Evaluating the Performance of Passivhaus Dwellings Pre and Post Occupancy

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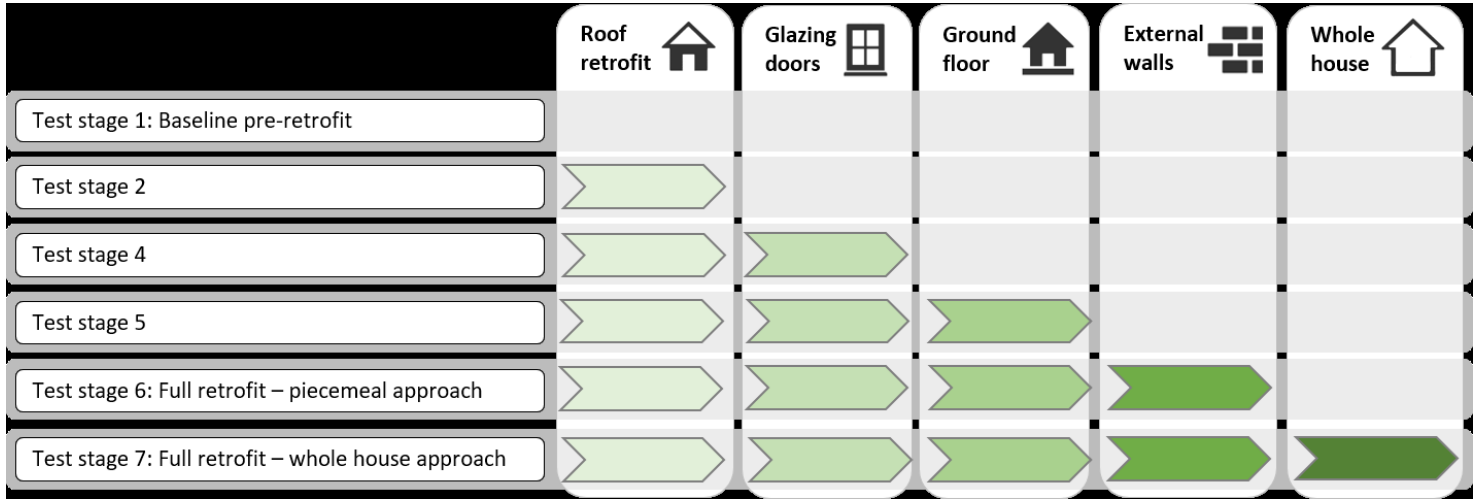
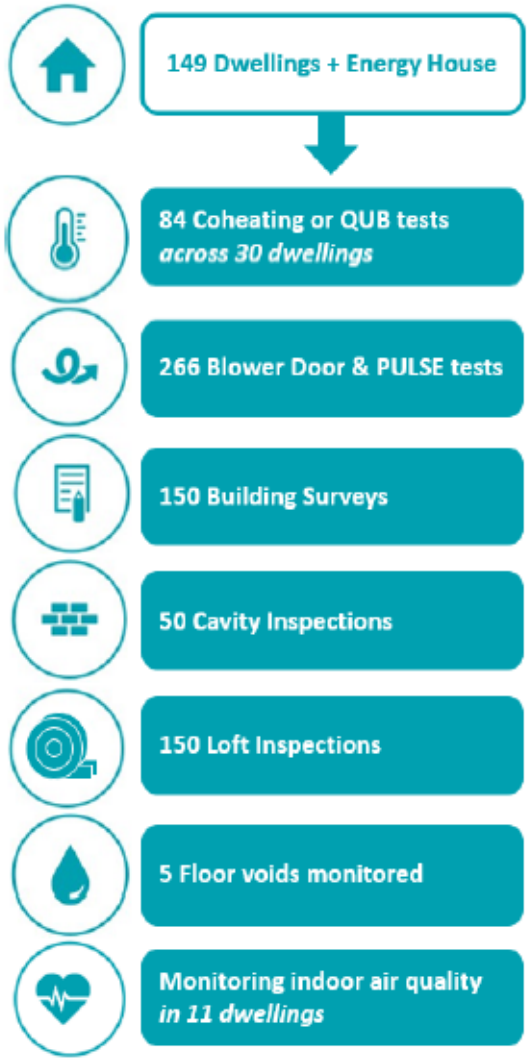
Demonstration of Energy Efficiency Potential (DEEP)

Building an evidence base for Whole House Retrofit in policy

Apply principles of retrofit considering the whole house system to move away from single measure retrofit.



