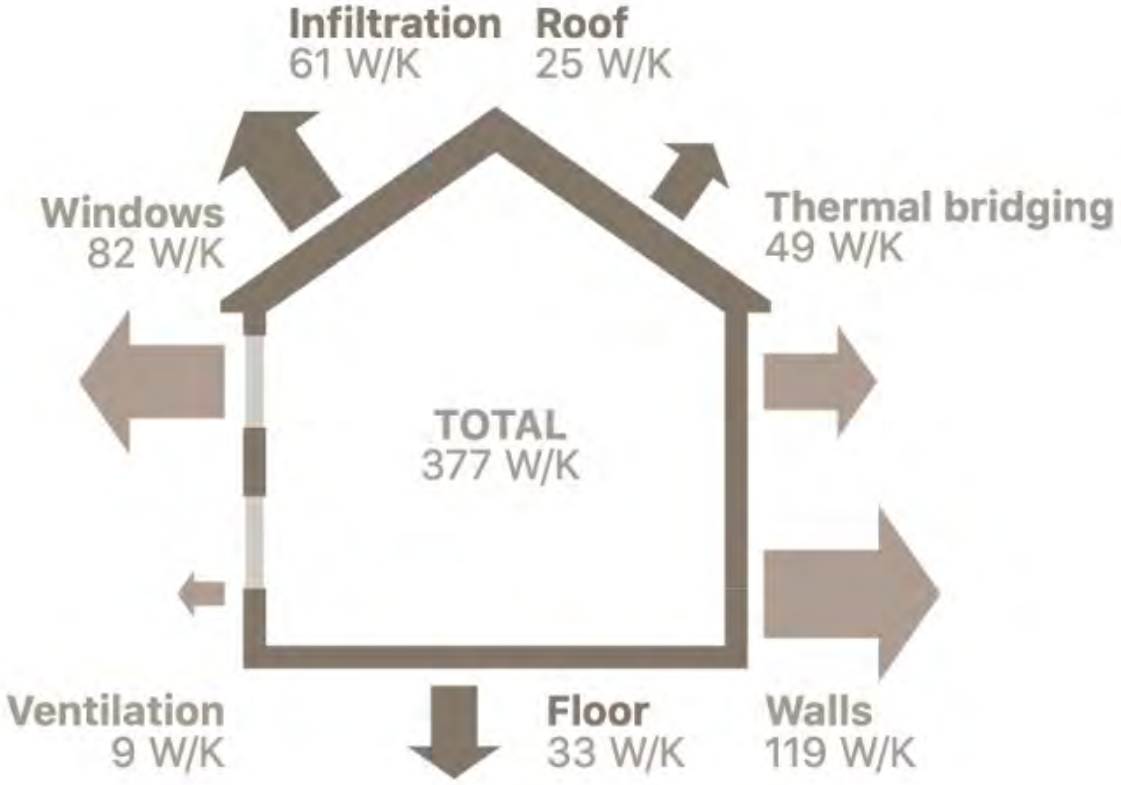
Heat loss summary before retrofit (from retrofit report)



Heat Loss Comparison

- Total heat loss per degrees difference drops by 366W/K
- Mainly due to draughtproofing and insulation
- Peak heat load ~ 9.4kW, a drop of 11.7kW compared to no retrofit work
- Analysing data, there was a peak power demand of **8.14kW**
- This is roughly equal to the predicted
- But not all measures in the retrofit report were implemented

Heat loss summary scenario for suggested measures (from retrofit report)



EPC Rating

- 54% of houses with an EPC in Cumbria are rated D or below
- This is one of the highest for any county
- Reasons: older housing stock than UK average, lower average wages than UK average, EPC penalises traditional insulation (lime-based)
- Oct 2026 EPC regulations will mean heat pumps are more valuable
- Government target is C

House Holder Feedback

- House holder priorities for the retrofit 1) energy cost 2) comfort and 3) carbon savings
- “About the retrofit process, we’ve done some research ourselves which led to CAfS webinars… etc. and the CAfS service was invaluable as a source of information – focusing on a plan of action.”
- “The main successes of the retrofit are the house being at a reasonable temperature more consistently. The old boiler system was inefficient and noisy; the heat pump doesn’t have this issue. Energy consumption has halved, and costs have also reduced.”
- “The whole project was expensive. Some aspects like the solar/batteries have an obvious financial benefit but improvements to the fabric of the house contribute to the long-term capital value.”
- “Overall, we would consider it a success”

Conclusion

Smart Meter

- Having a working smart meter is essential to maximise savings (via tariffs)
- There is a North-South divide in smart meter connectivity
- The radio-based network in Cumbria is not reliable
- Our electricity supplier has now replaced the transmitter with a 4G based one which works as intended – allowing tariffs

Retrofit

- Even in a traditional building, retrofit still provides significant cost and carbon savings
- Comfort
- Decarbonising traditional homes
- Grants/interest-free loans are needed to have a real impact because of initial costs