Appendix A. Dwelling survey pro-forma

Ref	Address					Front faces:		Date:
Approx age		Weather				Ext temp:		Int temp:
Property type		B to B	Terr	End Terr	Semi	Det	Flat	Maisonette
Storeys & heights		Basement		GF	FF	2F		Conditioned volume
Approx floor areas								0 m3

Estimated original external wall U-value

Intervention:

Walls	External	1		2	
	Party	LHS	RHS	Rear	Extend to ridge?
	Extension	1		2	
	Bay	1		2	
	Dormer	1		2	
	Internal	1		2	

Chimney breasts: flue used / not used ; flues vented N / Y / where?

Relationship external ground level to internal floor level

DPC presence type position

Wall insulation	External walls: External wall/intermediate floor treatment: Lower bay walls: Window reveals: Party walls: Int walls jn with ext: Chimney breasts: External walls/ground floor treatment: Basement walls: Stair spandrel with basement: Stair soffit over basement: Dormer apron: Dormer cheeks:
Floors	Floor joists run: To party walls. Front to rear Ground floor over basement: Ground floor suspended timber over void: Stair soffit over basement stair:
Floor insulation	Ground floor over basement: Floor voids to external walls:
Roof & covering	Main: Main 2: Dormer: Extension 1: Bay: Extension 2: Extent of eaves overhang:
Roof void insulation	Noted on site: or As Spec: Not viewed: Verbal statement: Pitched, in line with rafters: Horizontal: Horizontal at eaves and at apex: Dormer soffits: Dormer apron: Dormer cheeks: Hatch to roof voids: Bay roof: Extension roofs:
Windows/doors	Replaced with: Windows: Front door: Fanlight: Rear door: Dormer: Door to basement:

Spot moisture meter readings			
Ground floor:	Front wall:	Front floorboard:	
	Rear wall:	Rear floorboard:	
	Party walls:		
	Chimneybreast front:	Chimneybreast sides:	
Basement:	Front wall:	Front ceiling:	
	Rear wall:	Rear ceiling:	
Upper floors:			

Heating / hot water / cooking							
Hob type:	gas	electric	Oven type:	gas	electric		
Shower:	Y N	Bath:	Y N				
Heating:	gas	electric	other		Boiler make:		Flue:

Walk round plan layout

Appendix B. Air tightness test reports

Air tightness test field reports

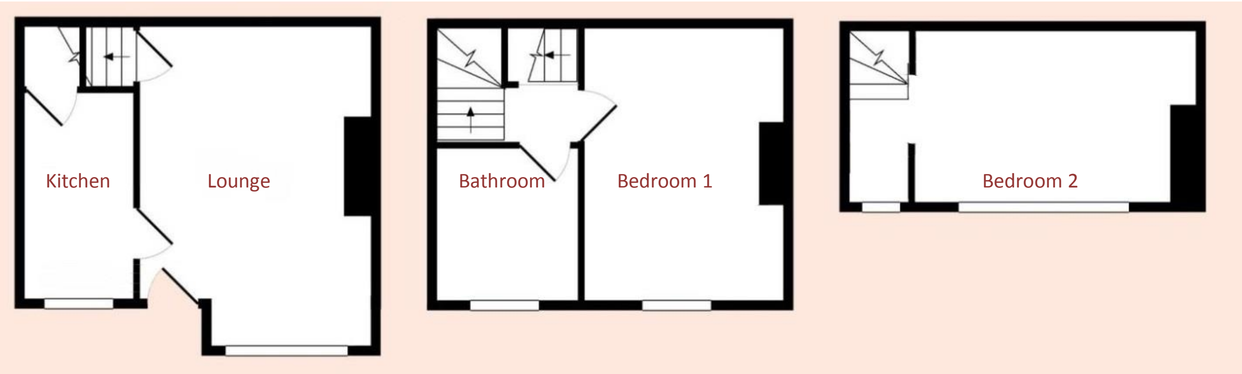
Dwelling C-01, before and after retrofit

Date of Tests: 26th February 2013 20th January 2014

Tested by: David Farmer, Martin Fletcher & Dominic Miles-Shenton

Compiled by: Dominic Miles-Shenton

Floorplan:



Ground Floor First Floor Second Floor

Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability	Air Change Rate	r2	Air Permeability	Air Change Rate	r2	Air Permeability	Air Change Rate
		m3/(h.m2) @ 50Pa	h-1 @ 50Pa		m3/(h.m2) @ 50Pa	h-1 @ 50Pa		m3/(h.m2) @ 50Pa	h-1 @ 50Pa
Dwelling C-01	26-Feb-13	15.34	19.07	0.998	18.2	22.63	0.995	16.77	20.85
	20-Jan-14†	6.25	7.78	1.000	6.60	8.21	1.00	6.43	7.99

† Dwelling volume and envelope area as previous test, these will need recalculating following a full measured survey on the refurbished property

Comments:

The post-refurbishment final mean air permeability of 6.43 m3/(h.m2) @ 50Pa showed a 62% reduction over the value obtained for the dwelling in its original condition and is testament to the level of application and attention to detail displayed throughout this project. The most noticeable reductions were observed at the ground floor and around service penetrations. Leakage detection was performed under dwelling depressurisation using thermography, with some additional leakage detection was performed in the cellar with the house pressurised and the cellar door closed.

Leakage Detection – 20th January 2014

Leakage Around Blower Door Frame

A small amount of air leakage persisted around the blower door frame itself, at the one bottom corner and at the top of the frame.

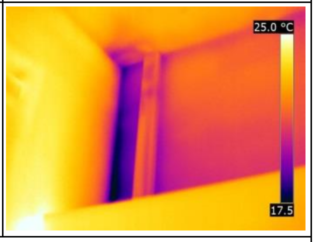


Kitchen

Some temporary sealing was applied at the base of the cellar door, but infiltration was observed at a number of areas around it. Air leakage was also detected around the extractor fan and at the window opening light. Some air movement could be distinguished at the external wall/ceiling junction into the intermediate floor void, but not at the vertical junctions. Air leakage through the ground floor was drastically reduced, and although some air could be observed emerging from beneath the plinth, very little was seen at the wall/floor junctions and around observable penetrations.



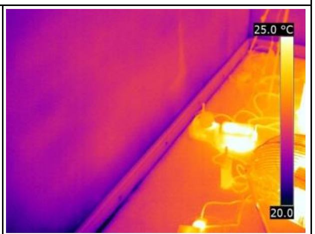




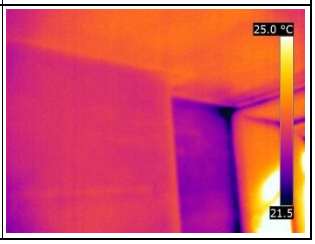

Lounge

Some air leakage was observed at more awkward junctions with the ground floor, but previously observed leakage through the floor itself and at the rear wall had been effectively eliminated. Air leakage around the internal wall insulation into the void behind the plasterboard was detected at a number of locations around the bay, with some direct infiltration at the TV socket and at the window head/frame junction.

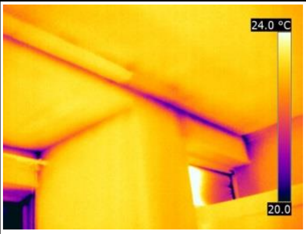


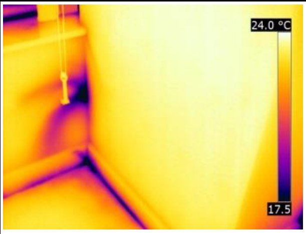








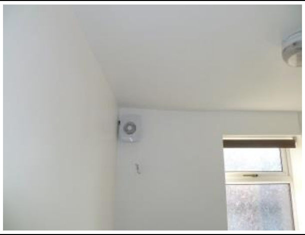
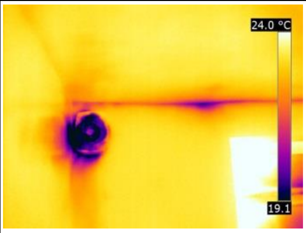



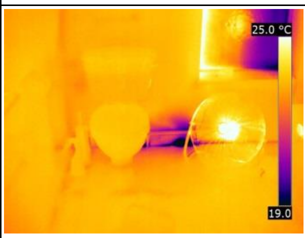
Stairs/1st Floor Landing
Air movement was observed, presumably entering from the cellar beneath.

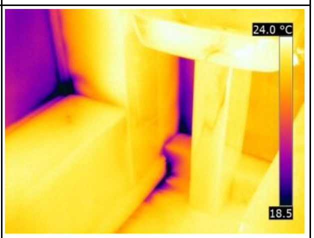


Bathroom
Air leakage was detected around the extractor fan and opening light of the window, and also at floor/external wall junction.

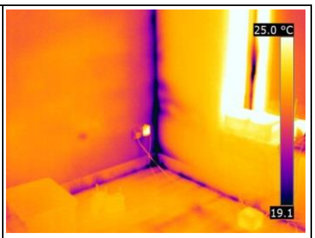


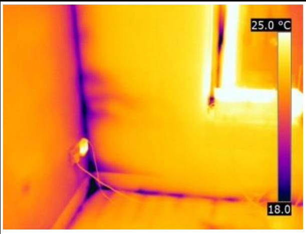


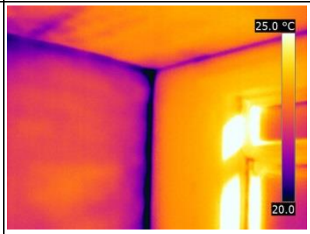



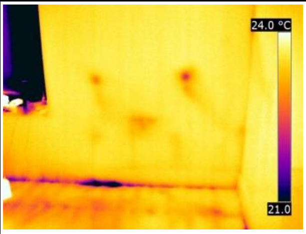
1st Floor Bedroom
A small amount of air leakage was observed at the floor junctions with the separating walls and the external wall. More significant infiltration was seen entering the void behind the plasterboard at the party wall/external wall junction and, to a lesser extent, at the ceiling junction with the external wall.
Air movement was also detected at small gaps around the window frame and at some isolated points on the external wall.
A slight difference could be seen on the ceiling between the areas directly underneath the 2nd floor bedroom and the roof void, although no direct air leakage paths could be observed.

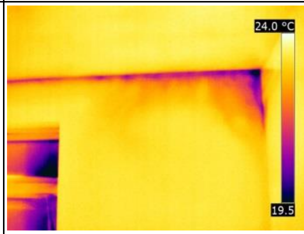


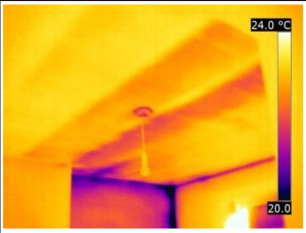


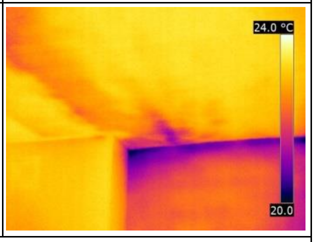



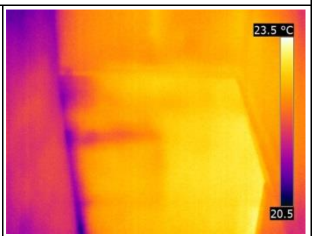



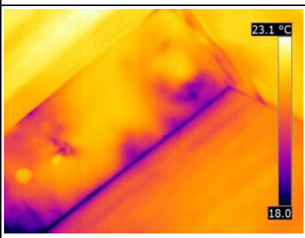



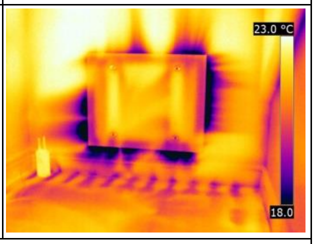
Stairs/2nd Floor Landing

Air movement was detected around the stairs (as in the lower stairs) but did not show up clearly under thermography as the infiltrating air was at a fairly ambient temperature. Some air leakage into the internal wall between the stairs and the 1st floor bedroom could be seen, and issues at the ceiling above the stairs were also made apparent. On the landing significant airflow could be seen around the access door to the roof void and between the floorboards directly adjacent to this up to the first floor joist. The airflow here was great enough to lift the landing carpet up off the floor.





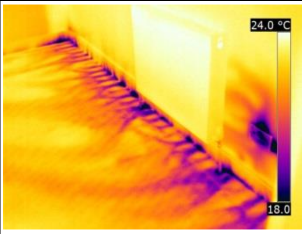



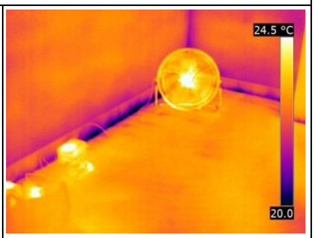



2nd Floor Bedroom

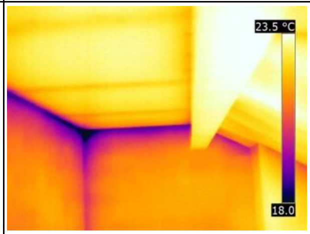
As on the landing, infiltration at the floor/knee wall junction was significant and lifted the carpet, flowing under the carpet and emerging elsewhere in the room at the floor perimeter. Some air could also be seen being drawn down from the central roof void into the internal wall adjacent to the stairs.

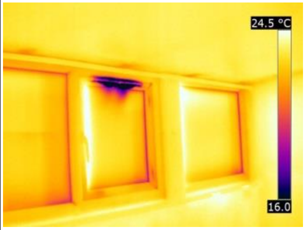
The new window performed very well apart from the trickle vent, which permitted air movement both through and around the closed vent. The final 2 thermal images highlight the difference between electrical pattresses on the rear separating wall and the knee wall backing on to the front roof void.

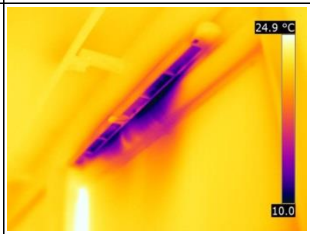



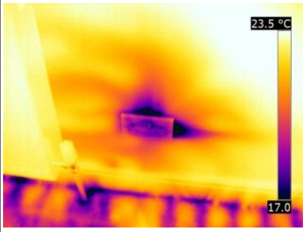







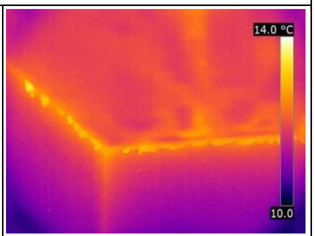



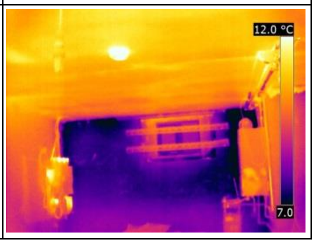

Cellar (under house pressurisation)

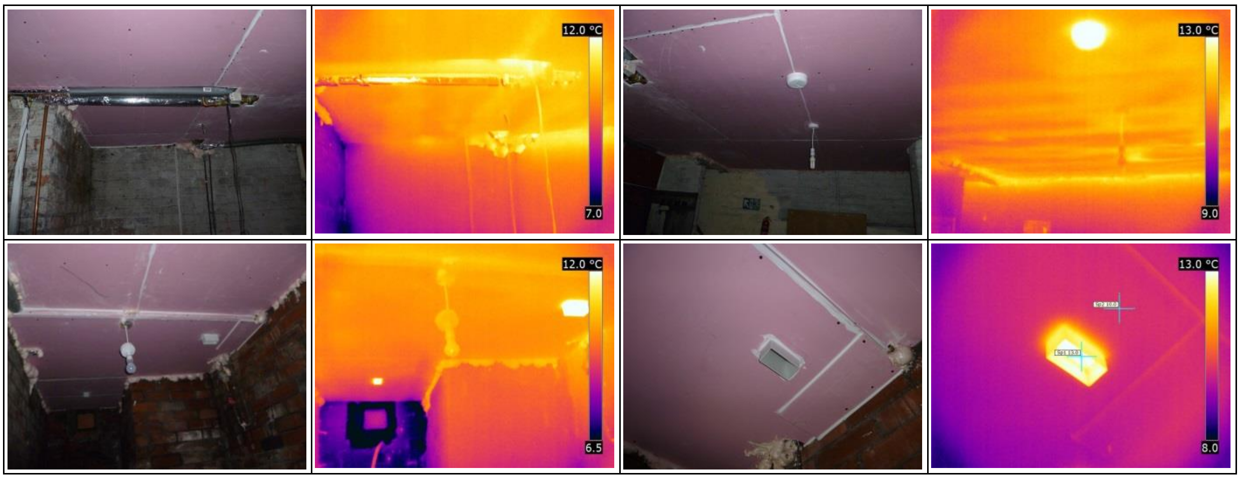
As no air leakage had been observed into the house through the gorund floor into the lounge and kitchen, a brief investigation was undertaken under dwelling pressurisation to see if warmer air could be seen being blown out to the house into the cellar. No signicant air movement was observed into the cellar around the perimeter or at service penetrations. A large thermal bridge was observed at the hearth, and warmed air entering the cellar through 2 ducts below the kitchen were the only noteworthy observations.











Results spreadsheets:

26th February 2013

MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

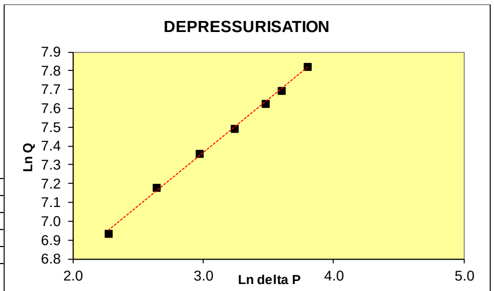
date:	26/02/2013	
test house address:	1	
company:	Latch Housing	
house type:	Back-to-back mid-terrace	
tester:	AS, DF, MP, DMS	
test reference number:		
outdoor temp (°C)	4.3	°C
indoor temp (°C)	21.4	°C
outdoor humidity (%rh)	78.1	%RH
indoor humidity (%rh)	36	%RH
outdoor barometric pressure	1044.1	mbar or hPa
indoor barometric pressure	1044.1	mbar or hPa
temperature corr. fact. depress.	0.942	WARNING!!
temperature corr. fact. press.	1.062	Extreme Test
wind speed (m/s):	1.8	Conditions
baseline pressure diff (Pa) (+/-)		Pa
house width:		m
house depth:		m
house height:		m
floor area:		m^2
volume:	144.105	m^3
envelope area including floor:	179.176	m^2
Pressure Difference for ELA	10	Pa
RESULTS:		
Q50 Mean Flow at 50Pa =	3004.20	m^3/h
Mean Air Leakage at 50Pa =	20.85	h^{-1}
Mean Air Permeability at 50 Pa =	16.77	m/h or m^3h/m^2
Equivalent Leakage Area =	0.139	m^2 at 10 Pa

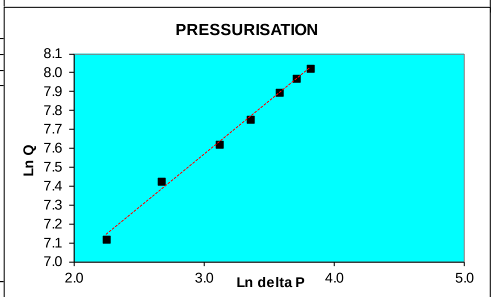
Version 15f 02 July 2010

Blower Door & Gauge Used	Model 3 with DG700	
Calculated Outdoor Air Density	1.31	kg/m^3
Calculated Indoor Air Density	1.23	kg/m^3

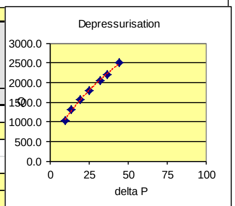
Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically

description of main construction details:
Cellar door partially sealed. Gas fire sealed at flue

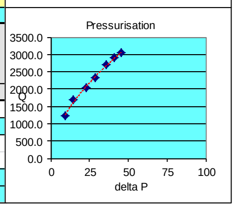




DEPRESSURISATION	RING (O=open or A,B,C,D,E)	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	A	44.5	2658	2501.3	OK	44.5	3.795	7.825	2747.91	15.34	19.07
Approx 57 Pa	A	36.6	2333	2195.4	OK	36.6	3.600	7.694	r^2	0.998	
Approx 49 Pa	A	32.4	2185	2056.1	OK	32.4	3.478	7.629	C_{env}	289.597	$m^3/h.Pa^n$
Approx 41 Pa	A	25.5	1905	1792.7	OK	25.5	3.239	7.491	n	0.566	
Approx 33 Pa	B	19.5	1675	1576.2	OK	19.5	2.970	7.363			
Approx 25 Pa	B	14	1397	1314.6	OK	14	2.639	7.181	C_L (corrected)	300.632	$m^3/h.Pa^n$
Approx 20 Pa	B	9.7	1094	1029.5	OK	9.7	2.272	6.937			



PRESSURISATION	RING (O=open or A,B,C,D,E)	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	A	45.7	2873	3053.0	OK	45.7	3.822	8.024	3260.48	18.20	22.63
Approx 57 Pa	A	40.9	2722	2892.6	OK	40.9	3.711	7.970	r^2	0.995	
Approx 49 Pa	A	35.8	2533	2691.7	OK	35.8	3.578	7.898	C_{env}	355.965	$m^3/h.Pa^n$
Approx 41 Pa	A	28.8	2187	2324.1	OK	28.8	3.360	7.751	n	0.563	
Approx 33 Pa	A	22.7	1922	2042.4	OK	22.7	3.122	7.622			
Approx 25 Pa	B	14.5	1579	1678.0	OK	14.5	2.674	7.425	C_L (corrected)	359.921	$m^3/h.Pa^n$
Approx 20 Pa	B	9.5	1163	1235.9	OK	9.5	2.251	7.120			



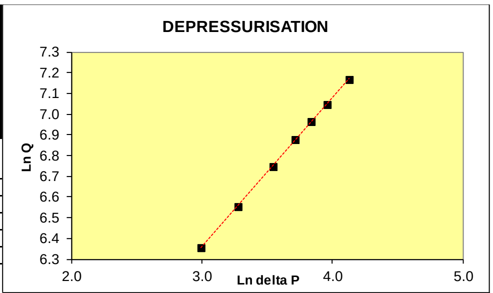
20th January 2014

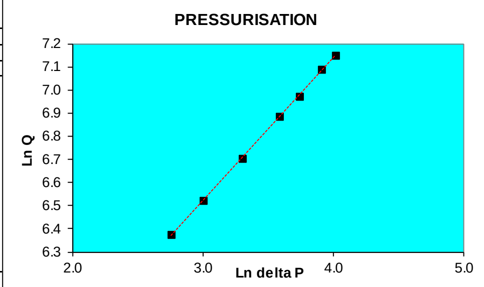
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

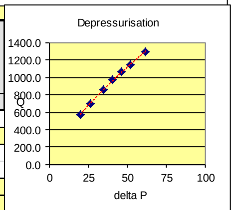
date:	20/01/2014		Version 16	22 October 2013
test house address:				
company:	Latch Housing			
house type:	Back-to-back mid-terrace			
tester:	DM, DF, MF			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	9.5	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	22.9	°C		
outdoor humidity (%rh)	63	%RH		
indoor humidity (%rh)	41.4	%RH		
outdoor barometric pressure	998.9	mbar or hPa	Calculated Outdoor Air Density	1.23 kg/m^3
indoor barometric pressure	999	mbar or hPa	Calculated Indoor Air Density	1.17 kg/m^3
temperature corr. fact. depress.	0.955	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.047	Extreme Test	Vol & env area from previous test - will need modifying following IWI and 2nd floor dormer window installation. Basement door sealed	
wind speed (m/s):	0.2	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house width:		m		
house depth:		m		
house height:		m		
floor area:		m^2		
volume:	144.105	m^3		
envelope area including floor:	179.176	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	1151.52	m^3/h		
Mean Air Leakage at 50Pa =	7.99	h^{-1}		
Mean Air Permeability at 50 Pa =	6.43	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.045	m^2 at	10	Pa

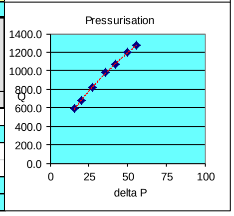
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^{3}h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	B	62.1	1359	1295.6	OK	62.1	4.129	7.167	1120.62	6.25	7.78
Approx 57 Pa	B	52.4	1207	1150.7	OK	52.4	3.959	7.048	r^2	1.000	
Approx 49 Pa	B	46.3	1112	1060.1	OK	46.3	3.835	6.966	C_{env}	65.924	m^3/h.Pan
Approx 41 Pa	B	40.9	1016	968.6	OK	40.9	3.711	6.876	n	0.723	
Approx 33 Pa	B	34.7	895	853.3	OK	34.7	3.547	6.749			
Approx 25 Pa	B	26.5	735	700.7	OK	26.5	3.277	6.552	C_L (corrected)	66.342	m^3/h.Pan
Approx 20 Pa	B	20	603	574.9	OK	20	2.996	6.354			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^{3}h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	B	55.5	1215	1274.4	OK	55.5	4.016	7.150	1182.41	6.60	8.21
Approx 57 Pa	B	49.8	1142	1197.9	OK	49.8	3.908	7.088	r^2	1.000	
Approx 49 Pa	B	42.2	1016	1065.7	OK	42.2	3.742	6.971	C_{env}	106.518	m^3/h.Pan
Approx 41 Pa	B	36.1	935	980.7	OK	36.1	3.586	6.888	n	0.618	
Approx 33 Pa	B	27.3	778	816.1	OK	27.3	3.307	6.704			
Approx 25 Pa	B	20.1	649	680.8	OK	20.1	3.001	6.523	C_L (corrected)	105.506	m^3/h.Pan
Approx 20 Pa	B	15.8	560	587.4	OK	15.8	2.760	6.376			









Dwellings C-02 and I-04, before retrofit

Tests Undertaken on: 30th September 2013

Tests Performed by: Dominic Miles-Shenton, Dr David Glew, Martin Fletcher, James Parker

C-02	I-04
	

Report Prepared by: Dominic Miles-Shenton

Results:

C-02					
Depressurisation Only		Pressurisation Only		**Mean**	
Air Permeability	Air Leakage Rate	Air Permeability	Air Leakage Rate	**Air Permeability**	**Air Leakage Rate**
$m^3/(h.m^2)$ @ 50Pa	h^{-1} @ 50Pa	$m^3/(h.m^2)$ @ 50Pa	h^{-1} @ 50Pa	**$m^3/(h.m^2)$ @ 50Pa**	**h^{-1} @ 50Pa**
22.87	28.39	25.27	31.37	**24.07**	**29.88**
I-04					
Depressurisation Only		Pressurisation Only		**Mean**	
Air Permeability	Air Leakage Rate	Air Permeability	Air Permeability	**Air Leakage Rate**	**Air Permeability**
$m^3/(h.m^2)$ @ 50Pa	h^{-1} @ 50Pa	$m^3/(h.m^2)$ @ 50Pa	$m^3/(h.m^2)$ @ 50Pa	**h^{-1} @ 50Pa**	**$m^3/(h.m^2)$ @ 50Pa**
27.00	33.52	28.84	35.81	**27.92**	**34.66**

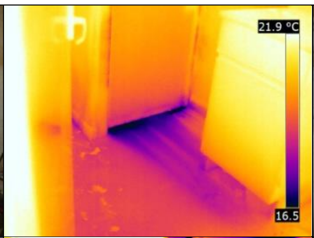
* Figures are based on roughly calculated envelope area and internal volumes, as accurate surveyed measurements were not available at the time.

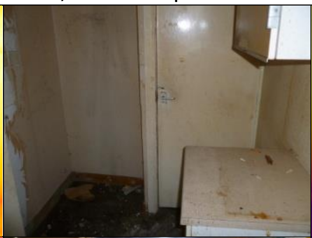
Leakage detection

Leakage detection was performed under pressurisation (using a smoke puffer at +50Pa) at 27 Ebor Place and depressurisation (using infra-red thermal imaging at -50Pa) in both properties. In general the properties both performed badly, far above current Building Regulations requirements for new-build properties of 10 $m^3/(h.m^2)$ @ 50Pa. The greatest difference between the 2 properties appeared to be the performance of the windows. The single-glazed sash windows at Ebor Place displayed significant amounts of decay of the timber frames and substantially more air leakage through and around the opening lights than the more modern double glazed units fitted in Hall Grove; although leakage between the frames and the walls was appreciable in both dwellings.

C-02:

Kitchen:
The most severe leakage occurred under and around the cellar door. Other poorly performing areas included the sections of un-tiled floor and the wall behind the kitchen units, the floor perimeter and the trickle ventilator.



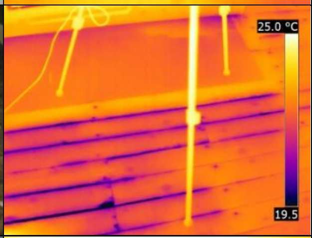


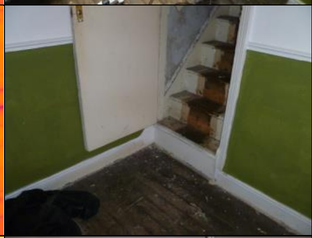


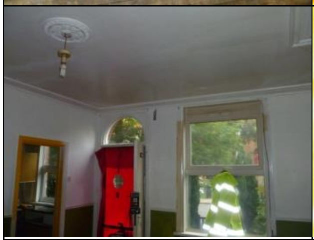
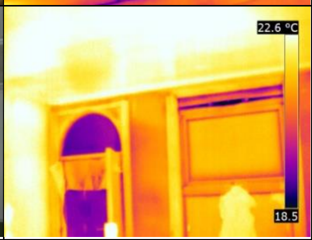
Lounge:

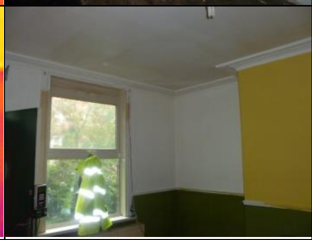
Airflow up through gaps between the floorboards was equally bad from both the open cellar and the closed cellar under the lounge floor and again the trickle vent did not fully close. A cooler strip between joists running across the lounge ceiling was presumed to be a link between the intermediate floor void and the chimney.





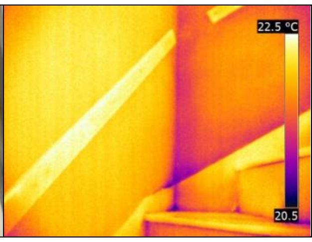








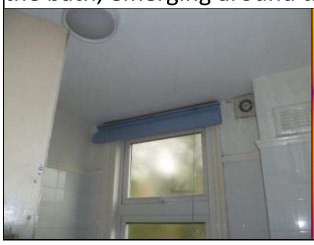
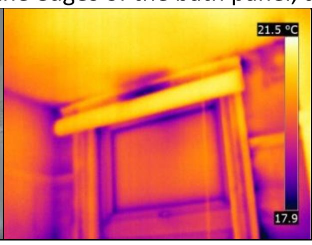
Ground Floor Stairs:

Only slight air leakage was detected through and around the stairs, this could be felt with the back of the hand better than observed on the thermal image so presumably the infiltrating air must had warmed by the time it emerged, signifying a longer of more convoluted infiltration path.

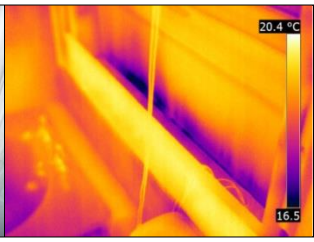



Bathroom:

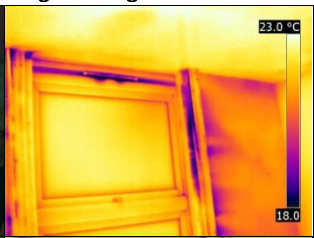
Significant leakage was detected around the window, through the closed trickle vent, around the frame and around the modesty panel at the bottom of the window. Considerable infiltration was also seen from underneath the bath, emerging around the edges of the bath panel, and through the airing cupboard floor.

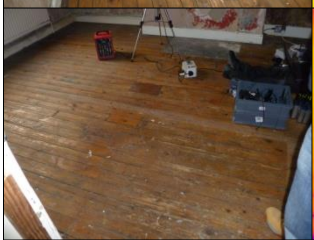
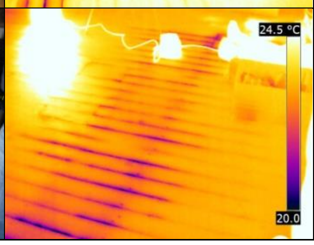




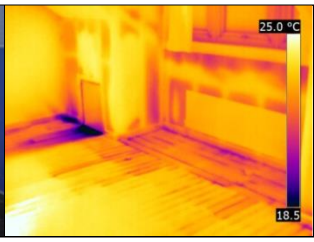

First Floor Bedroom:
Infiltration around the window frame was substantial, with a gap between the external wall and frame at the top-right of the window where it was possible to see directly to outside. Airflow up through gaps between the floorboards was detected across the whole floor, but only visible in the thermal images at the external wall, junction where the infiltrating air was coolest, and along the cooler strip running across floor above that previously observed in the lounge ceiling.

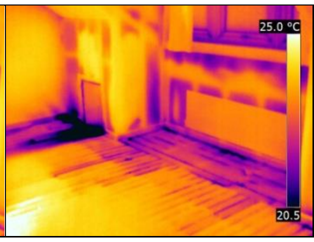



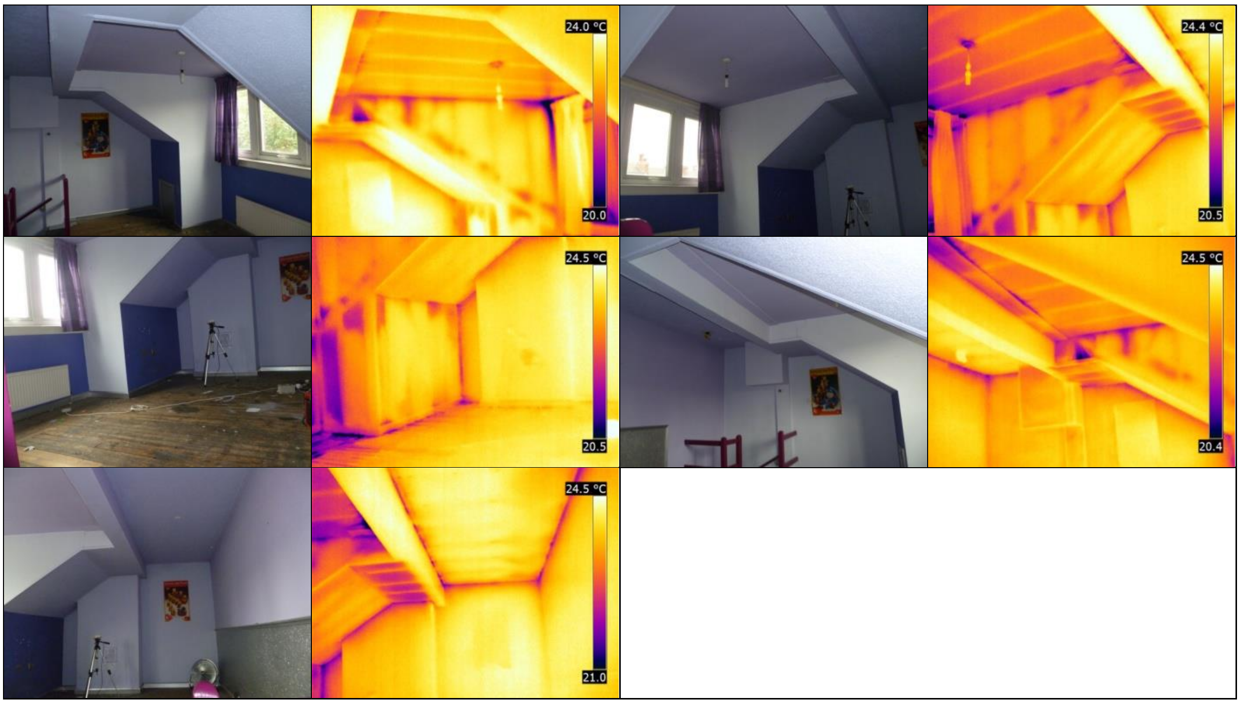


Top Floor Bedroom:
The main leakage paths were around the unsealed access door into the loft void to the left of the dormer and up through the floor (again this shows more clearly in the thermal images near the perimeter as the infiltrating air was coolest, but was detectable throughout the floor). Lesser infiltration was observed around the dormer window frame and sill and at a number of small gaps and cracks at junctions between walls and ceiling surfaces. In the sections of flat and sloping ceilings, knee walls and dormer cheeks, an indication to the level of insulation between the timber studs by using the surface temperature patterns to determine whether the studs allowed more or less heat to escape than the areas between them; although direct sun onto the sloping roof can cause confusion.