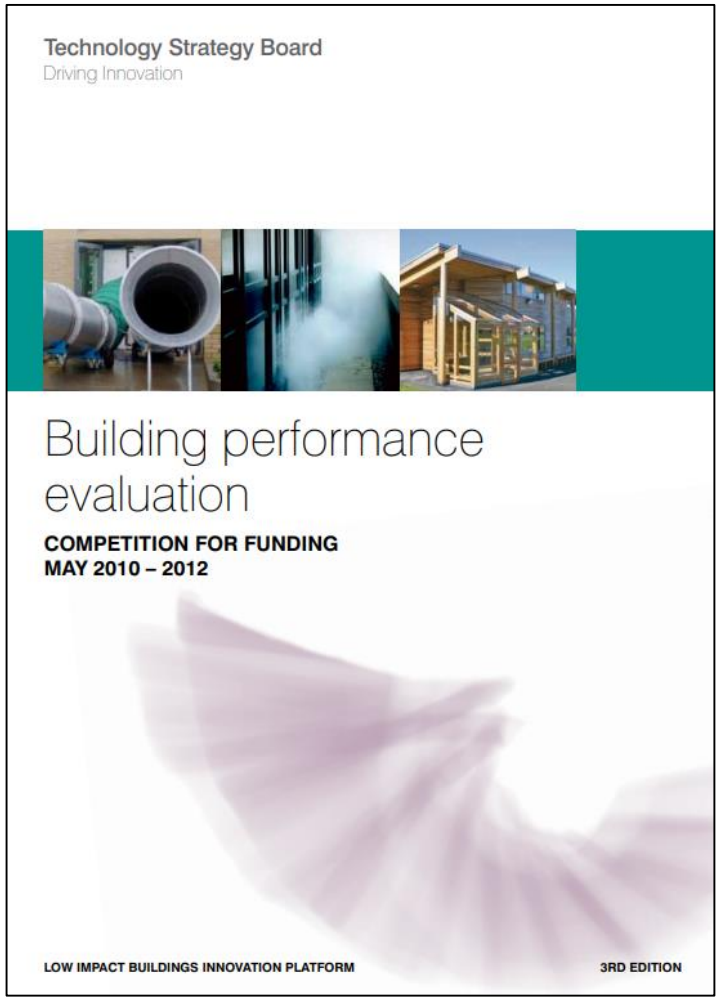


Technology Strategy Board (now Innovate UK)
Building Performance Evaluation Competition

£8million programme with the aim to assemble a substantial body of data on the as-built performance of dwellings.

Phase 1: Post construction and initial occupation

Phase 2: In-use performance and Post Occupancy Evaluation



Racecourse Passivhaus Estate in Houghton-le-Spring, Sunderland

Client: Gentoo (Social Housing Provider)
Project Architect: Mark Siddall, Adam James
Mechanical Services Engineer: Alan Clarke

The homes are part of an Assisted Living development of 28 bungalows, 25 of which are **Passivhaus Certified.**

The project evaluated the performance of the case study dwelling **immediately following completion** and **during occupation**.

Fabric Construction

Element	Construction Method	Design U-Value (W/m²K)
External Walls	Pre-fabricated timber-frame cassettes filled with 300mm insulation	0.12
Windows	Triple glazed, low-e soft coat krypton filled units	0.90
Roof	Pre-fabricated timber-frame cassette filled with 450mm insulation	0.09
Ground Floor	Concrete slab-on-ground, with 300mm insulation above the slab and 50mm screed.	0.10
Doors	Aluminium faced composite panelled doors	0.90

Airtightness Target: ≤0.6 air changes per hour @ 50Pa

Fabric Construction

Considerable care taken to maintain air barrier

“Over-stuffed” cassette to ensure full fill

Services

The dwelling has a whole house MVHR system.

Space heating is provided via a small, low temperature hot water heater battery installed in the MVHR ductwork, in addition to a heated towel radiator in the bathroom and a small radiator in the drying cupboard.

Hot water for occupant use and to supply the heater battery and radiators is provided via a combination of solar thermal and a communal boiler, serving 7 dwellings on the terrace.

Fabric Performance

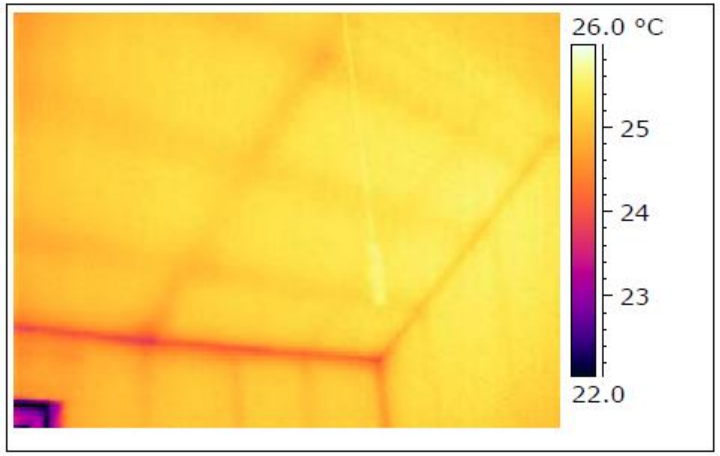
Element	Design U-value (W/m²K)	Measured U-Value (W/m²K)
Ground Floor	0.10	0.10
External Walls	0.12	0.12
Roof	0.09	0.13
Windows	0.90	0.68
Doors	0.90	0.68

