Measured indoor air temperatures, heat flux and power consumption in two unoccupied, electrically heated dwellings during two winters

Dataset descriptor

2024

(Version 1.0)

Citation information:

Please cite this document and/or the accompanying data/files as:

Eastwood, Max; Roberts, Ben M; Li, Matthew; Allinson, David (2024). Measured indoor air temperatures, heat flux and power consumption in two unoccupied, electrically heated dwellings during two winters. Loughborough University. Dataset. https://doi.org/10.17028/rd.lboro.26048944

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Version	Amendment	Page	Editor	Date
1.0	First release	N/A	ME	07/08/24

1 Introduction

This document provides details of the measurement of indoor dry bulb temperatures, heat flux, power consumption and surrounding weather conducted in the Loughborough Matched Pair test houses during winters 2021/22 and 2022/23.

Detailed descriptions of the test house floorplans, site plans, geometry, construction, windows, window coverings are available elsewhere (Roberts et al. 2019).

1.1 Document Aim

The aim of this guidance document is to provide the necessary information to allow other researchers to understand and use the dataset for their own research purposes. It accompanies further information in Roberts et al. 2018, 2019, 2022a, 2022b.

2 Measurement of indoor temperatures, heat flux and power consumption

The Loughborough Matched Pair test houses were used for all measurements of indoor temperature, heat flux and power consumption (Figure 1). Monitoring of the variables took place simultaneously in both houses over 2 winters; from 16 December 2021 to 19 May 2022 and 1 November 2022 to 15 May 2023 (inclusive).

Figure 1: The Loughborough Matched Pair. The West house is on the left of the photograph, the East house on the right.

Details of test house location, description, geometry, site plan, construction, and airtightness has been provided previously (see Roberts et al. 2018, 2019, 2022a, 2022b). Prior to data collection, the airtightness of the test houses was measured by fan depressurisation and pressurisation (blower door test), as described in Eastwood et al. (2023).

Co-heating tests were undertaken in both dwellings simultaneously, to provide a benchmark measured HTC. The set-up and results of the co-heating tests are presented by Eastwood et al. (2023), and the data for which are included within this publication.

The two test houses were unoccupied during the monitoring: no windows or external doors were opened. The two test houses were heated to different indoor conditions, over 7 phases across the two heating seasons.

2.1 Sensors, locations, and monitoring periods

2.1.1 Measurement of indoor dry bulb temperatures

Measurement of dry bulb temperature was conducted in all rooms, and in the centre of both loft (attic) spaces using U-type thermistors calibrated in a water bath against a calibrated thermometer. To measure dry bulb temperature, the thermistors were hung on a tripod and shielded from solar radiation.

Additional U-type thermistors were placed beneath the floors of both dining rooms and kitchens, and within the party wall cavity (see Table 2 for data collection dates).

2.1.2 Measurement of heat flux

Measurement of heat flux was conducted using heat flux plates (HFPs). HFPs were fixed onto the walls and floors of the test houses (locations shown in Figure 2) using double-sided tape, according to the manufacturer's specifications (Hukseflux, 2021). HFPs were placed in locations away from direct solar radiation and the uniformity of surfaces were verified using an infrared camera. Wallpaper was removed to ensure a good thermal contact between the wall and the HFP. Prior to installation, all HFPs were pair calibrated as a group.

2.1.3 Measurement of power consumption

Electricity consumption was measured at the electricity meters in each of the test houses, using a current clamp connected to a Plogg electricity metering plug. The current clamp was attached to the main incoming electricity cable. Additional Plogg electricity metering plugs were installed in every room of the test houses. This enabled electricity consumption to be monitored for individual rooms, as well as providing a back-up in case of gaps in the data recorded by the device at the meter.

Electricity consumption in all rooms was monitored for the duration of both heating seasons, with consumption at the meters commencing 24/02/2022 (at the start of experiment phase 2).

Table 1: Summary of indoor equipment used and uncertainty

Data type	Variable	Device	Measurement interval (mins)	Uncertainty (±)
Indoor temperature	Dry bulb	U-type thermistor connected via wire to DT85 DataTaker	10	0.3°C
Heat flux	Heat flux	Hukseflux HFP01 Heat Flux Plate connected wirelessly via Eltek GS44H transmitters to Eltek RX250AL datalogger	10	±6%
Power	Power consumption	Plogg electricity metering plugs	10	±1%

2.1.4 Measurement of weather conditions

Weather data were measured in the gardens of the test houses (Table 2 and Table 3).

Table 2: Weather stations

Station name	Station code	Location	Data from	Data to	Variables measured
Test house	TH	Ground-mounted on a 10m high pole in the north-facing garden to the rear of the test house.	01/06/2022 [a]	30/09/2022	Dry bulb temperature; wind speed; wind direction; global horizontal irradiance.

