InGlaze Secondary Glazing Test

Energy House Labs Test Report

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1 Introduction

This report provides the results of thermal performance measurements of the InGlaze secondary glazing system. The impact of applying InGlaze secondary glazing to a single glazed timber sash window was measured under controlled conditions at the University of Salford Energy House 1 test facility.

2 Methodology

2.1 Test facility

The Energy House 1 test facility contains the Energy House, a replica Victorian solid wall end-terrace house constructed within an environmental chamber. The Energy House was built using reclaimed materials and traditional construction methods and can be retrofitted to most fabric thermal performance standards. The chamber can replicate external air temperatures between -12 °C and +30 °C and simulate rainfall, wind, and solar radiation. The Energy House has a conventional hydronic central heating system with radiators in each room that is served by either a domestic gas condensing combination boiler or an air source heat pump. Its building automation control system enables simulation of occupant behaviour, such as window and door opening, lighting and appliance use, and domestic hot water (DHW) draw-offs. The Energy House shares a party wall with an adjoining building, referred to as Pemberton House. Environmental conditions in the chamber and Pemberton House can be controlled and repeated across multiple test periods. This makes it possible to measure the impact of changes on building fabric, space heating provision, and occupancy behaviour with greater confidence and speed than houses in the field. Pemberton House contains both a double glazed and a single glazed test window.

2.2 Test window

InGlaze secondary glazing was tested on the single glazed timber sash window in Pemberton House (Figure 1). The upper and lower sash windowpanes are 4 mm thick.

2.3 Centre pane in situ U-value measurements

2.3.1 In situ U-value and R-value measurement method

The centre pane in-situ U-Value and R-value of each windowpane was measured in accordance with ISO 9869:1 (ISO, 2014). Measurements were performed with no window covering (baseline) and with InGlaze secondary glazing installed using two different methods. Measurements were performed for each scenario for a minimum of 72 hours, with the final 24-hour period being the reporting period.

2.3.2 Environmental conditions

The internal temperature was maintained at 20°C using an electric resistance heater connected to a PID temperature controller. Between the heater and glazing, shielding was placed to reduce radiative heat gain incident on the glazing panel and HFPs. To perform the test within steady state conditions, the chamber blast chiller system was set to achieve and maintain 4.5 °C throughout the test period.

2.3.3 Measurement Equipment

Internal and external temperature measurements were made using Campbell Scientific Hygrovue 10 sensors (±0.1 °C)[1]. Heat flux measurements were made using a Hukseflux HFP01 (±3%)[2] heat flux

[1] (*HygroVUE10 - Digital Temperature and Relative Humidity Sensor with M12 Connector*, 2024)

[2] (*HFP01 Heat Flux Plate | Hukseflux | the World's Most Popular Heat Flux Sensor*, 2023)

plates (HFPs). HFPs were fixed using tape to the centre of each glazing panel with thermal contact paste between the HFP and glazing. The data was collected at 1-minute intervals using a Campbell CR1000X data logger.

Figure 1 – Single glazed test window. Internal (left). Centre pane heat flux plates circled. The heat shield and internal temperature sensor (located out of frame) are denoted by the blue arrow. External (right). Temperature sensor circled.

2.4 InGlaze secondary glazing tests

InGlaze was tested under two installation scenarios:

1. A single secondary glazing panel covering the entire window assembly was fitted to the window frame by InGlaze. This installation method does not allow the window to be opened.
2. A secondary glazing panel applied to each sash by the Energy House Labs research team[3]. This scenario allows the window to be opened.

3 Results

Test results are provided in Table 1 and Figure 2.

Table 1: Centre pane in-situ U-value and R-value measurements.