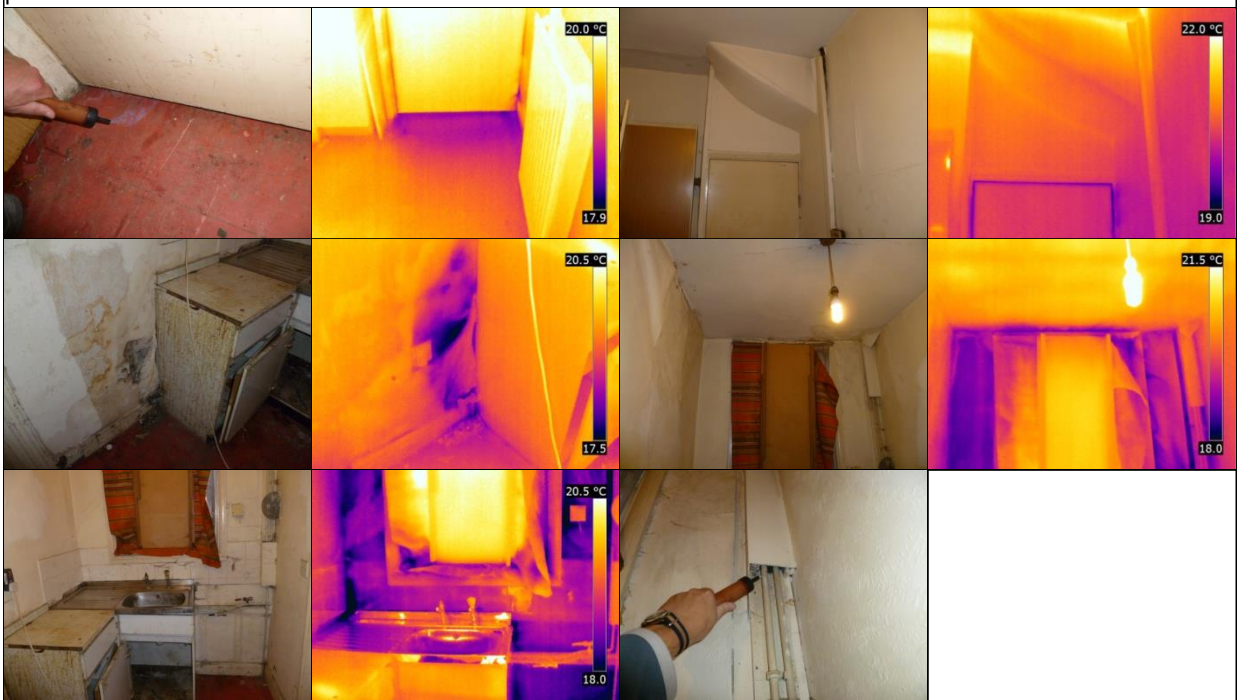





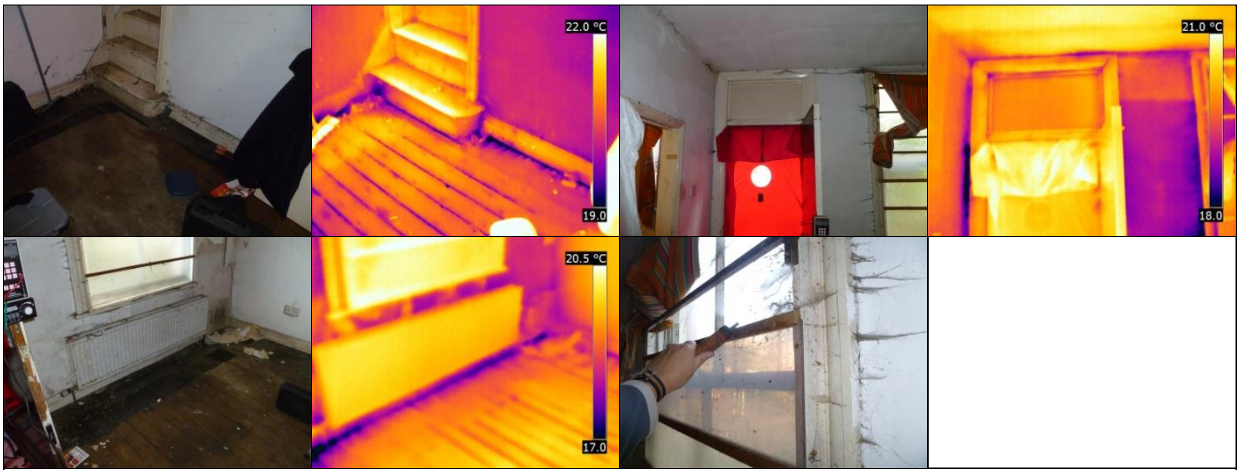


I-04

Kitchen:
As at Hall Grove, the most severe leakage occurred under and around the cellar door, although substantial air movement was also observed from behind the kitchen units, around the window and around unsealed service penetrations.

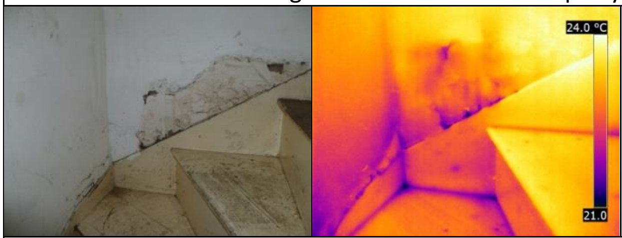


Lounge:
Airflow up through gaps between the floorboards was again present throughout the room and particularly at the floor/wall junctions. Leakage was detectable around most of the door and window frames, and daylight visible between the upper and lower sash.



Ground Floor Stairs:

Again, only slight air leakage was detected through and around the stairs, although more air leakage was identified around the stringers on the rear and side party walls.

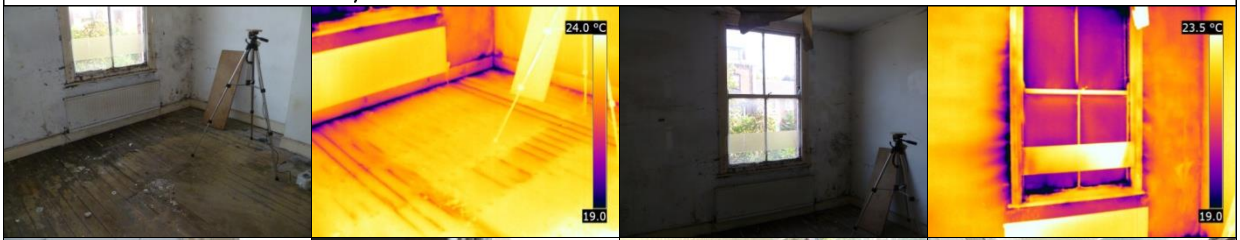


Bathroom:

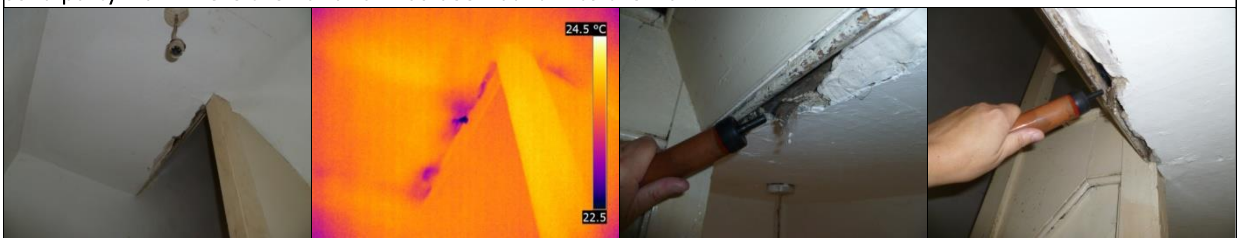
Air leakage was significant around the bath panel, the floor/wall junctions (particularly around the base of the boxed in service riser) and through the airing cupboard floor. As in the lounge, considerable airflow occurred at the window between the sashes.

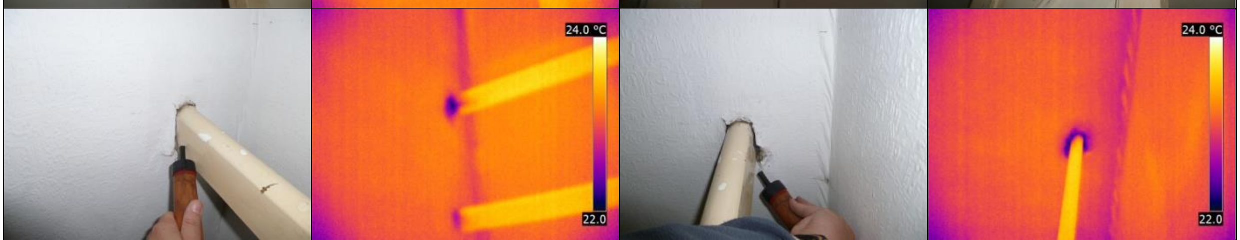
First Floor Bedroom:

Infiltration up through the floor, at all floor/wall junctions and through and around the window and frame was again substantial. A gap of up to 6mm has developed between the bottom rail of the lower sash and the glazing where the wood has rotted away.



First Floors Stairs:
Infiltration was detected at gaps in the ceiling into the intermediate floor void, and also into the wet-plastered solid party wall where the hand rail has been built in to the wall.





Top Floor Bedroom:
Air leakage was detected in numerous places: up through gaps between the floorboards and at most floor/wall junctions; around the dormer window frame, sill, trickle vent and crack in the glazing; at a number of small gaps and cracks at junctions between walls and ceiling surfaces; and through a large hole in the dormer roof.


22.0 °C
20.0
23.3 °C
18.0
23.5 °C
18.5
24.0 °C
20.0
25.0 °C
20.0
24.0 °C
18.5
24.0 °C
18.5
24.5 °C
22.0

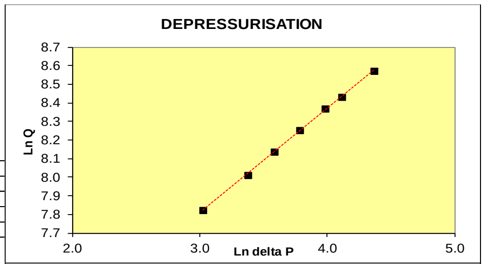
Pressurisation Test Spreadsheets:

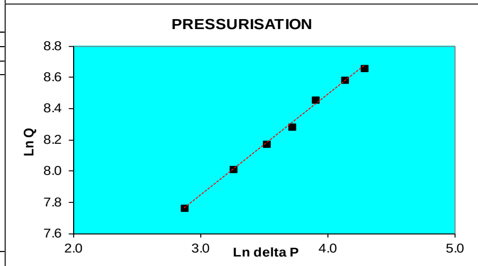
C-02:

CeBE Centre for the Built Environment — leeds metropolitan university

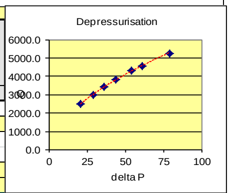
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	30/09/2013		Version 15h	28 June 2013	
test house address:	:				
company:	Leeds Federated				
house type:	back-to-back mid-terrace (including Room-in-Roof)				
tester:	DMS, DG, MF, JP				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	14.6	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	22.8	°C			
outdoor humidity (%rh)	64.9	%RH			
indoor humidity (%rh)	70.6	%RH			
outdoor barometric pressure	1001.7	mbar or hPa	Calculated Outdoor Air Density	1.21	kg/m^3
indoor barometric pressure	1001.6	mbar or hPa	Calculated Indoor Air Density	1.17	kg/m^3
temperature corr. fact. depress.	0.972		description of main construction details:		
temperature corr. fact. press.	1.029		Approx. envelope area and volume (180 m2 & 145 m3) used until accurate measurements obtained.		
wind speed (m/s):	1				
baseline pressure diff (Pa) (+/-)		Pa			
house width:		m			
house depth:		m			
house height:		m			
floor area:		m^2			
volume:	145	m^3			
envelope area including floor:	180	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	4332.59	m^3/h			
Mean Air Leakage at 50Pa =	29.88	h^{-1}			
Mean Air Permeability at 50 Pa =	24.07	m/h or m^3h/m^2			
Equivalent Leakage Area =	0.184	m^2 at	10	Pa	

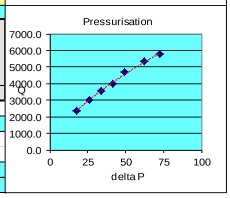




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	O	79.1	5441	5272.1	OK	79.1	4.371	8.570	4116.04	22.87	28.39
Approx 57 Pa	O	61.4	4736	4588.9	OK	61.4	4.117	8.431	r^2	0.999	
Approx 49 Pa	O	53.9	4449	4310.9	OK	53.9	3.987	8.369	C_{env}	458.694	$m^3/h.Pa^n$
Approx 41 Pa	A	43.9	3967	3843.8	OK	43.9	3.782	8.254	n	0.560	
Approx 33 Pa	A	35.9	3537	3427.2	OK	35.9	3.581	8.139			
Approx 25 Pa	A	29.2	3111	3014.4	OK	29.2	3.374	8.011	C_L (corrected)	459.998	$m^3/h.Pa^n$
Approx 20 Pa	A	20.6	2572	2492.1	OK	20.6	3.025	7.821			



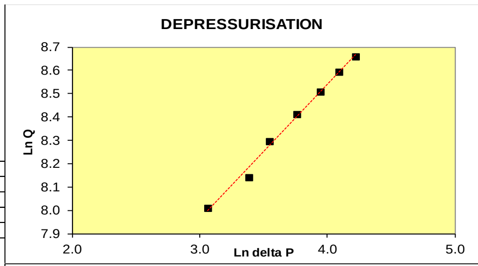
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	O	72.9	5593	5772.2	OK	72.9	4.289	8.661	4549.15	25.27	31.37
Approx 57 Pa	O	62.4	5178	5343.9	OK	62.4	4.134	8.584	r^2	0.997	
Approx 49 Pa	O	49.5	4550	4695.8	OK	49.5	3.902	8.454	C_{env}	370.771	$m^3/h.Pa^n$
Approx 41 Pa	A	41.3	3842	3965.1	OK	41.3	3.721	8.285	n	0.643	
Approx 33 Pa	A	33.7	3428	3537.9	OK	33.7	3.517	8.171			
Approx 25 Pa	A	26	2927	3020.8	OK	26	3.258	8.013	C_L (corrected)	367.466	$m^3/h.Pa^n$
Approx 20 Pa	A	17.7	2286	2359.3	OK	17.7	2.874	7.766			

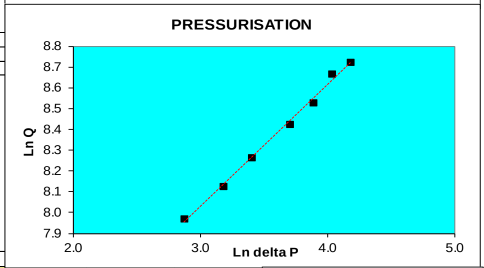


I-04:

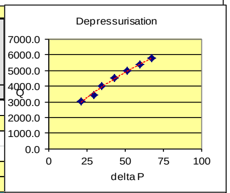
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	30/09/2013		Version 15h	28 June 2013
test house address:				
company:	Leeds Federated			
house type:	back-to-back mid-terrace (including Room-in-Roof)			
tester:	DMS, DG, MF, JP			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	16.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	22.2	°C		
outdoor humidity (%rh)	64.7	%RH		
indoor humidity (%rh)	71.7	%RH		
outdoor barometric pressure	1001.7	mbar or hPa	Calculated Outdoor Air Density	1.20 kg/m^3
indoor barometric pressure	1001.6	mbar or hPa	Calculated Indoor Air Density	1.17 kg/m^3
temperature corr. fact. depress.	0.980		description of main construction details:	
temperature corr. fact. press.	1.021		Approx. envelope area and volume (180 m2 & 145 m3) used until accurate measurements obtained.	
wind speed (m/s):	2.2			
baseline pressure diff (Pa) (+/-)		Pa		
house width:		m		
house depth:		m		
house height:		m		
floor area:		m^2		
volume:	145	m^3		
envelope area including floor:	180	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	5025.85	m^3/h		
Mean Air Leakage at 50Pa =	34.66	h^{-1}		
Mean Air Permeability at 50 Pa =	27.92	m/h or m^3h/m^2		
Equivalent Leakage Area =	0.218	m^2 at	10	Pa

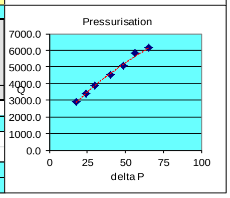




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	O	67.9	5901	5764.6	OK	67.9	4.218	8.659	4859.92	27.00	33.52
Approx 57 Pa	O	59.7	5528	5400.2	OK	59.7	4.089	8.594	r^2	0.993	
Approx 49 Pa	O	51.7	5079	4961.6	OK	51.7	3.945	8.509	C_{env}	503.886	$m^3/h.Pa^n$
Approx 41 Pa	O	43	4608	4501.5	OK	43	3.761	8.412	n	0.579	
Approx 33 Pa	A	34.8	4108	4013.0	OK	34.8	3.550	8.297			
Approx 25 Pa	A	29.6	3519	3437.7	OK	29.6	3.388	8.143	C_L (corrected)	503.989	$m^3/h.Pa^n$
Approx 20 Pa	A	21.4	3087	3015.6	OK	21.4	3.063	8.012			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	O	65.4	6011	6153.2	OK	65.4	4.181	8.725	5191.78	28.84	35.81
Approx 57 Pa	O	56.4	5673	5807.2	OK	56.4	4.032	8.667	r^2	0.995	
Approx 49 Pa	O	48.9	4945	5062.0	OK	48.9	3.890	8.530	C_{env}	528.658	$m^3/h.Pa^n$
Approx 41 Pa	A	40.6	4452	4557.3	OK	40.6	3.704	8.424	n	0.586	
Approx 33 Pa	A	30.1	3792	3881.7	OK	30.1	3.405	8.264			
Approx 25 Pa	A	24	3300	3378.1	OK	24	3.178	8.125	C_L (corrected)	523.674	$m^3/h.Pa^n$
Approx 20 Pa	A	17.7	2830	2897.0	OK	17.7	2.874	7.971			



Dwelling C-02 after retrofit

Date of Test: 2nd April 2014

Tested by: D Miles-Shenton, D Farmer & D Glew

Compiled by: Dominic Miles-Shenton

Test Results:

Test no.	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability $m^3/(h.m^2)$ @ 50 Pa	Air Change Rate h^{-1} @ 50 Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50 Pa	Air Change Rate h^{-1} @ 50 Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50 Pa	Air Change Rate h^{-1} @ 50 Pa
01	30-Sep-13	22.87	28.39	0.999	25.27	31.37	0.997	24.07	29.88
02	21-Oct-13	23.78	29.53	0.999	25.34	31.45	0.998	24.56	30.49
03	02-Apr-14	19.45	24.15	0.999	20.97	26.03	0.998	20.21	25.09

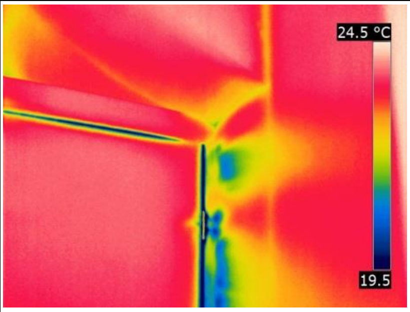
The pressurisation tests were performed using both pressurisation and depressurisation, with the mean of these being used for energy calculation purposes. Tests 01 and 02 were performed prior to dwelling renovation, at the beginning and end of the initial coheating test. Test 03 was performed at the heat-up stage of the coheating test following renovation.

Leakage detection for test 01 was reported on previously, along with the test on 27 Ebor Place. Leakage detection for test 03 was only performed under dwelling depressurisation at approximately -55 Pa using thermography, and is detailed below.

The change in measured air permeability between the test 02 and test 03 was not as great as expected. Some of the reasons for this are outlined in the leakage detection section below. What is not clear is the change in permeability of the external walls following removal of the original wet-plastered finish and replacement with insulated plasterboard on adhesive dabs. As airtightness was not included in the contractor's specifications no attempt had been made to make these walls airtight after the original plaster had been removed, with a reliance on the internal finish to provide an adequate primary air barrier. Some previous areas of air leakage, such as around openings and leakage around the room in roof structure had been addressed with some success; however, the most significant infiltration path (through the ground floor) remained.

Leakage Detection & Observations

Thermal images from test 03 are displayed below showing either a 5 ^{o}C or 10 ^{o}C span, allowing fairer comparison between them to be made; simplistically, a 5 ^{o}C span indicating a significant leakage path, a 10 ^{o}C span signifying one that is either more severe or substantially more direct. Where applicable, images captured under depressurisation are shown next to those captured under no induced pressure to show the extent to which the increased air movement has affected the observations. Also shown are some additional thermal images and observations from previous site visits and tests, these are dated and placed in the appropriate column.

<table>
<tr><th></th><th>Under depressurisation</th><th>No induced pressure differential</th></tr>
<tr><td colspan="3">Kitchen
The fact that the cellar door was a boundary between conditioned and unconditioned space had been recognised by insulating it, but it had not been made airtight with a 10 ~ 15 mm gap at the bottom and leakage around the remainder of it.
Infiltration into the intermediate floor void from the party wall could be observed extending fully across the kitchen ceiling in places and emerging out of the downlighters.
Air leakage around the ventilation unit was considerable, despite the unit being temporarily sealed for test purposes.
Air leakage from behind the kitchen units was also significant, implying that the kitchen units had been installed before the walls, junctions and penetrations behind had been suitably sealed.</td></tr>
<tr><td></td><td>
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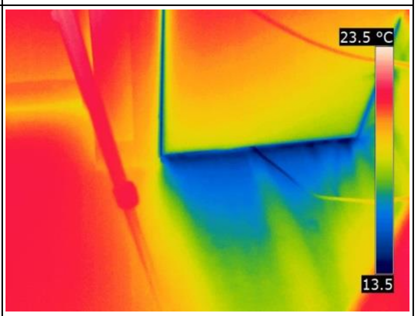
<tr><td></td><td>
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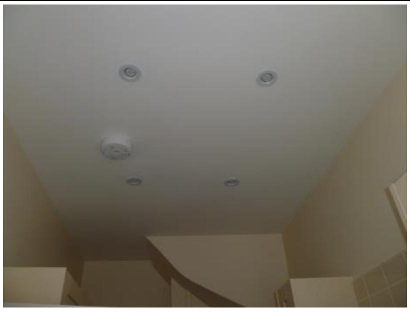
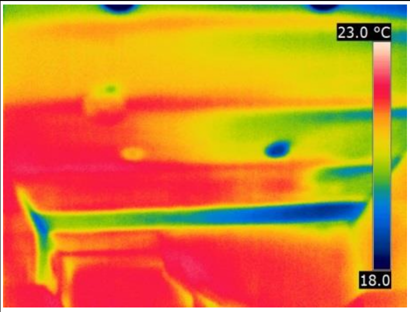
<td></td>
<td>
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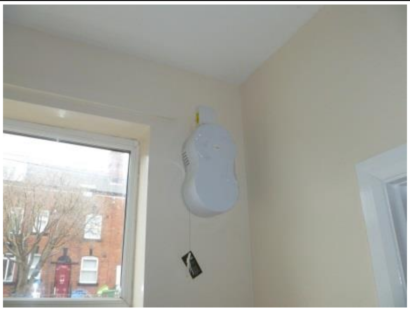
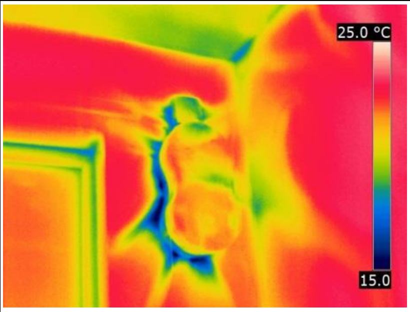
<td></td>
<td>
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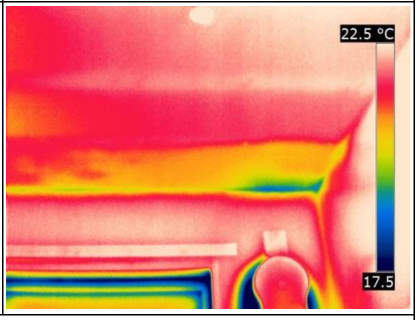
<td>
</td>
</tr>
<tr>
<td>

18-Mar-2014</td>
<td colspan="2">The hole bored for kitchen ventilation shown here during construction. This appeared to be well-sealed externally for weather-tightness, but not apparently sealed to the wall internally, allowing air movement from behind the insulated plasterboard ① and the cavity in the solid wall ② to enter the dwelling.</td>
</tr>
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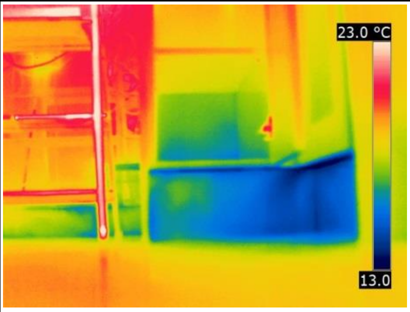
<td>
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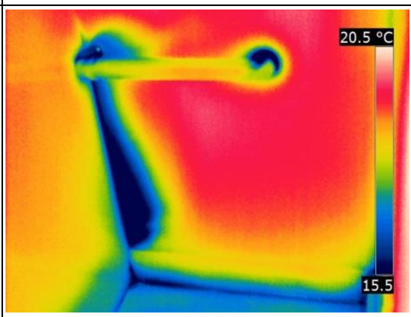
<td>
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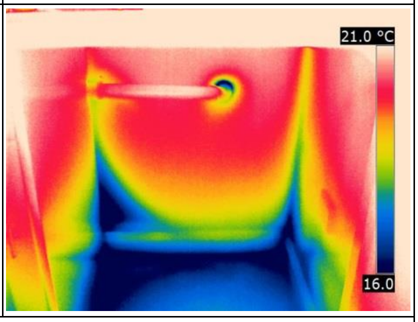
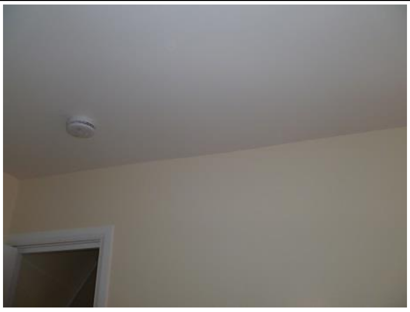
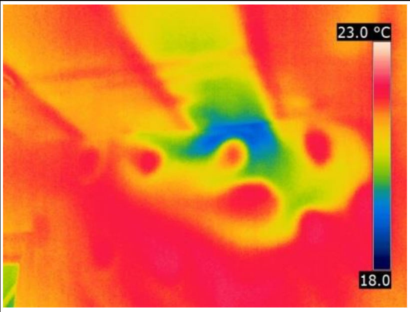
<td>
</td>
</tr>
<tr>
<td colspan="3">Lounge
The strip of coolest air observed across the kitchen ceiling from the party wall could be seen extending across the top of the partition wall into the intermediate floor void above the lounge and down into the void behind the plasterboard on the internal partition wall. At the junctions of this internal partition wall with the external wall and with the ground floor cooler air could also be observed entering the void behind the dry lining. A similar phenomenon could be seen on the opposing party</td>
</tr>
</table>

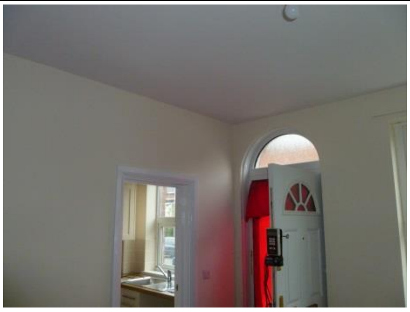
wall to a lesser extent due to the insulated plasterboard used; however some cooler air could be seen emerging from the electrical service penetrations.

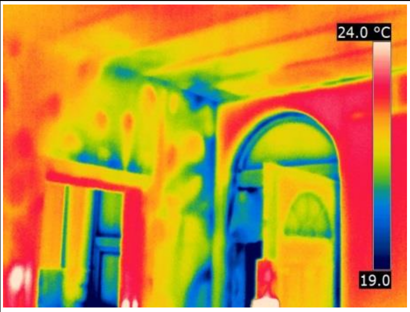
Some of the joints between insulation boards were visible under depressurisation, but temperature differences were slight, and air leakage around the window was drastically reduced from previous tests on this property.

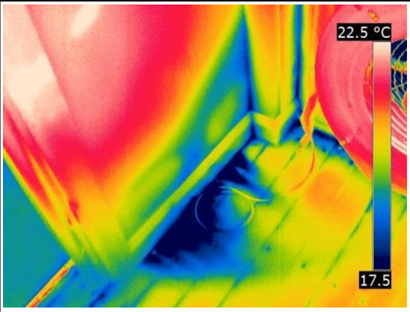
As in tests 01 & 02, the most serious infiltration path was up through the timber ground floor, with cold, moist air being drawn in from the cellar. At the time of the test the air temperature and relative humidity in the lounge was 21.9 ^{o}C and 44.4%, compared to 13.7 ^{o}C and 83.0% in the cellar. The images captured under no induced pressure difference show that this air will be entering the habitable space under normal circumstances and could create comfort and moisture-related issues. It could also be easily distinguished where the floor had been insulated beneath the lounge and where it had not.

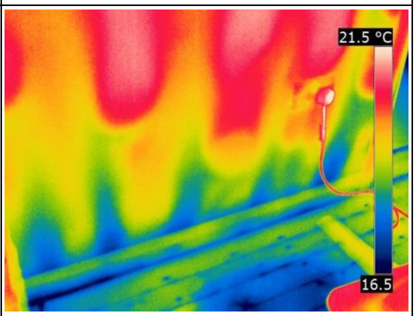


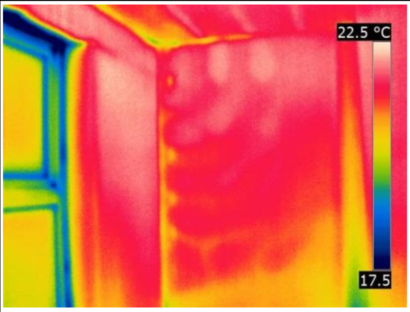
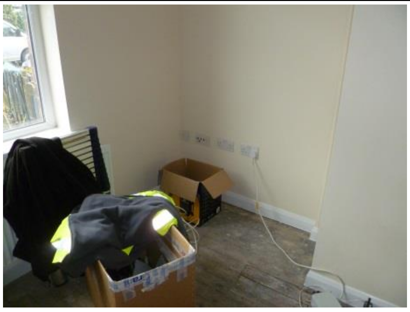
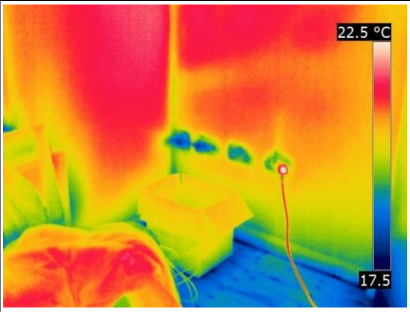
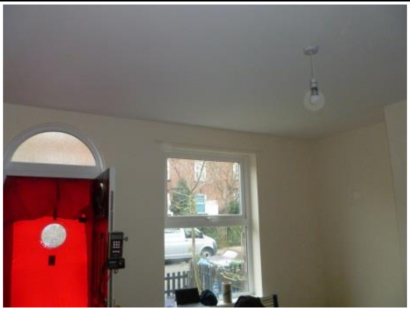
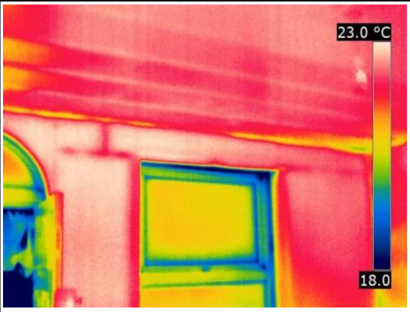


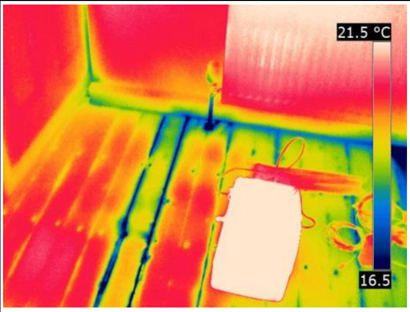


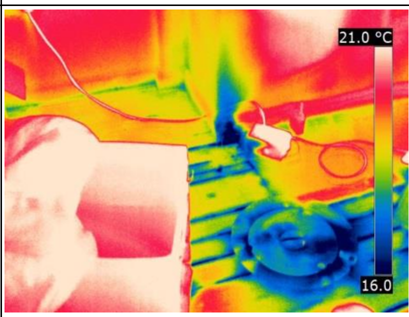
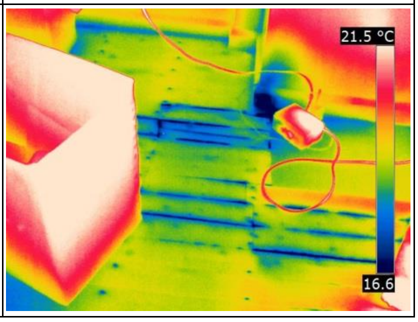


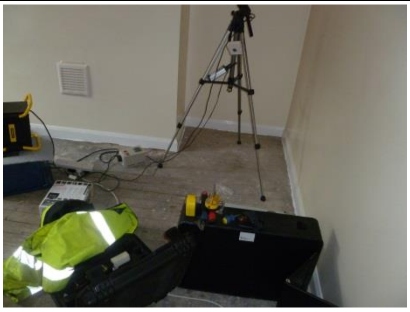


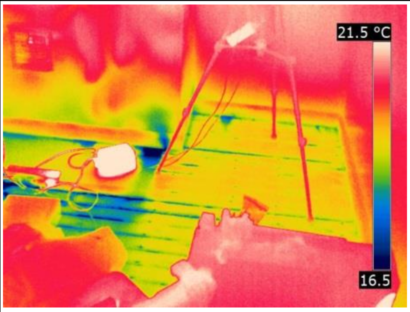


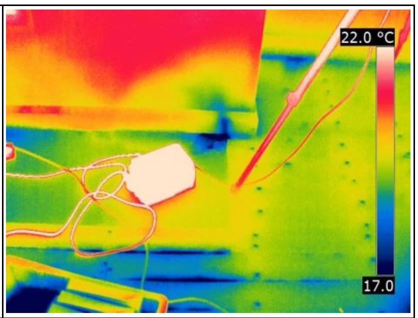


22.5 °C
17.5


22.5 °C
17.5


23.0 °C
18.0

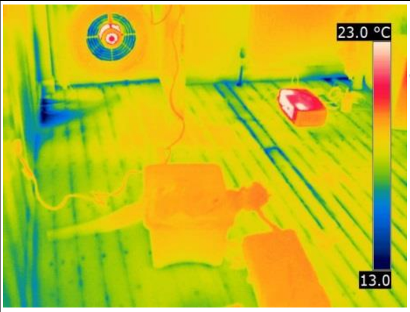

21.5 °C
16.5

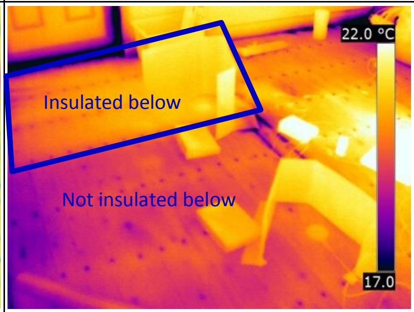

21.0 °C
16.0

21.5 °C
16.6







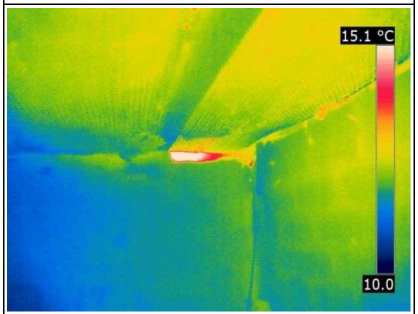


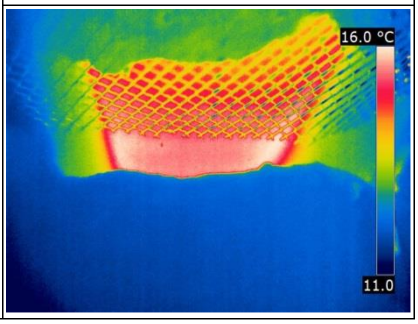


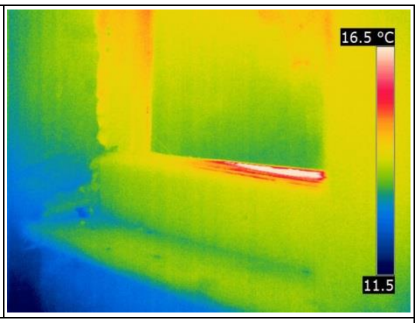
03-Apr-2014

Cellar

No leakage detection was performed in the cellar but some observations were made using thermal imaging such as: the amount of heat being given off by the voltage optimisation unit (outside of the thermal envelope), the difference in temperature between areas of the lounge floor that had or had not been insulated, and the gap beneath the door to the kitchen.