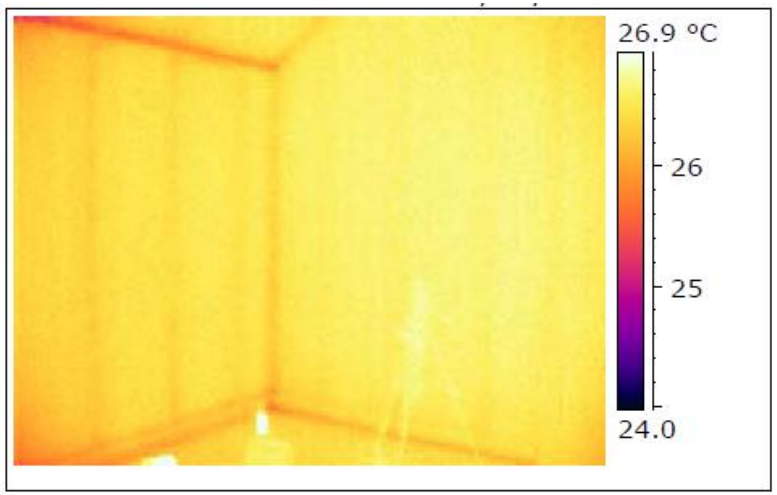
Airtightness Target: ≤0.6 air changes per hour @ 50Pa
Measured Airtightness: 0.49 air changes per hour @ 50Pa

Airtightness had deteriorated to 1.00 AC/H @50Pa at the point of in-use monitoring commencement, and to 1.32 AC/H @50Pa at monitoring end.

This is still **very airtight relative to typical construction**.

Fabric Performance



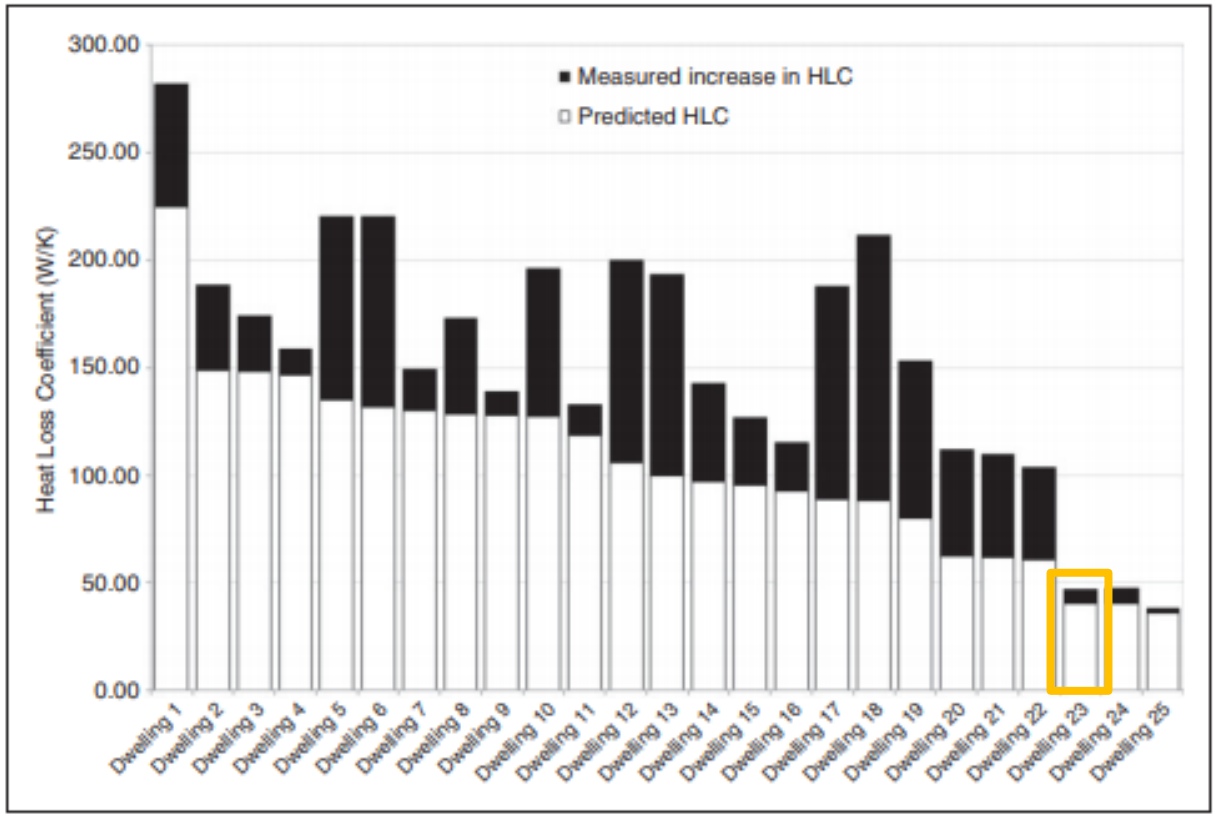


No significant heat loss via thermal bridging at junctions

Fabric Performance – Whole House Heat Loss and Performance Gap

Predicted Heat Loss Coefficient: 43.4 W/K
Measured Heat Loss Coefficient: 46.7 W/K

Coheating tests revealed that fabric performance *in situ* was very close to design intent, with a <u>small performance gap</u>.