Test	U-Value [W/m²K]	U-value change on baseline [W/m²K]	U-value change on baseline [%]	R-value [m²K/W]	R-value change on baseline [m²K/W]	R-value change on baseline [%]
Baseline	4.79 (±0.32)	-	-	0.21 (±0.01)	-	-
Whole window	2.38 (±0.16)	-2.40 (±0.35)	-50 (±8)%	0.42 (±0.03)	+0.21 (±0.03)	+101 (±16)%
Individual sash	2.82 (±0.19)	-1.97 (±0.37)	-41 (±8)%	0.35 (±0.02)	+0.15 (±0.03)	+70 (±14)%

3 InGlaze were unable to visit the test facility to install their system on each sash. Installation instructions were provided to the research team during their initial visit.

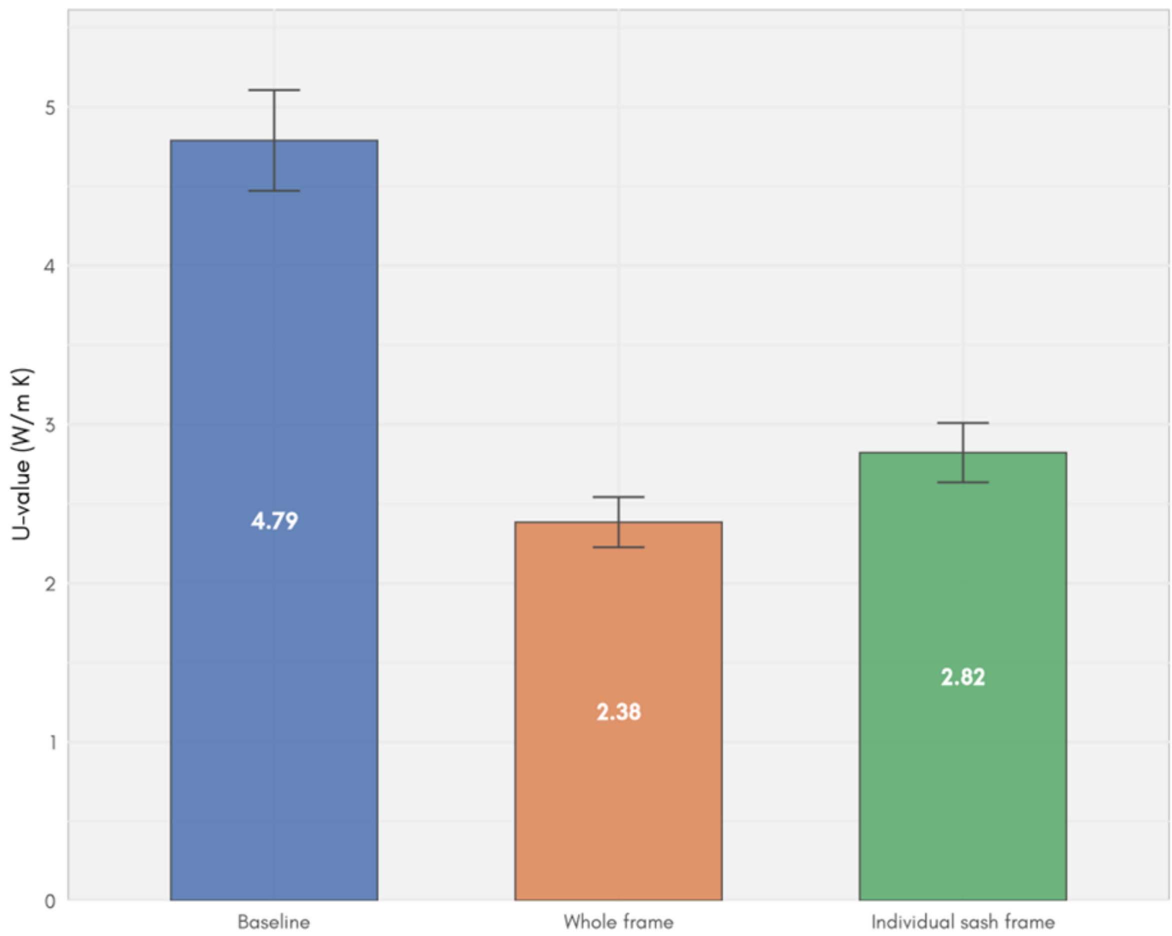


Figure 2: Centre pane in-situ U-value measurements

Installing InGlaze to the entire window resulted in a centre pane in-situ U-value of 2.38 (±0.16) W/m^{2}K, which is a 2.40 (±0.35) W/m^{2}K (50 (±8)%) reduction from the baseline centre pane U-value of 4.79 (±0.32) W/m^{2}K.