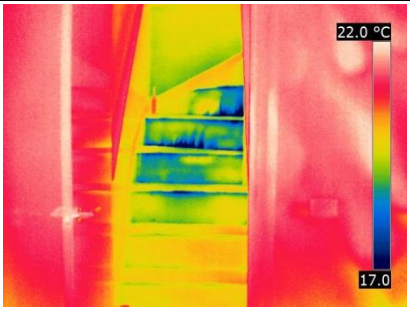


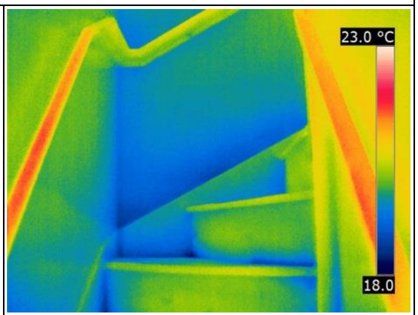


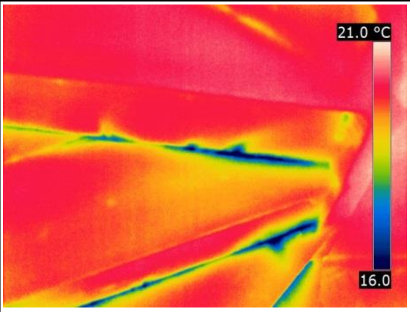


Ground to 1st Floor Stairs

Infiltration was observed under depressurisation at the steps which were exposed to the cellar stairway where they had been insulated beneath but had not been sealed. The surface temperatures of the stairs here actually appeared cooler than those below them due to the air movement.







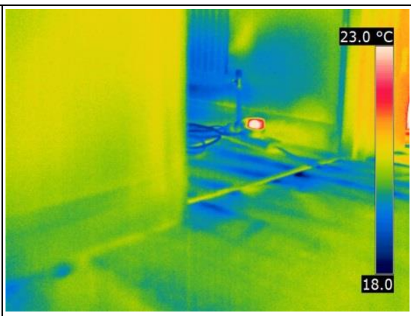
Bathroom

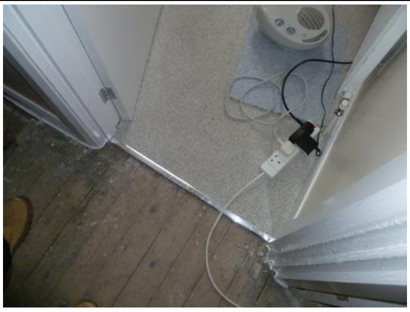
Air movement through the intermediate floor in the bathroom was visible in the thermal images even through the floor covering.

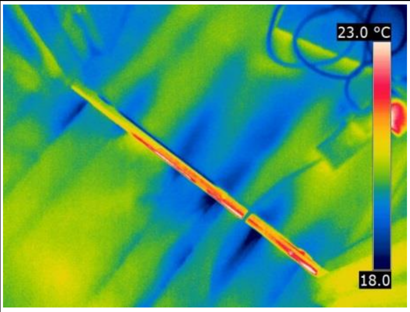
There was significant leakage between the trickle vent and the window frame and some around the opening light. The privacy panel at the bottom of the window appeared cooler where it had been boxed in on the bathroom external wall, presumably without filling the void with insulation. This may provide some risk of interstitial condensation, particularly as there is no mechanical ventilation in the bathroom.

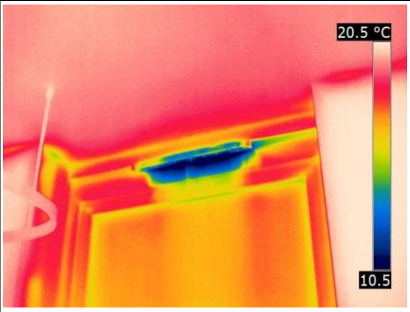
Infiltration was also detected around both plumbing and electrical penetrations, emerging around the boxed in pipework, bath panel and central light fixing.

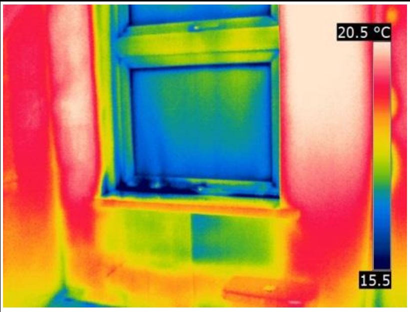
In the airing cupboard, air could be detected entering through the intermediate floor and aound the pipework penetrations into the ceiling.



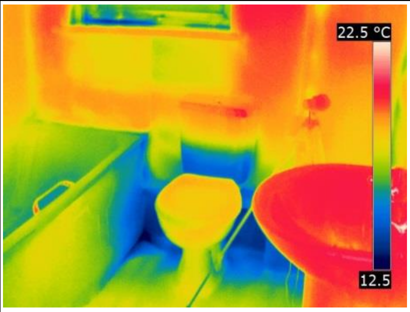


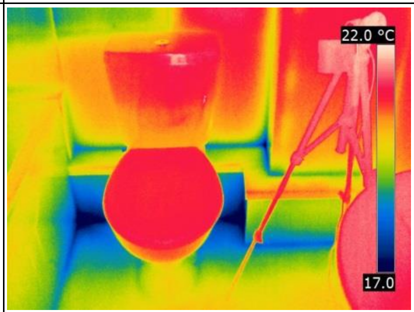

23.0 °C
18.0

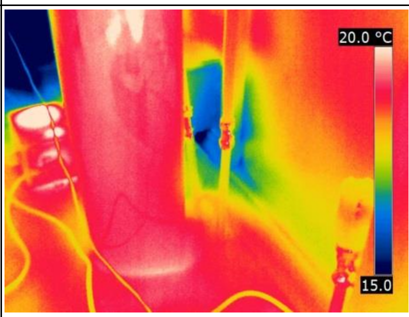

20.5 °C
10.5

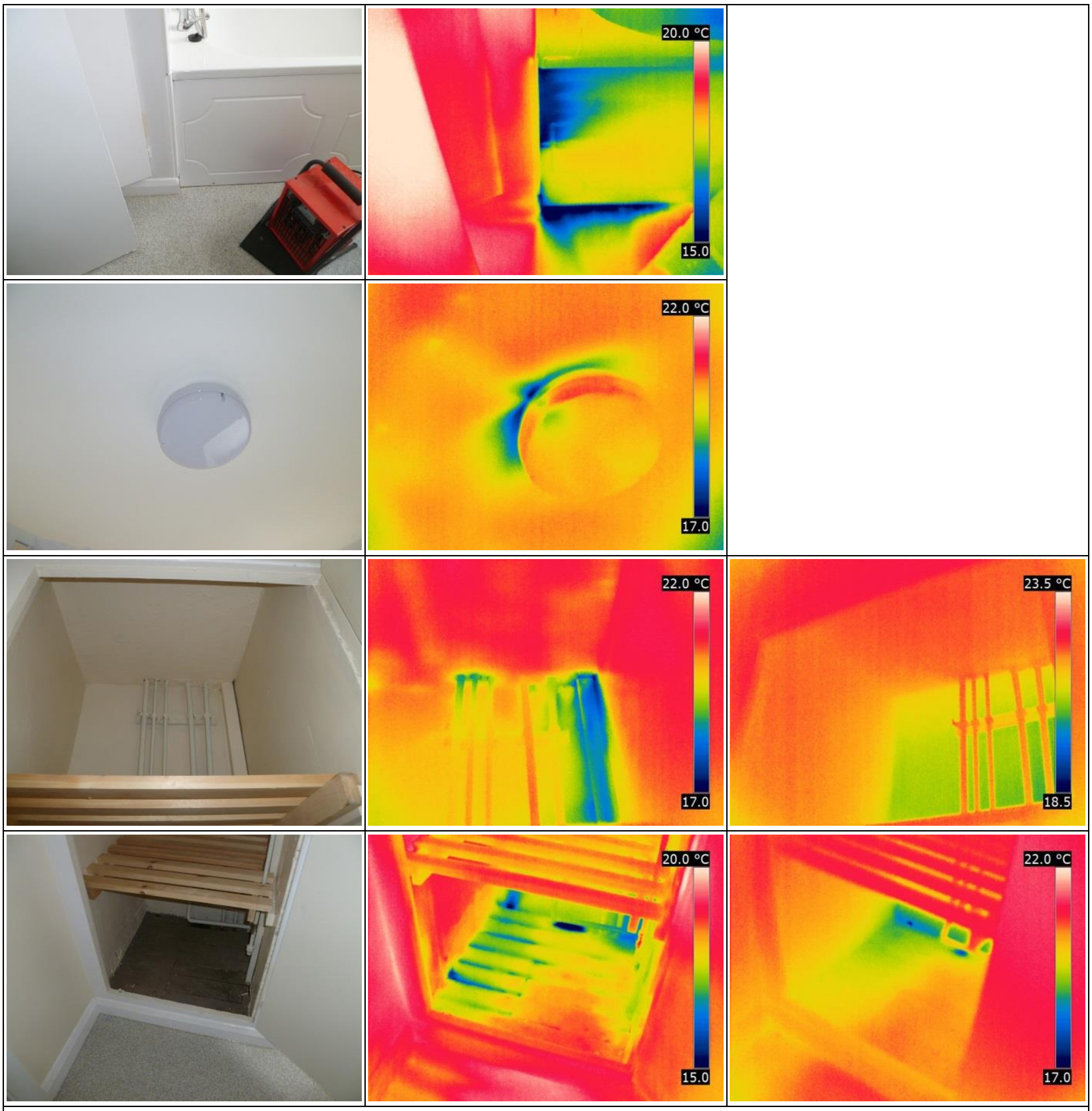

20.5 °C
15.5


21.5 °C
16.5


22.5 °C
12.5


22.0 °C
17.0


20.0 °C
15.0

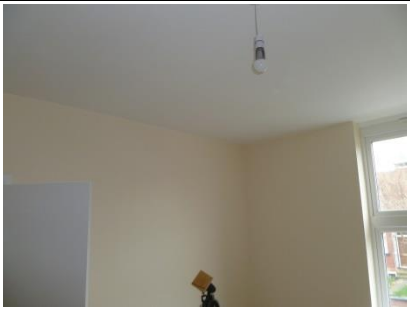


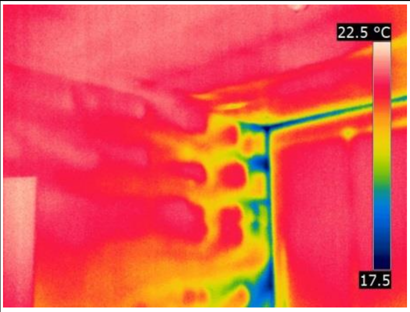
1st Floor Bedroom

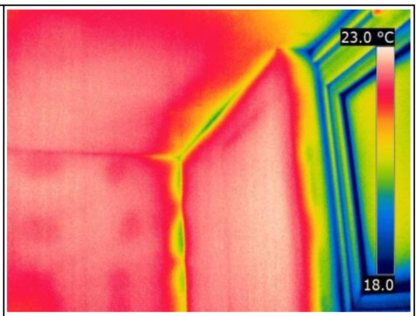
The internal wall between the bathroom and bedroom had been dry lined and displayed infiltration entering the void behind the dry lining apparently originating from the external wall junction. The wet plaster finish that had formerly lined the external wall had been removed, and the wall had not been pointed or parged prior to the application of the insulated plasterboard, gaps at unfilled perpends and at the floor junction could be responsible for the infiltration observed here. Air movement between gaps in the insulation panels was minimal in all but one small section on the external wall and previously observed infiltration around the window had been dealt with very effectively, with only small amounts remaining around the trickle vent and at one end of the window sill.

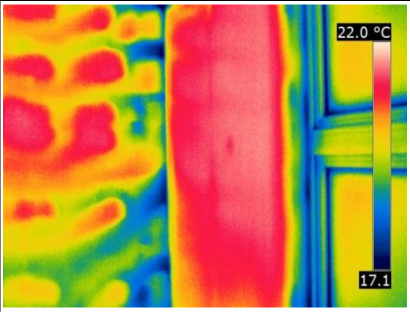
It was possible to observe a cooler area of bedroom ceiling directly beneath the cold roof void above it, but markedly less than had been seen prior to renovation.

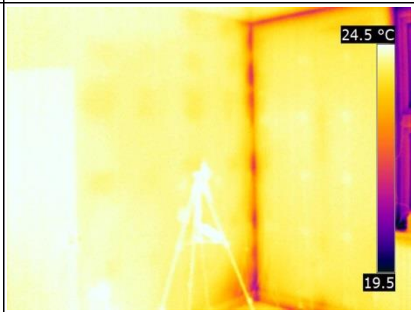
Some air leakage was also detected around the air brick on the chimney breast.



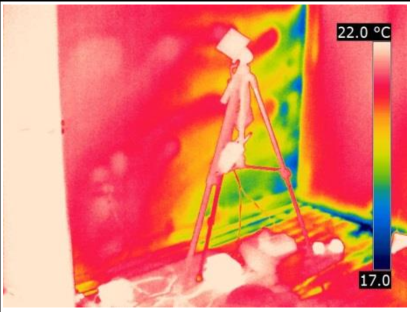


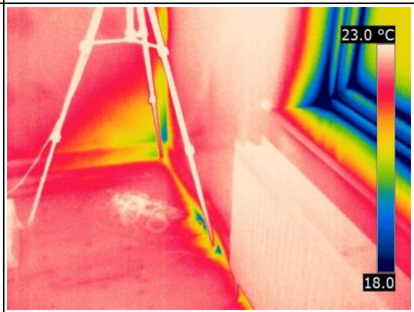


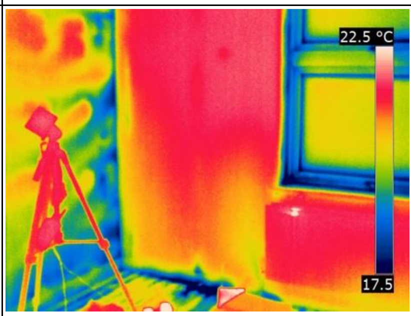


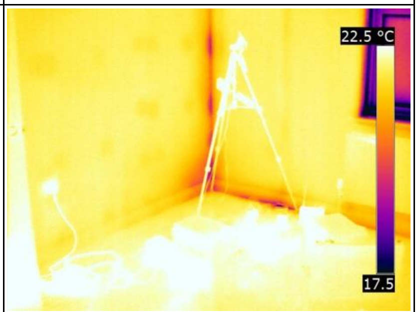


03-Apr-2014









03-Apr-2014

13-Feb-2014

13-Feb-2014

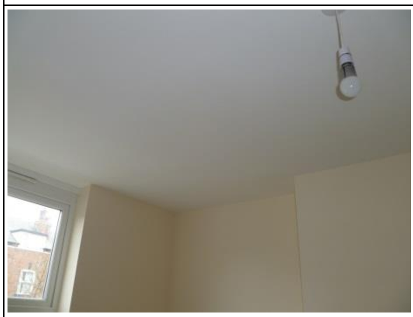
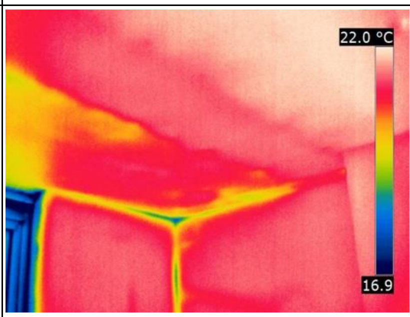

11-Feb-2014

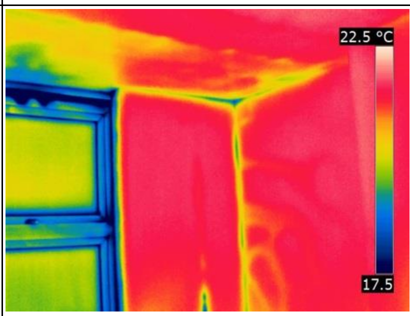


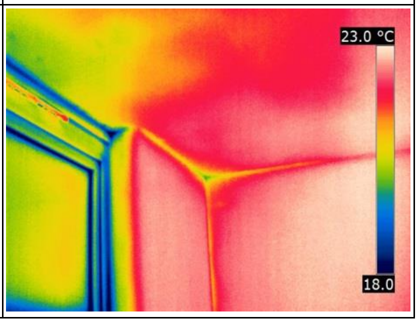
21-Oct-2013

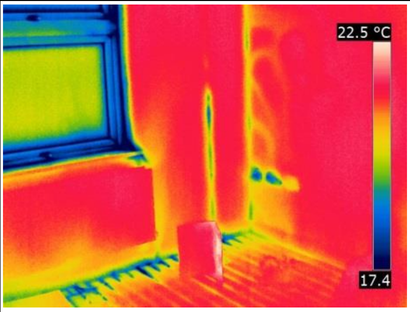
21-Oct-2013

From depressurisation prior to renovation:
With the wet plastered walls the observed infiltration was limited to the floor wall junction and around the window frame.

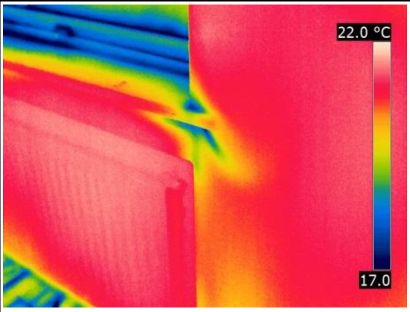


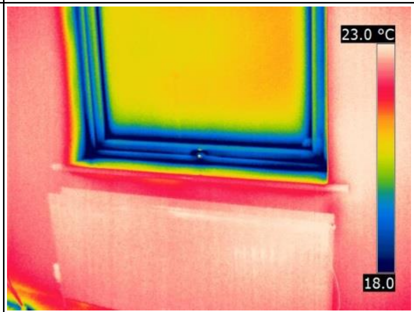

22.5 °C
17.4

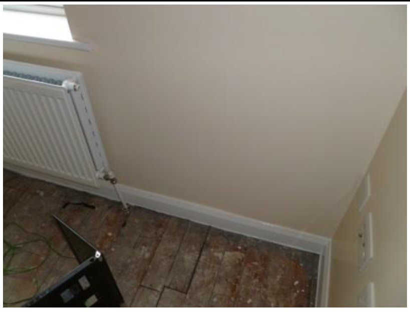

23.0 °C
18.0

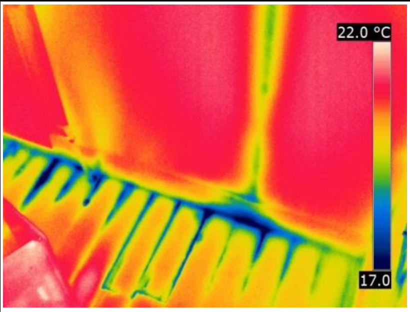

21.9 °C
17.0

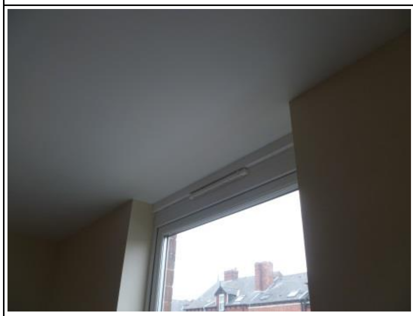
03-Apr-2014

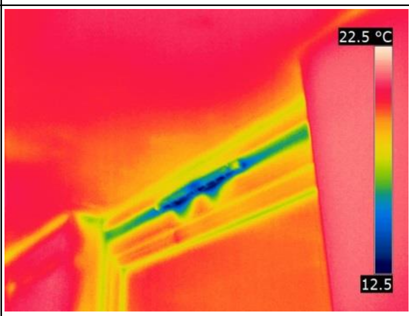

22.0 °C
17.0

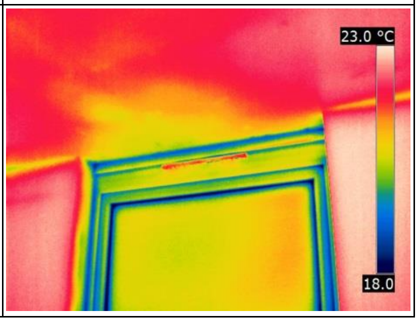

23.0 °C
18.0




22.0 °C
17.0




22.5 °C
12.5


23.0 °C
18.0

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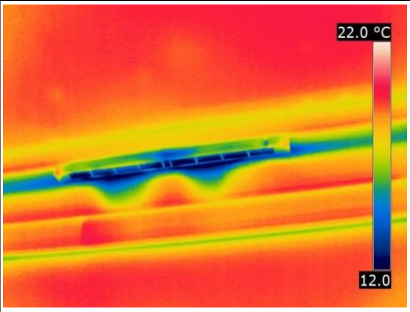
<tr><td></td><td>
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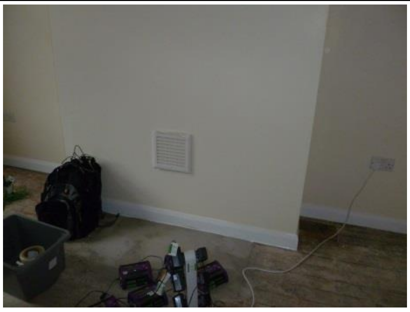
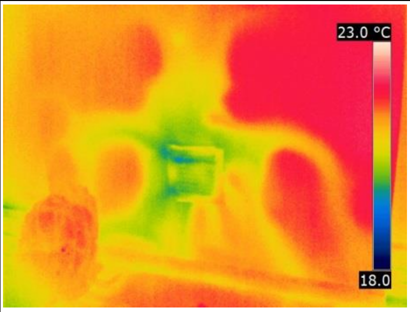
<tr><td></td><td>
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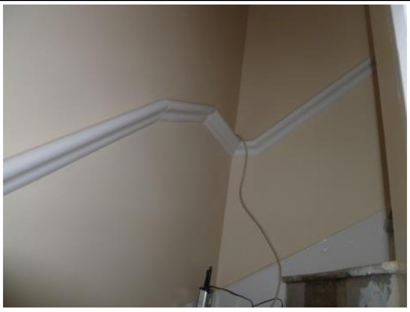
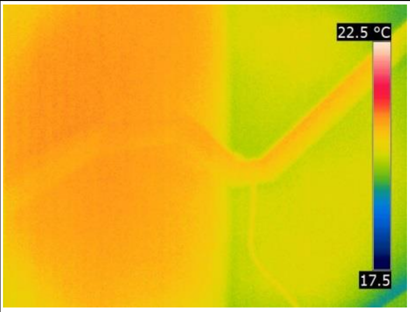
<tr><td colspan="3">2nd Floor Stairs & Landing
On the stairs there was little to be observed with the variation in wall temperatures reflecting those from different neighbouring properties or distinguishing between internal or party elements.
The landing ceiling showed heat loss at areas where the insulation was not ideally fitted around penetrations and more complex junctions intensified by air movement and infiltration around some penetrations. The access door to the roof space was not draught-stripped and performed particularly badly under depressurisation; however under normal conditions this would be an exfiltration area and with heated air leaving the conditioned space looks very different through thermography.</td></tr>
<tr><td></td><td>
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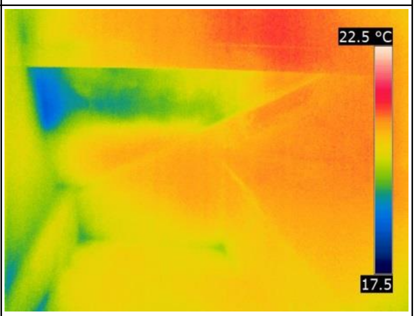
<tr><td></td><td>
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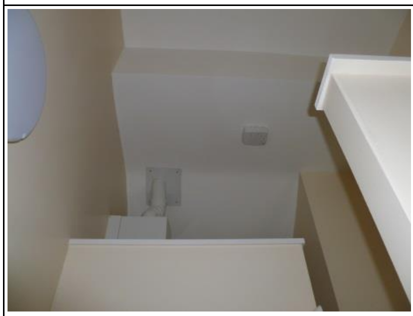
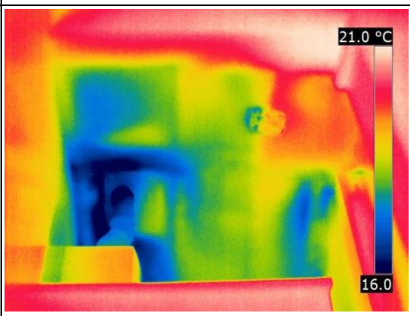
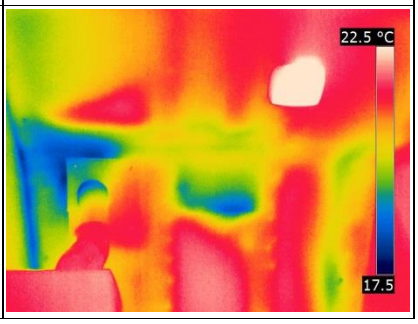
<tr><td></td><td>
</td><td>
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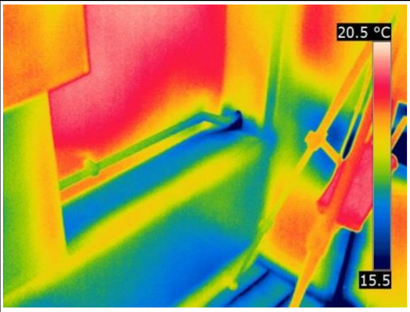
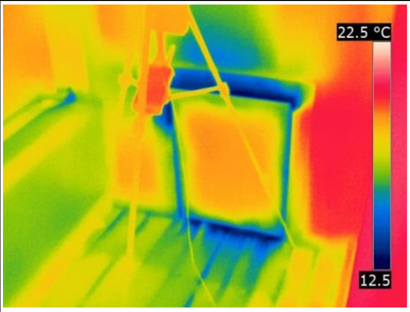
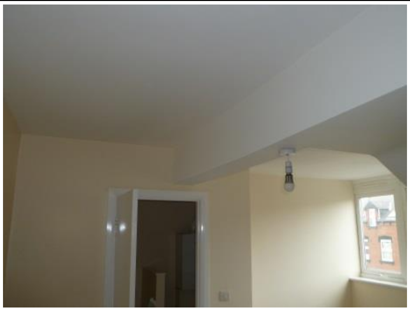


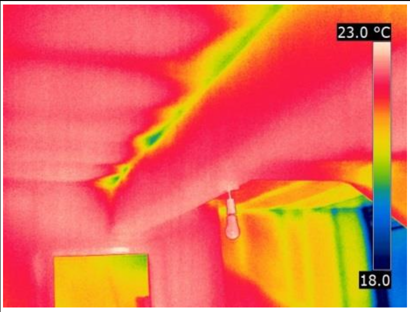


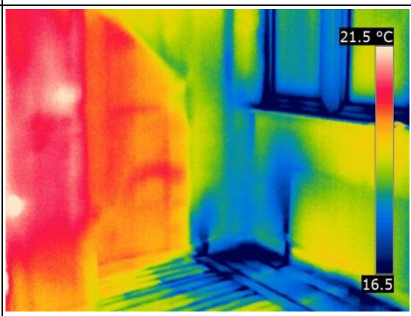
03-Apr-2014

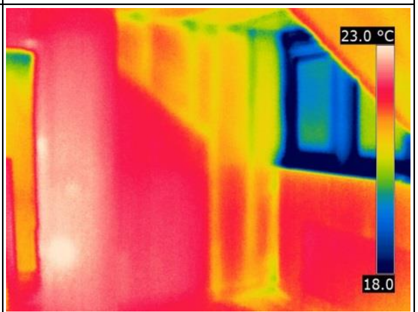
2nd Floor Bedroom

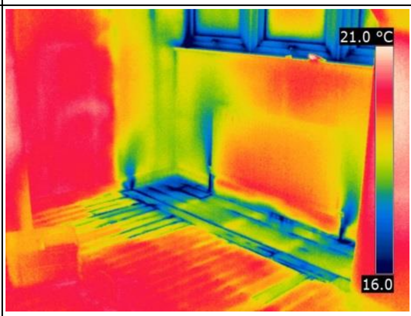
Air leakage up through the intermediate floor and through the window remained similar to that observed in the tests prior to renovation, but the rest of the room in roof structure had improved dramatically. The high visibility of the thermal bridging through the timber formwork indicating that there is effective insulation between.



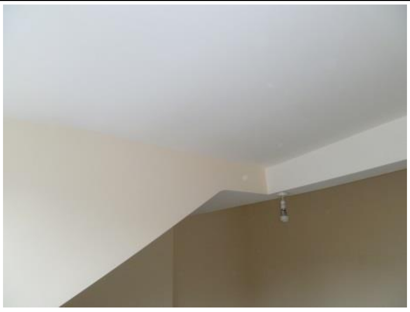


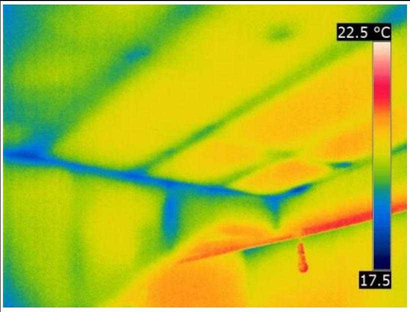


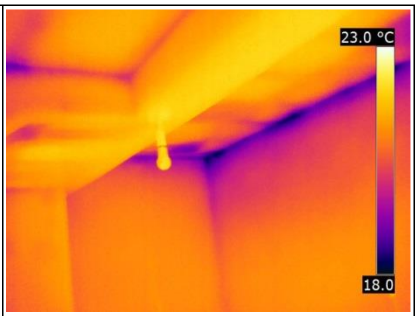




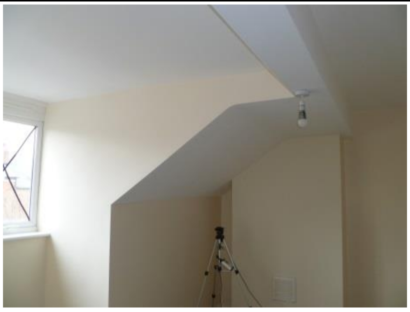
03-Apr-2014

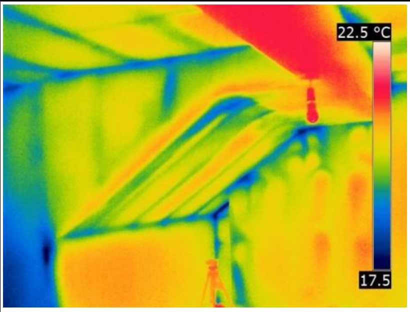


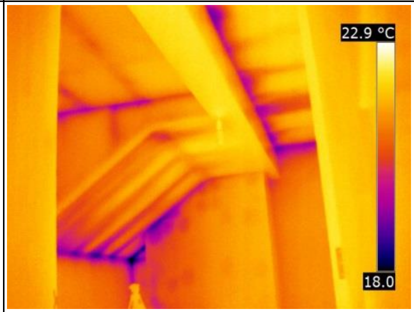




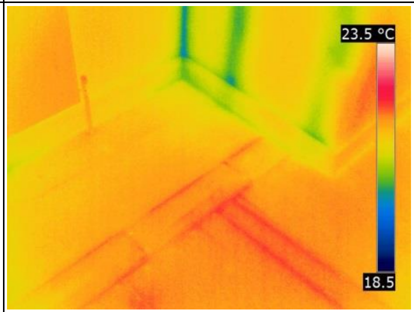
03-Apr-2014

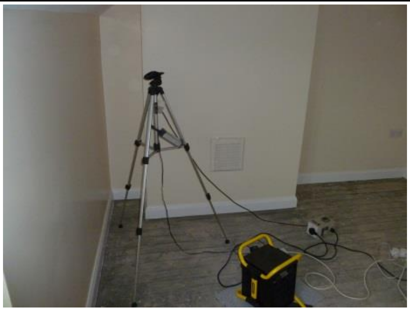


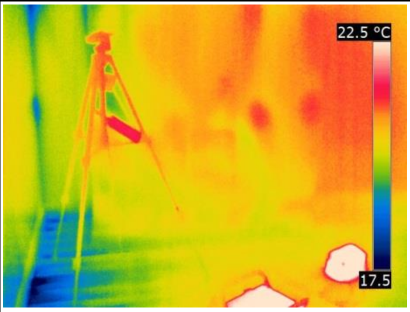




03-Apr-2014

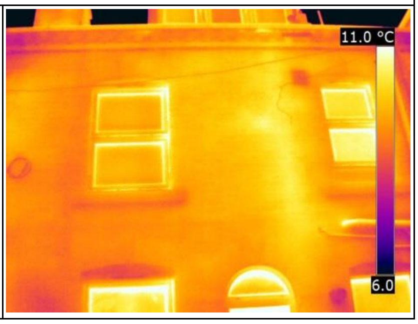






External

The junction of the internal wall between the 1st floor bedroom and bathroom with the external wall shows up quite significantly on thermal images captures from outside the dwelling. With no thermal break between the internal and external wall and the junction in the bathroom intermittently exposed to high humidity levels with no mechanical extraction, the risk of condensation and/or mould growth might want to be evaluated.