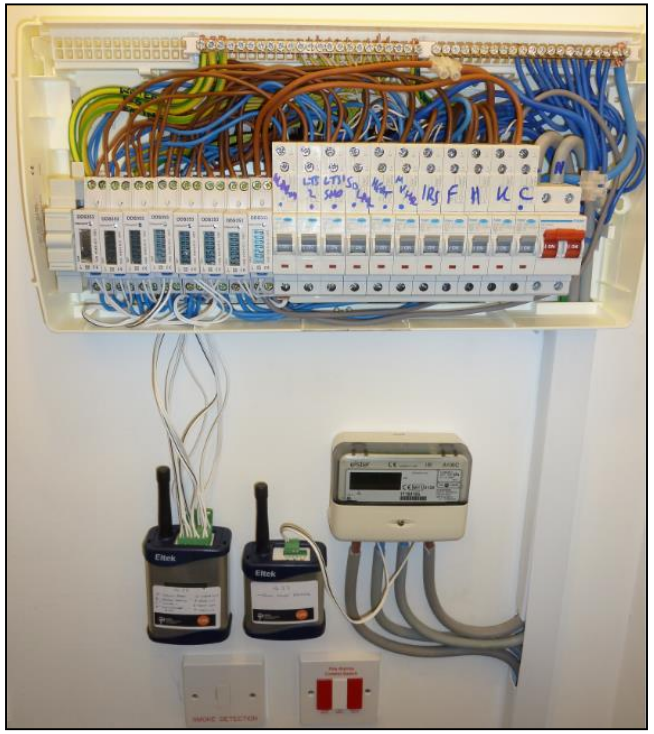


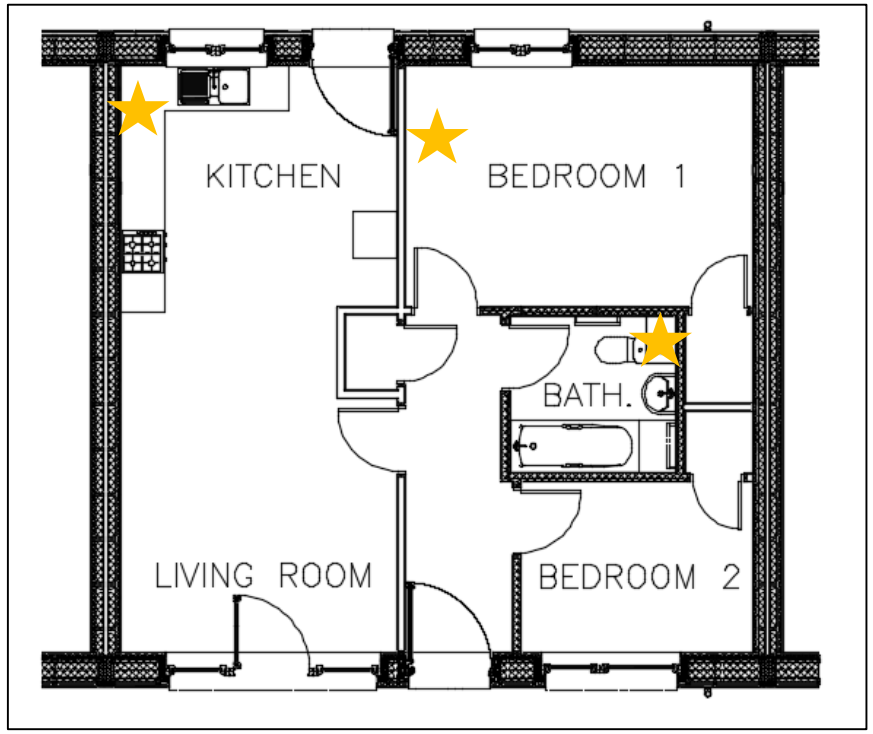
Leeds Beckett new build coheating database from: Johnston, D., Miles-Shenton, D., & Farmer, D. (2015). Quantifying the domestic building fabric 'performance gap.' *Building Services Engineering Research and Technology*, *36*(5), 614–627.

