Low Carbon
Built Environment
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Photo: Six bungalows following the retrofit

Six 1970s Off-Gas Bungalow Retrofits

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Case study

The six 1970s bungalows are L-shaped and terraced with an identical layout, each with floor area of 64m². The homes are off mains gas and prior to retrofit used oil, LPG or individual electric room heaters as a heating source. Since the retrofit the homes are all electric. Low carbon solutions have been selected using a whole house retrofit strategy combining reduced energy demand, renewable energy supply and energy storage [1].

Our goals were to:
- Extend the life of the homes by implementing affordable and replicable whole house energy systems.
- 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: before retrofit


Photo: during retrofit

Low carbon solutions

Following the planning, design and procurement process, where appropriate stakeholders were fully engaged, the following low carbon solutions were installed:
- Reduce energy demand: passive measures including external wall insulation, loft insulation and window and door replacement as well as active measures including LED lights and mechanical ventilation with heat recovery (MVHR).
- Renewable energy supply: 5.8 kWp building integrated photovoltaic (BIPV) solar panels on two roof orientations with a ground source heat pump (GSHP) to provide domestic hot water and space heating.
- Energy storage: a Tesla Powerwall 2 lithium-ion battery (13.5 kWh).

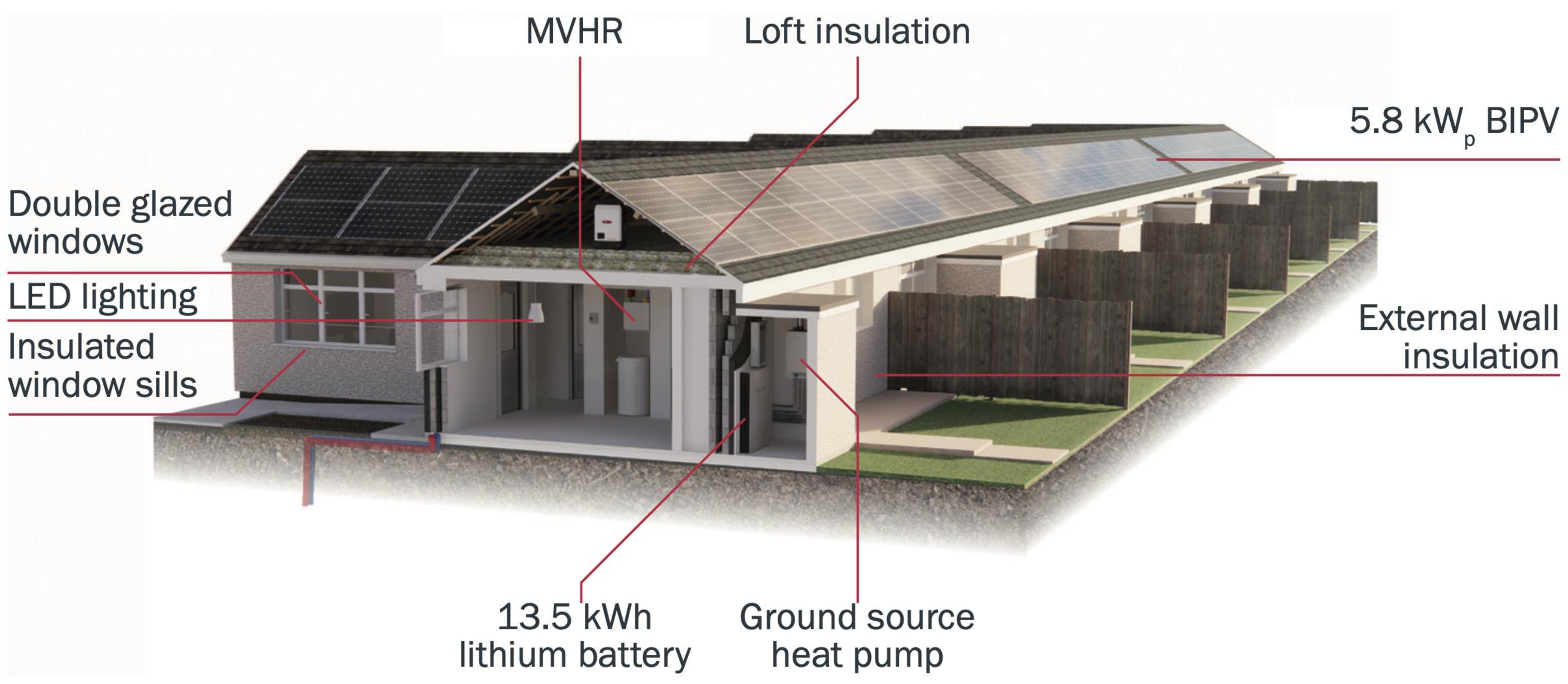

Figure: Low carbon solutions installed

Research methods and project workflow

- One year of pre-retrofit monitoring data and detailed surveys were undertaken in planning phase to understand the homes and identify potential strategies. These were optimised using computer models such as HTB2 and VirVil SketchUp [2]. Pre-retrofit monitoring focused on the fabric, helping the project team make decisions about additional insulation for the walls and window replacement.
- A package of solutions tailored to the homes were selected allowing priorities such as location, orientation, shape and likely occupancy patterns to be included in the design.
- The procurement phase followed ensuring the use of local and cost-effective supply chain where possible.
- Installation was scheduled to minimise disruption for residents' and emphasis was give to detailed commissioning.
- The building evaluation methodology used monitoring techniques and a protocol developed by the Welsh School of Architecture as well as literature and guidance on building metrics and performance evaluation protocols [3,4]. This involved monitoring all the systems performance with 150 energy and environmental sensors pre- and post-retrofit to demonstrate the impact of all the solutions.

Results

- The average pre-retrofit annual energy consumption from either the electricity grid or oil/LPG was 16,117kWh for the 6 bungalows. Post-retrofit, the all-electric homes average consumption reduced to 4,560kWh. 53% of electricity supply was from either the solar panels or batteries with an average of only 2,142kWh imported from the electricity grid.
- From April to September, electricity import was close to zero and approximately 2,000 kWh of PV generated energy that wasn't used in the homes was exported to the grid.
- Carbon emissions reduced by 99% with a 77% reduction in energy bills.
- The GSHP COP is very stable over the year at an average at 3.1.
- Pre-retrofit monitoring showed that living rooms were cold and draughty high fluctuations in temperature throughout the day. The internal temperatures are much more consistent since the retrofit works, remaining around the temperature set on the thermostat.