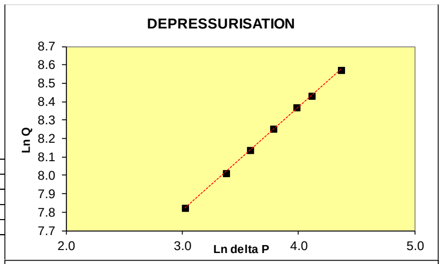
Results Spreadsheets

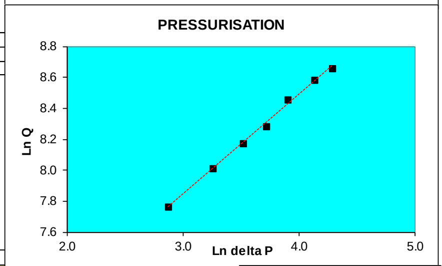
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

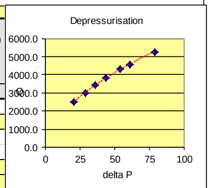
date:	30/09/2013		Version 15h	28 June 2013
test house address:				
company:	Leeds Federated			
house type:	back-to-back mid-terrace (including Room-in-Roof)			
tester:	DMS, DG, MF, JP			
test reference number:	test 01		Blow er Door & Gauge Used	Model 3 w ith DG700
outdoor temp (°C)	14.6	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	22.8	°C		
outdoor humidity (%rh)	64.9	%RH		
indoor humidity (%rh)	70.6	%RH		
outdoor barometric pressure	1001.7	mbar or hPa	Calculated Outdoor Air Density	1.21 kg/m³
indoor barometric pressure	1001.6	mbar or hPa	Calculated Indoor Air Density	1.17 kg/m³
temperature corr. fact. depress.	0.972		description of main construction details:	
temperature corr. fact. press.	1.029		Approx. envelope area and volume (180 m2 & 145 m3) used until accurate measurements obtained.	
w ind speed (m/s):	1			
baseline pressure diff (Pa) (+/-)		Pa		
house w idth:		m		
house depth:		m		
house height:		m		
floor area:		m²		
volume:	145	m³		
envelope area including floor:	180	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	4332.59	m³/h		
Mean Air Leakage at 50Pa =	29.88	h⁻¹		
Mean Air Permeability at 50 Pa =	24.07	m/h or m³h/m²		
Equivalent Leakage Area =	0.184	m² at	10	Pa

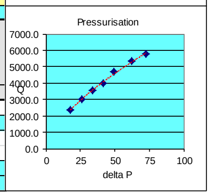
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	O	79.1	5441	5272.1	OK	79.1	4.371	8.570	4116.04	22.87	28.39
Approx 57 Pa	O	61.4	4736	4588.9	OK	61.4	4.117	8.431	r^2	0.999	
Approx 49 Pa	O	53.9	4449	4310.9	OK	53.9	3.987	8.369	C_{env}	458.694	m^3/h.Pa*n*
Approx 41 Pa	A	43.9	3967	3843.8	OK	43.9	3.782	8.254	n	0.560	
Approx 33 Pa	A	35.9	3537	3427.2	OK	35.9	3.581	8.139			
Approx 25 Pa	A	29.2	3111	3014.4	OK	29.2	3.374	8.011	C_L (corrected)	459.998	m^3/h.Pa*n*
Approx 20 Pa	A	20.6	2572	2492.1	OK	20.6	3.025	7.821			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	O	72.9	5593	5772.2	OK	72.9	4.289	8.661	4549.15	25.27	31.37
Approx 57 Pa	O	62.4	5178	5343.9	OK	62.4	4.134	8.584	r^2	0.997	
Approx 49 Pa	O	49.5	4550	4695.8	OK	49.5	3.902	8.454	C_{env}	370.771	m^3/h.Pa*n*
Approx 41 Pa	A	41.3	3842	3965.1	OK	41.3	3.721	8.285	n	0.643	
Approx 33 Pa	A	33.7	3428	3537.9	OK	33.7	3.517	8.171			
Approx 25 Pa	A	26	2927	3020.8	OK	26	3.258	8.013	C_L (corrected)	367.466	m^3/h.Pa*n*
Approx 20 Pa	A	17.7	2286	2359.3	OK	17.7	2.874	7.766			









MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

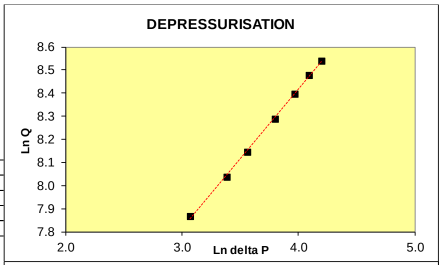
Centre for the Built Environment — leeds metropolitan university

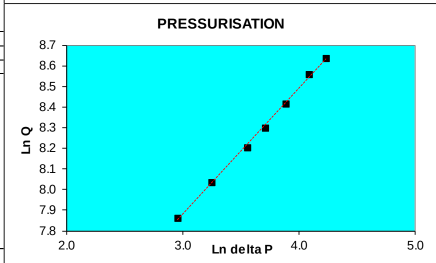
date:	21/10/2013	Version 15h 28 June 2013
test house address:	[illegible]	
company:	Leeds Federated	
house type:	back-to-back mid-terrace (including Room-in-Roof)	
tester:	DMS, DG, MF, JP, DJ	
test reference number:	test 02	Blower Door & Gauge Used: Model 3 with DG700

outdoor temp (°C)	14.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically
indoor temp (°C)	22.6	°C	
outdoor humidity (%rh)	100	%RH	
indoor humidity (%rh)	52	%RH	
outdoor barometric pressure	993	mbar or hPa	Calculated Outdoor Air Density: 1.20 kg/m^3
indoor barometric pressure	993	mbar or hPa	Calculated Indoor Air Density: 1.16 kg/m^3
temperature corr. fact. depress.	0.972		description of main construction details:
temperature corr. fact. press.	1.029		Post-coheating. Approx. envelope area and volume (180 m2 & 145 m3) used until accurate measurements obtained.
wind speed (m/s):	0.2		
baseline pressure diff (Pa) (+/-)		Pa	
house width:		m	
house depth:		m	
house height:		m	
floor area:		m^2	
volume:	145	m^3	
envelope area including floor:	180	m^2	
Pressure Difference for ELA	10	Pa	

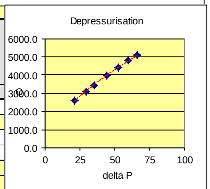
RESULTS:

Q50 Mean Flow at 50Pa =	4420.88	m^3/h
Mean Air Leakage at 50Pa =	30.49	h^{-1}
Mean Air Permeability at 50 Pa =	24.56	m/h or m^3h/m^2
Equivalent Leakage Area =	0.184	m^2 at 10 Pa

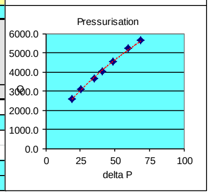




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	O	66.4	5263	5117.3	OK	66.4	4.196	8.540	4281.24	23.78	29.53
Approx 57 Pa	O	60	4943	4806.2	OK	60	4.094	8.478	r^2	0.999	
Approx 49 Pa	O	52.9	4558	4431.8	OK	52.9	3.968	8.397	C_{env}	402.950	m^3/h.Pa*n*
Approx 41 Pa	O	44.7	4091	3977.8	OK	44.7	3.800	8.288	n	0.604	
Approx 33 Pa	A	35.3	3551	3452.7	OK	35.3	3.564	8.147			
Approx 25 Pa	A	29.6	3188	3099.8	OK	29.6	3.388	8.039	C_L (corrected)	402.474	m^3/h.Pa*n*
Approx 20 Pa	A	21.6	2683	2608.7	OK	21.6	3.073	7.867			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	O	68.8	5485	5641.1	OK	68.8	4.231	8.638	4560.52	25.34	31.45
Approx 57 Pa	O	59.8	5081	5225.6	OK	59.8	4.091	8.561	r^2	0.998	
Approx 49 Pa	A	48.8	4398	4523.2	OK	48.8	3.888	8.417	C_{env}	423.227	m^3/h.Pa*n*
Approx 41 Pa	A	40.9	3911	4022.3	OK	40.9	3.711	8.300	n	0.611	
Approx 33 Pa	A	35	3562	3663.4	OK	35	3.555	8.206			
Approx 25 Pa	A	25.8	3001	3086.4	OK	25.8	3.250	8.035	C_L (corrected)	418.142	m^3/h.Pa*n*
Approx 20 Pa	A	19.2	2531	2603.1	OK	19.2	2.955	7.864			



MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

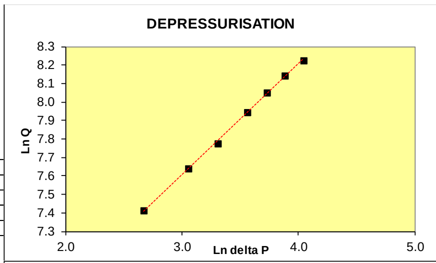
Centre for the Built Environment — leeds metropolitan university

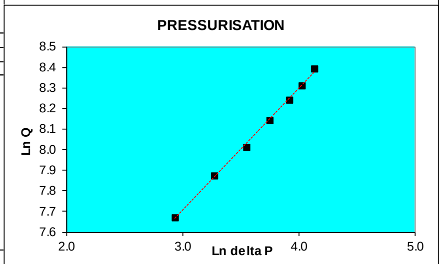
date:	02/04/2014	Version 15h 28 June 2013
test house address:	[illegible]	
company:	Leeds Federated	
house type:	back-to-back mid-terrace (including Room-in-Roof)	
tester:	DMS, DG, DF	
test reference number:	test 03	Blower Door & Gauge Used: Model 3 with DG700

outdoor temp (°C)	9.5	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically
indoor temp (°C)	21.9	°C	
outdoor humidity (%rh)	80.9	%RH	
indoor humidity (%rh)	44.4	%RH	
outdoor barometric pressure	998.9	mbar or hPa	Calculated Outdoor Air Density: 1.23 kg/m^3
indoor barometric pressure	998.9	mbar or hPa	Calculated Indoor Air Density: 1.17 kg/m^3
temperature corr. fact. depress.	0.958	WARNING!!	description of main construction details:
temperature corr. fact. press.	1.044	Extreme Test	Approx. envelope area and volume (180 m2 & 145 m3) used until accurate measurements obtained. Post-renovation, start of 2nd coheating test
wind speed (m/s):	0.3	Conditions	
baseline pressure diff (Pa) (+/-)		Pa	
house width:		m	
house depth:		m	
house height:		m	
floor area:		m^2	
volume:	145	m^3	
envelope area including floor:	180	m^2	
Pressure Difference for ELA	10	Pa	

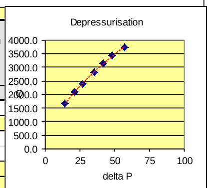
RESULTS:

Q50 Mean Flow at 50Pa =	3638.20	m^3/h
Mean Air Leakage at 50Pa =	25.09	h^{-1}
Mean Air Permeability at 50 Pa =	20.21	m/h or m^3h/m^2
Equivalent Leakage Area =	0.156	m^2 at 10 Pa

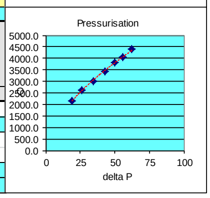




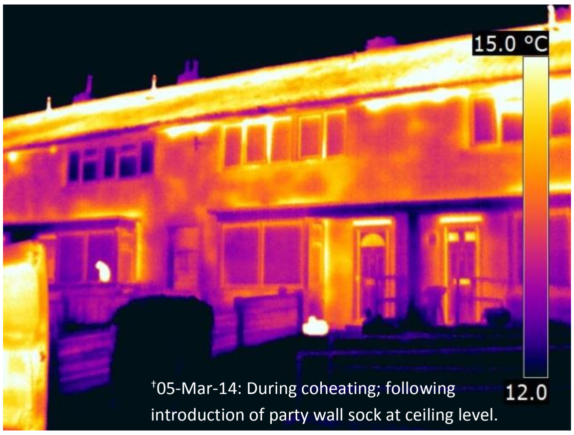
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	A	57.2	3906	3738.9	OK	57.2	4.047	8.227	3501.82	19.45	24.15
Approx 57 Pa	A	48.7	3590	3436.4	OK	48.7	3.886	8.142	r^2	0.999	
Approx 49 Pa	A	41.7	3283	3142.6	OK	41.7	3.731	8.053	C_{env}	332.985	m^3/h.Pa*n*
Approx 41 Pa	A	35.3	2941	2815.2	OK	35.3	3.564	7.943	n	0.599	
Approx 33 Pa	A	27.3	2488	2381.6	OK	27.3	3.307	7.776			
Approx 25 Pa	A	21.2	2177	2083.9	OK	21.2	3.054	7.642	C_L (corrected)	335.930	m^3/h.Pa*n*
Approx 20 Pa	A	14.5	1731	1657.0	OK	14.5	2.674	7.413			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	A	62.4	4223	4411.7	OK	62.4	4.134	8.392	3774.58	20.97	26.03
Approx 57 Pa	A	56.1	3895	4069.1	OK	56.1	4.027	8.311	r^2	0.998	
Approx 49 Pa	A	50.2	3644	3806.8	OK	50.2	3.916	8.245	C_{env}	376.351	m^3/h.Pa*n*
Approx 41 Pa	A	42.6	3294	3441.2	OK	42.6	3.752	8.144	n	0.592	
Approx 33 Pa	A	34.8	2888	3017.1	OK	34.8	3.550	8.012			
Approx 25 Pa	A	26.4	2515	2627.4	OK	26.4	3.273	7.874	C_L (corrected)	373.024	m^3/h.Pa*n*
Approx 20 Pa	A	18.8	2058	2150.0	OK	18.8	2.934	7.673			



Dwelling C-03 before and after retrofit 1



Date of Tests: 19th February 2014 & 6th March 2014

Tested by: D Miles-Shenton, D Farmer, D Glew & F Thomas

Compiled by: Dominic Miles-Shenton

Test Results:

Date	Depressurisation Only			Pressurisation Only			Mean	
	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa	r^2	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa	r^2	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa
19-Feb-14	16.40	17.70	0.998	16.61	17.93	0.991	16.50	17.81
06-Mar-14	16.14	17.43	0.999	18.09	19.53	0.987	17.12	18.48

The pressurisation tests were performed using both pressurisation and depressurisation, with the mean of these being used for energy calculation purposes.

Leakage detection in the first test (19-Feb-14) was performed under pressurisation only using smoke detection at approximately +50 Pa; the internal/external ΔT was insufficient for leakage detection under depressurisation using thermography. For the second test (06-Mar-14) leakage detection was only performed under dwelling depressurisation at approximately -50 Pa using thermography, with the coheating test air circulation fans created too much turbulence for satisfactory smoke detection.

The change in measured air permeability between the 2 tests is small, with variation in results for depressurisation within the realms of experimental tolerances but a more significant increase under pressurisation. It is unlikely that this is due to the intervention between tests of installation of the cavity stop sock in one party wall, but may be due to some shrinkage and drying caused by the coheating test itself (with the dwelling constantly electrically heated to 22 ^{o}C throughout the period between the 2 tests with no internal moisture generation), 3 small (10mm ∅) holes made in the party walls to allow thermocouple probes to measure the cavity temperatures and allow inspection/measurement of the cavities and some deterioration in the temporary sealing applied for the tests.


19-Feb-2014

The mean air permeability of 16.50 $m^3/(h.m^2)$ @ 50Pa was greater than is currently acceptable for new build dwellings under the Building Regulations.

The main leakage paths observed were into the intermediate floor, through and around trickle vents and service penetrations (particularly those through the first floor ceiling into the loft space, including around the loft hatch).

Leakage Detection & Observations

Stairs There was little air leakage at the lower part of the stairs, but significant air leakage at the landing and final step up to the intermediate floor.	
	
Intermediate Floor Air leakage was rife through numerous gaps between floorboard throughout the dwelling and at all junctions of the floor with external and party walls.	

			
Service Penetrations Leakage at service penetrations was commonplace, particularly in the bathroom around the boxed in services for the toilet and around the bath panel.			
			
Cylinder Cupboard Air movement into both the loft space and intermediate floor was particularly severe here, with large openings into both permitting substantial air flow.			
			

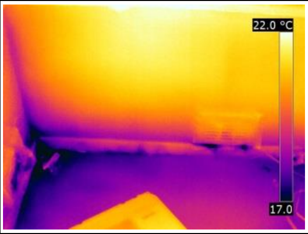
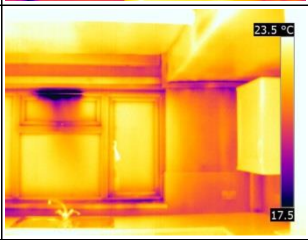
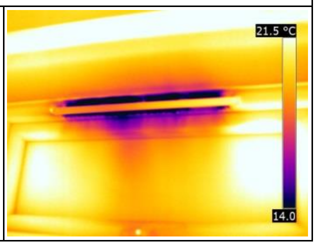
 06-Mar-2014

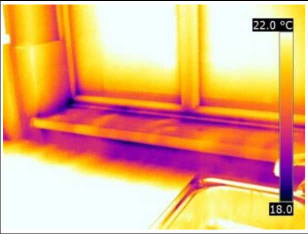
The mean air permeability measured through depressurisation of 17.12 $m^3/(h.m^2)$ @ 50Pa was greater than the previous test. The greatest increase was under dwelling pressurisation, with little change in the result for depressurisation.

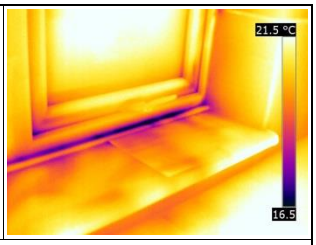
Leakage detection showed similar air infiltration paths and magnitude to the previous test; however, additional leakage was also observed around the windows and at junctions of the first floor ceiling and internal partition walls.

Leakage detection was performed under depressurisation (approx. -50 Pa) throughout. The internal/external ΔT was sufficient to allow this, The thermal images below show infiltrating air at a range of temperatures, the cooler air represents more direct leakage paths the warmer infiltrating air shows more complex indirect paths; they do not necessarily portray the magnitude of airflow (e.g. air infiltration through the intermediate floor in the cylinder cupboard was substantial, but does not show clearly in the thermal images as the infiltrating air has already warmed up somewhat by the time it emerges). In some instances thermal images captured under depressurisation are shown next to those captured under no artificially induced pressure, this allows some determination as to how much of the effect observed is due to air movement and how much is due to thermal conductance or bridging issues.

Leakage Detection & Observations

Lounge Air leakage detected at the fireplace, trickle vents and at the gap between the wall vent and skirting board on the front bay. No leakage was detected at the floor/wall junctions.			
			
Kitchen As in the lounge, there was very little detectable air movement aside from that around openings and service penetrations. Air leakage was detected behind the kitchen units on the external wall, although the exact paths were obscured by the units, and around the intermittant extract fan. Additional air leakage was observed at the external wall where the boxing for services beneath the bathroom met the wall; air emerging from here was significantly warmer than the air entering around the window, indicating a more complex or convoluted leakage path. The most severe leakage was observed around the window, particularly around the closed trickle vent but also at the frame/sill junction and underneath the sill.			
			
			

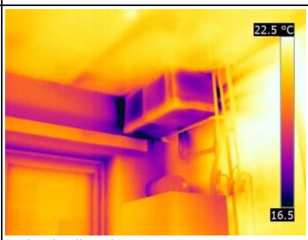



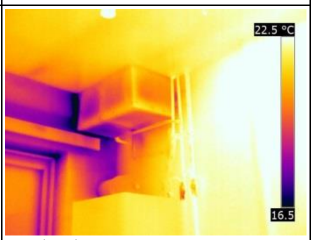
Utility/Boiler Room
Infiltration here was again limited to around openings and service penetrations. The door was draught-stripped and performed well apart from the area where no draught-stripping was applied around the lock. Other notable areas of air flow were observed at exposed and boxed-in penetrations, and at the base of the external wall where the temporary sealing of a wall vent (for test purposes) did not adhere adequately to the damp wall allowing additional infiltration.
Comparison of thermal images under depressurisation and under no artificially-induced negative pressure (using the same temperature range) is used to help to aviod misinterpretation of which observations are due to air leakage and which are due to other effects. As the ground floor is naturally an infiltration zone some air ingress will occur here under normal conditions.



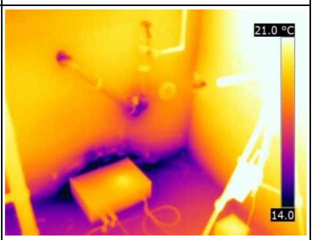
under dwelling depressurisation


no induced negative pressure

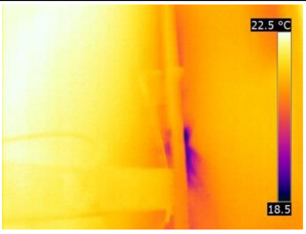
under dwelling depressurisation


no induced negative pressure


under dwelling depressurisation


no induced negative pressure

Hall & Stairs
There appeared to be significant infiltration at the meter cupboards, although due to the close proximity to the blower door it was not possible to determine the actual air paths, and apart from a small area at the party/external wall junction the was no other air leakage detected at any junctions or around the lower part of the stairs.



under dwelling depressurisation

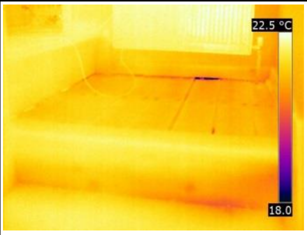
no induced negative pressure

Landing

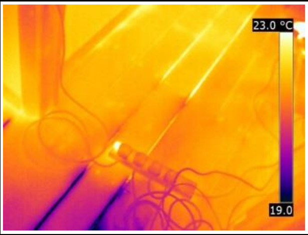
As in the previous pressurisation test, significant air movement was detected at the junction of the stairs with the intermediate floor. Air was detected emerging from the intermediate floor throughout the dwelling, the doorway between the landing and bedroom 2 reveals air surfacing at a range of temperatures (from cooler in the landing to warmer in the bedroom) indicating how complex some of the air movement throughout the dwelling can be.

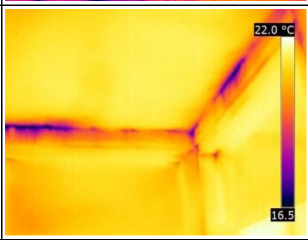
Also, under depressurisation, air could be detected being drawn in from the loftspace at junctions of the ceiling and partition walls, and around the loft hatch. This was not observable under no induced depressurisation as the loft boundary is an exfiltration zone under normal conditions and any air movement would be from the habitable space into the loft.

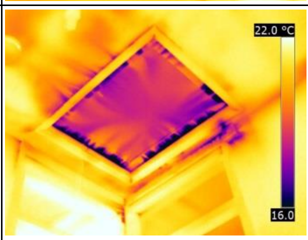
under dwelling depressurisation



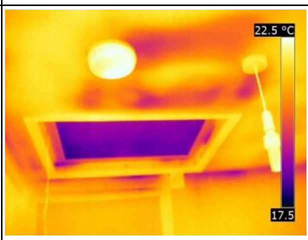
no induced negative pressure







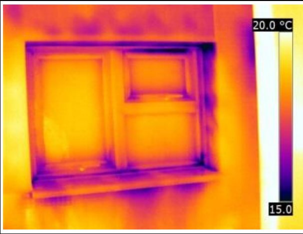
under dwelling depressurisation



no induced negative pressure

Bathroom

With the coheating test equipment running it was not possible to view most of the bathroom, but some leakage around the window was detectable.

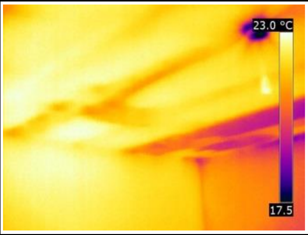


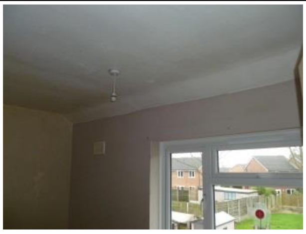
Bedroom 2 (Rear Bedroom)

Solid wet-plastered internal partition walls meant that there was no air being drawn into wall voids from the loft, but some infiltration was observed aroung the central light fitting. Depressurisation appeared to have no obvious effect on the poorly performing sloping sections at the eaves.

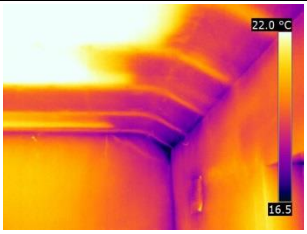
The floor above the ginnel seemed markedly worse under depressurisation, with air entering the room not just at the floor/skirting junction but also substantial air flow through gaps between the floor boards.

The different temeratures of compartments between the built-in joists on the external wall seem to indicate varying levels of infilteration around the built-in joists themselves, from the external cavity.

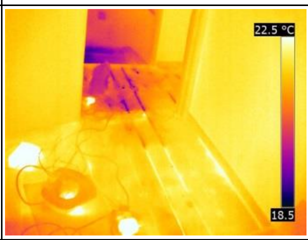




under dwelling depressurisation



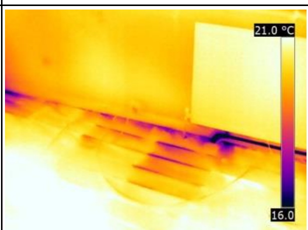
no induced negative pressure



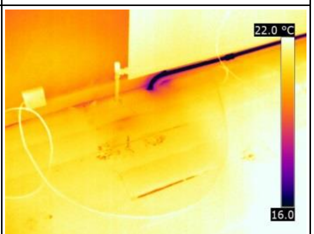
Colder air can be seen emerging from the intermediate floor from above the externally accessible store on the ground floor, warmer air from the areas above the kitchen and utility room.

under dwelling depressurisation

no induced negative pressure



under dwelling depressurisation



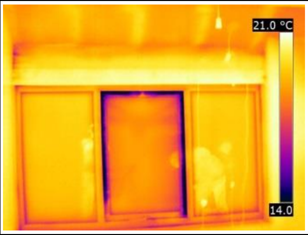
no induced negative pressure

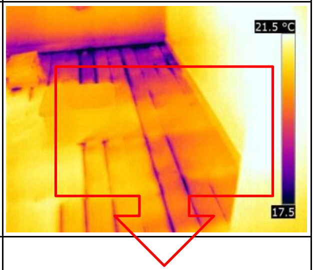
Bedroom 1 (Main Front Bedroom)

Similar observations to those made in Bedroom 2. Also there was significant air leakage around 3 sides of the opening light of the window.

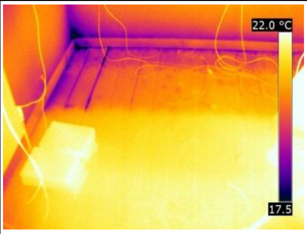
under dwelling depressurisation

no induced negative pressure





under dwelling depressurisation



no induced negative pressure

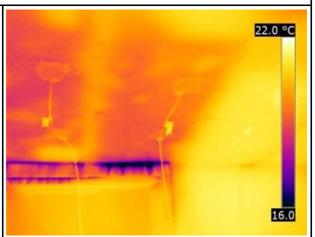
Again, colder air can be seen emerging from the floor directly above the ground floor store.

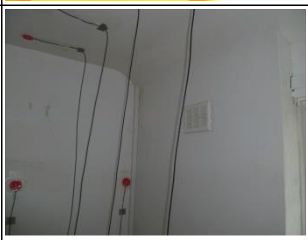
Bedroom 3 (Small Front Bedroom)

As in bedroom 1 there was infiltration at the window, and air was being drawn down from the loft at the ceiling/partition wall junction and through the electrical conduit at the party/external wall junction.

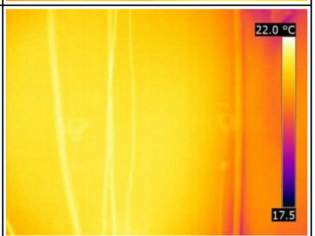
At the floor perimeter significant air movement was detected along both the party wall and external wall, with some lesser infiltration also detected at the electrical socket on the party wall.

There was considerable air movement in the cylinder cupboard, with gaps in both the cupboard ceiling and floor allowing large amounts of air exchange with the conditioned space.

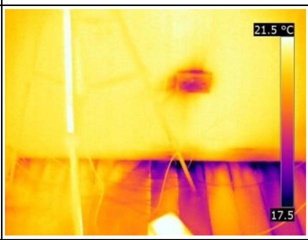


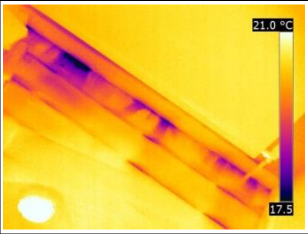


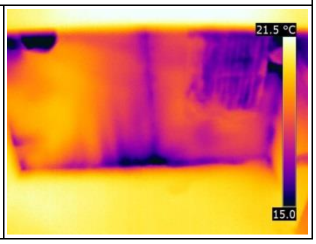
under dwelling depressurisation



no induced negative pressure







Results Spreadsheets

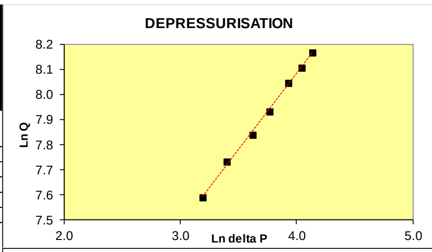
LEEDS METROPOLITAN UNIVERSITY
Leeds Sustainability Institute
CeBE

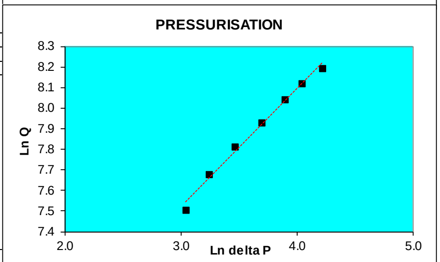
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

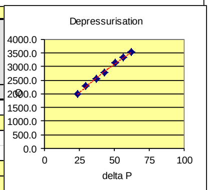
date:	19/02/2013		Version 16a	19 February 2014	
test house address:	.				
company:					
house type:					
tester:	DMS, DG, FT				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	9.6	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	11.2	°C			
outdoor humidity (%rh)	76.6	%RH			
indoor humidity (%rh)	72.1	%RH			
outdoor barometric pressure	1017.2	mbar or hPa	Calculated Outdoor Air Density	1.25	kg/m^3
indoor barometric pressure	1017.2	mbar or hPa	Calculated Indoor Air Density	1.24	kg/m^3
temperature corr. fact. depress.	0.994		description of main construction details:		
temperature corr. fact. press.	1.006				
wind speed (m/s):					
baseline pressure diff (Pa) (+/-)		Pa			
house width:	5.03	m			
house depth:	6.8	m			
house height:	5.156	m			
floor area:		m^2			
volume:	176.35582	m^3			
envelope area including floor:	190.39	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	3141.62	m^3/h			
Mean Air Leakage at 50Pa =	17.81	h^{-1}			
Mean Air Permeability at 50 Pa =	16.50	m/h or m^3h/m^2			
Equivalent Leakage Area =	0.138	m^2 at	10	Pa	

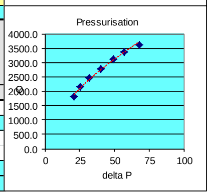
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	62.6	3550	3529.5	OK	62.6	4.137	8.169	3121.77	16.40	17.70
Approx 57 Pa	a	56.9	3343	3323.7	OK	56.9	4.041	8.109	r^2	0.998	
Approx 49 Pa	a	50.8	3145	3126.8	OK	50.8	3.928	8.048	C_{env}	286.048	$m^3/h.Pa^n$
Approx 41 Pa	a	43.2	2805	2788.8	OK	43.2	3.766	7.933	n	0.607	
Approx 33 Pa	a	37.4	2559	2544.2	OK	37.4	3.622	7.842			
Approx 25 Pa	a	30	2296	2282.7	OK	30	3.401	7.733	C_L (corrected)	290.582	$m^3/h.Pa^n$
Approx 20 Pa	a	24.3	1992	1980.5	OK	24.3	3.190	7.591			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	67.8	3605	3626.0	OK	67.8	4.217	8.196	3161.47	16.61	17.93
Approx 57 Pa	a	56.9	3347	3366.5	OK	56.9	4.041	8.122	r^2	0.991	
Approx 49 Pa	a	49.3	3086	3104.0	OK	49.3	3.898	8.040	C_{env}	327.968	$m^3/h.Pa^n$
Approx 41 Pa	a	40.2	2760	2776.1	OK	40.2	3.694	7.929	n	0.575	
Approx 33 Pa	a	32	2459	2473.3	OK	32	3.466	7.813			
Approx 25 Pa	a	25.6	2147	2159.5	OK	25.6	3.243	7.678	C_L (corrected)	332.764	$m^3/h.Pa^n$
Approx 20 Pa	a	21	1810	1820.5	OK	21	3.045	7.507			







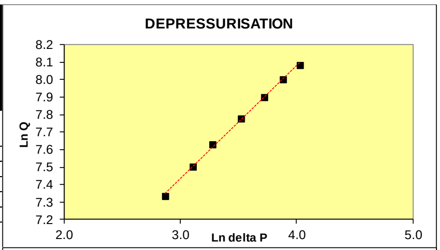


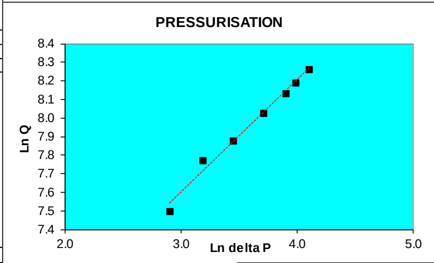
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

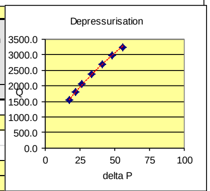
date:	06/03/2013		Version 16a	19 February 2014
test house address:				
company:				
house type:				
tester:	DMS, DF			
test reference number:	2		Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	11	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	21.9	°C		
outdoor humidity (%rh)	51.1	%RH		
indoor humidity (%rh)	43.6	%RH		
outdoor barometric pressure	1007.3	mbar or hPa	Calculated Outdoor Air Density	1.23 kg/m^3
indoor barometric pressure	1007.2	mbar or hPa	Calculated Indoor Air Density	1.18 kg/m^3
temperature corr. fact. depress.	0.963	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.038	Extreme Test	Depressurisation 13:16 - 13:50 Pressurisation 14:03 - 14:16	
wind speed (m/s):	1	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house width:	5.03	m		
house depth:	6.8	m		
house height:	5.156	m		
floor area:		m^2		
volume:	176.35582	m^3		
envelope area including floor:	190.39	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	3258.97	m^3/h		
Mean Air Leakage at 50Pa =	18.48	h^{-1}		
Mean Air Permeability at 50 Pa =	17.12	m/h or m^3h/m^2		
Equivalent Leakage Area =	0.135	m^2 at	10	Pa

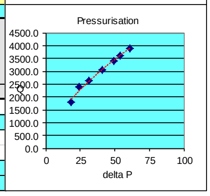
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	56.2	3375	3244.2	OK	56.2	4.029	8.085	3073.60	16.14	17.43
Approx 57 Pa	a	48.5	3110	2989.5	OK	48.5	3.882	8.003	r^2	0.999	
Approx 49 Pa	a	41.4	2809	2700.1	OK	41.4	3.723	7.901	C_{env}	243.860	$m^3/h.Pa^n$
Approx 41 Pa	a	33.9	2486	2389.6	OK	33.9	3.523	7.779	n	0.645	
Approx 33 Pa	a	26.5	2137	2054.2	OK	26.5	3.277	7.628			
Approx 25 Pa	a	22.4	1883	1810.0	OK	22.4	3.109	7.501	C_L (corrected)	246.135	$m^3/h.Pa^n$
Approx 20 Pa	a	17.6	1594	1532.2	OK	17.6	2.868	7.334			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	60.7	3725	3875.2	OK	60.7	4.106	8.262	3444.34	18.09	19.53
Approx 57 Pa	a	54	3470	3609.9	OK	54	3.989	8.191	r^2	0.987	
Approx 49 Pa	a	49.5	3277	3409.1	OK	49.5	3.902	8.134	C_{env}	330.389	$m^3/h.Pa^n$
Approx 41 Pa	a	40.9	2947	3065.8	OK	40.9	3.711	8.028	n	0.601	
Approx 33 Pa	a	31.4	2533	2635.1	OK	31.4	3.447	7.877			
Approx 25 Pa	a	24.3	2287	2379.2	OK	24.3	3.190	7.775	C_L (corrected)	328.632	$m^3/h.Pa^n$
Approx 20 Pa	a	18.2	1734	1803.9	OK	18.2	2.901	7.498			









Dwelling C-03 after retrofit 2

Date of Test: 17th & 25th March 2014

Tested by: D Miles-Shenton, D Farmer, D Glew & F Thomas

Compiled by: Dominic Miles-Shenton

Test Results:

Test no.	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa
01	19-Feb-14	16.40	17.70	0.998	16.61	17.93	0.991	16.50	17.81
02	06-Mar-14	16.14	17.43	0.999	18.09	19.53	0.987	17.12	18.48
03	17-Mar-14	14.50	15.66	0.995	15.34	16.56	0.995	14.92	16.11
04	25-Mar-14	13.78	14.88	0.997	14.65	15.81	0.999	14.21	15.34

The pressurisation tests were performed using both pressurisation and depressurisation, with the mean of these being used for energy calculation purposes.

Leakage detection for test 01 (19-Feb-14) and test 02 (06-Mar-14) was reported on in *Pressure Test Report 1*. Leakage detection for test 03 and test 04 was only performed under dwelling depressurisation at approximately -50 Pa using thermography, and is detailed below.

The change in measured air permeability between the test 02 and test 03 was significant. Some of the temporary sealing used on wall vents and waste outlets had been replenished, but it is unlikely this will have had much on an effect on the test result. The filling of the cavity party wall with blown fibre insulation was the only other intervention between these tests and must therefore have been responsible for the major part of this reduction. A further increase in airtightness was recorded between test 03 and test 04 following the re-fit and top-up of the loft insulation and installation of draught-stripping around the loft hatch.


17-Mar-2014 (test 03)

The mean air permeability of 14.92 $m^3/(h.m^2)$ @ 50Pa showed an increase in airtightness following the fill of the party wall cavity.

Leakage detection was performed under depressurisation (approx. -50 Pa) throughout. The internal/external ΔT was 12^oC. The main leakage paths observed were again into the intermediate floor and through and around openings, trickle vents and service penetrations (particularly those through the first floor ceiling into the loft space, including around the loft hatch).

Even with a decrease in air permeability of >2 $m^3/(h.m^2)$ @ 50Pa compared to the previous pressurisation test there were no noticeable changes in severity of any observed infiltration paths, however what was different was that infiltration from the filled party wall was emerging as warm air and is displayed most clearly around the pattress box chased into the party wall and the intermediate floor junction in bedroom 3.

 25-Mar-2014 (test 04)

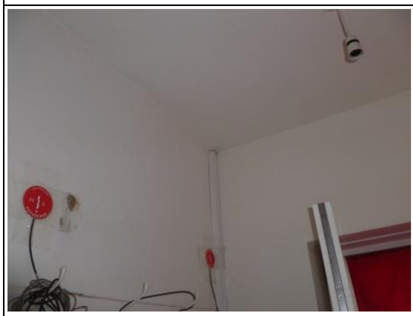
The mean air permeability measured through depressurisation of 14.21 $m^3/(h.m^2)$ @ 50Pa showed another reduction from the previous test.

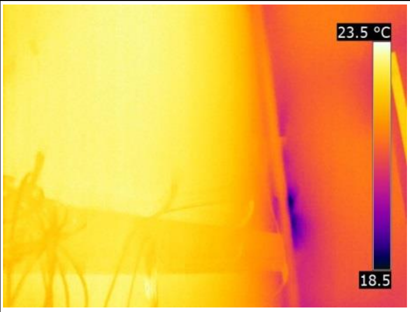
Leakage detection showed similar air infiltration paths and magnitude to the previous test with the reduction due to the installation of draught-stripping around the loft hatch.

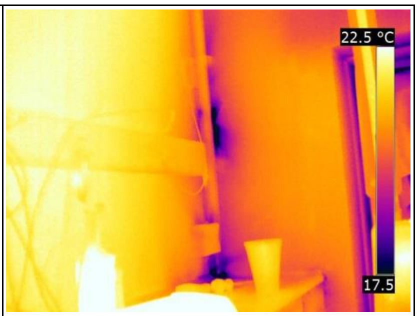
Leakage detection was again performed under depressurisation (approx. -50 Pa) throughout. The internal/external ΔT was 14^oC, 2^oC greater than test 03, this should be considered when comparing the thermal images below.

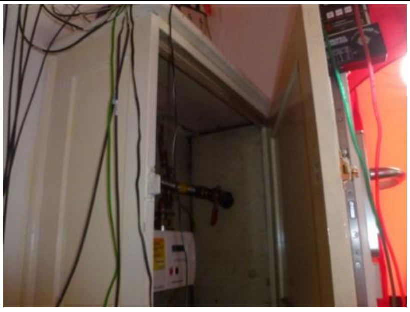
Leakage Detection & Observations

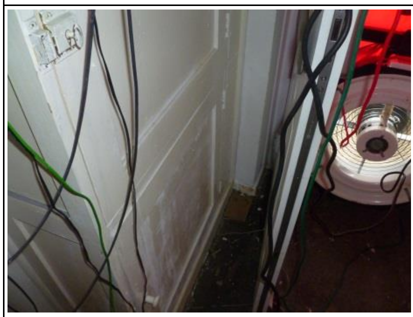
Thermal images from test 03 and test 04 are shown below in adjacent columns to highlight any changes between the 2 tests. All the thermal images below show either a 5^oC or 10^oC span, allowing fairer comparison between them to be made.