Remote monitoring of:

- Temperature
- Relative humidity
- CO_2
- Sub metered Electricity
- Water
- Space Heating
- Water Heating

Plus occupant feedback using BUS survey





★ Monitoring Location (Temperature, Relative Humidity and CO_2)

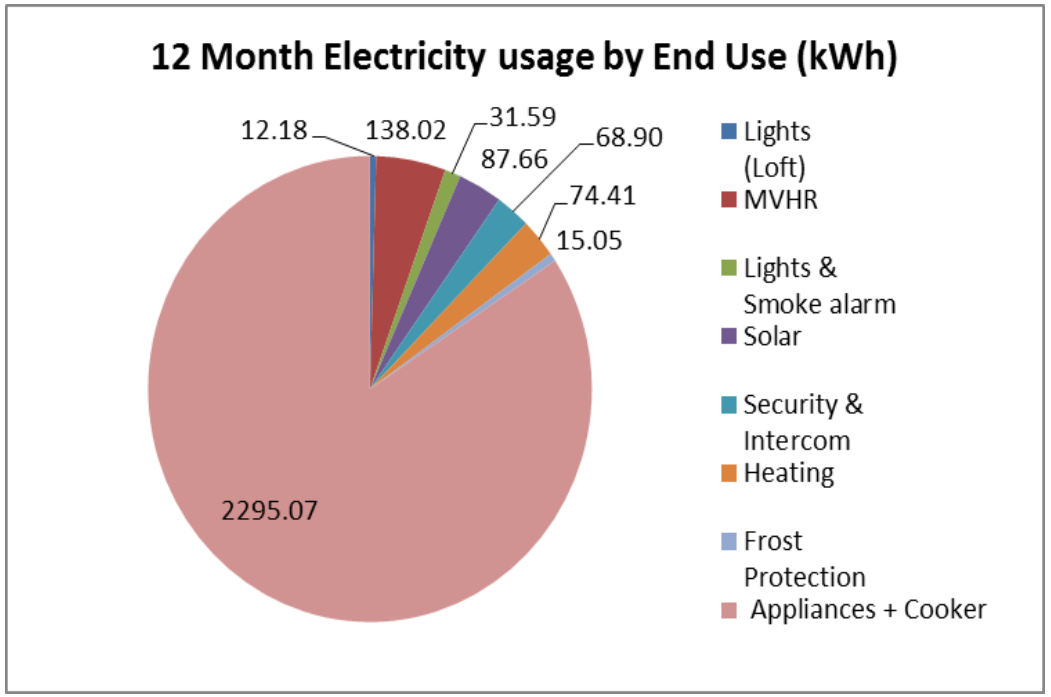
Data collection for 2 years

In-use energy performance

Space heating demand of **23.3 kWh/m²/year** which, although falling just short of Passivhaus intention, is still 84% less than UK average.

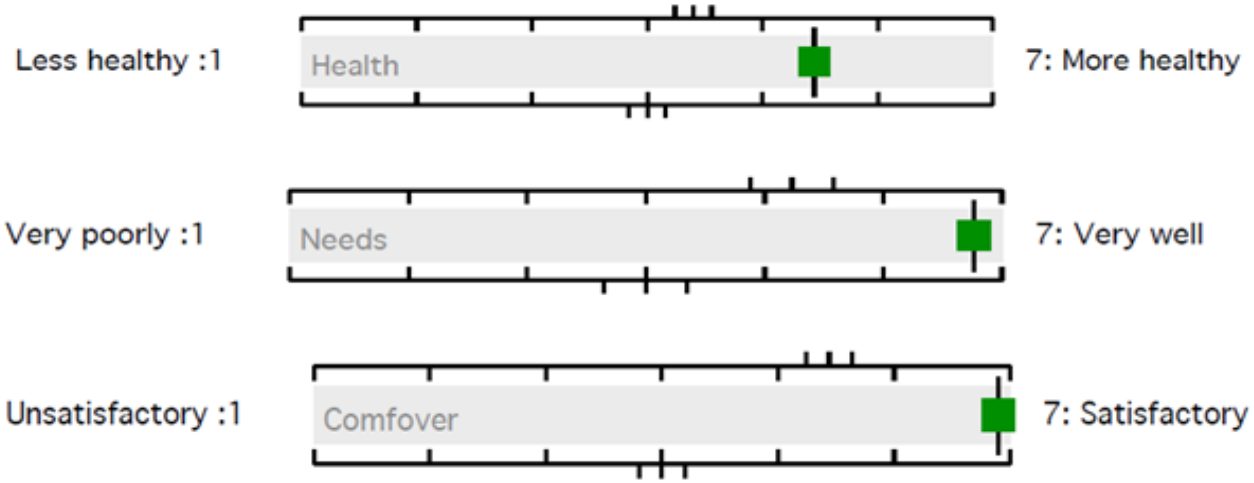
MVHR system was found to be balanced and operating effectively at both the beginning and end of the research (a span of 36 months).

Electricity use was dominated by appliances and socket-load. This energy use far exceeded that which was accounted for in design PHPP and contributed significant additional internal heat gains. These are occupant effects we **cannot control** but which affect lifetime performance.

