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# Three Solid Wall Owner-Occupied Domestic Retrofits

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*Photo: Homes post retrofit*

## Case study

Collaborating with Neath Port Talbot County Borough Council and residents, a package of low carbon solutions was identified and implemented for three pre-1919, owner-occupied homes. Despite being similar in age and having similar fabric, the homes had diverse occupancy patterns, levels of maintenance, orientations and heating systems which required different demand reduction, renewable energy supply and storage options [1].

Our goals were to:

- Evaluate the performance of pre-installed hybrid ASHPs.
- Identify potential affordable and replicable low carbon solutions.
- Reduce energy use, energy bills and carbon emissions.
- Improve thermal comfort for residents.
- Evidence this through a comprehensive programme of computer modelling and monitoring.

*Photo: post retrofit*

## Low carbon solutions

A hybrid 6kW air source heat pump with oil was already installed in all 3 homes as well as external wall insulation.

Following planning, design and procurement process where appropriate stakeholders were fully engaged, the following low carbon solutions were installed:

- Reduce energy demand: passive measures including making-good external wall insulation, window and door repair and replacement and loft insulation top up. Either a positive input ventilation (PIV) or Mechanical Ventilation Heat Recovery (MVHR) system.
- Renewable energy supply: bolt-on solar photovoltaic (PV) panels ranging from 3.5 to 5.6 $kW_p$ depending on roof size.
- Energy storage: a Tesla Powerwall 2 battery (13.5 kWh) optimised for self-sufficiency and supported by electrical works.


*Figure: Low carbon solutions on one of the homes*

## Research methods and project workflow


- Pre-retrofit monitoring data and detailed surveys were undertaken in planning phase to understand the homes and identify potential strategies. These were then optimised using computer models such as DesignBuilder, HTB2 and VirVil SketchUp [2].
- A package of solutions tailored to the homes were selected in collaboration with relevant stakeholders, taking into account location, orientation, shape and likely occupancy patterns. The LCBE team led the design of the tailored solutions and created a specification package to procure suppliers/installers.
- Following procurement of the measures and implementation, a comprehensive monitoring programme took place [3,4]. This involved the performance evaluation of the installed systems and its benefits in energy and comfort.
- Pre- and post-retrofit monitoring allowed for the quantification of the benefits and for comparisons against predictions and benchmarks. Monitoring also assisted in building diagnostics indicating errors in installation and commissioning such as inaccuracies with the MVHR performance.

## Results

- After the fabric improvements, internal temperature increased was more stable throughout the day, in-line with the thermostat setting.
- By improving the fabric including making repairs to windows and doors, topping up loft insulation etc, up to 37% of space heating energy was saved.
- Combining an ASHP with PV and battery as part of a whole house retrofit approach provides yearly electricity bill savings of up to 72%.
- Two of the homes have switched to an energy supplier that allows them to export energy to the grid, generating an income from the renewables and battery storage. This has resulted in household having a positive annual energy 'bill', making money.