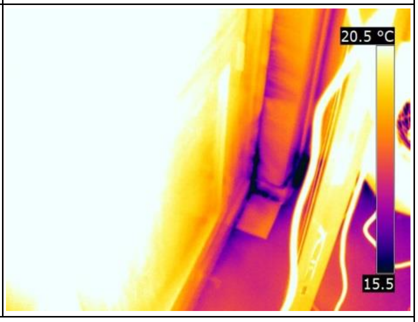
	17-Mar-2014 (test 03)	25-Mar-2014 (test 04)
Hall Similar leakage paths were observed to those identified in previous tests, although infiltration around the gas and electric meter cupboards may have reduced slightly as previously there appeared to be too much turbulence to capture reasonable thermal images, whereas now this was possible.		
		





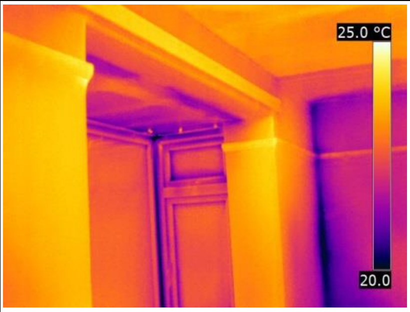




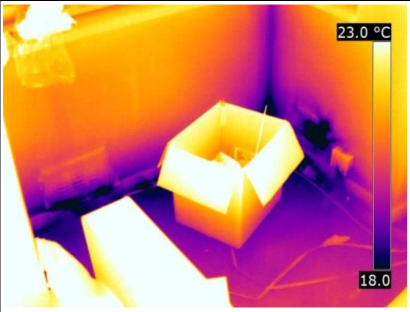


Lounge

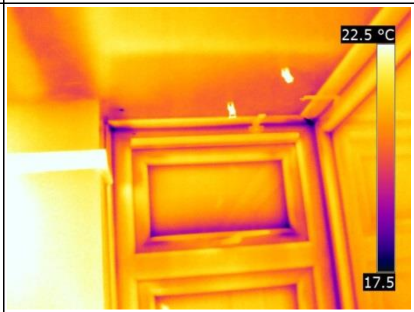
Again, there was no significant change in detected leakage paths to those identified in previous tests. With the steady increase in ΔT with each test some areas of lesser leakage were now more clearly detectable through thermal imaging, such as small gaps around the bay window and the compartmentalisation of the intermediate floor void.

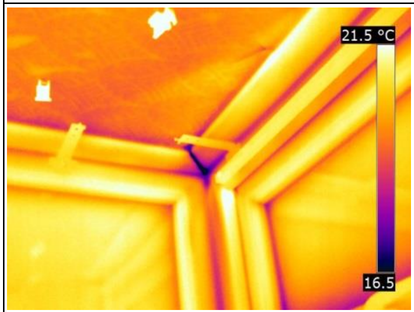

25.0 °C
20.0


24.0 °C
19.0

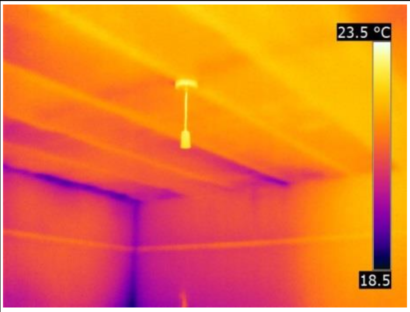

23.0 °C
18.0


26.0 °C
16.0

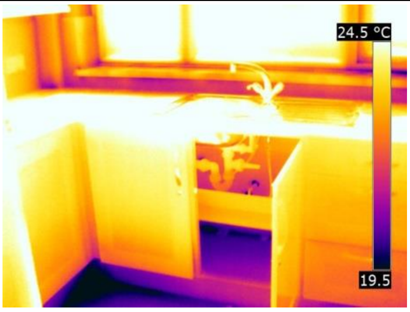

22.5 °C
17.5

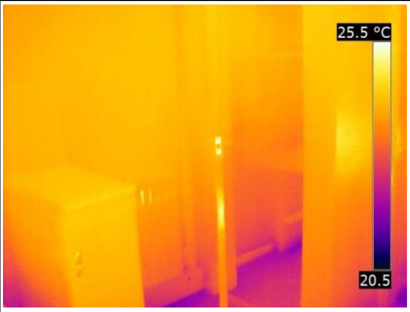

21.5 °C
16.5

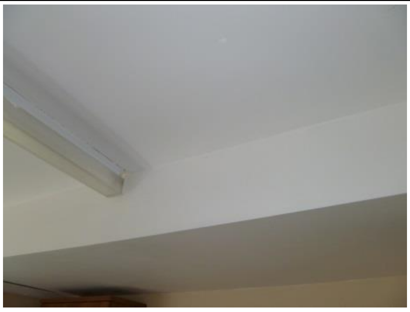
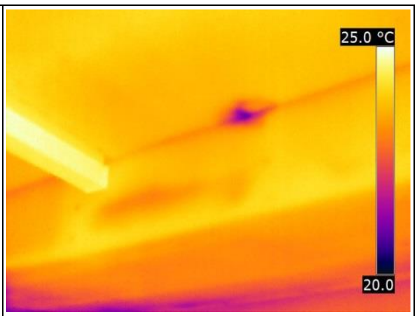
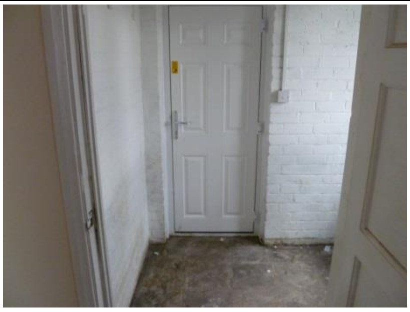
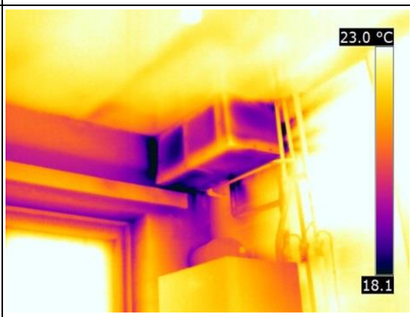
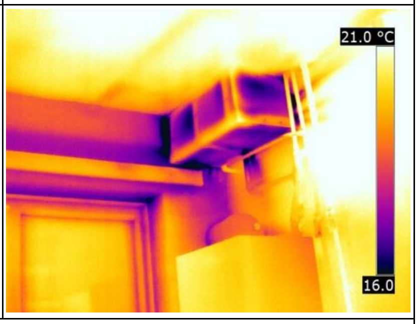

23.0 °C
18.0



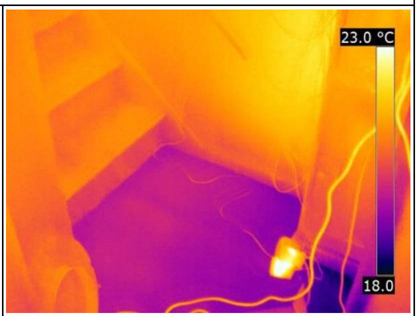
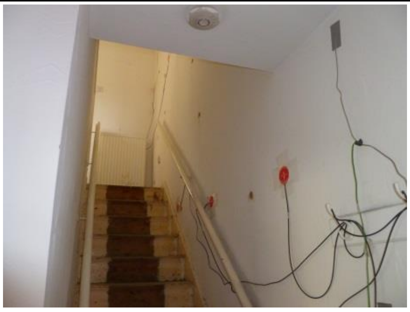
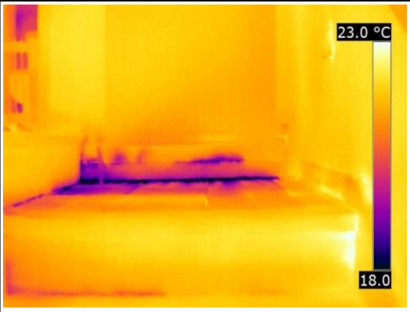
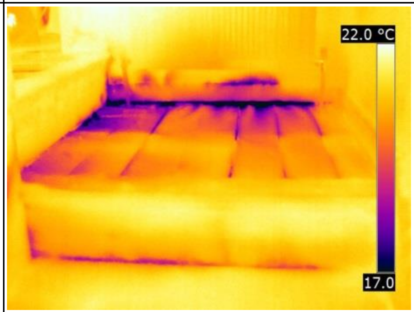
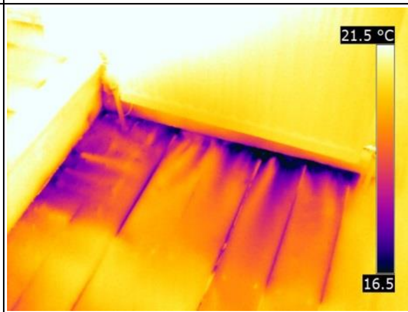
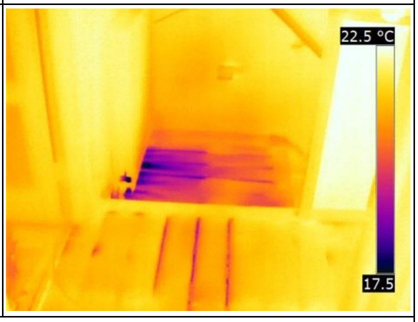
Kitchen & Utility Room
Once again, the detected leakage paths remained very similar to those identified in previous tests, and the increase in ΔT enhancing thermographic leakage detection.





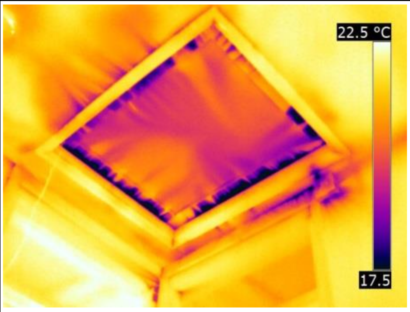
		25.0 °C 20.0
	26.0 °C 16.0	24.5 °C 14.5
	23.5 °C 18.5	20.5 °C 15.5
	24.0 °C 14.0	22.5 °C 12.5
	23.0 °C 18.1	21.0 °C 16.0
Stairs		

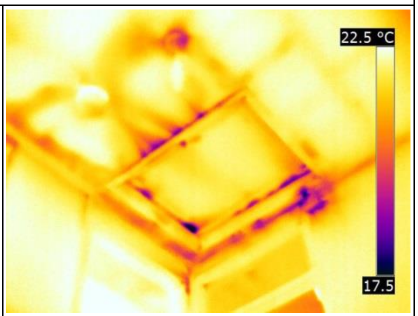
Although there appeared to be no significant differences in the severity of air leakage here between the tests what was observed through thermal imaging was that the infiltration from the recently filled party wall was emerging as warm air, whereas in test 02 it had been cooler, particularly around the electrical pattress box on the party wall and junction of the landing with the filled party wall.

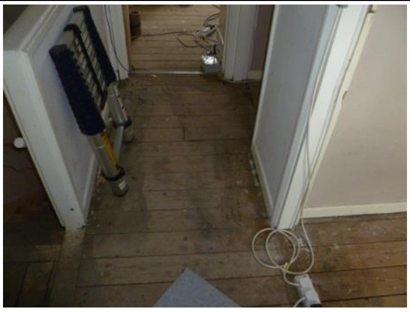
		
		
		
		
		

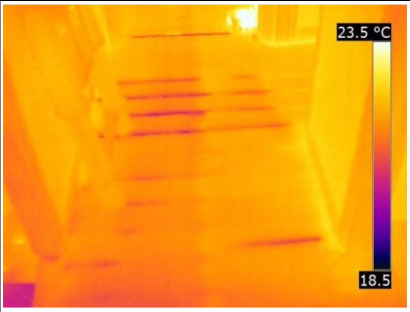
Landing

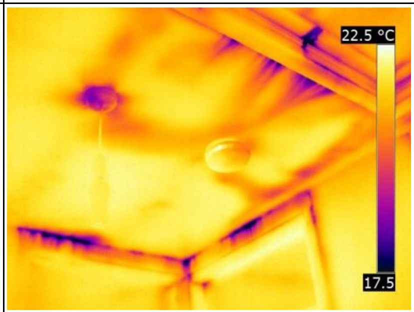
Air leakage detected here was similar to previously observed with the exception of the loft hatch, where the draught-stripping applied as part of the loft upgrade drastically reduced air movement between the loft door and hatch.

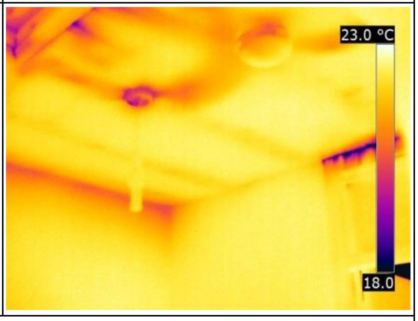




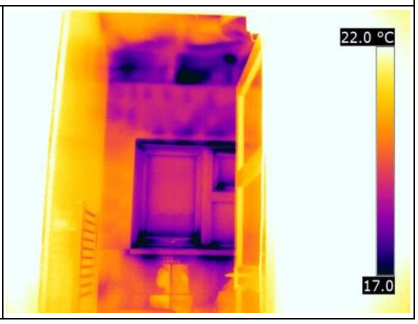


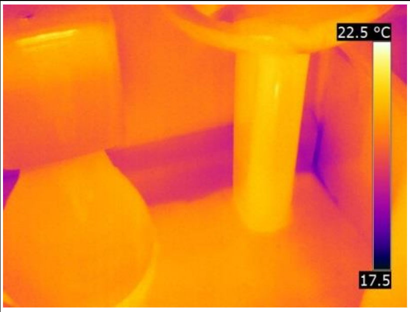


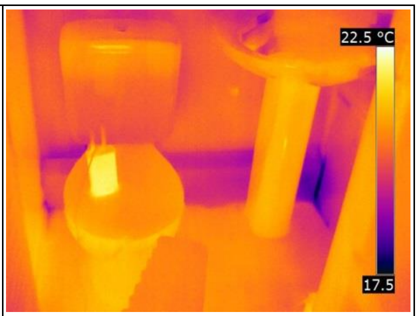


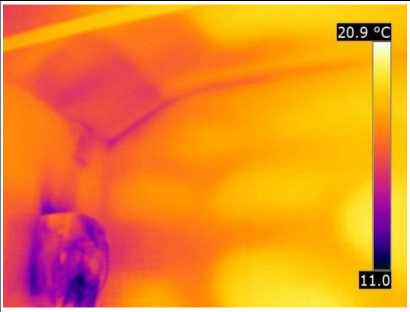


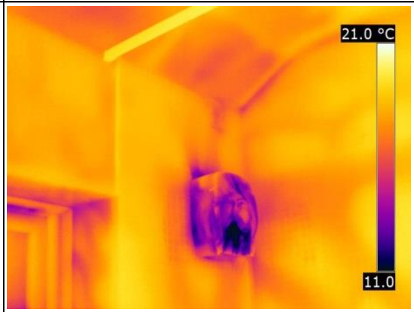
Bathroom
As previously noted, the detected infiltration paths remained similar to those identified in previous tests.

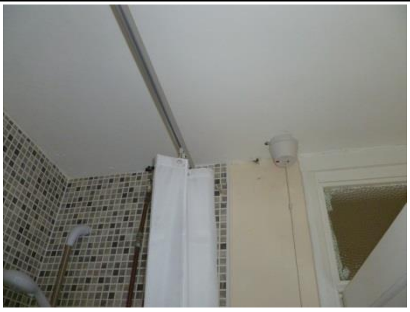


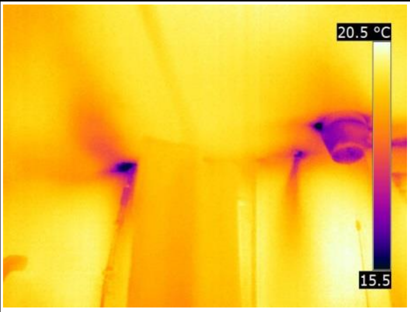


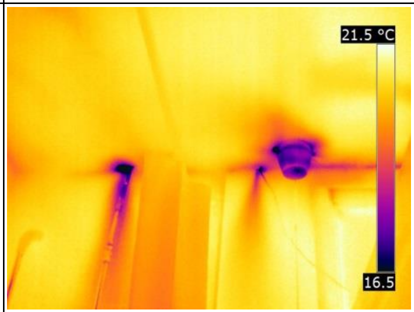


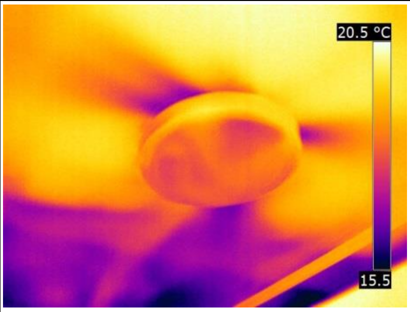






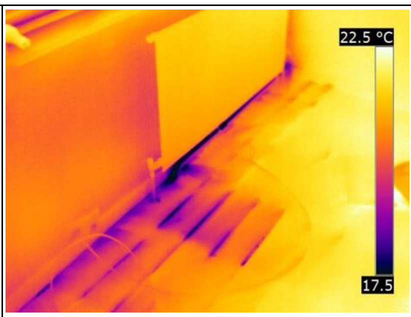


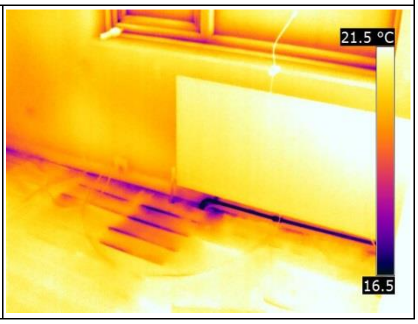


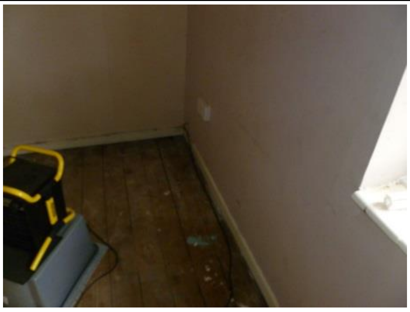


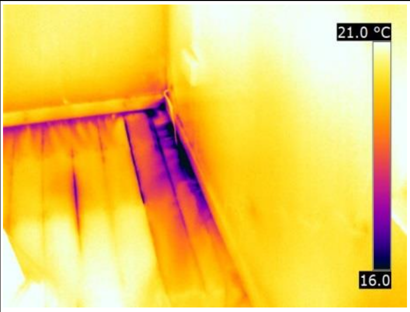
Bedroom 2 (Rear)

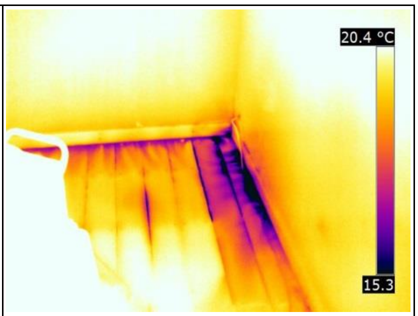
Air leakage paths were unchanged from previous tests The upgrade of the loft insulation between test 03 and test 04 is shown by the more even ceiling temperatures; however, air leakage around the central light fixing appeared to be unaffected.

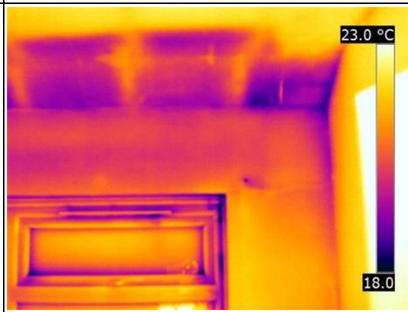


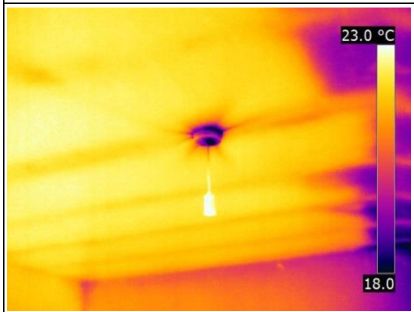


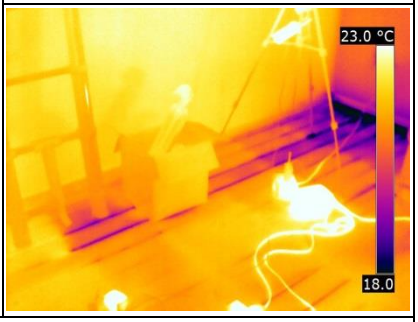








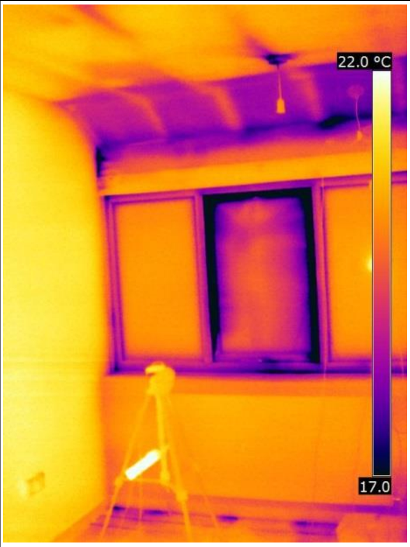


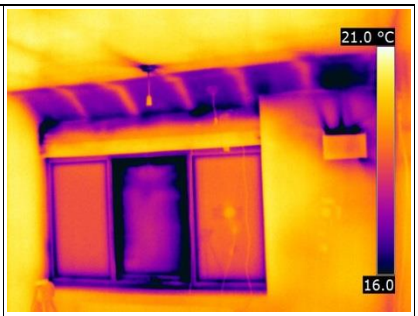


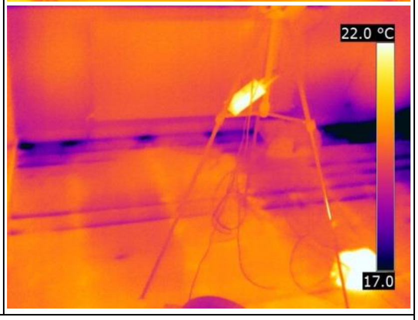
Bedroom 1

As in bedroom 2, the upgrade of the loft insulation between the 2 tests is shown by the more even ceiling temperatures. The electrical pattress box on this unfilled party wall still shows infiltration of cold air, unlike those on the filled party wall which now show warmer air emerging. Otherwise, the only differences observed between these tests (and previous ones) was due to the increased ΔT.

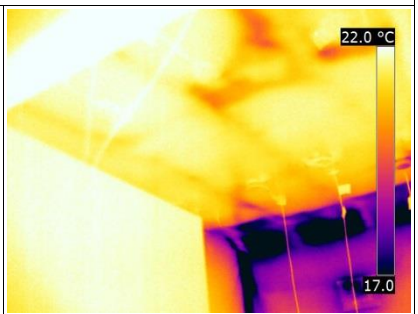

23.5 °C
18.5
22.5 °C
17.5
22.0 °C
17.0
21.0 °C
16.0
21.0 °C
16.0
21.5 °C
16.5
21.0 °C
15.9

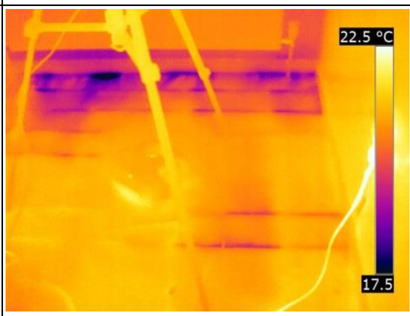


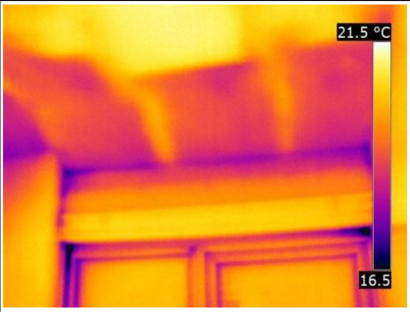


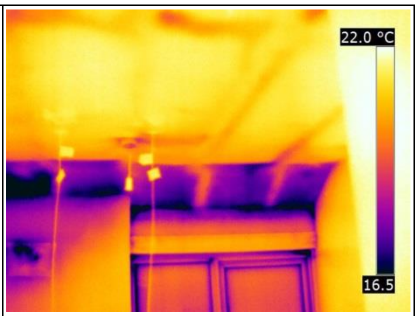


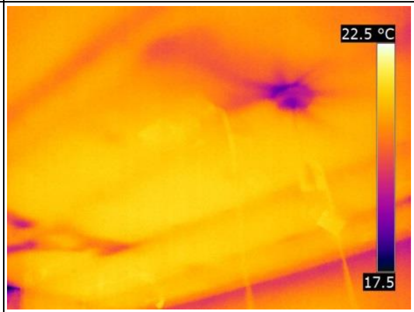
Bedroom 3
As in the other bedrooms the loft upgrade is shown by more even ceiling temperatures, and other differences observed between tests due to the increased ΔT for the latter test. The electrical pattress box on the party wall and the floor/wall junction beneath it show infiltration of warm air emerging from the filled party wall cavity; previously (without the party wall cavity filled) infiltration here had been detected as cooler air.

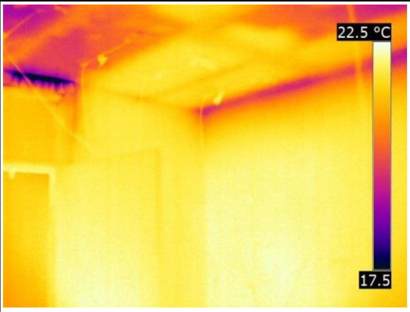


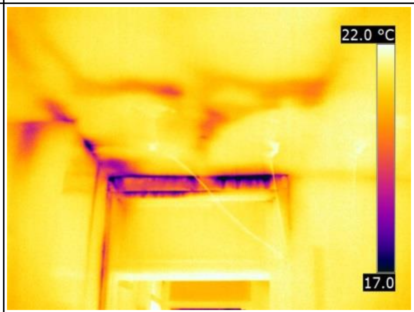


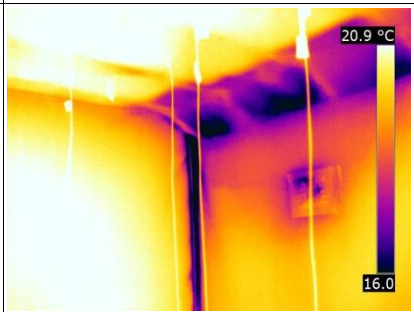


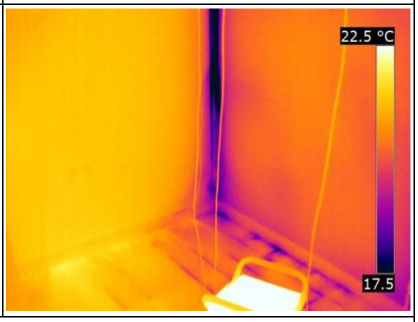






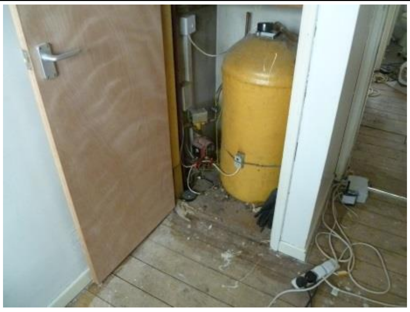


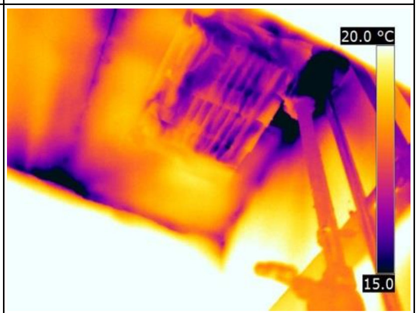


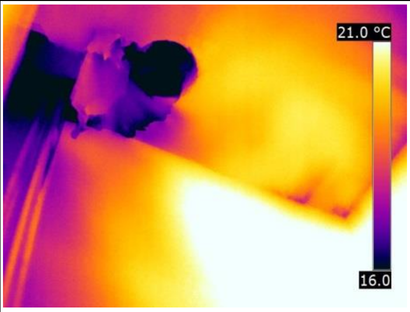


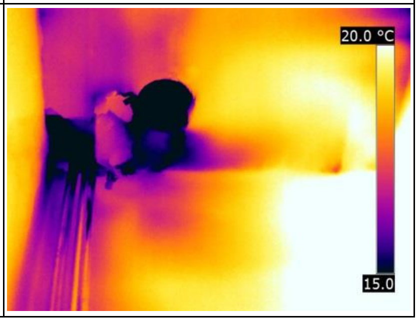
From test 02 (06-Mar-14) prior to party wall cavity fill:

Cylinder Cupboard
There was no noticeable change in air leakage patterns in the cylinder cupboard between these tests and the previous one.







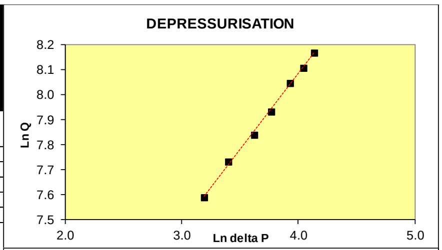


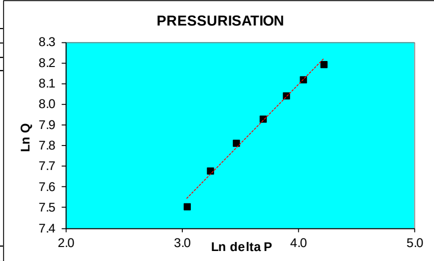
Results Spreadsheets

MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

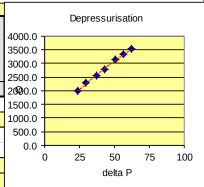
LEEDS METROPOLITAN UNIVERSITY — Leeds Sustainability Institute — CeBE

date:	19/02/2013		Version 16a	19 February 2014
test house address:	.			
company:				
house type:				
tester:	DMS, DG, FT			
test reference number:	test 01		Blow er Door & Gauge Used	Model 3 w ith DG700
outdoor temp (°C)	9.6	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	11.2	°C		
outdoor humidity (%rh)	76.6	%RH		
indoor humidity (%rh)	72.1	%RH		
outdoor barometric pressure	1017.2	mbar or hPa	Calculated Outdoor Air Density	1.25 kg/m^3
indoor barometric pressure	1017.2	mbar or hPa	Calculated Indoor Air Density	1.24 kg/m^3
temperature corr. fact. depress.	0.994		description of main construction details:	
temperature corr. fact. press.	1.006			
w ind speed (m/s):				
baseline pressure diff (Pa) (+/-)		Pa		
house w idth:	5.03	m		
house depth:	6.8	m		
house height:	5.156	m		
floor area:		m^2		
volume:	176.35582	m^3		
envelope area including floor:	190.39	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	3141.62	m^3/h		
Mean Air Leakage at 50Pa =	17.81	h^{-1}		
Mean Air Permeability at 50 Pa =	16.50	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.138	m^2 at	10	Pa

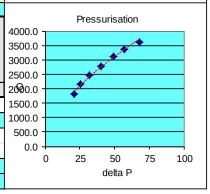




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^{3}h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	62.6	3550	3529.5	OK	62.6	4.137	8.169	3121.77	16.40	17.70
Approx 57 Pa	a	56.9	3343	3323.7	OK	56.9	4.041	8.109	r^2	0.998	
Approx 49 Pa	a	50.8	3145	3126.8	OK	50.8	3.928	8.048	C_{env}	286.048	m^3/h.Pan
Approx 41 Pa	a	43.2	2805	2788.8	OK	43.2	3.766	7.933	n	0.607	
Approx 33 Pa	a	37.4	2559	2544.2	OK	37.4	3.622	7.842			
Approx 25 Pa	a	30	2296	2282.7	OK	30	3.401	7.733	C_L (corrected)	290.582	m^3/h.Pan
Approx 20 Pa	a	24.3	1992	1980.5	OK	24.3	3.190	7.591			



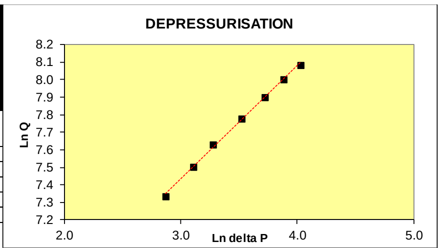
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^{3}h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	67.8	3605	3626.0	OK	67.8	4.217	8.196	3161.47	16.61	17.93
Approx 57 Pa	a	56.9	3347	3366.5	OK	56.9	4.041	8.122	r^2	0.991	
Approx 49 Pa	a	49.3	3086	3104.0	OK	49.3	3.898	8.040	C_{env}	327.968	m^3/h.Pan
Approx 41 Pa	a	40.2	2760	2776.1	OK	40.2	3.694	7.929	n	0.575	
Approx 33 Pa	a	32	2459	2473.3	OK	32	3.466	7.813			
Approx 25 Pa	a	25.6	2147	2159.5	OK	25.6	3.243	7.678	C_L (corrected)	332.764	m^3/h.Pan
Approx 20 Pa	a	21	1810	1820.5	OK	21	3.045	7.507			

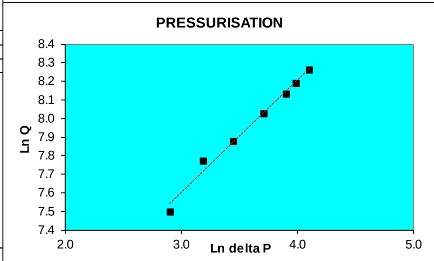


MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

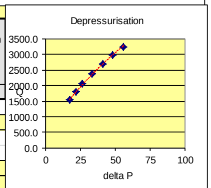
LEEDS METROPOLITAN UNIVERSITY — Leeds Sustainability Institute — CeBE

date:	06/03/2013		Version 16a	19 February 2014
test house address:	.			
company:				
house type:				
tester:	DMS, DF			
test reference number:	test 02		Blow er Door & Gauge Used	Model 3 w ith DG700
outdoor temp (°C)	11	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	21.9	°C		
outdoor humidity (%rh)	51.1	%RH		
indoor humidity (%rh)	43.6	%RH		
outdoor barometric pressure	1007.3	mbar or hPa	Calculated Outdoor Air Density	1.23 kg/m^3
indoor barometric pressure	1007.2	mbar or hPa	Calculated Indoor Air Density	1.18 kg/m^3
temperature corr. fact. depress.	0.963	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.038	Extreme Test	Depressurisation 13:16 - 13:50 Pressurisation 14:03 - 14:16	
w ind speed (m/s):	1	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house w idth:	5.03	m		
house depth:	6.8	m		
house height:	5.156	m		
floor area:		m^2		
volume:	176.35582	m^3		
envelope area including floor:	190.39	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	3258.97	m^3/h		
Mean Air Leakage at 50Pa =	18.48	h^{-1}		
Mean Air Permeability at 50 Pa =	17.12	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.135	m^2 at	10	Pa

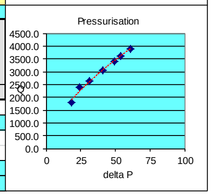




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^{3}h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	56.2	3375	3244.2	OK	56.2	4.029	8.085	3073.60	16.14	17.43
Approx 57 Pa	a	48.5	3110	2989.5	OK	48.5	3.882	8.003	r^2	0.999	
Approx 49 Pa	a	41.4	2809	2700.1	OK	41.4	3.723	7.901	C_{env}	243.860	m^3/h.Pan
Approx 41 Pa	a	33.9	2486	2389.6	OK	33.9	3.523	7.779	n	0.645	
Approx 33 Pa	a	26.5	2137	2054.2	OK	26.5	3.277	7.628			
Approx 25 Pa	a	22.4	1883	1810.0	OK	22.4	3.109	7.501	C_L (corrected)	246.135	m^3/h.Pan
Approx 20 Pa	a	17.6	1594	1532.2	OK	17.6	2.868	7.334			

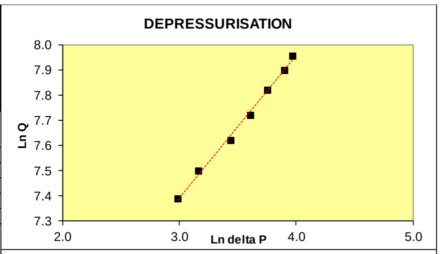


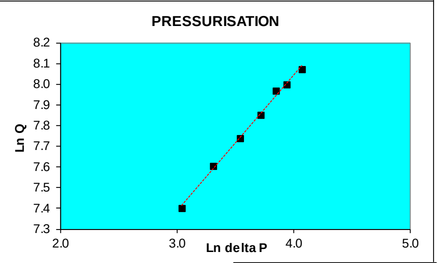
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^{3}h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	60.7	3725	3875.2	OK	60.7	4.106	8.262	3444.34	18.09	19.53
Approx 57 Pa	a	54	3470	3609.9	OK	54	3.989	8.191	r^2	0.987	
Approx 49 Pa	a	49.5	3277	3409.1	OK	49.5	3.902	8.134	C_{env}	330.389	m^3/h.Pan
Approx 41 Pa	a	40.9	2947	3065.8	OK	40.9	3.711	8.028	n	0.601	
Approx 33 Pa	a	31.4	2533	2635.1	OK	31.4	3.447	7.877			
Approx 25 Pa	a	24.3	2287	2379.2	OK	24.3	3.190	7.775	C_L (corrected)	328.632	m^3/h.Pan
Approx 20 Pa	a	18.2	1734	1803.9	OK	18.2	2.901	7.498			