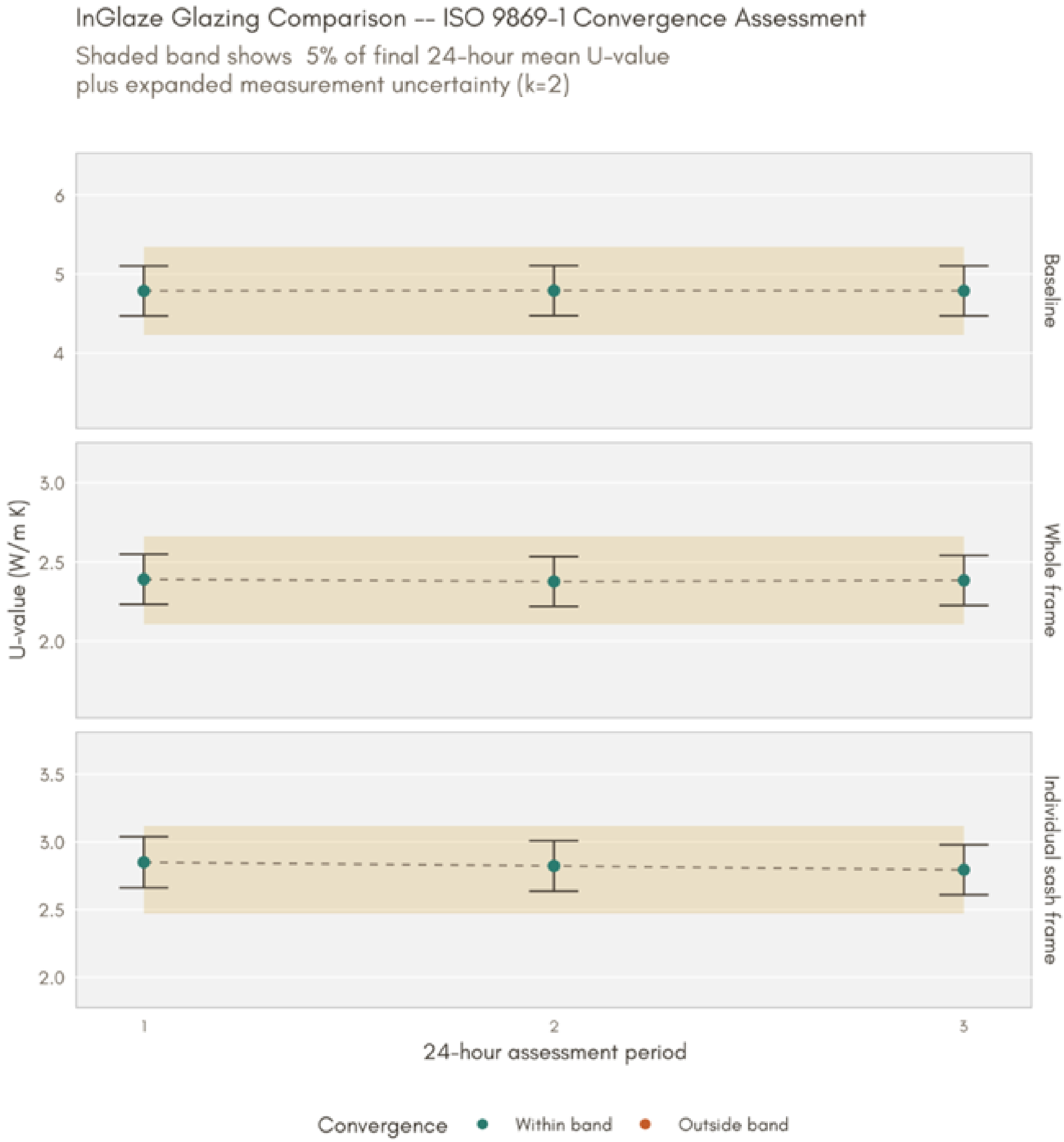
Fitting InGlaze to each sash resulted in a centre pane in-situ U-value of 2.82 (±0.19) W/m^{2}K, which is a 1.97 (±0.37) W/m^{2}K (41 (±8)%) reduction from the baseline centre pane U-value.