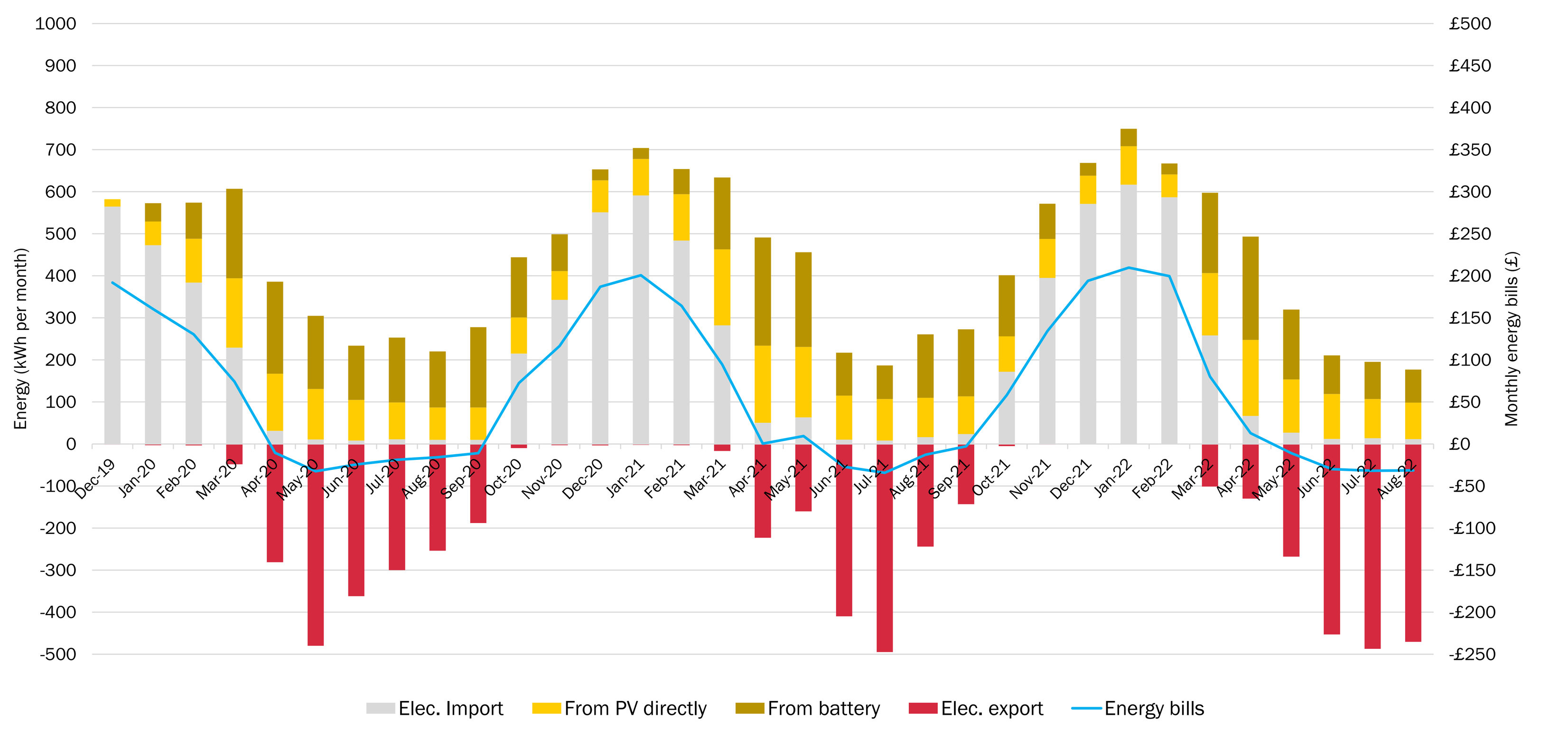

Figure: Pre- and post-retrofit energy import and export for one bungalow illustrating energy bills

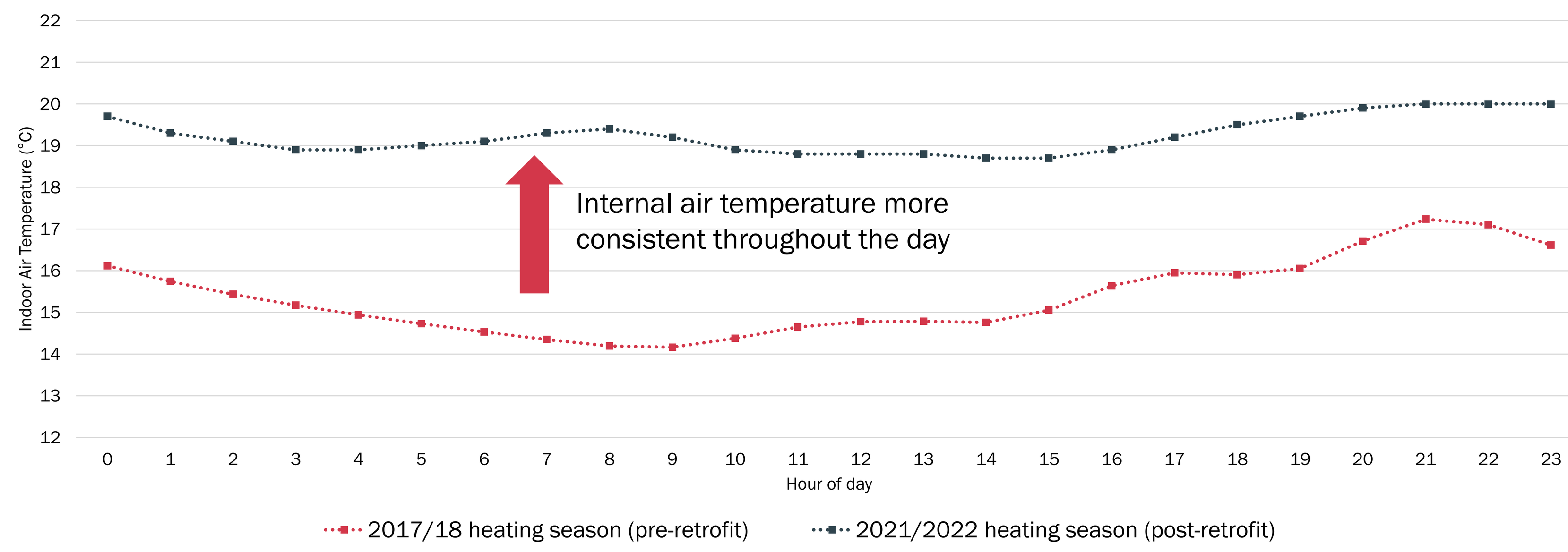

Figure: Lounge temperature pre- and post-retrofit

Lessons learnt

- A lead contractor sub-contracting work is preferable for the installation of integrated PV solar panels where reroofing is required to ensure issues are the responsibility of one company.
- It is good practice for all installers to meet on site before starting work and to agree a full delivery plan as a team to ensure efficiency and establish communication channels.
- GSHPs with low temperature radiators tend to be more efficient over a year than Air Source Heat Pumps. They are silent with a stable COP and low maintenance.
- The sharing of solutions such as heat pumps and batteries was considered across all six homes during the planning stage. However, concerns over long term ownership and the need for shared space to locate equipment ruled these options out.
- Close and regular on-site supervision is essential to ensure high quality installations. Commissioning and handover need to be carried out appropriately.
- The lessons learnt by Swansea Council through the experience are now being replicated across their new build and existing housing stock of 13,700 homes.

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