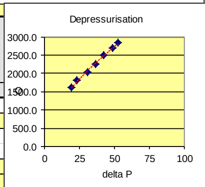
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	17/03/2014	Version 16a	19 February 2014	
test house address:				
company:				
house type:				
tester:	DMS			
test reference number:	test 03		Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	9.8	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	21.6	°C		
outdoor humidity (%rh)	72.1	%RH		
indoor humidity (%rh)	42.7	%RH		
outdoor barometric pressure	1009.1	mbar or hPa	Calculated Outdoor Air Density	1.24 kg/m³
indoor barometric pressure	1008.9	mbar or hPa	Calculated Indoor Air Density	1.19 kg/m³
temperature corr. fact. depress.	0.960	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.042	Extreme Test		
wind speed (m/s):	1.7	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house width:	5.03	m		
house depth:	6.8	m		
house height:	5.156	m		
floor area:		m²		
volume:	176.35582	m³		
envelope area including floor:	190.39	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	2841.13	m³/h		
Mean Air Leakage at 50Pa =	16.11	h⁻¹		
Mean Air Permeability at 50 Pa =	14.92	m/h or m³/h/m²		
Equivalent Leakage Area =	0.121	m² at	10	Pa

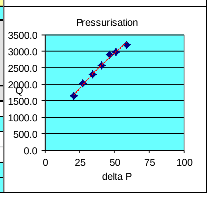




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	a	52.7	2977	2854.8	OK	52.7	3.965	7.957	2761.29	14.50	15.66
Approx 57 Pa	a	49.2	2811	2695.6	OK	49.2	3.896	7.899	r^2	0.995	
Approx 49 Pa	a	42.6	2601	2494.2	OK	42.6	3.752	7.822	C_{env}	297.050	m³/h.Pan
Approx 41 Pa	a	37	2353	2256.4	OK	37	3.611	7.722	n	0.566	
Approx 33 Pa	a	31.2	2131	2043.5	OK	31.2	3.440	7.622			
Approx 25 Pa	a	23.6	1885	1807.6	OK	23.6	3.161	7.500	C_L (corrected)	301.127	m³/h.Pan
Approx 20 Pa	a	19.8	1688	1618.7	OK	19.8	2.986	7.389			

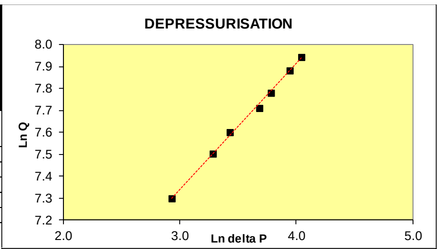


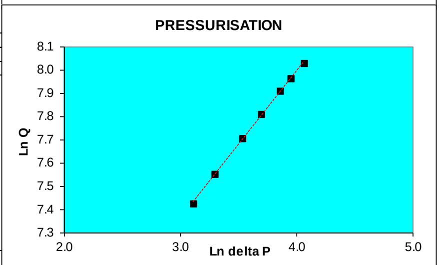
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa	a	58.9	3069	3200.4	OK	58.9	4.076	8.071	2920.97	15.34	16.56
Approx 57 Pa	a	51.5	2855	2977.2	OK	51.5	3.942	7.999	r^2	0.995	
Approx 49 Pa	a	46.9	2767	2885.4	OK	46.9	3.848	7.967	C_{env}	227.321	m³/h.Pan
Approx 41 Pa	a	41.1	2469	2574.7	OK	41.1	3.716	7.853	n	0.654	
Approx 33 Pa	a	34.6	2207	2301.5	OK	34.6	3.544	7.741			
Approx 25 Pa	a	27.4	1929	2011.6	OK	27.4	3.311	7.607	C_L (corrected)	226.498	m³/h.Pan
Approx 20 Pa	a	21	1569	1636.2	OK	21	3.045	7.400			



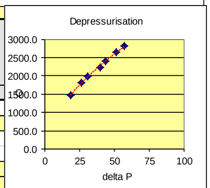
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	25/03/2014	Version 16a	19 February 2014	
test house address:				
company:				
house type:				
tester:	DMS			
test reference number:	test 04		Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	7.9	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	21.6	°C		
outdoor humidity (%rh)	91	%RH		
indoor humidity (%rh)	38	%RH		
outdoor barometric pressure	999.4	mbar or hPa	Calculated Outdoor Air Density	1.23 kg/m³
indoor barometric pressure	999.3	mbar or hPa	Calculated Indoor Air Density	1.18 kg/m³
temperature corr. fact. depress.	0.953	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.049	Extreme Test	Post loft top-up d 14:40 p 15:17	
wind speed (m/s):	1.1	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house width:	5.03	m		
house depth:	6.8	m		
house height:	5.156	m		
floor area:		m²		
volume:	176.35582	m³		
envelope area including floor:	190.39	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	2706.07	m³/h		
Mean Air Leakage at 50Pa =	15.34	h⁻¹		
Mean Air Permeability at 50 Pa =	14.21	m/h or m³/h/m²		
Equivalent Leakage Area =	0.115	m² at	10	Pa

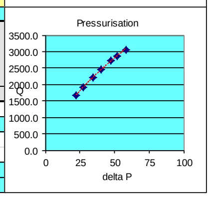




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	a	57.3	2952	2814.4	OK	57.3	4.048	7.943	2623.70	13.78	14.88
Approx 57 Pa	a	51.6	2784	2654.2	OK	51.6	3.944	7.884	r^2	0.997	
Approx 49 Pa	a	43.9	2512	2394.9	OK	43.9	3.782	7.781	C_{env}	276.148	m³/h.Pan
Approx 41 Pa	a	39.8	2339	2230.0	OK	39.8	3.684	7.710	n	0.572	
Approx 33 Pa	a	30.8	2097	1999.3	OK	30.8	3.428	7.601			
Approx 25 Pa	a	26.7	1899	1810.5	OK	26.7	3.285	7.501	C_L (corrected)	279.488	m³/h.Pan
Approx 20 Pa	a	18.8	1549	1476.8	OK	18.8	2.934	7.298			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa	a	58.1	2922	3064.9	OK	58.1	4.062	8.028	2788.43	14.65	15.81
Approx 57 Pa	a	51.9	2740	2874.0	OK	51.9	3.949	7.963	r^2	0.999	
Approx 49 Pa	a	47.5	2598	2725.0	OK	47.5	3.861	7.910	C_{env}	234.120	m³/h.Pan
Approx 41 Pa	a	40.4	2349	2463.8	OK	40.4	3.699	7.809	n	0.635	
Approx 33 Pa	a	34.2	2120	2223.7	OK	34.2	3.532	7.707			
Approx 25 Pa	a	27.1	1819	1907.9	OK	27.1	3.300	7.554	C_L (corrected)	232.451	m³/h.Pan
Approx 20 Pa	a	22.5	1599	1677.2	OK	22.5	3.114	7.425			



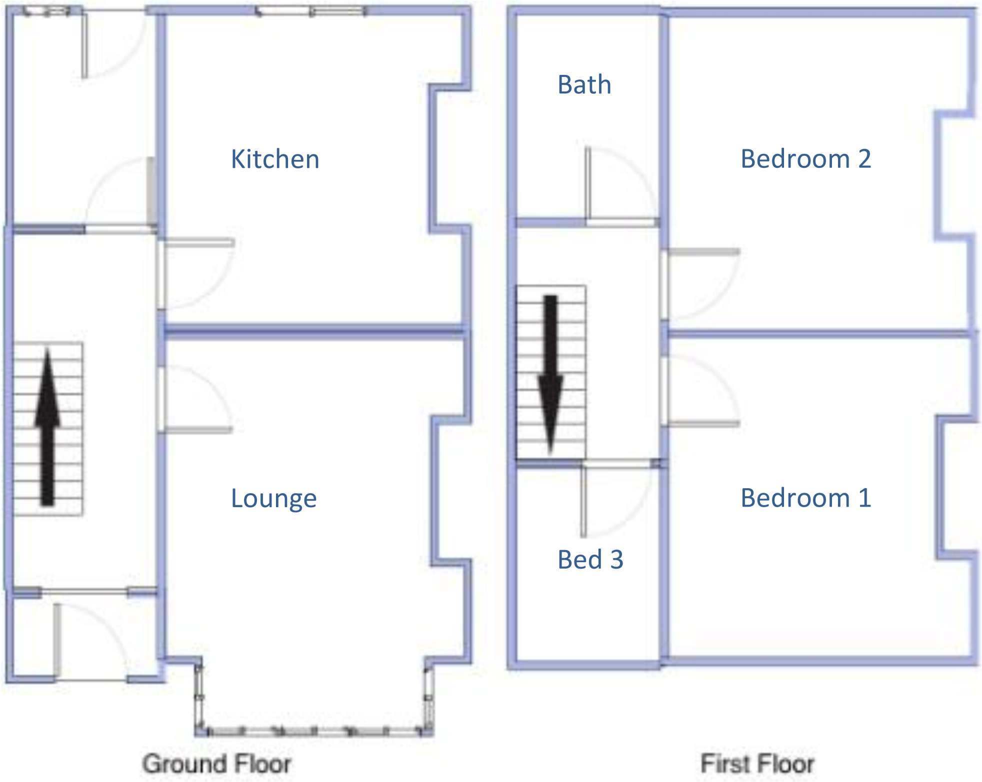
Dwellings I-02 and I-03 before retrofit

Date of Tests: 11th March 2013

Tested by: Dominic Miles-Shenton, David Farmer, Matthew Peat, Dr Anne Stafford

Compiled by: Dominic Miles-Shenton

Floorplans:



Results:

Dwelling I-02	Air Permeability:	Pressurisation Only	19.27 $m^3/(h.m^2)$ @ 50Pa
		Depressurisation Only	19.14 $m^3/(h.m^2)$ @ 50Pa
		Mean Air Permeability	19.21 $m^3/(h.m^2)$ @ 50Pa
		Mean Air Leakage Rate:	22.89 air changes h^{-1} @ 50Pa

Dwelling I-03 Unable to obtain result – incomplete air barrier on 1st floor.

Dwelling I-02 before retrofit

A mean air permeability of 19.21 $m^3/(h.m^2)$ @ 50Pa is fairly typical of a wet plastered dwelling of this age and this condition. The main air leakage paths appeared to be around the rear entrance, around the windows, through external wall penetrations, into the intermediate floor void and through the ground floor from the cellar. Leakage detection was performed under dwelling depressurisation, pre-heating the dwelling using space and fan heaters allowed this to be viewed more effectively using thermography. Direct infiltration from outside showed up more clearly as the temperature difference was greatest; as the cellar was warmer than the outside air, infiltration through the ground floor did not show up as well in the thermal images below even though the volume of air movement through the suspended timber ground floor was often greater than that observed via other routes.

Leakage Detection

<table>
<tr><td colspan="4">Hall
Leakage detected around the window above the front door and through the hall floor.</td></tr>
<tr>
<td></td>
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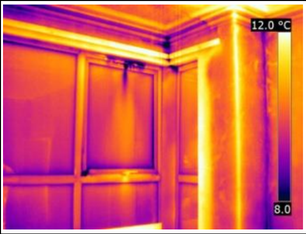
</tr>
<tr><td colspan="4">Lounge
Substantial air leakage observed at the bay window, through and around the closed trickle ventilators, around some glazing panels and particularly one of the opening lights. The gas fire fitted to the chimney breast was not sealed around.</td></tr>
<tr>
<td></td>
<td>
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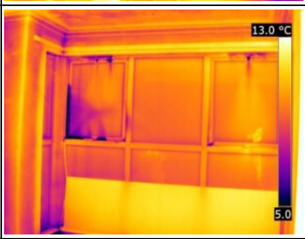
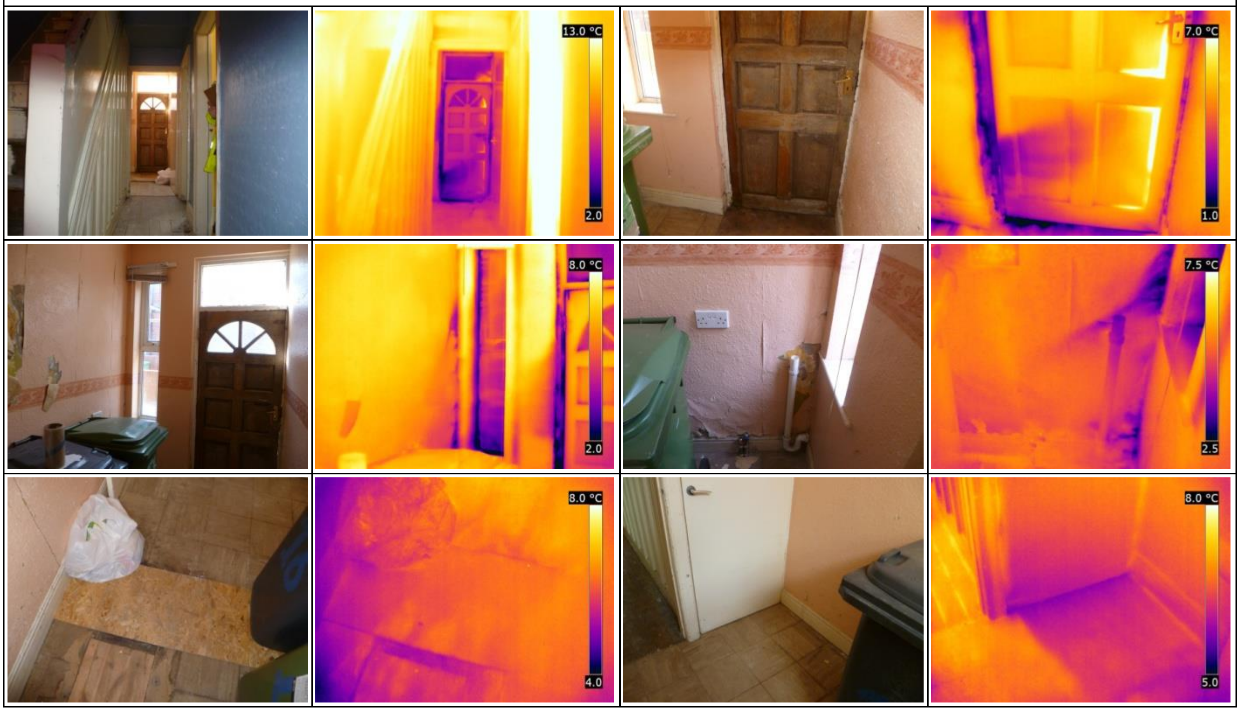
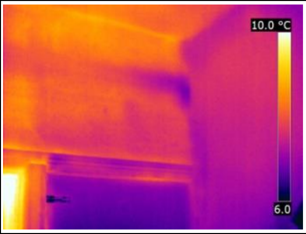
<td>
</td>
<td></td>
<td>
</td>
</tr>
<tr><td colspan="4">Kitchen
Infiltration was again observed around the window. Penetrations around the boiler, extraction fan, wall-mounted control unit and kitchen sink waste pipe all allowed air movement around them. Air</td></tr>
</table>

leakage was also noted from the void behind the kitchen units and at the junction of external wall, party wall and floor, the cold temperature of the infiltrating air here suggesting that this leakage path was directly from outside rather than coming up from the cellar.

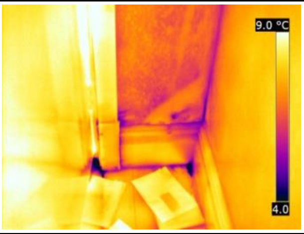
Rear Lobby

Significant air paths were detected around the back door and the window. Also, there was external air entering at the party wall junction with the external wall. The greatest infiltration was felt around the gap at the bottom of the cellar door and around a piece of OSB used to repair the floor, although these do not appear as bad on the thermal images below as the infiltrating air from the cellar was notably warmer than the external air entering at other locations mentioned. Cooler air was also observed entering the partition wall above the cellar door, it was unclear whether this was being drawn up from the cellar or coming in from the “cavity” in the solid party wall (see comments for Bedroom 2).

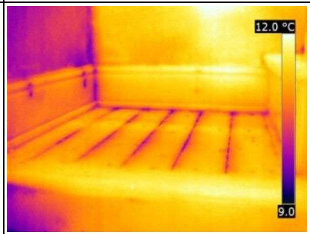


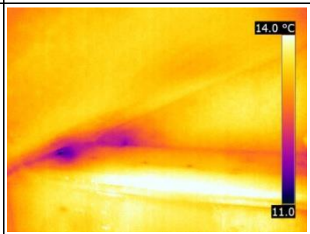
Stairs/Landing
Infiltration was observed through gaps between boards and around the loft hatch. The temperature of the infiltrating air was considerably higher than direct leakage paths from outside, indicating that the air movement was from the cellar and loft space.

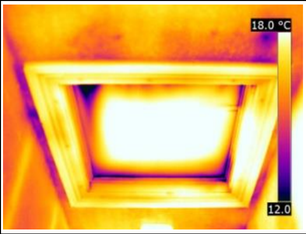



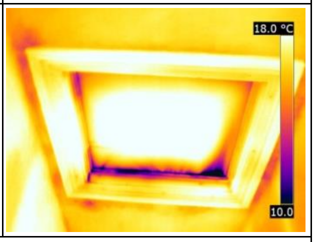




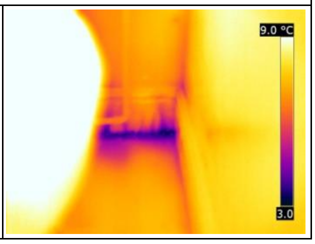


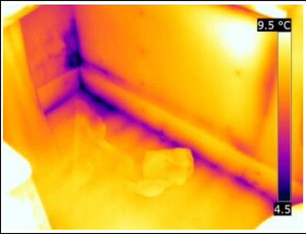



Bathroom
Again, air leakage was observed at the window. Air movement was also seen at the intermediate floor perimeter at temperatures which suggest this air was coming directly out of the external wall.



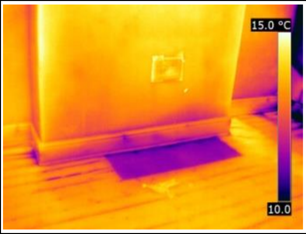



Bedroom 1

As previously observed, leakage at the trickle vent, window and intermediate floor perimeter. It was possible to see discrete temperature changes between joists across the intermediate floor void as the distance from the external wall increased. Air was also observed entering through the floor around the chimney breast and at the base of the partition wall backing on to Bedroom 2, although at significantly higher temperatures than the direct leakage from outside.



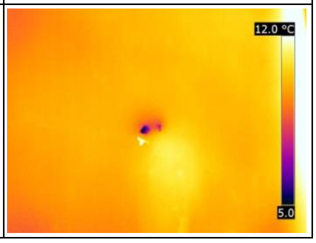




Bedroom 2

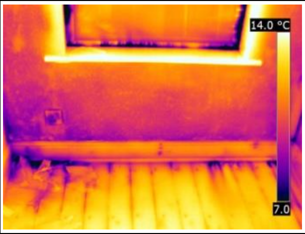
Air leakage was once again detected around the window and again at the floor perimeter. Here the infiltration at the external wall junction with the floor was even more apparent than in Bedroom 1, and the stratification of floor temperature moving away from the external wall more clearly defined. A penetration into the wall to the left of the window showed external air being drawn into the bedroom from outside, as this penetration was not completely through the wall it was investigated further to attempt to determine the air path. Under dwelling pressurisation smoke could be observed going into the hole in the wall but not emerging externally until it reached the eaves; confirming that the infiltration at this penetration was coming from the “cavity” inside the solid external wall. A cavity which may link the whole external façade and quite possibly connect to a similar one in the party wall.



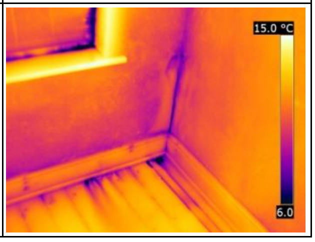





Bedroom 3
Infiltration around the window and intermediate floor, as mentioned previously.

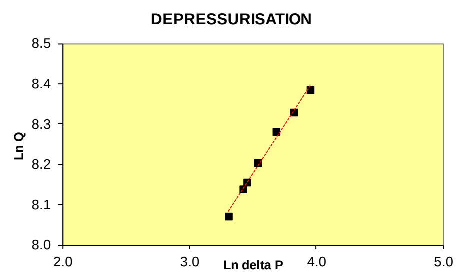


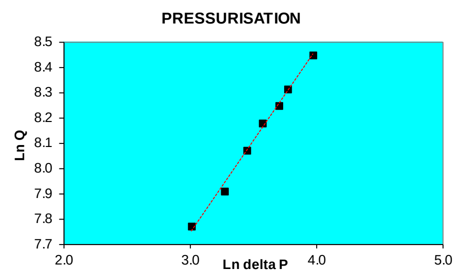


Results spreadsheet

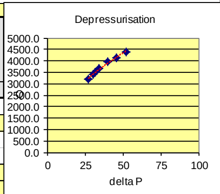
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	11/03/2013		Version 15f	02 July 2010
test house address:				
company:	Canopy Housing			
house type:				
tester:	AS, DF, MP, DMS			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	3.3	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	8.5	°C		
outdoor humidity (%rh)	43.7	%RH		
indoor humidity (%rh)	58.1	%RH		
outdoor barometric pressure	1024.9	mbar or hPa	Calculated Outdoor Air Density	1.29 kg/m³
indoor barometric pressure	1024.5	mbar or hPa	Calculated Indoor Air Density	1.26 kg/m³
temperature corr. fact. depress.	0.982		description of main construction details:	
temperature corr. fact. press.	1.019			
wind speed (m/s):	2			
baseline pressure diff (Pa) (+/-)		Pa		
house width:		m		
house depth:		m		
house height:		m		
floor area:		m²		
volume:	197.338	m³		
envelope area including floor:	235.188	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	4517.00	m³/h		
Mean Air Leakage at 50Pa =	22.89	h⁻¹		
Mean Air Permeability at 50 Pa =	19.21	m/h or m³h/m²		
Equivalent Leakage Area =	0.219	m² at	10	Pa

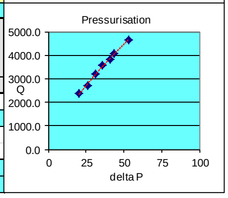




DEPRESSURISATION	RING (O=open or A,B,C,D,E)	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	A	52.2	4471	4381.8	OK	52.2	3.955	8.385	4502.49	19.14	22.82
Approx 57 Pa	A	45.7	4227	4142.6	OK	45.7	3.822	8.329	r^2	0.992	
Approx 49 Pa	A	39.9	4031	3950.5	OK	39.9	3.686	8.282	C_{env}	654.968	m³/h.Pa*n*
Approx 41 Pa	A	34.5	3732	3657.5	OK	34.5	3.541	8.205	n	0.483	
Approx 33 Pa	A	31.7	3555	3484.0	OK	31.7	3.456	8.156			
Approx 25 Pa	A	30.6	3494	3424.3	OK	30.6	3.421	8.139	C_L (corrected)	679.882	m³/h.Pa*n*
Approx 20 Pa	A	27.4	3266	3200.8	OK	27.4	3.311	8.071			



PRESSURISATION	RING (O=open or A,B,C,D,E)	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa	A	53.3	4567	4660.0	OK	53.3	3.976	8.447	4531.51	19.27	22.96
Approx 57 Pa	A	43.5	4001	4082.5	OK	43.5	3.773	8.314	r^2	0.994	
Approx 49 Pa	A	40.7	3745	3821.3	OK	40.7	3.706	8.248	C_{env}	264.356	m³/h.Pa*n*
Approx 41 Pa	A	35.6	3488	3559.0	OK	35.6	3.572	8.177	n	0.723	
Approx 33 Pa	A	31.6	3134	3197.8	OK	31.6	3.453	8.070			
Approx 25 Pa	A	26.4	2670	2724.4	OK	26.4	3.273	7.910	C_L (corrected)	268.203	m³/h.Pa*n*
Approx 20 Pa	A	20.3	2322	2369.3	OK	20.3	3.011	7.770			



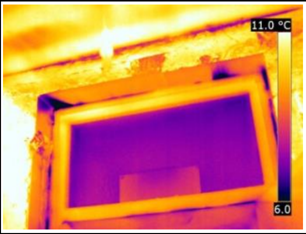
Dwelling I-03 before retrofit

With Bedroom 3 open to the attic and with incomplete internal walls and floor it was not possible to obtain a representative test result for this property at the time of the test. It was possible, however, to perform some leakage detection under depressurisation. With the front external wall insulated internally but not sealed around and some plasterboard fixed but not skimmed, this property was still under construction and any observations made and leakage paths detected may not be representative of the property in its finished state.

Leakage Detection

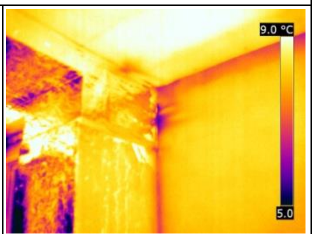
Hall

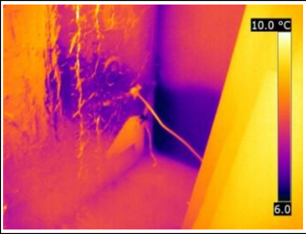
Leakage at the unfinished opening, coming from gaps around the as yet unsealed junction between the frame and the external wall.



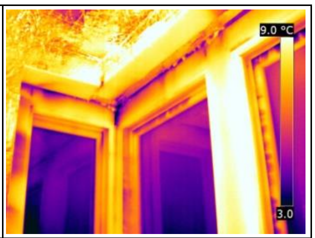
Lounge

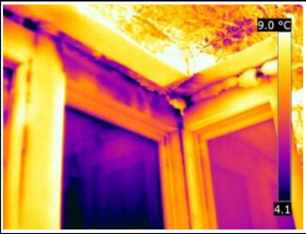
Air leakage detected around the bay window and around the wall insulation at external/internal wall junctions, at the wall/floor junctions and around the bay roof. The penetration through the insulation appeared well-sealed with no detectable air movement. Some air leakage was also observed at the intermediate floor junction with the party wall.

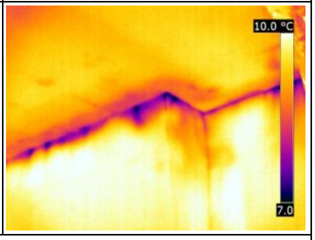






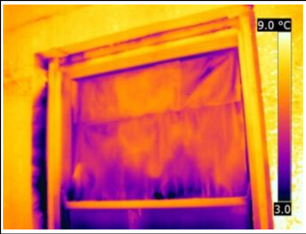


Kitchen

Infiltration detected around and through the window as seen in the lounge.


Rear Lobby

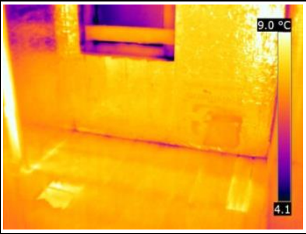
As previously observed, plus considerable air movement around the back door.

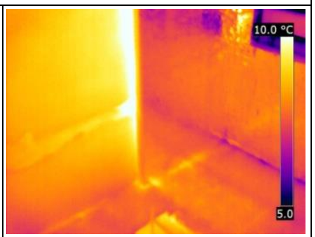


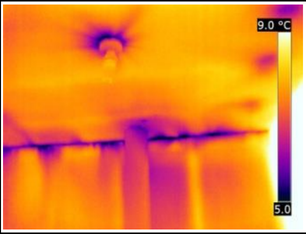

Stairs/Landing

As in the next door property, leakage was observed around the loft hatch. Some temperature differences could be seen in the partition walls where air was being drawn down from the attic.


Bathroom
As previously observed at the window and around the external wall insulation. Some significant infiltration was observed from the loft space, both into the partition wall void and around the central light fixing in the ceiling.

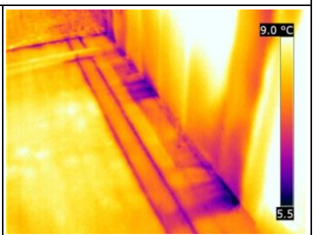



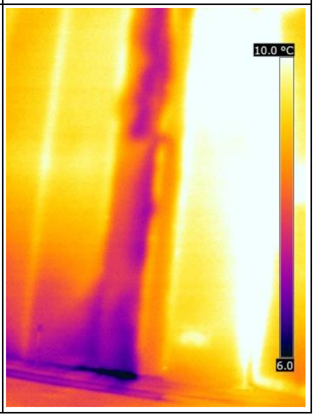



Bedroom 1
Infiltration was observed as previously, at the window and around the external wall insulation. Substantial infiltrating air was being drawn in along and into the internal wall backing onto bedroom 3, which was open to the attic, and up through gaps between the floorboards running parallel to this partition wall. Some air movement was also observed at the ceiling junction with the partition wall backing onto bedroom 2.









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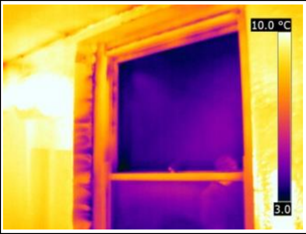
<td></td>
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<tr>
<td colspan="4">Bedroom 2
As described previously, plus additional leakage at the ceiling/party wall junction.</td>
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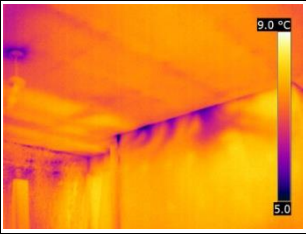
<td></td>
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Dwelling I-02 and I-03 after air barrier and dwelling completion

Date of Tests: 21st November 2013

Tested by: Dominic Miles-Shenton & Martin Fletcher

Compiled by: Dominic Miles-Shenton

Both properties are in the latter stages of major refurbishment with some internal finishings yet to be completed, particularly in the case of No. 16.

This report follows on from a similar report compiled for the first set of pressurisation tests carried in March 2013, when No.16 was in an un-renovated condition and No.18 was midway through refurbishment. Another pressurisation test was performed on No. 16 in May upon initial air barrier completion.

Floorplans:

Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa
Dwelling I-02	11-Mar-13	19.14	22.82	0.992	19.27	22.96	0.994	19.21	22.89
	14-May-13†	12.96	15.45	0.998	13.60	16.21	0.999	13.28	15.83
	21-Nov-13	11.48	13.69	0.999	12.70	15.13	0.998	12.09	14.41
Dwelling I-03	11-Mar-13	Unable to completed test due to incomplete air barrier, leakage detection only.							
	21-Nov-13	7.31	8.71	0.991	7.47	8.90	0.997	7.39	8.80

† Additional temporary sealing applied around the cellar door.

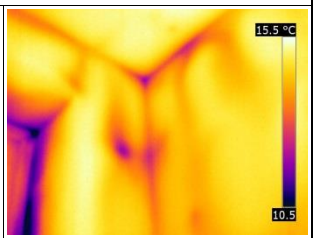
Dwelling I-02 air barrier completion and dwelling completion

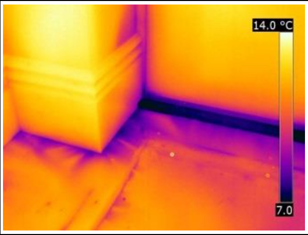
A mean air permeability of 12 $m^3/(h.m^2)$ @ 50Pa showed only a small increase in airtightness from the test performed at initial air barrier completion in May. The main air leakage paths appeared to be in the same areas as in earlier tests; around the front entrance (not previously identified as the blower door was positioned here for the previous tests, for this test the blower door was positioned in the rear entrance), around the windows, through external wall penetrations, into the intermediate floor void and through the ground floor from the cellar. Leakage detection was performed under dwelling depressurisation using thermography, pre-heating the dwelling using its existing heating system, and under pressurisation using a smoke puffer.

Leakage Detection – 21st November 2013

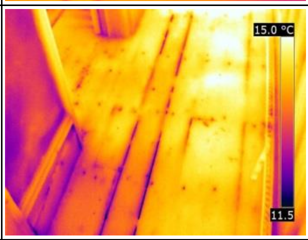
Hall
Leakage detected around the front door and through the hall floor.





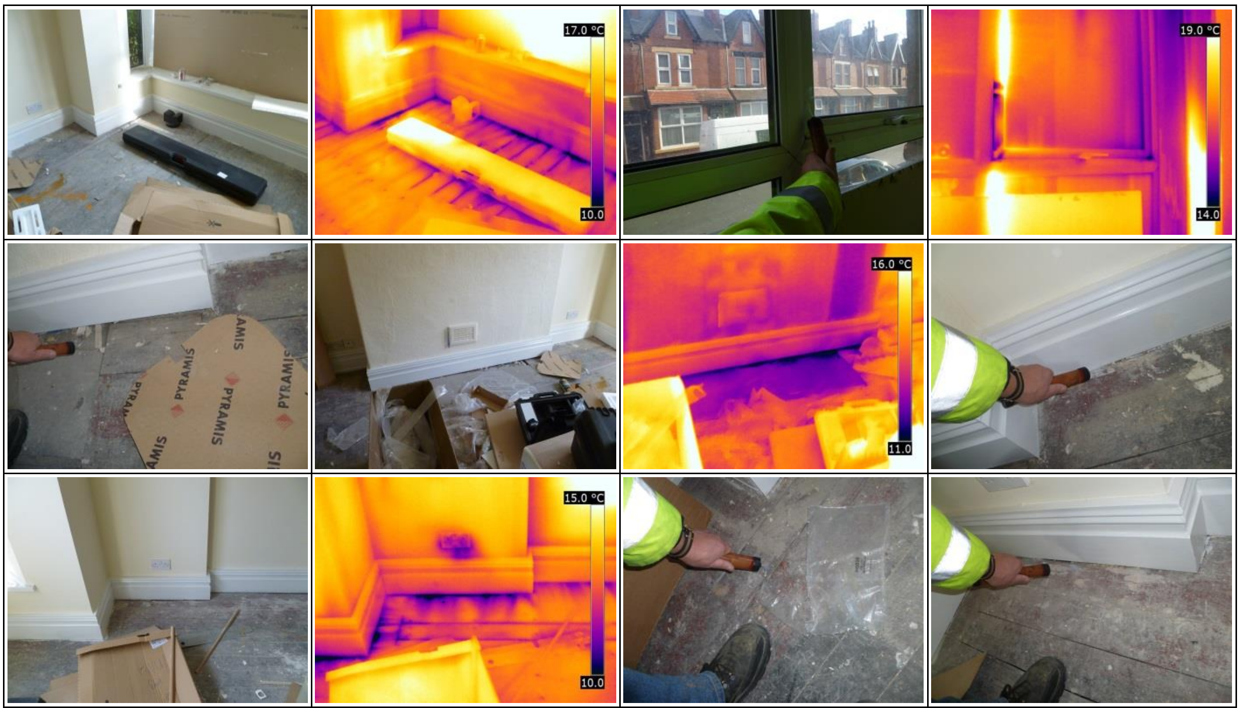





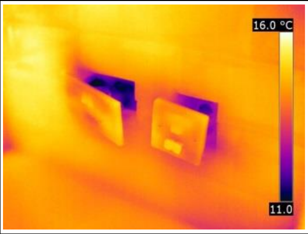




Lounge
As in previous tests, substantial air leakage observed at the bay window, both through and around the closed trickle ventilators, around some glazing panels and particularly one of the opening lights, and at the floor perimeter on both the party wall (most notably at the chimney breast) and the internal partition wall adjacent to the hall.





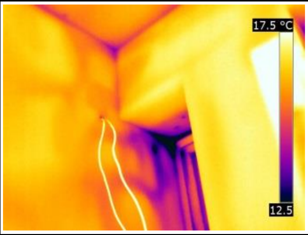
Kitchen
Infiltration was again observed around the window, particularly between the trickle vent and the window frame. The penetration for the extraction fan was temporarily sealed for the test, but still allowed significant air movement into the void behind the plasterboard directly from outside, hopefully this will reduce markedly once the device is installed and sealed around externally. Leakage was also detected around the wall-mounted patresses, from areas obscured by the kitchen units and at the floor/party wall junction around the chimney breast.

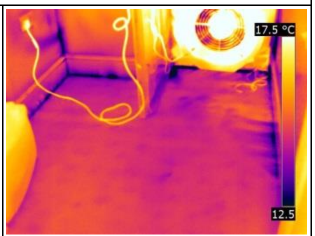






Rear Lobby

Air paths were detected around the window, this was not direct leakage into the room but from outside into the void behind the plasterboard. Air leakage was also seen at the room perimeter, around the floor covering, and around the cellar door.