4 Summary

Measurements performed under controlled conditions found that the application of InGlaze secondary glazing reduced heat loss through single glazing by 50% when applied to the entire window and by 41% when applied to each sash. The lower performance when applied to each sash could be due to it being fitted by an inexperienced installer, or differences in the size of the air gap between original and secondary glazing.

It must be noted that the values reported represent the heat loss through the centre of the glazing panels and not the whole window assembly. Furthermore, installing secondary glazing to individual glazing panels may result in lower airtightness benefits than applying secondary glazing to the entire window reveal.

Appendix A - 24-hour Average Centre Pane U-Value



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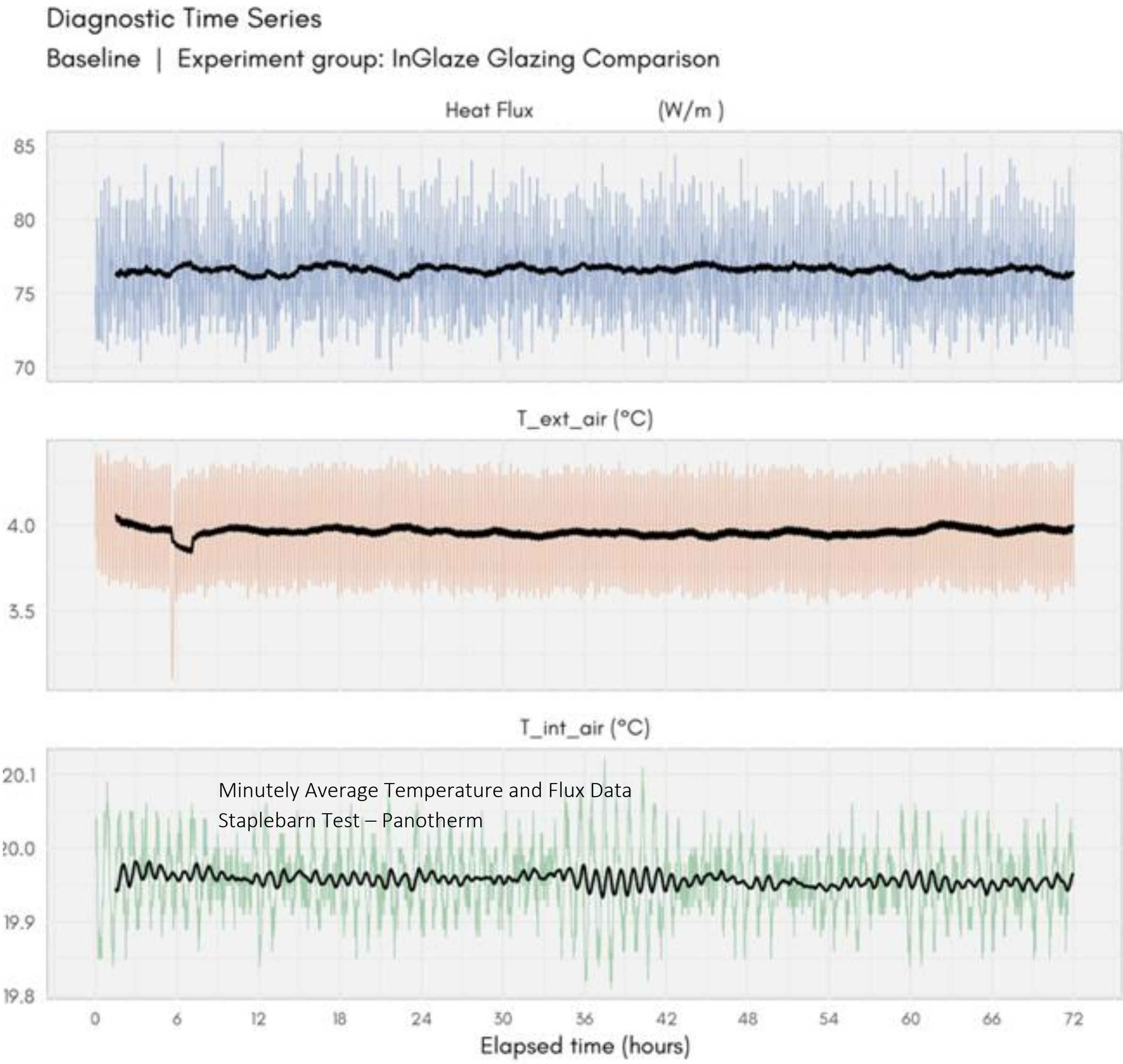
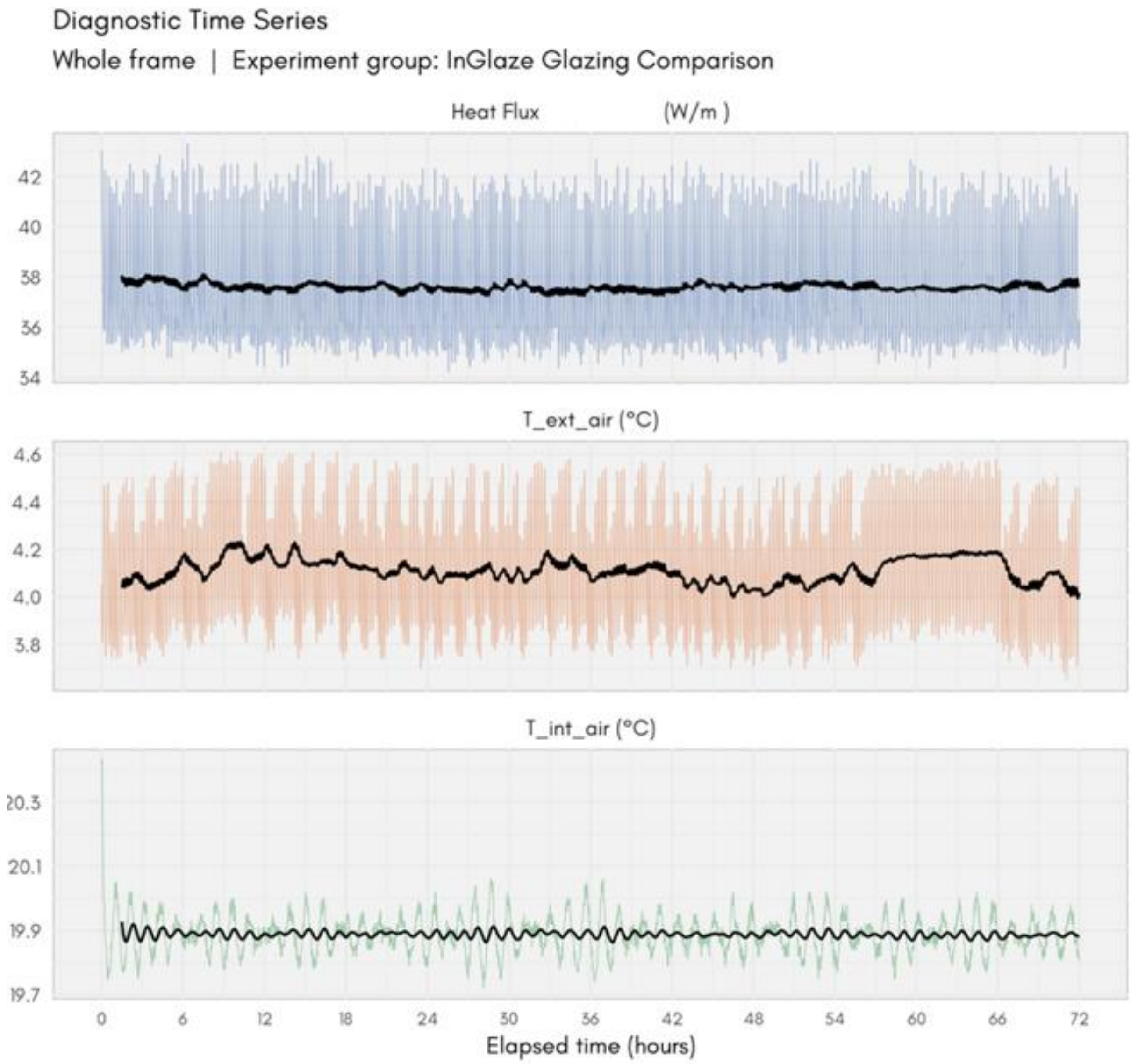
Appendix B - 72h Temperature and Heat Flux Plots