Table 3: Weather data collection devices, measurement intervals, and uncertainty

Data type	Device	Units	Measurement interval	Height from ground (m)	Uncertainty (±)
Dry bulb temperature	U-type thermistor [a]	°C	20 seconds	1.1	0.3°C
Wind speed	Ultrasonic anemometer	m/s	20 seconds	10	2%
Wind direction	Ultrasonic anemometer	°	20 seconds	10	3°
Global horizontal solar irradiance	Pyranometer	W/m^2	20 seconds	10	5%

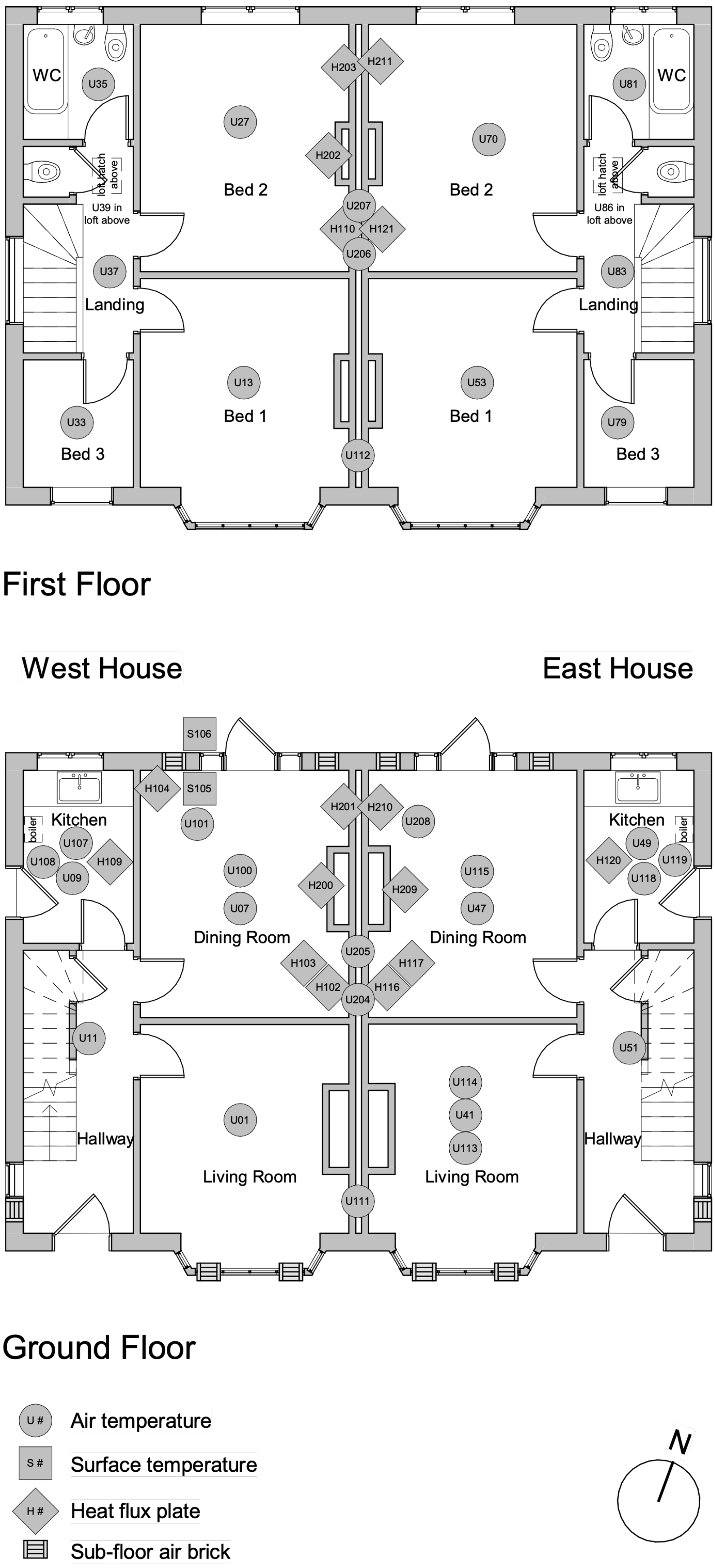

Figure 2: Floorplan with sensor locations. Refer to Table 4 for information on sensor height from floor.

Table 4: Description of sensor locations and data periods. Sensor codes correspond to Figure 2.