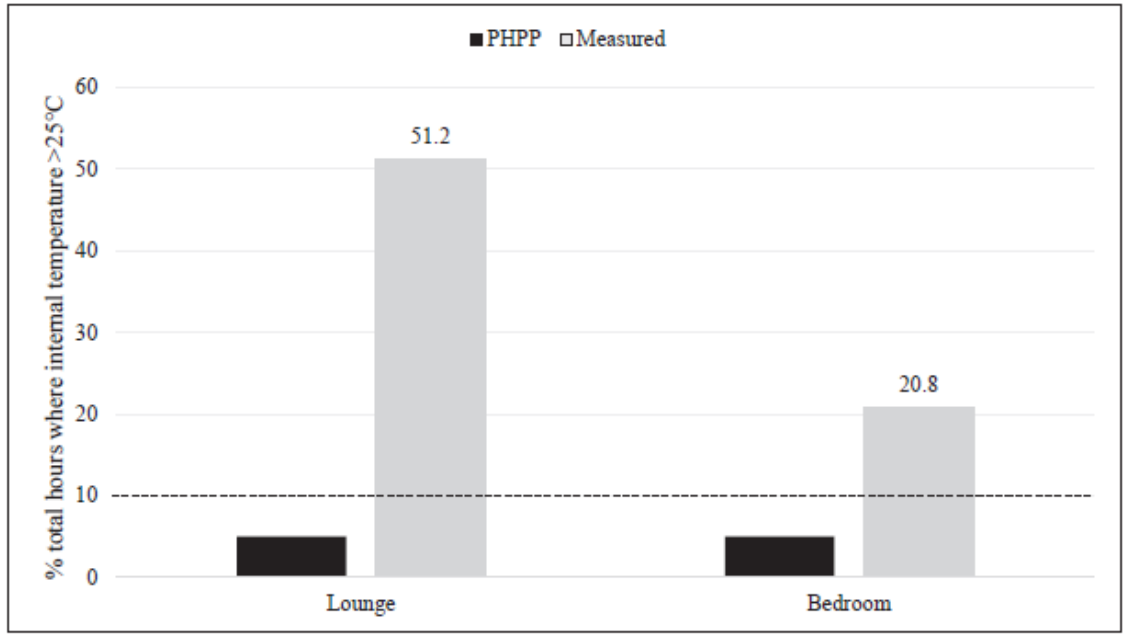


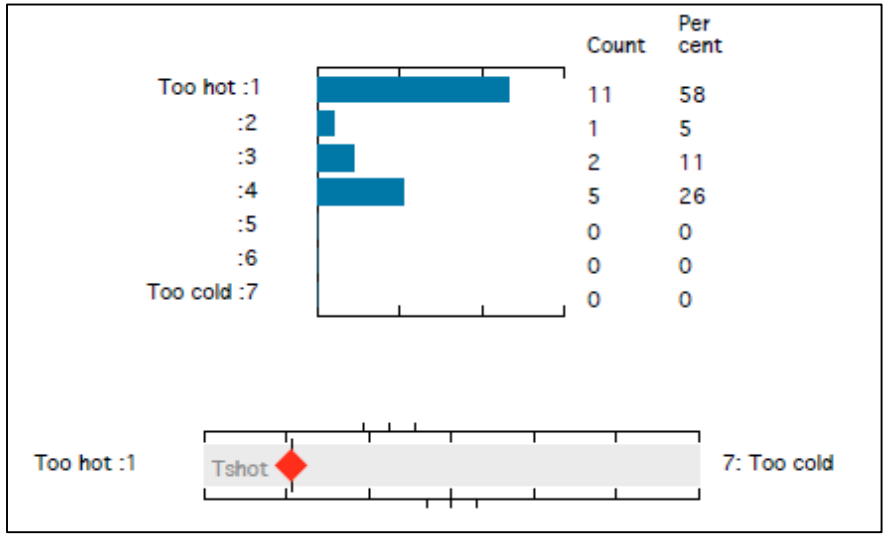
Can't comment on heating as we have never had heating on since we moved in.

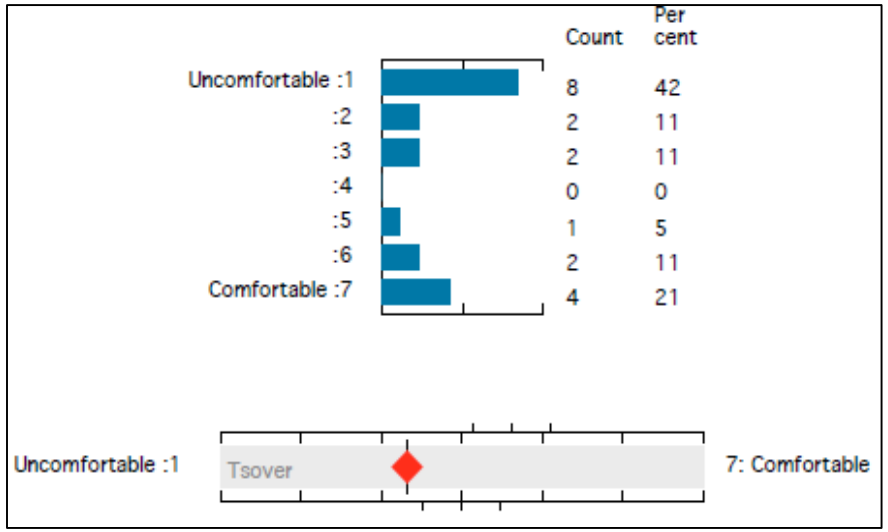
The bungalow has helped enormously health-wise.