Minutely Average Temperature and Flux Data
Staplebarn Test – Panotherm


Diagnostic Time Series
Whole frame | Experiment group: InGlaze Glazing Comparison
Heat Flux (W/m)
42
40
38
36
34
T_ext_air (°C)
4.6
4.4
4.2
4.0
3.8
T_int_air (°C)
20.3
20.1
19.9
19.7
0
6
12
18
24
30
36
42
48
54
60
66
72
Elapsed time (hours)

Diagnostic Time Series
Individual sash frame | Experiment group: InGlaze Glazing Comparison
Heat Flux (W/m)
47.5
45.0
42.5
T_ext_air (°C)
4.50
4.25
4.00
3.75
T_int_air (°C)
20.1
20.0
19.9
19.8
0
6
12
18
24
30
36
42
48
54
60
66
72
Elapsed time (hours)

Appendix C – In-situ U-value measurement method

In-situ U-value measurements of each thermal element were undertaken in accordance with ISO 9869-1. The thermal transmittance of a building element (U-value) is defined in ISO 7345[4] as the *"Heat flow rate in the steady state divided by area and by the temperature difference between the surroundings on each side of a system"*. To account for thermal storage and release, ISO 9869-1 uses a cumulative moving average of the heat flow rate and ΔT to calculate in-situ U-values. However, steady state conditions at the Energy House allows in-situ U-values to be calculated as defined by ISO 7345 using the following equation.

$$U = \frac{q}{\Delta T}$$

Where:

U = in-situ U-value (W/m^{2}K)

q = 24-hour mean heat flow rate (W/m^2)

ΔT = 24-hour mean internal to external air temperature difference (K)

The heat flow rate was measured using Hukseflux HFP-01 heat flux plates (HFPs). The HFPs were affixed to centre of glazing panels using adhesive tape and thermal contact paste. Care was taken to ensure that HFPs were not unduly influenced by excessive air movement by positioning air circulation fans in such a way that air was not blown directly on to the HFPs.

The ΔT for each in-situ U-value measurement was calculated using the internal and external air temperature differential measured in the vicinity of each HFP.

In-situ U-value uncertainty

ISO 9869 applies an uncertainty value of 14-28% to in-situ U-value measurements. However, this uncertainty is based on measurements undertaken in the field without control of external conditions. The ISO 9869 uncertainty calculation was modified for the controlled environment and to include type A and type B uncertainties. Full details of the uncertainty calculation method can be found in Henshaw *et al* (2024)[5].

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[4] ISO (1987) ISO 7345: Thermal insulation –Physical quantities and definitions. Geneva, Switzerland, International Organization for Standardisation.

[5] https://doi.org/10.1016/j.enbuild.2024.114794

References

Henshaw, G., Deyranlou, A., Rimmer, K., Hernandez, H. P. D., Fitton, R., & Keshmiri, A. (2024). Experimental and computational assessment of an energy-saving innovation in a customised testing cabin. *Energy and Buildings*, *323*, 114794. https://doi.org/10.1016/j.enbuild.2024.114794

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