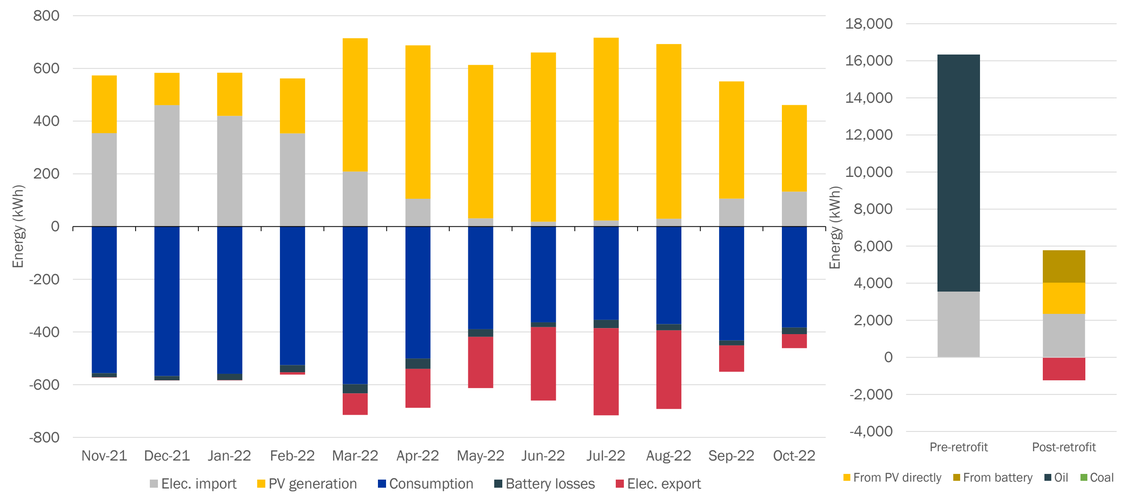


*Figure: Pre- and post-retrofit energy import and export for one of the homes*

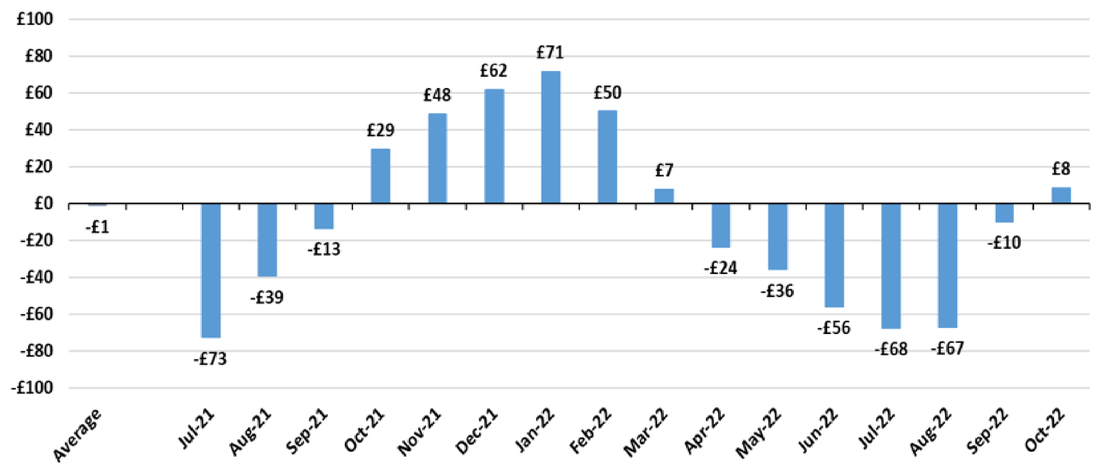


*Figure: Post-retrofit electricity bill including standing charges for one home*

## Lessons learnt

- Prior to the LCBE teams involvement, installation of the hybrid ASHP had reduced carbon emissions but had a negative impact on energy bills leaving residents worse of financially. The addition of the PV and battery enabled on site electricity to be generated, significantly reducing energy import and therefore bills.
- The orientation of a pair of semi-detached homes meant that one of the homes had large south-east/south-west facing rooves, the other had north-west/north-east facing rooves. Potential energy generation varied significantly between the two. A battery would not be appropriate for the home with the north facing roof, the home was occupied during the day and potential to generate enough energy to store was limited, not providing value for money.
- Heat loss through poorly fitted or damaged windows and doors, uninsulated loft hatches, gaps around pipework and chimneys can be significant. These are relatively small, cheaper changes that can help to reduce energy demand.
- The LCBE team suggested that owners could use Smart Export Guarantee Tariffs to make the best out of their solar panels and battery. Residents who are flexible to adjust their lifestyle and use variable tariffs can benefit with reduced bills.

### References

1. Patterson, J. L., Coma Bassas, E. and Varriale, F., Systems based approach to replicable low cost housing: renewable energy supply, storage and demand reduction, Smart Energy Regions - Skills, knowledge, training and supply chains, Welsh School of Architecture, 2016, pp. 239-245.
2. Jones, P., Lannon, S., Li, X., Bassett, T. and Waldron, D., Intensive building energy simulation at early design stage. Presented at: Building Simulation 2013: 13th International Conference of the International Building Performance Simulation Association, Chambéry, France, 25-28 August 2013.
3. Perisoglou, E., Ionas, M., Patterson, J. and Jones, P., Building monitoring protocol development for deep energy retrofit. IOP Conference Series: Earth and Environmental Science 329, 2019.
4. Perisoglou, E., Li, X., Ionas, M., Patterson, J., Bassas, E.C. and Jones, P., Evaluation of building and systems performance for a deep domestic retrofit. In Journal of Physics: Conference Series (Vol. 1343, No. 1, p. 012176). IOP Publishing, 2019.

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