Cellar

Some leakage detection was performed in the cellar under dwelling depressurisation, using smoke to identify where air from the cellar was entering the property. Generally the cellar ceiling was well sealed with air entering the floor void from a few gaps in the seals and from behind the consumer unit.

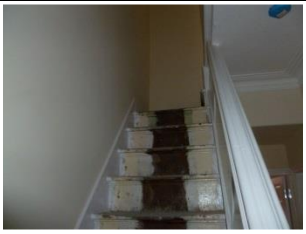






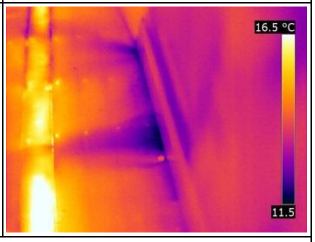
Stairs/Landing

Little infiltration was observed through the stairs apart from one large knot hole and the junction between the stairs and the intermediate floor. On the landing very cold air was being drawn in through the loft hatch, with some lesser air leakage detected around ceiling penetrations. The landing floor junction with the void over the stairs performed relatively badly and air leakage into the intermediate floor void was also detected..



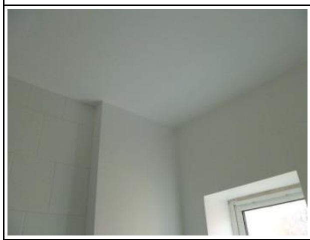
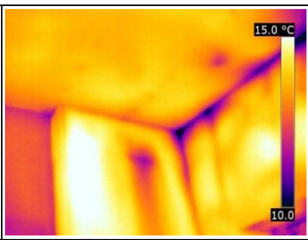


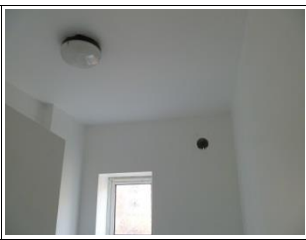
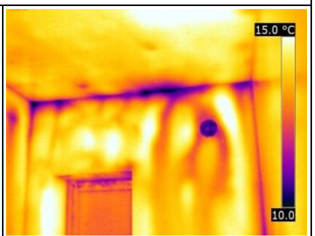


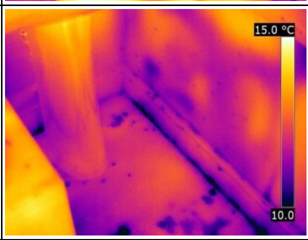


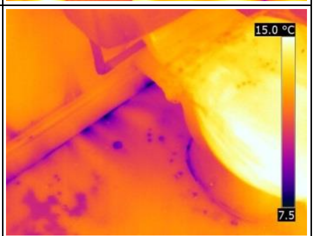
Bathroom

On the external wall air leakage was observed at the ceiling and floor junction, behind the plasterboard at the ceiling junction and into the room at the floor junction. Infiltration seen at the intermediate floor junction behind the WC was at temperatures which suggest this air was coming directly out of the external wall. The same issue with the extractor fan penetration as in the kitchen was also repeated. Again, air leakage was observed at the window.

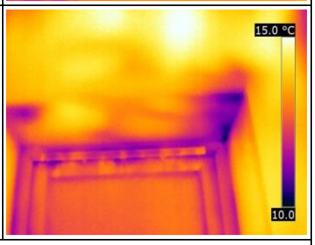



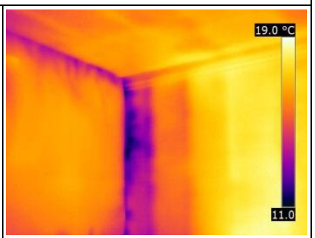




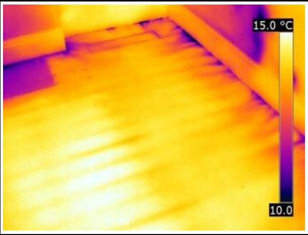
Bedroom 1

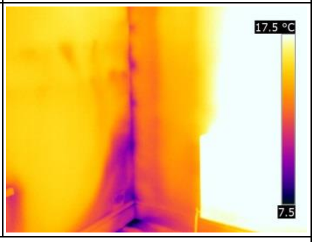
As observed in previous tests, leakage at the trickle vent, window and intermediate floor perimeter and it was possible to see discrete temperature changes between joists across the intermediate floor void as the distance from the external wall increased. This compartmentalisation was also seen in the internal partition wall adjacent to bedroom 3, although the location of the radiator will also have had a significant effect here. There was a considerable amount of air movement behind the plasterboard of the external wall showing up as cooler areas in external wall, particularly by the window sill and partition wall junction.





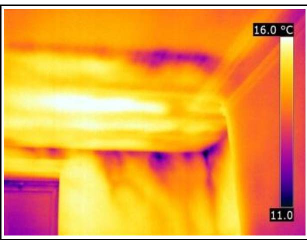


Bedroom 2

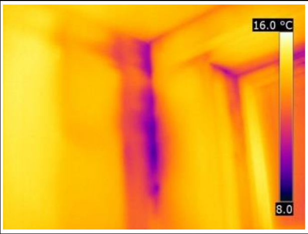
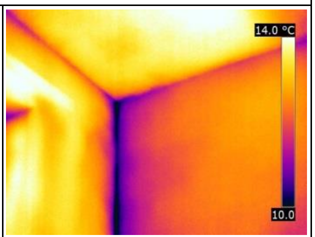
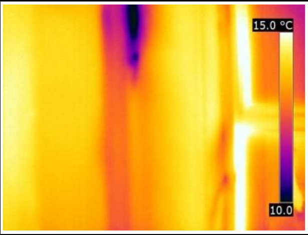
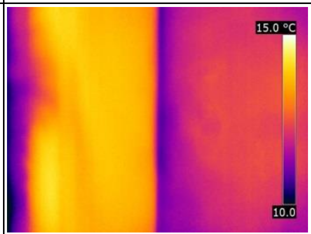
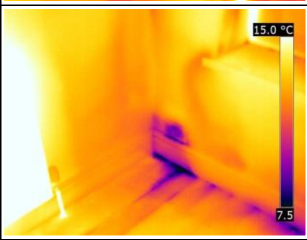
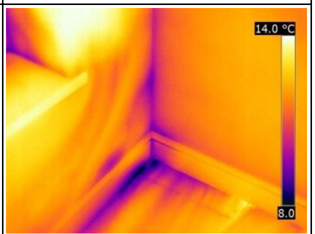
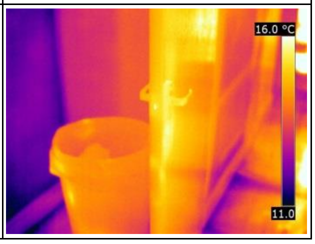
The infiltration at the external wall junctions with the floor and ceiling were still apparent, although not appearing quite as serious as in either the bathroom or bedroom 1. However, the infiltration through the electrical socket on the external wall was particularly cold.



Bedroom 3
The compartmentalisation of the partition wall observed from bedroom 1 was also apparent from this room, as again was some air movement behind the plasterboard on the external wall and at the window reveals; although little air movement was observed entering here from the attic. Also, the void above the stairs showed similar temperature variation between sections. Air movement around the floor perimeter was also detected once more.

Results spreadsheet

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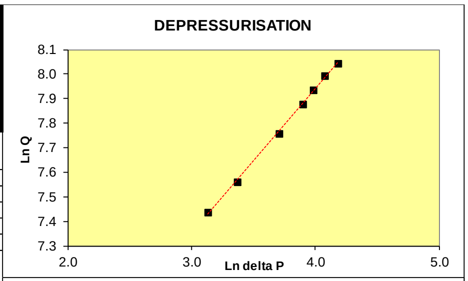
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

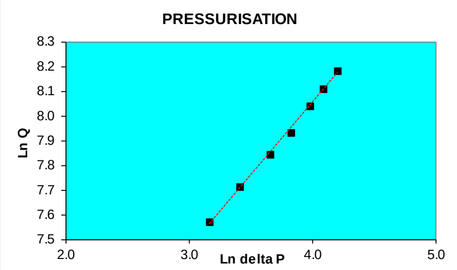
date:	21/11/2013		Version 16	22 October 2013
test house address:				
company:	Latch			
house type:	Renovated Through Terrace			
tester:	dms mf			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	8.4	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	16.5	°C		
outdoor humidity (%rh)	77	%RH		
indoor humidity (%rh)	62.6	%RH		
outdoor barometric pressure	1003.3	mbar or hPa	Calculated Outdoor Air Density	1.24 kg/m^3
indoor barometric pressure	1003.5	mbar or hPa	Calculated Indoor Air Density	1.20 kg/m^3
temperature corr. fact. depress.	0.972		description of main construction details:	
temperature corr. fact. press.	1.029		Solid walled, through terrace, 2 storey, internally insulated external walls, cold roof, timber suspended ground floor.	
wind speed (m/s):	1.9			
baseline pressure diff (Pa) (+/-)		Pa		
house width:		m		
house depth:		m		
house height:		m		
floor area:		m^2		
volume:	197.338	m^3		
envelope area including floor:	235.188	m^2		
Pressure Difference for ELA	10	Pa		

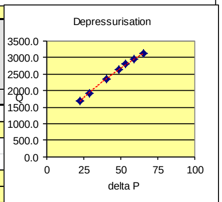
RESULTS:				
Q50 Mean Flow at 50Pa =	2843.44	m^3/h		
Mean Air Leakage at 50Pa =	14.41	h^{-1}		
Mean Air Permeability at 50 Pa =	12.09	m/h or m^3h/m^2		
Equivalent Leakage Area =	0.124	m^2 at	10	Pa

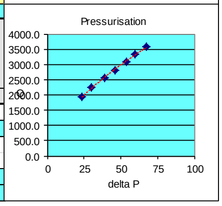
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	65.6	3206	3113.1	OK	65.6	4.184	8.043	2700.61	11.48	13.69
Approx 57 Pa	a	59.1	3051	2962.6	OK	59.1	4.079	7.994	r^2	0.999	
Approx 49 Pa	a	53.7	2883	2799.5	OK	53.7	3.983	7.937	C_{env}	266.692	$m^3/h.Pa^n$
Approx 41 Pa	a	49.3	2721	2642.2	OK	49.3	3.898	7.879	n	0.589	
Approx 33 Pa	a	40.6	2411	2341.2	OK	40.6	3.704	7.758			
Approx 25 Pa	a	29	1979	1921.7	OK	29	3.367	7.561	C_L (corrected)	270.083	$m^3/h.Pa^n$
Approx 20 Pa	a	22.9	1747	1696.4	OK	22.9	3.131	7.436			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	67.2	3477	3580.7	OK	67.2	4.208	8.183	2986.27	12.70	15.13
Approx 57 Pa	a	59.5	3235	3331.5	OK	59.5	4.086	8.111	r^2	0.998	
Approx 49 Pa	a	53.7	3011	3100.8	OK	53.7	3.983	8.039	C_{env}	302.233	$m^3/h.Pa^n$
Approx 41 Pa	a	45.9	2711	2791.9	OK	45.9	3.826	7.934	n	0.585	
Approx 33 Pa	a	38.9	2480	2554.0	OK	38.9	3.661	7.845			
Approx 25 Pa	a	30.2	2171	2235.8	OK	30.2	3.408	7.712	C_L (corrected)	302.398	$m^3/h.Pa^n$
Approx 20 Pa	a	23.7	1883	1939.2	OK	23.7	3.165	7.570			









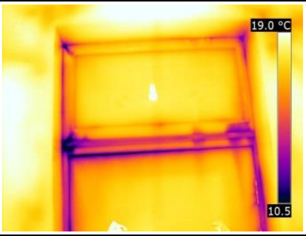
Dwelling I-03 Dwelling completion

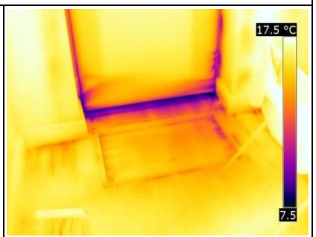
A mean air permeability of 7.39 $m^3/(h.m^2)$ @ 50Pa is in advance of current Building Regulations requirements for new build dwellings and will be expected to improve on completion. The main air leakage paths appeared to be around the front entrance, around the trickle vents (between the vents and frames), around concealed kitchen and bathroom penetrations, at room perimeters on both the intermediate and ground floors, at the loft hatch and around the door to the cellar. Leakage detection was performed under dwelling depressurisation using thermography, pre-heating the dwelling using its existing heating system, and under pressurisation using a smoke puffer.

Leakage Detection – 21st November 2013

Hall

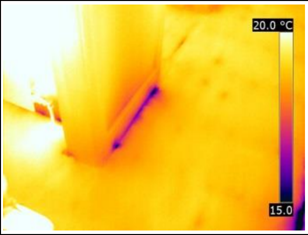
Leakage detected around the front door and threshold, and at the floor perimeter at the stairs and the short section of internal wall between the kitchen and lounge doors.



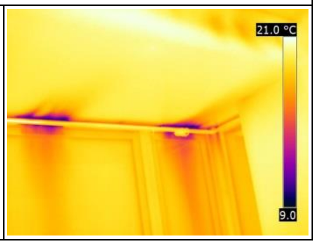


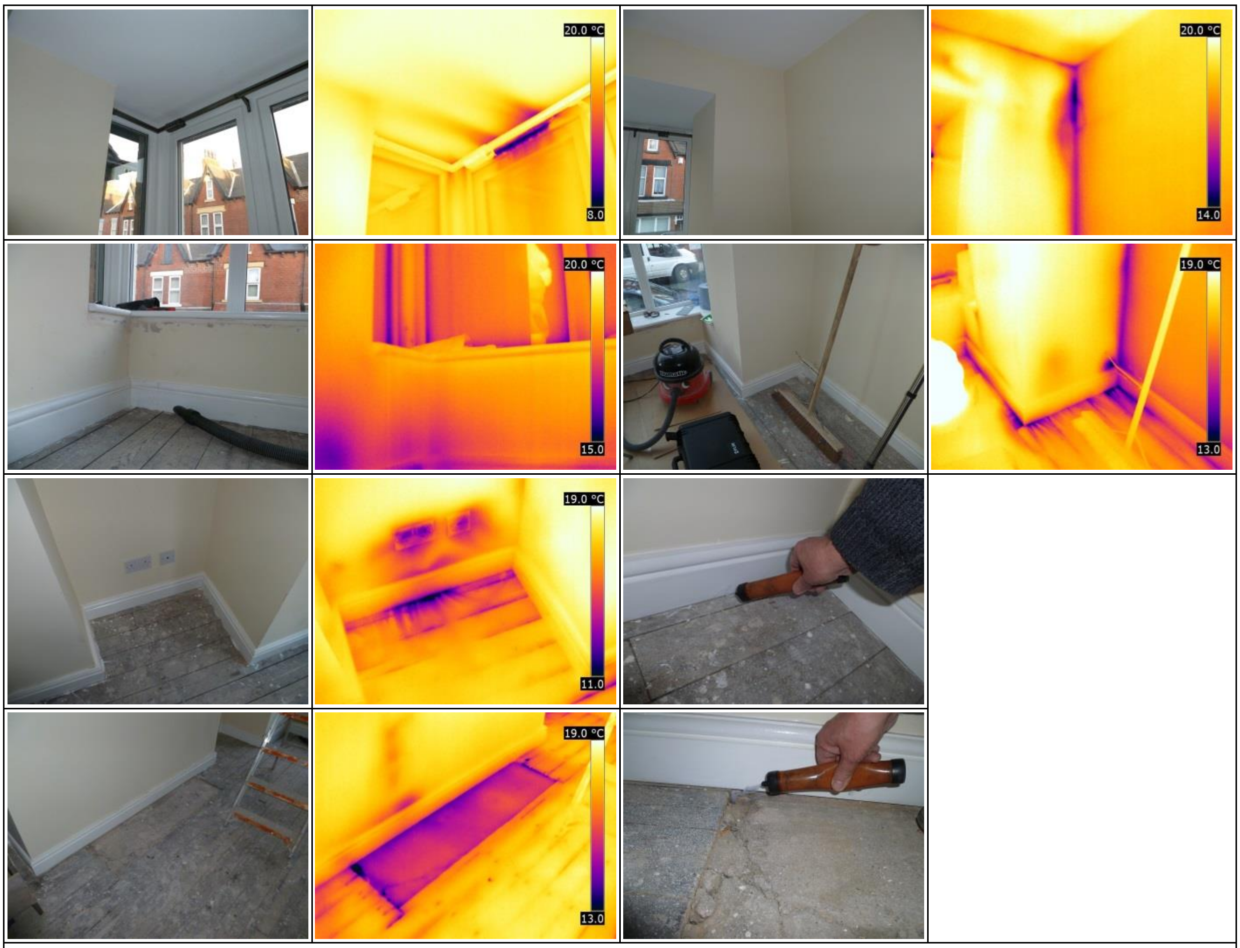



Lounge

Air leakage was detected at the floor perimeter; on the internal wall adjacent to the kitchen, on the party wall at the chimney breast and beneath the electrical socket and around the side of the bay adjacent to the hall. Air leakage was again detected at the trickle vents, this time primarily between the vents and the window frames rather than through the vents themselves. No significant air leakage was detected around the external wall insulation, around the window reveals and sills or through the windows themselves, as had been apparent previously and in No.16.

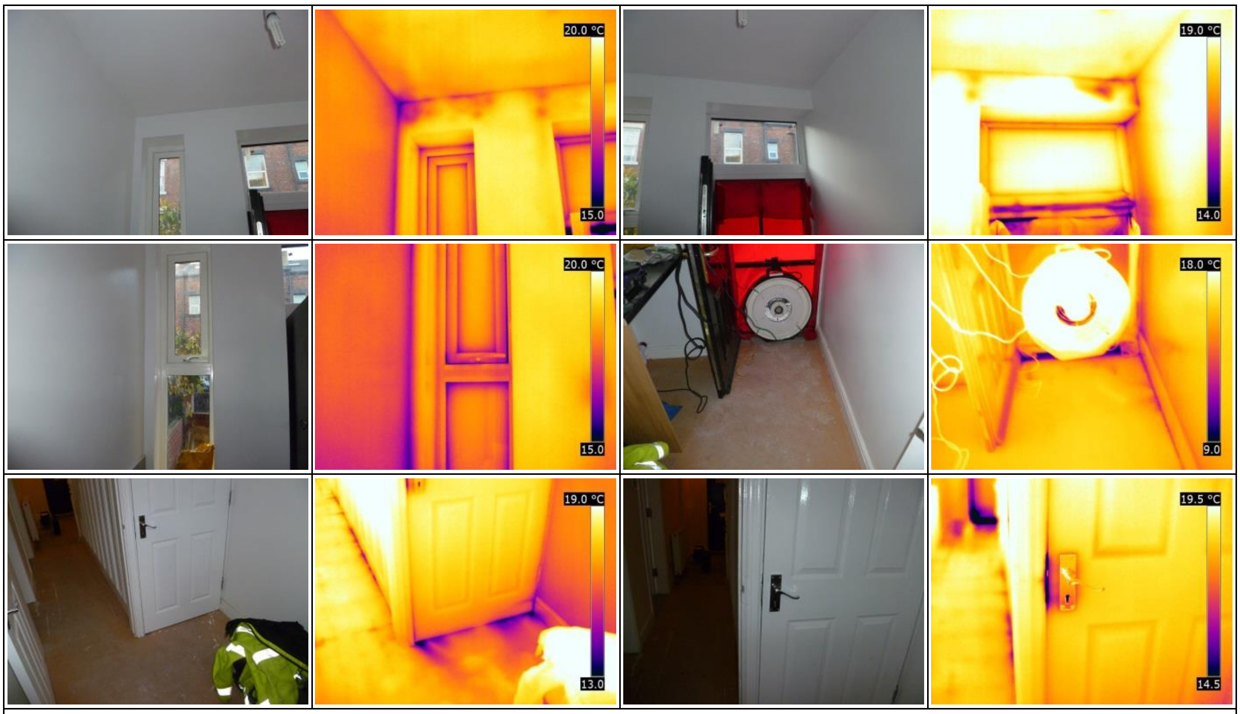






Kitchen
Infiltration detected around the trickle vent and somewhere behind the kitchen units. There were indications of air movement at the external wall junction with the intermediate floor and through the ground floor beneath the floor covering, but this was again comparatively minor compared to previous observations and No.16.

Rear Lobby / Utility
As previously observed there was minor air leakage at the external wall junction with the intermediate floor and at the ground floor perimeter. However, more significant air movement was detected around the cellar door around the lock and underneath the door.



Stairs/Landing

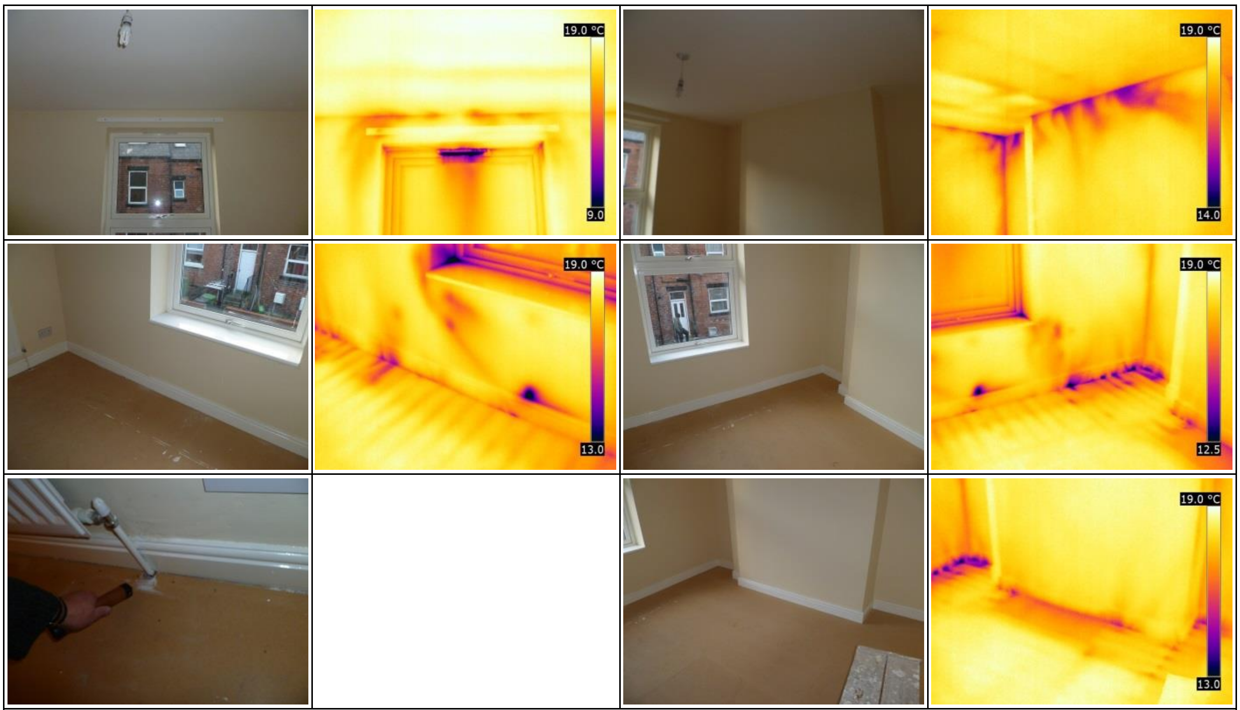
Some air leakage was observed through small gaps in the stairs, this was greatest at the junction of the stairs and the intermediate floor. As in the next door property leakage was observed around the loft hatch, possibly to the same extent but in this dwelling it was perceived as worse because the rest of the building was much more airtight. Air leakage was also observed into the intermediate floor voids at the floor perimeter.

Bathroom

No cooler air was detected being drawn down from the loft at the wall/ceiling junctions, just a small amount around the penetrations for the central light and MVHR extract grille. There was much more significant air movement into/out of the connected service voids behind the pedestal and bath panel, this was barely detectable using thermography as the emitted air was at near room temperature but under pressurisation proved to be the areas where smoke was drawn most strongly in the whole house. Infiltration was also detected at the external wall junction with the intermediate floor and at the trickle vent.

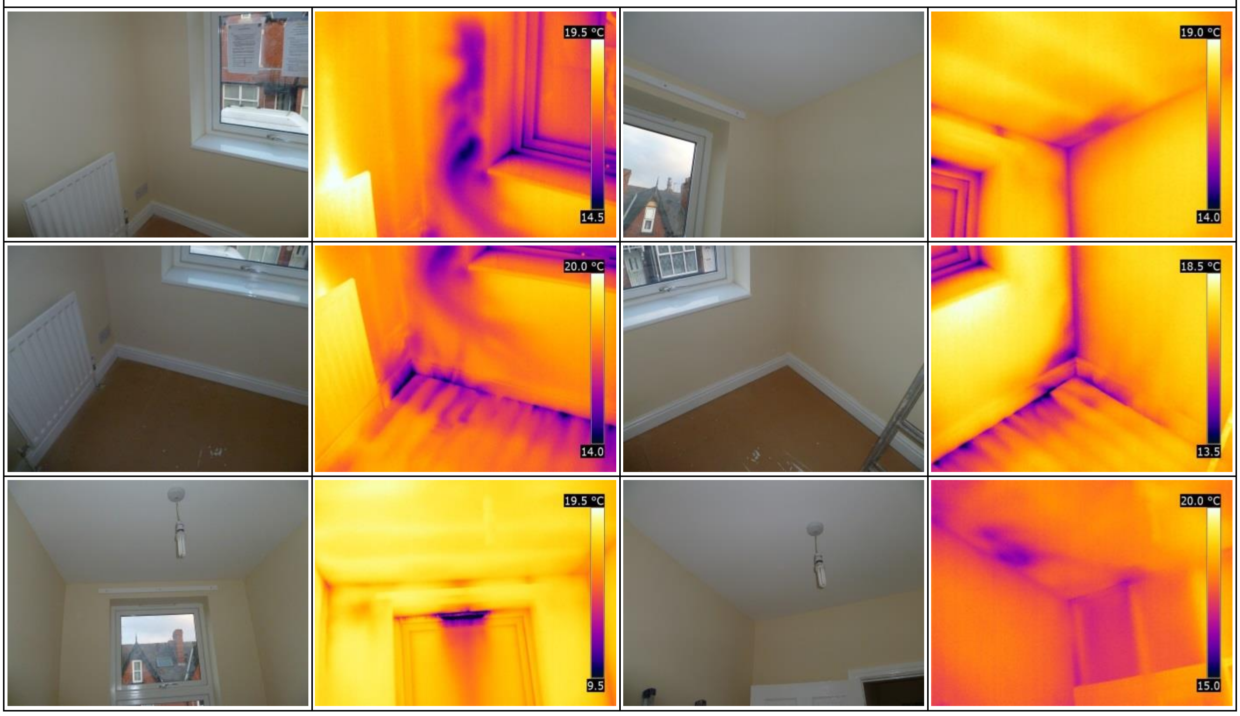
Bedroom 1
Infiltration was observed at the loft perimeter, behind the plasterboard, and more significantly at the junction of the external wall and intermediate floor. Some air movement was also detectable around the window sill.

Bedroom 2
As in bedroom 1, air movement was detected at the floor and loft perimeters and at the trickle vent. At the external wall junction with the intermediate floor there were a number of spots where this was much more clearly seen, with the section of intermediate floor between the wall and the first floor joist noticeably cooler. Also, there was increased air movement around the window opening, behind the plasterboard, than had been previously detected in this property.



Bedroom 3

Air leakage around the window was detected, more so than throughout the rest of the dwelling. The external wall junction with the intermediate floor was also less airtight than elsewhere in the house. Leakage around the trickle vent was again conspicuous and small areas of the ceiling and the internal wall adjacent to the void above the stairs also showed cooler areas, but not as marked as those seen in No.16.



Results spreadsheet

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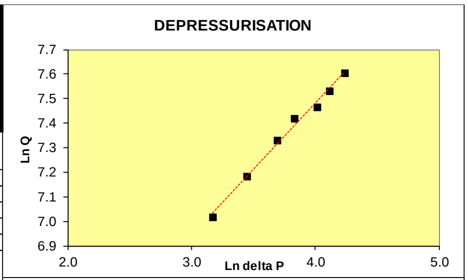
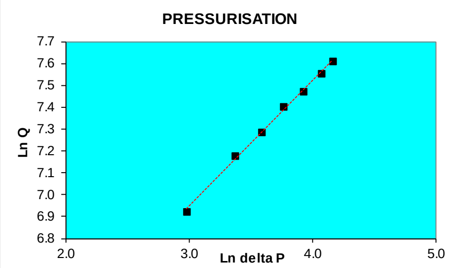
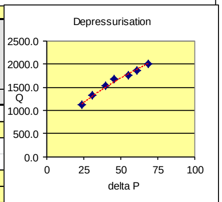
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	21/11/2013		Version 16	22 October 2013
test house address:	1[illegible]			
company:	Latch			
house type:	Renovated Through Terrace			
tester:	dms mf			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	8.7	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	17.4	°C		
outdoor humidity (%rh)	73.6	%RH		
indoor humidity (%rh)	62.6	%RH		
outdoor barometric pressure	1004.9	mbar or hPa	Calculated Outdoor Air Density	1.24 kg/m^3
indoor barometric pressure	1005	mbar or hPa	Calculated Indoor Air Density	1.20 kg/m^3
temperature corr. fact. depress.	0.970		description of main construction details:	
temperature corr. fact. press.	1.031		Solid walled, through terrace, 2 storey, internally insulated external walls, cold roof, timber suspended ground floor.	
wind speed (m/s):	2.1			
baseline pressure diff (Pa) (+/-)		Pa		
house width:		m		
house depth:		m		
house height:		m		
floor area:		m^2		
volume:	197.338	m^3		
envelope area including floor:	235.188	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	1737.28	m^3/h		
Mean Air Leakage at 50Pa =	8.80	h^{-1}		
Mean Air Permeability at 50 Pa =	7.39	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.080	m^2 at	10	Pa

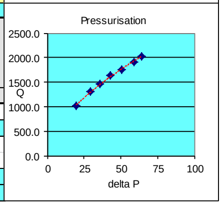




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^{3}h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	69.1	2072	2007.0	OK	69.1	4.236	7.604	1718.35	7.31	8.71
Approx 57 Pa	a	61	1927	1866.6	OK	61	4.111	7.532	r^2	0.991	
Approx 49 Pa	a	55.2	1807	1750.3	OK	55.2	4.011	7.468	C_{env}	205.470	m^3/h.Pa^n
Approx 41 Pa	b	45.9	1726	1671.9	OUT OF RANGE	45.9	3.826	7.422	n	0.539	
Approx 33 Pa	b	40	1579	1529.5	OK	40	3.689	7.333			
Approx 25 Pa	b	31.4	1363	1320.2	OK	31.4	3.447	7.186	C_L (corrected)	208.457	m^3/h.Pa^n
Approx 20 Pa	b	23.8	1151	1114.9	OK	23.8	3.170	7.017			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^{3}h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	64.3	1956	2019.3	OK	64.3	4.164	7.611	1756.22	7.47	8.90
Approx 57 Pa	a	58.8	1850	1909.9	OK	58.8	4.074	7.555	r^2	0.997	
Approx 49 Pa	a	50.9	1706	1761.2	OK	50.9	3.930	7.474	C_{env}	187.324	m^3/h.Pa^n
Approx 41 Pa	b	43.2	1592	1643.6	OK	43.2	3.766	7.405	n	0.572	
Approx 33 Pa	b	36.1	1418	1463.9	OK	36.1	3.586	7.289			
Approx 25 Pa	b	29.2	1272	1313.2	OK	29.2	3.374	7.180	C_L (corrected)	187.280	m^3/h.Pa^n
Approx 20 Pa	b	19.7	982	1013.8	OK	19.7	2.981	6.921			



Dwelling I-02 after additional air tightness measures

Date of Tests: 28th November 2013

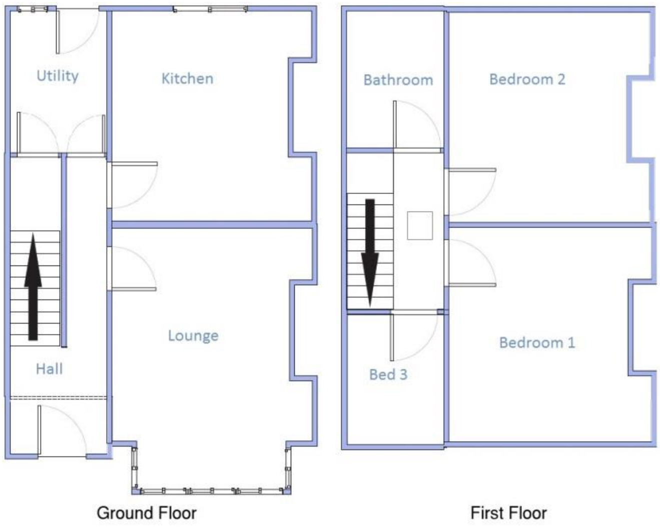
Tested by: Dominic Miles-Shenton & Martin Fletcher

Compiled by: Dominic Miles-Shenton

This report follows on from Pressurisation Test Report compiled one week previously when 18 Hillcrest View was near completion. For this test the dwelling was effectively finished.

In addition, a test of the flow rates of the MVHR system was also conducted.

Floorplan:



Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa	r^2	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa	r^2	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa
Dwelling I-02	11-Mar-13	19.14	22.82	0.992	19.27	22.96	0.994	19.21	22.89
	14-May-13†	12.96	15.45	0.998	13.60	16.21	0.999	13.28	15.83
	21-Nov-13	11.48	13.69	0.999	12.70	15.13	0.998	12.09	14.41
Dwelling I-03	11-Mar-13	Unable to completed test due to incomplete air barrier, leakage detection only.							
	21-Nov-13	7.31	8.71	0.991	7.47	8.90	0.997	7.39	8.80
	28-Nov-13	4.70	5.61	1.000	4.76	5.68	1.000	4.73	5.64

†Additional temporary sealing applied around the cellar door.

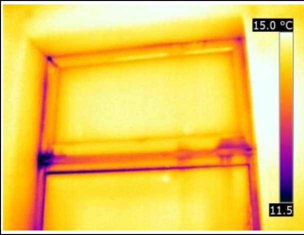
Dwelling I-03 additional air tightness measures

The final mean air permeability of 4.73 $m^3/(h.m^2)$ @ 50Pa is a very creditable result and reflects the level of application and attention to detail displayed throughout this refurbishment project. The main air leakage paths identified previously were still present, but had been reduced. Most noticeable reductions were observed around the trickle vents, the cellar door, the floor/party wall junctions around the chimney breasts and around the bathroom penetrations. Leakage detection was performed under dwelling depressurisation using thermography, the lower internal/external temperature differential needs to be considered if directly comparing images from the leakage detection below with that compiled a week previously.

Leakage Detection – 28th November 2013

Hall

Leakage detected as previously around the front door and threshold and at the floor junction with the base of the stairs, but all at a reduced rate.

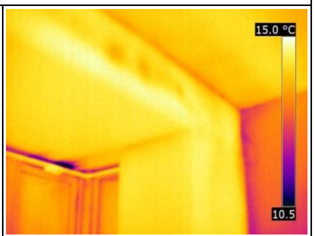





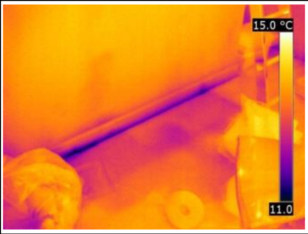
Lounge

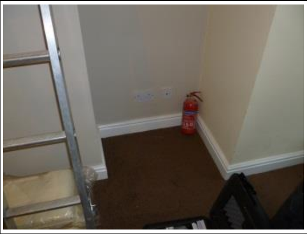
Air leakage was reduced at the floor perimeter, both on the internal wall adjacent to the kitchen and on the party wall at the chimney breast and beneath the electrical socket at the side of the bay. Air leakage was significantly reduced at the trickle vents.



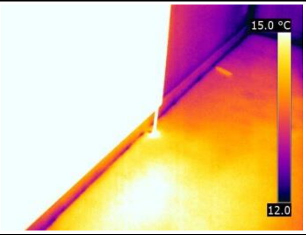


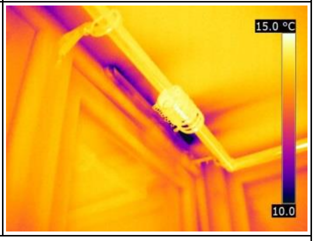




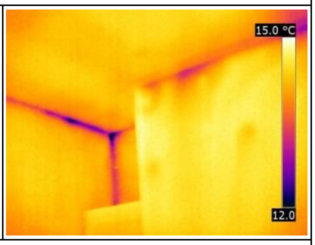


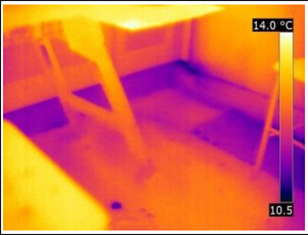


Kitchen
Infiltration at the trickle vent was again significantly reduced. Air leakage remained from the void behind the kitchen units and to a lesser extent around the ceiling perimeter on both external and party walls.