One recurring complaint from occupants was that the home was often too hot, with data indicating significant exceedance of the PHPP 25°C threshold.







When questioned further, it emerged that guidance around MVHR use, to keep windows and doors closed to retain heat, had been misinterpreted.

Residents were leaving their MVHR in heat recovery mode all summer and avoiding opening windows and night-purging.

Control Unit For MVHR

This button is the **Control Unit** for **Mechanical Ventilation Heat Recovery**.

This is located inside your drying cupboard.

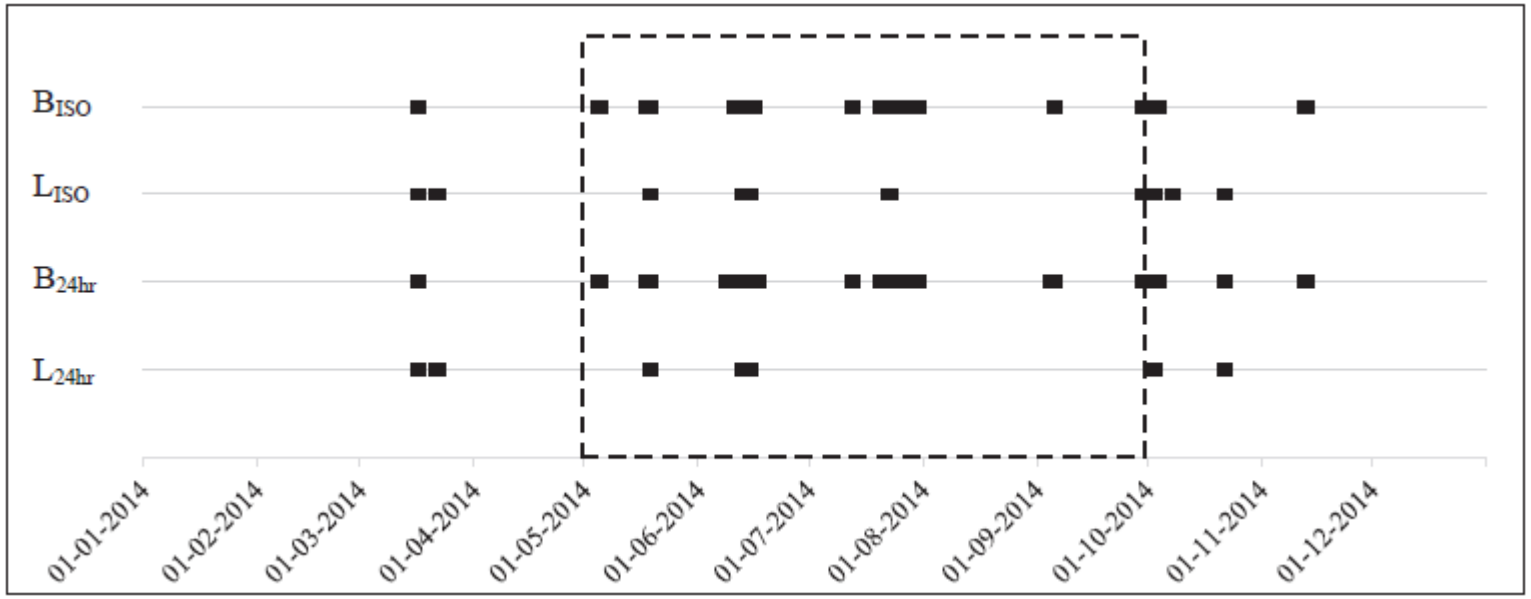
This control **SHOULD NOT** be altered, as the system is set-up with the correct settings for your property.

When it is summer and you are not heating your home, the windows can be opened and the mechanical ventilation heat recovery system (MVHR) can be switched to 'extract-only' when needed to ventilate the bathrooms or kitchen.