Room	Sensor Type	Location in room	Height from floor (m)	West House		East House	
				Sensor code	Season used	Sensor code	Season used
Living room	U	Centre	1.1	U01	1,2	U41	1,2
	U	Centre	0.1	-		U113	1
	U	Centre	2.2	-		U114	1
	U	Party wall cavity	0.5	U111	1,2	-	
	P	Wall socket	n/a	P302	1,2	P311	1,2
Dining Room	U	Centre	1.1	U07	1,2	U47	1,2
	U	Centre, sub-floor	-0.2	U100	1	U115	1,2
	U	NW Corner	1.1	U101	1	U208	2
	U	Party wall cavity	0.5	U204	2	-	
	U	Party wall cavity	1.8	U205	2	-	
	S	NW Corner, internal	1.1	S105	1,2	-	
	S	NW Corner, external	1.1	S106	1,2	-	
	H	Party wall	1.5	H102	1,2	H116	1,2
	H	Floor	0	H103	1	H117	1
	H	External wall (NW)	1.1	H104	1	-	
	H	Party wall	1.5	H200	2	H209	2
	H	Party wall	1.5	H201	2	H210	2
	P	Wall socket	n/a	P303	1,2	P312	1,2
Kitchen	U	Centre	1.1	U09	1,2	U49	1,2
	U	Centre, sub-floor	-0.1	U107	1	U118	1,2
	U	Perimeter, sub-floor	-0.1	U108	1	U119	1,2
	H	Floor	0	H109	1	H120	1
	P	Wall socket	n/a	P304	1,2	P313	1,2
Hall	U	Centre	1.1	U11	1,2	U51	1,2
	P	Electricity meter	n/a	P300	1,2	P301	1,2
	P	Wall socket	n/a	P305	1,2	P314	1,2
Front bedroom	U	Centre	1.1	U13	1,2	U53	1,2
	U	Party wall cavity	0.5	U112	1,2	-	
	P	Wall socket	n/a	P306	1,2	P315	1,2
Rear bedroom	U	Centre	1.1	U27	1,2	U70	1,2
	U	Party wall cavity	0.5	U206	2	-	
	U	Party wall cavity	1.8	U207	2	-	
	H	Party wall	1.5	H110	1,2	H121	1,2
	H	Party wall	1.5	H202	2	-	
	H	Party wall	1.5	H203	2	H211	2
	P	Wall socket	n/a	P307	1,2	P316	1,2
Single bedroom	U	Centre	1.1	U33	1,2	U79	1,2
	P	Wall socket	n/a	P308	1,2	P317	1,2
Bathroom	U	Centre	1.1	U35	1,2	U81	1,2
	P	Wall socket	n/a	P309	1,2	P318	1,2
Landing	U	Centre	1.1	U37	1,2	U83	1,2
	P	Wall socket	n/a	P310	1,2	P319	1,2
Loft	U	Centre	1.1	U39	1,2	U86	1,2

2.2 Experiment phases and heating conditions

Across the two heating seasons, the two test houses were heated to different conditions over seven experiment phases (Table 5). One of three heating conditions were imposed on either of the test houses at any given time: constant-25, bi-modal and free-running.

Table 5: Experiment phase dates and heating conditions imposed on the two test houses

Phase	Heating Season	Start Date	End Date	Heating conditions in each test house	
				West House	East House
P1	1	14/01/2022	24/02/2022	constant-25	constant-25
P2		24/02/2022	17/03/2022	constant-25	free-running
P3		23/03/2022	20/05/2022	constant-25	constant-25
P4	2	31/10/2022	24/01/2023	constant-25	constant-25
P5		01/02/2023	08/03/2023	bi-modal	bi-modal
P6		14/03/2023	18/04/2023	constant-25	constant-25
P7		22/04/2023	16/05/2023	constant-25	free-running

Under constant-25 conditions, electric heaters and fans are used to maintain a continuous, elevated, homogeneous indoor air temperature of 25ºC throughout the test house for the duration of the experiment phase. These conditions represent those used when undertaking a co-heating test, as defined by (Johnston et al., 2013).

Under bi-modal conditions, a test house is heated twice daily - between 07:00 and 09:00, and between 18:00 and 23:00, as per the schedule defined by SAP 10 (BRE, 2022). The heating set points, also defined by SAP 10, are 21ºC for the living area and 19ºC for the rest of the test house.

Under free-running conditions all purpose-provided heating was switched off, replicating a vacant dwelling. The monitoring equipment used to measure the conditions within a test house in free-running mode still provided some heat gains, but these were deemed negligible compared to the internal gains during either of the other two heating conditions.

3 Format of data release

File formats for data release are provided (Table 6). The files are listed in the README included with the dataset.

Table 6: Guide to file format for data release

Data type	Code	Example
Winter 2021/22	W1	“W1_...”
Winter 2022/23	W2	“W2_...”
West house (dry-bulb temperature, heat flux and power consumption)	West	“…_West_...”
East house	East	“…_East_...”
Weather conditions	Weather	“…_Weather_...”
Measurement at 10-minute intervals	10minute	“…_..._10minute”
Measurement at 20-second intervals	20second	“…_..._20second”

4 Acknowledgements

The monitoring work was funded by Max Eastwood’s PhD, as part of the EPSRC and SFI Centre for Doctoral Training in Energy Resilience and the Built Environment (ERBE) (grant EP/S021671/1).

The monitoring equipment was funded from various sources including, The London-Loughborough (LoLo) EPSRC Centre for Doctoral Training in Energy Demand (grant EP/H009612/1 and EP/L01517X/1), and the Digital Energy Feedback and Control Technology Optimization (DEFACTO) project, which was also funded by the EPSRC (grant EP/K00249X/1).

The contributions of the following technical staff in the School of Architecture, Building and Civil Engineering at Loughborough University are acknowledged: Mark Harrod, Neil Parkes and Dean Sanham.

Use of the test houses would not be possible without the ongoing maintenance and 24-hour security provided by Loughborough University.

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