Dos and don'ts:

Do keep your windows closed as much as possible

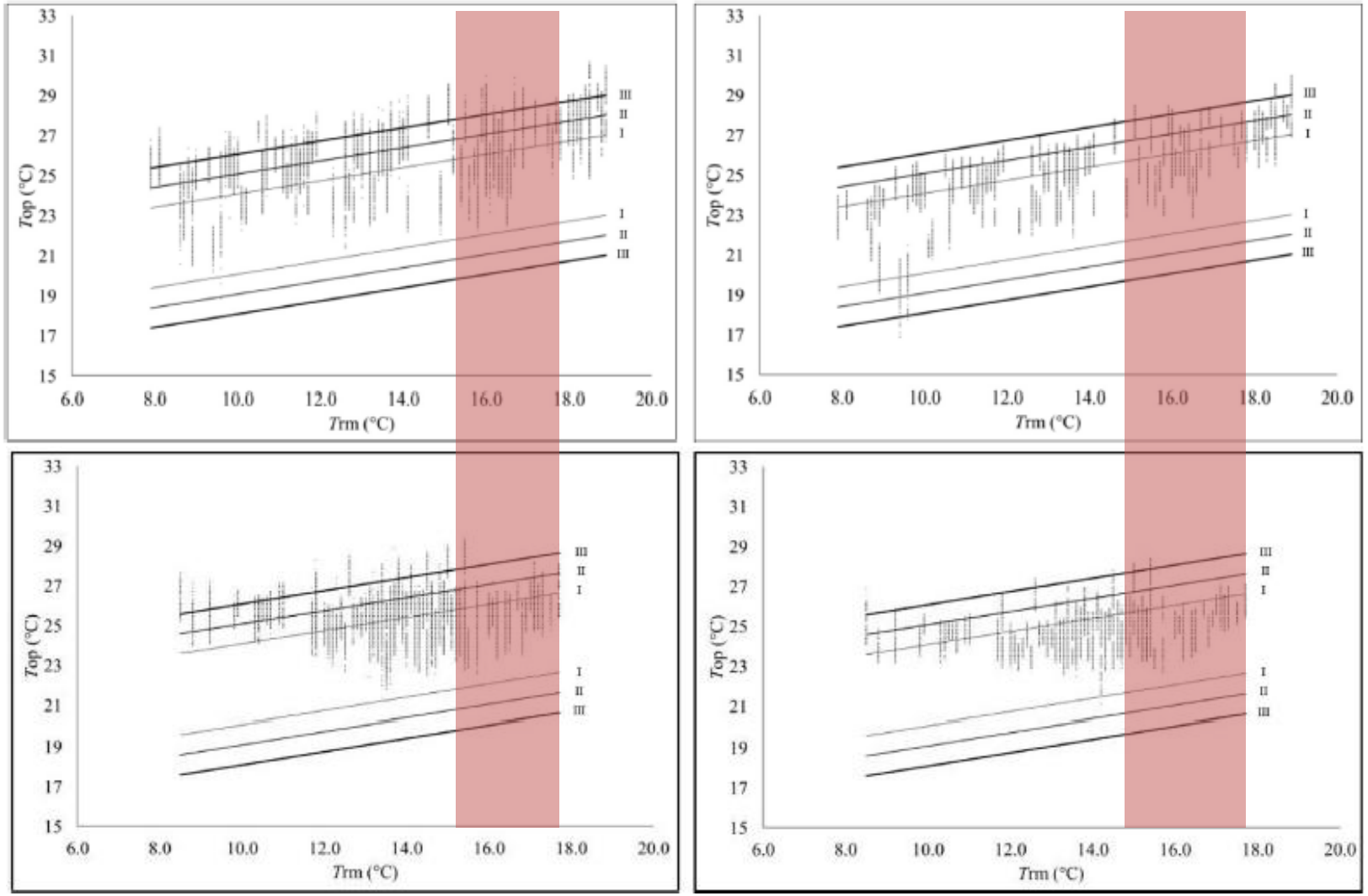
There was also evidence of overheating **outside summer months** caused by high internal gains and occupant behaviour.



Overheating Analysis

Leeds Sustainability Institute

Updated guidance to open windows and use MVHR boost mode during summer led to a reduction in overheating events.



2013

2014

Lounge

Bedroom

Conclusions

Even with “perfect” fabric performance, it is important to do POE and monitoring to make sure the prediction of *in situ* performance matches reality.

As designers and architects, doing a good job during construction is only half of the story.

It is important to check assumptions around occupant **energy use** and **behaviour** to ensure that all of the effort put into building design and construction is not undermined.

When built and operated properly, Passivhaus works!

Project Publications:

Fletcher, M., Johnston, D., Glew, D., Parker, J (2017) An empirical evaluation of temporal overheating in an assisted living Passivhaus dwelling in the UK *Building and Environment*, 121, p. 106-118, UK

Parker, J., Fletcher, M., Johnston, D. (2016) Predicting future overheating in a Passivhaus dwelling using a calibrated dynamic thermal simulation models, *Sustainable Ecological Engineering Design for Society (SEEDS) Annual Conference*, Leeds, UK

Johnston, D., Fletcher, M. (2013) TSB BPE Project 450070 Phase 1 Final Report: Post-Construction and Initial Occupation, Technology Strategy Board/Leeds Beckett University, UK

Johnston, D., Fletcher, M. (2015) TSB BPE Project 450070 Phase 2 Final Report: In-use Performance and Post Occupancy Evaluation, Technology Strategy Board/Leeds Beckett University, UK

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