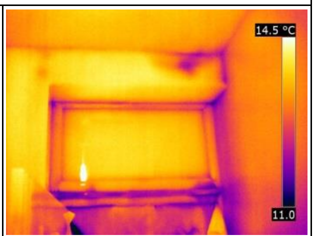




Rear Lobby / Utility
As previously observed there was minor air leakage at the external wall junction. Air movement around the cellar door was reduced, with airflow through and around the handle effectively eliminated. Some air movement was also detected around the waste penetration for the washing machine.



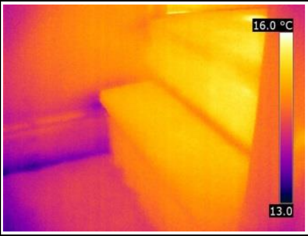


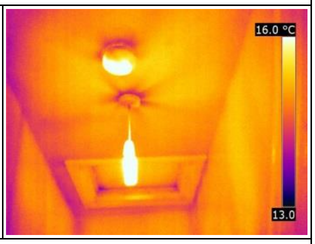


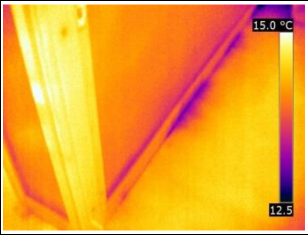


Stairs/Landing

Air leakage at the stairs appeared to be limited to the edges of the 2 steps at the intermediate floor junction. Leakage around the loft hatch had been reduced substantially. Air leakage was still observed at the intermediate floor perimeter.

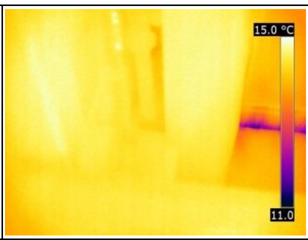



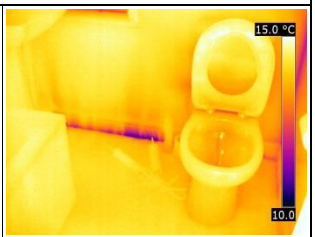



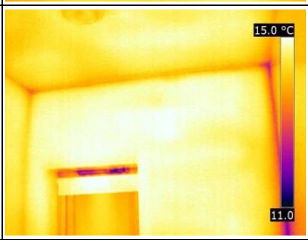



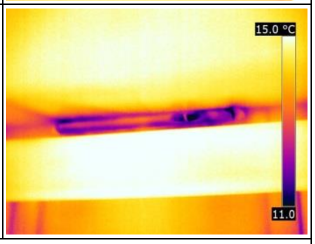
Bathroom

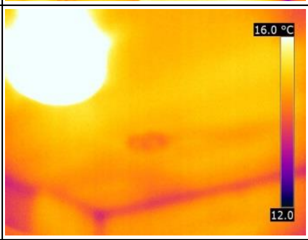
The additional sealing around the service voids behind the pedestal and bath panel greatly reduced the leakage detected at this detail, but it was still one of the major air leakage areas in the property. Infiltration previously detected at the external wall junction with the intermediate floor was still present.

Bedroom 1

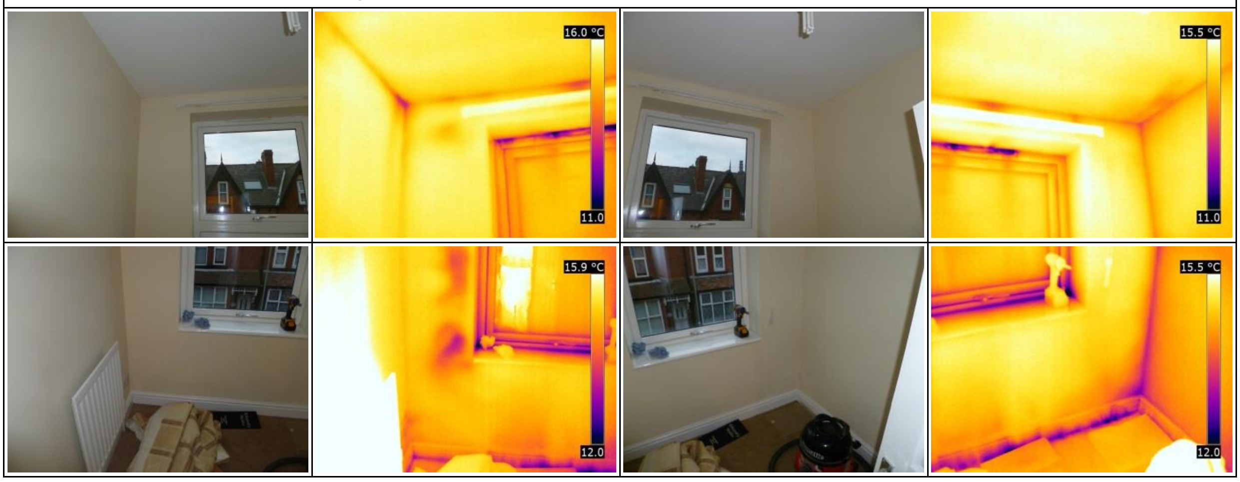
Infiltration at the junction of the external wall and intermediate floor was still detected, with air entering the property at a temperature actually cooler than the external air temperature and the infiltration at the trickle vent.

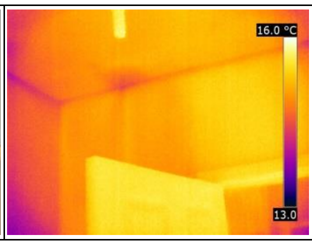
Bedroom 2

Air movement previously detected at the floor perimeters and at the trickle vent had been reduced, but still remained at the number of spots on the external wall.

Bedroom 3

Air leakage around the window and at the external wall junction with the intermediate floor still detectable. Leakage around the trickle vent was again significantly reduced. The internal wall adjacent to the void above the stairs again showed cooler areas.





Results spreadsheet

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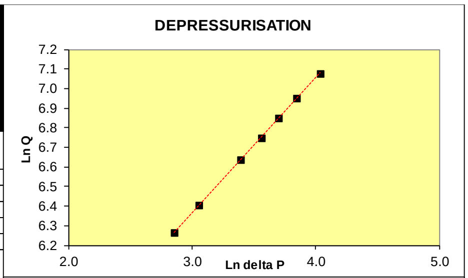
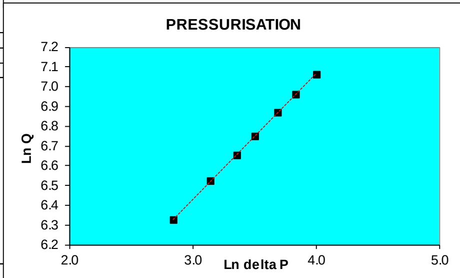
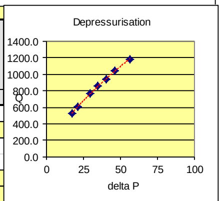
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	28/11/2013		Version 16	22 October 2013
test house address:				
company:	Latch			
house type:	Renovated Through Terrace			
tester:	dms, mf			
test reference number:			Blow er Door & Gauge Used	Model 3 w ith DG700
outdoor temp (°C)	9.8	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	15.5	°C		
outdoor humidity (%rh)	81.3	%RH		
indoor humidity (%rh)	66	%RH		
outdoor barometric pressure	1026	mbar or hPa	Calculated Outdoor Air Density	1.26 kg/m³
indoor barometric pressure	1026	mbar or hPa	Calculated Indoor Air Density	1.23 kg/m³
temperature corr. fact. depress.	0.980		description of main construction details:	
temperature corr. fact. press.	1.020		Completed Dw elling - Solid w alled, through terrace, 2 storey, internally insulated external w alls, cold roof, timber suspended ground floor.	
w ind speed (m/s):	0			
baseline pressure diff (Pa) (+/-)		Pa		
house w idth:		m		
house depth:		m		
house height:		m		
floor area:		m²		
volume:	197.338	m³		
envelope area including floor:	235.188	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	1113.14	m³/h		
Mean Air Leakage at 50Pa =	5.64	h⁻¹		
Mean Air Permeability at 50 Pa =	4.73	m/h or m³h/m²		
Equivalent Leakage Area =	0.044	m² at	10	Pa

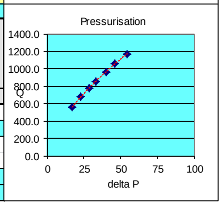




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	b	56.6	1210	1185.3	OK	56.6	4.036	7.078	1106.20	4.70	5.61
Approx 57 Pa	b	46.7	1064	1042.3	OK	46.7	3.844	6.949	r^2	1.000	
Approx 49 Pa	b	40.5	962	942.4	OK	40.5	3.701	6.848	C_{env}	73.601	m³/h.Pan
Approx 41 Pa	b	35.1	871	853.2	OK	35.1	3.558	6.749	n	0.689	
Approx 33 Pa	b	29.8	779	763.1	OK	29.8	3.395	6.637			
Approx 25 Pa	b	21.3	619	606.4	OK	21.3	3.059	6.408	C_L (corrected)	74.701	m³/h.Pan
Approx 20 Pa	b	17.4	537	526.1	OK	17.4	2.856	6.265			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa	b	54.6	1142	1165.8	OK	54.6	4.000	7.061	1120.07	4.76	5.68
Approx 57 Pa	b	46.1	1036	1057.6	OK	46.1	3.831	6.964	r^2	1.000	
Approx 49 Pa	b	40	944	963.6	OK	40	3.689	6.871	C_{env}	90.880	m³/h.Pan
Approx 41 Pa	b	33.2	839	856.5	OK	33.2	3.503	6.753	n	0.640	
Approx 33 Pa	b	28.7	759	774.8	OK	28.7	3.357	6.653			
Approx 25 Pa	b	23.2	668	681.9	OK	23.2	3.144	6.525	C_L (corrected)	91.772	m³/h.Pan
Approx 20 Pa	b	17.2	547	558.4	OK	17.2	2.845	6.325			



MVHR Grille Flow Measurements:

	Standard Mode		Boost Mode	
	Supply	Extract	Supply	Extract
	ls^{-1}	ls^{-1}	ls^{-1}	ls^{-1}
Lounge	4.9		10.4	
Kitchen		3.0		9.8
Utility		4.0		5.1
Bedroom 1	2.5		6.6	
Bedroom 2	3.3		7.7	
Bathroom		3.2		7.5
Total	**10.7**	**10.2**	**24.7**	**22.4**

Dwellings I-05, I-06 and I-07 before retrofit

Date of Tests: 7th February 2014

Tested by: Dominic Miles-Shenton & David Glew

Compiled by: Dominic Miles-Shenton

Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa
I-05	07-Feb-14†	12.38	13.41	0.998	13.67	14.82	0.994	13.02	14.11
I-06	Unable to completed test due to incomplete air barrier.								
I-07	07-Feb-14	11.42	12.38	0.999					

†Additional temporary sealing applied around security plate fixings on both ground floor and basement windows and doors.

I-05

The final mean air permeability of 13.02 $m^3/(h.m^2)$ @ 50Pa is greater than is currently acceptable for new build dwellings under the Building Regulations, but lower than similar back-to-back dwellings in Leeds tested by the research team prior to renovation (6 tests ranging from 28.0 to 16.8, with an average of 23.4 $m^3/(h.m^2)$ @ 50Pa).

Leakage detection was performed throughout under dwelling pressurisation (approx. +40 Pa) using a handheld smoke puffer and on areas of the top 2 floors under depressurisation (approx. -40 Pa) using thermography, where the internal/external ΔT was sufficient to allow this due to the elevation of the internal temperature from solar gain.

Due to the extent to which additional temporary sealing had to be used, to seal around penetrations of the fixings for the security screens coming through windows and doors, the test was performed at lower differential pressures than would normally be used in this type of test. The test range of -34 to +37 Pascal was used reduce the likelihood of failure of these temporary seals.

Additional Sealing

The fixings for the temporary security screens on the basement and ground floor meant that substantial additional sealing was necessary for the pressurisation test to be conducted. The basement door required fully sealing, as did the centre light of the basement kitchen window which had been purposefully removed. The lounge windows were taped and sealed around where penetrations prevented them closing and the front door required additional sealing at the top and bottom to allow an airtight seal to be made around the blower door frame.

Leakage Detection

Basement

In the basement lobby air leakage was detected around the door frame, through visible cracks where it met both party and internal walls. The trickle vent in the kitchen window also performed poorly; although it closed reasonably effectively there was significant air movement between the clip-in vent and the window frame itself. The intermittent extract fan also permitted air movement between itself and the wall, even though the fan itself was temporarily sealed for the purpose of the test.

The most substantial air leakage was detected into the voids behind the kitchen unit. This was observed at both wall and floor mounted units. As the basement is likely to be the main infiltration zone when the house is occupied, it is envisaged that cold air ingress from behind the units may not only have energy performance issues but may also result in discomfort to future occupants.

Hall and Basement Stairs

Some air movement was observed both through and around the cellar stairs, through visible craks and gaps.


Ground Floor Living Room

As in the basement, air leakage was observed around and through the trickle vent, and to a lesser extent around some gaps around the window frames. The lounge floor generally performed well, but in the small number of places where there were gaps air movement was detected, this was most severe at the room perimeter and corners in particular.

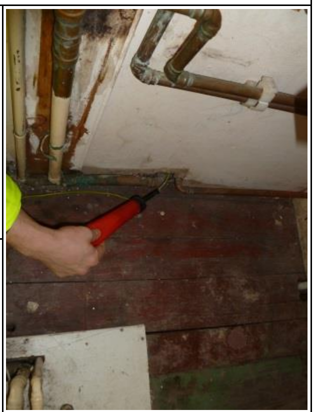



First Floor Bathroom

Significant air movement into the boxed in service void behind the pedestal was detected, and also into the void beneath the bath. Although sealant had been applied to the perimeters of these, less attention had been made to the service penetrations into them.

In the airing cupboard there had been little attention paid to penetrations into either intermediate floor, and sizeable air leakage into both the cupboard floor and ceiling was observed.




First Floor Bedroom

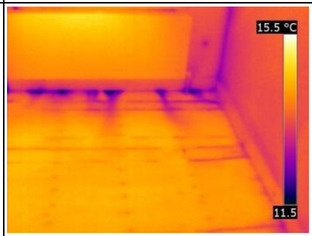
As in the lounge, air leakage was observed through the floor. This was most severe nearest the junctions with the external wall and side party wall. Apart from the trickle vent there was much less air leakage around the window than observed in previous rooms.

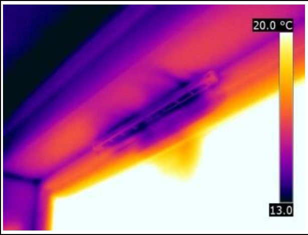
Even with a very small ΔT joints between the IWI panels were appearing to be detectable through thermography (arrowed), it would be interesting to see if this worsens as ΔT increases.

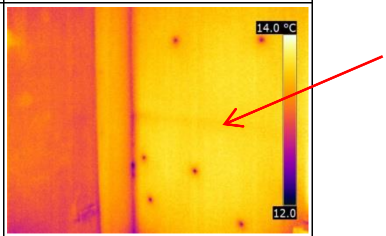








Upper Floor Stairs and Landings

Leakage was again detected around the stairs and through electrical penetrations into the intermediate floor voids.

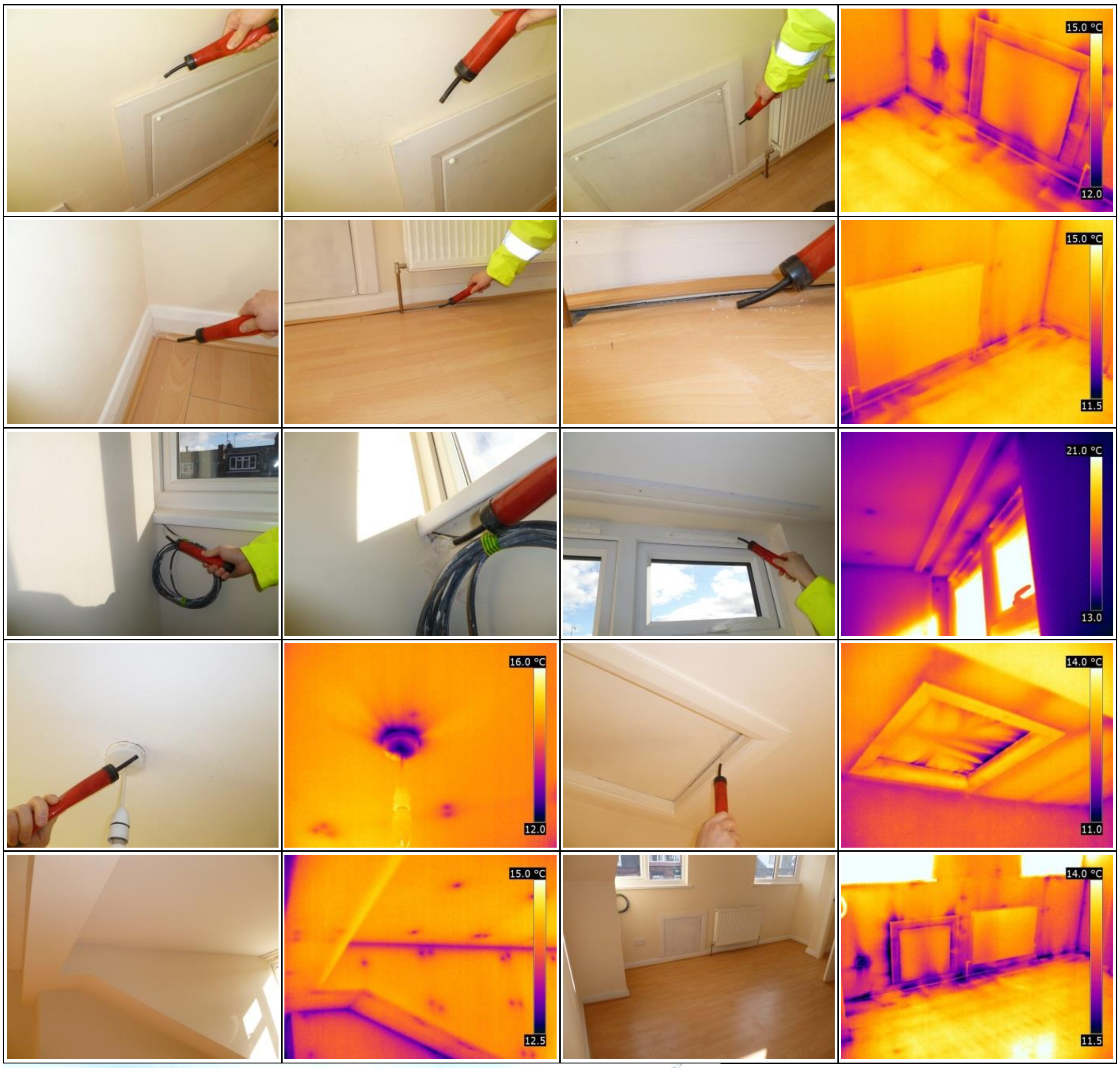

Second Floor Bedroom

In the bedroom cupboard unfinished detailing around penetrations and junctions permitted significant airflow.

The access hatch to the cold roof void at the front of the property leaked both around the hatch and between the hatch and door, the electrical penetration through the same knee wall also performed quite badly. The floor covering prevented air movement through the floor, but leakage at the floor perimeter was prevalent, particularly at the knee wall junction.

Air leakage at the window was only observed around the trickle vent and at the penetration under the window sill. Leakage into the loft space was only observed around the lighting penetration and the loft door, which did not seat properly into the hatch.



I-06

The fixings for the security screens on the basement kitchen window and front door were such that it would have been highly unlikely that any temporary sealing would have been strong enough to withstand even reduced test pressures, as such no pressurisation test was performed.

Observations

		Difficulties in sealing around the fixings for the security screens prevented an acceptable pressurisation test being performed on the dwelling in its current condition.
		The boxed section on the kitchen side party wall may link the consumer unit to outside via unsealed service penetrations, allowing a direct air leakage path.
		The bathroom suite is yet to be installed. Air leakage at penetrations here may not be representative of a test result of the finished dwelling should the house be tested prior to its installation.
		The floor and ceiling of the airing/boiler cupboard are unsealed and will permit air exchange with the intermediate floor voids. Once occupied, air entering the floor voids here may have extremely high moisture content and present elevated condensation risks.
		Numerous large gaps between floorboard allowing air exchange between floor voids and habitable rooms.

		Unsealed electrical penetrations at window sill and at the vertical conduit and first floor bedroom ceiling junction. Also, the trickle vent in the dormer window cannot be installed due to the ceiling level, leaving the hole for its placement part exposed.
 		The access hatches to the roof spaces either side of the dormer do not appear to be suitably draught-proofed and sealed for openings between the conditioned space and externally-ventilated cold roof voids.

I-07

The pressurisation test was performed using depressurisation only as the occupants were present at the time of testing, and blowing cold air into the dwelling to pressurise it would have caused them discomfort.

The air permeability of 11.42 $m^3/(h.m^2)$ @ 50Pa under depressurisation only is again greater than is currently acceptable for new build dwellings under the Building Regulations, but more airtight than the result obtained for No. 35.

Leakage detection was performed under depressurisation using thermography, at approximately -40 Pa.

Leakage Detection

Basement

Air leakage was detected around the basement lobby door and frame, and around the trickle vent in the basement kitchen window.

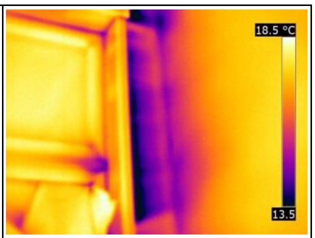
Significant air movement was detected around both the floor and wall mounted kitchen units, this was coldest around the penetrations in the cupboard beneath the sink.

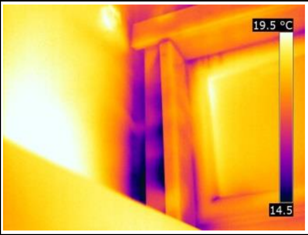
Cold air was observed emerging from the kitchen cupboard; however, it was not possible to determine whether this was air leakage or just that the air in the cupboard was cooler than that in the kitchen.

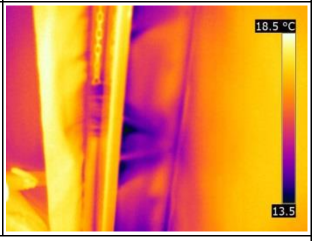
Hall and Basement Stairs

Cooler air appeared to be drawn into the lower landing of the cellar stairs.

Around the front door and window, the architrave was not sealed to the wall and significant infiltration observed.

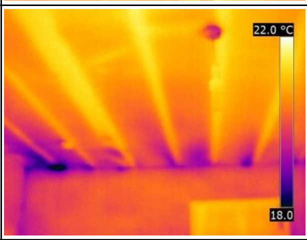


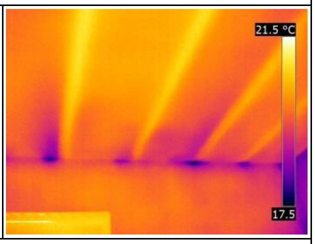




Ground Floor Living Room

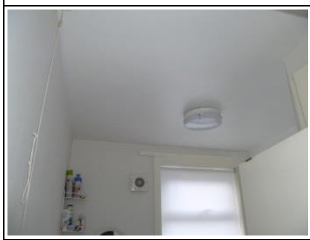
At the party wall junction with the external wall infiltration was detected around the IWI.
Air leakage was also observed around the vent in the external wall.
Leakage could be seen at the window at the trickle vents and to a lesser extent around the window frame.
On the rear party wall, cooler air could be seen being drawn into the intermediate floor void around the built in joists.

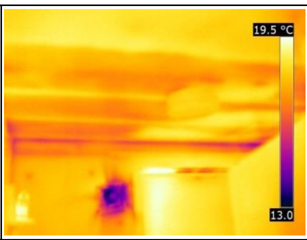




First Floor Bathroom

Infiltration was again observed into the intermediate floor void, and at the intermittent extract fan and trickle vent.

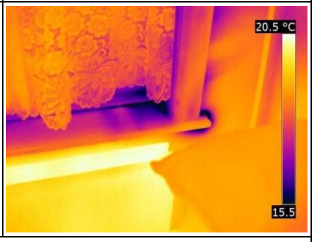




First Floor Bedroom

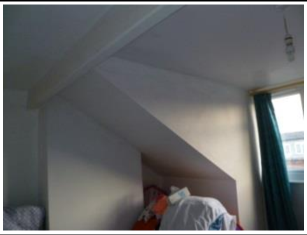
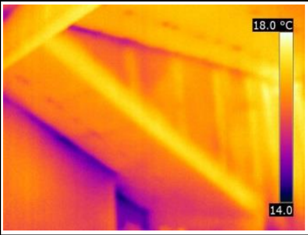
As observed previously around the property, infiltration was detected at the party wall junction with the external wall around the IWI and at the window trickle vent, architrave and frame perimeter.

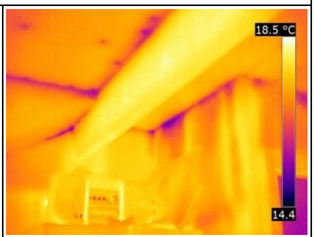


Second Floor Bedroom

Cooler air could be detected being drawn down from the loft space into partition wall voids, around the access hatch to the cold roof at the front of the house and at the floor perimeter.

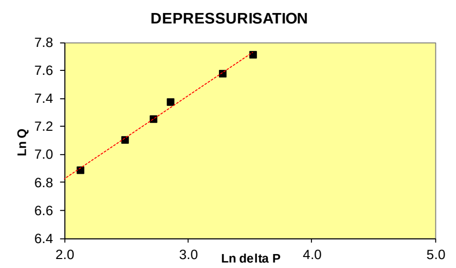



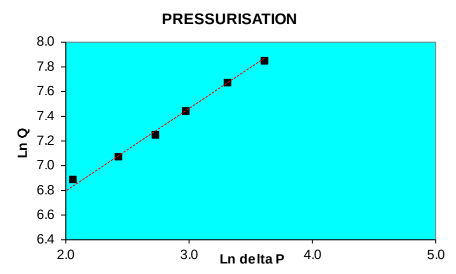


Results Spreadsheets

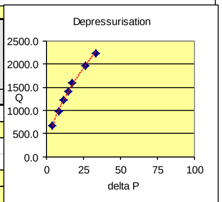
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	07/02/2104		Version 16	22 October 2013	
test house address:	35 Arthington View				
company:	leeds fed				
house type:	b2b terrace				
tester:	DMS, DG				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	9.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	10.2	°C			
outdoor humidity (%rh)	66.5	%RH			
indoor humidity (%rh)	68	%RH			
outdoor barometric pressure	984.5	mbar or hPa	Calculated Outdoor Air Density	1.21	kg/m³
indoor barometric pressure	984.6	mbar or hPa	Calculated Indoor Air Density	1.21	kg/m³
temperature corr. fact. depress.	0.996		description of main construction details:		
temperature corr. fact. press.	1.004				
wind speed (m/s):	2				
baseline pressure diff (Pa) (+/-)		Pa			
house width:	4.9	m			
house depth:	4.4	m			
house height:	10.4	m			
floor area:	21.6	m²			
volume:	215	m³			
envelope area including floor:	233	m²			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	3034.54	m³/h			
Mean Air Leakage at 50Pa =	14.11	h⁻¹			
Mean Air Permeability at 50 Pa =	13.02	m/h or m³h/m²			
Equivalent Leakage Area =	0.123	m² at	10	Pa	

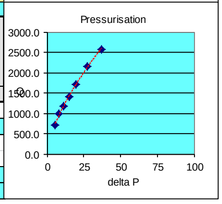




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	a	33.8	2246	2237.7	OK	33.8	3.520	7.713	2883.51	12.38	13.41
Approx 57 Pa	a	26.5	1962	1954.7	OK	26.5	3.277	7.578	r^2	0.998	
Approx 49 Pa	b	17.4	1605	1599.1	OK	17.4	2.856	7.377	C_{env}	281.017	m³/h.Pa*n*
Approx 41 Pa	b	15.1	1423	1417.7	OK	15.1	2.715	7.257	n	0.594	
Approx 33 Pa	b	12	1226	1221.5	OK	12	2.485	7.108			
Approx 25 Pa	b	8.4	988	984.3	OK	8.4	2.128	6.892	C_L (corrected)	282.066	m³/h.Pa*n*
Approx 20 Pa	b	4.4	678	675.5	OK	4.4	1.482	6.515			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa	a	36.9	2563	2572.5	OK	36.9	3.608	7.853	3185.57	13.67	14.82
Approx 57 Pa	a	27.4	2145	2153.0	OK	27.4	3.311	7.675	r^2	0.994	
Approx 49 Pa	b	19.6	1698	1704.3	OK	19.6	2.976	7.441	C_{env}	232.938	m³/h.Pa*n*
Approx 41 Pa	b	15.3	1402	1407.2	OK	15.3	2.728	7.249	n	0.668	
Approx 33 Pa	b	11.3	1171	1175.4	OK	11.3	2.425	7.069			
Approx 25 Pa	b	7.8	979	982.6	OK	7.8	2.054	6.890	C_L (corrected)	233.361	m³/h.Pa*n*
Approx 20 Pa	b	5.8	717	719.7	OK	5.8	1.758	6.579			

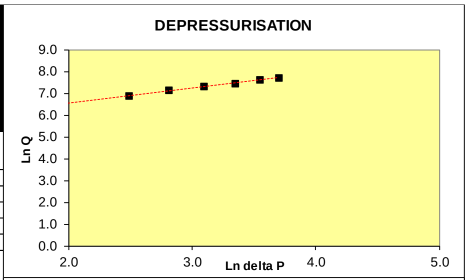


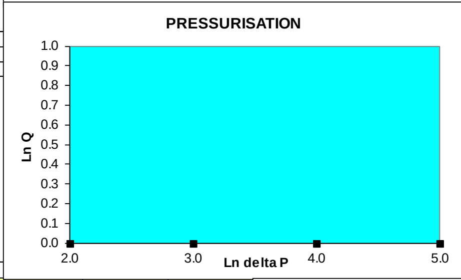
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

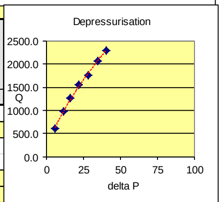
date:	07/02/2104	Version 16	22 October 2013	
test house address:	[illegible]			
company:	leeds fed			
house type:	b2b terrace			
tester:	DMS, DG			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	9.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	18.6	°C		
outdoor humidity (%rh)	66.5	%RH		
indoor humidity (%rh)	53.7	%RH		
outdoor barometric pressure	984.5	mbar or hPa	Calculated Outdoor Air Density	1.21 kg/m³
indoor barometric pressure	984.8	mbar or hPa	Calculated Indoor Air Density	1.17 kg/m³
temperature corr. fact. depress.	0.968		description of main construction details:	
temperature corr. fact. press.	1.033			
wind speed (m/s):	2			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	4.9	m		
house depth:	4.4	m		
house height:	10.4	m		
floor area:	21.6	m²		
volume:	215	m³		
envelope area including floor:	233	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =		m³/h		
Mean Air Leakage at 50Pa =		h⁻¹		
Mean Air Permeability at 50 Pa =		m/h or m³h/m²		
Equivalent Leakage Area =		m² at	10	Pa

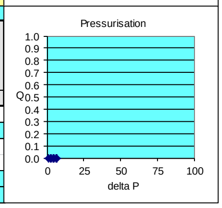
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	40.5	2360	2281.3	OK	40.5	3.701	7.733	2661.99	11.42	12.38
Approx 57 Pa	a	34.8	2137	2065.8	OK	34.8	3.550	7.633	r^2	0.999	
Approx 49 Pa	a	28.3	1822	1761.3	OK	28.3	3.343	7.474	C_{env}	179.012	$m^3/h.Pa^n$
Approx 41 Pa	b	22	1603	1549.6	OK	22	3.091	7.346	n	0.689	
Approx 33 Pa	b	16.6	1308	1264.4	OK	16.6	2.809	7.142			
Approx 25 Pa	b	12	1007	973.4	OK	12	2.485	6.881	C_L (corrected)	179.523	$m^3/h.Pa^n$
Approx 20 Pa	b	6.1	643	621.6	OK	6.1	1.808	6.432			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa											
Approx 57 Pa									r^2		
Approx 49 Pa									C_{env}		$m^3/h.Pa^n$
Approx 41 Pa									n		
Approx 33 Pa											
Approx 25 Pa									C_L (corrected)		$m^3/h.Pa^n$
Approx 20 Pa											









LEEDS METROPOLITAN UNIVERSITY
Leeds Sustainability Institute

CeBE

Dwelling I-05, I-06 and I-07 after retrofit

Date of Tests: 7th & 10th April 2014

Tested by: Dominic Miles-Shenton & David Glew

Compiled by: Dominic Miles-Shenton

Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa
I-05	07-Feb-14[†]	12.38	13.41	0.998	13.67	14.82	0.994	13.02	14.11
I-06	07-Feb-14	Unable to completed test due to incomplete air barrier.							
	07-Apr-14	11.73	12.71	1.000	12.05	13.06	1.000	11.89	12.89
I-07	07-Feb-14	11.42	12.38	0.999	Tests performed under depressurisation only to avoid discomfort to occupants.				
	10-Apr-14	10.53	11.41	0.999					

[†]Additional temporary sealing applied around security plate fixings on both ground floor and basement windows and doors.

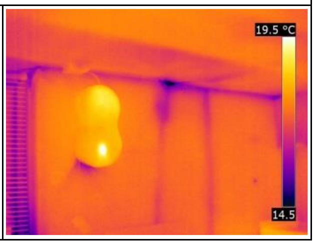

I-06

Previously, it had not been possible to pressure test this property due to the security screen on the ground floor and basement. These had now been removed and the house was occupied and carpeted throughout, allowing a pressurisation test to be performed using the ATTMA TSL1A protocol. Leakage detection was performed using thermography under dwelling depressurisation, but with the internal/external ΔT of only 6 ^{o}C some of the more complex indirect air leakage paths showed infiltrating air already warmed up to near internal temperatures and so do not show up on the thermal images.

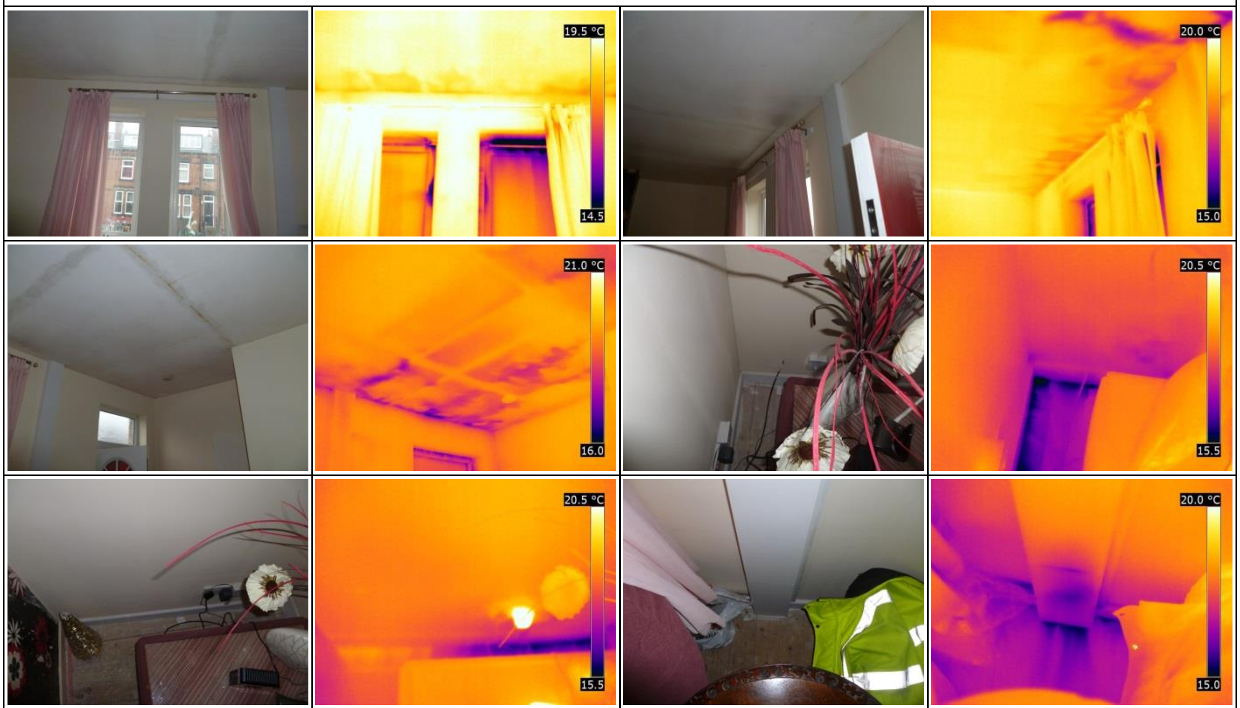
Leakage Detection & Observations

Basement
The central opening light of the kitchen window had been replaced, following the removal of the security screen, but air movement was detected around its perimeter even when fully closed.
Cool vertical stripes were visible under depressurisation on the external wall where air was being drawn down through the chased-in electrical services. Some compartmentalisation of the ceiling void was visible, where the section between the external wall and nearest joist was noticeably cooler than between the next 2 joists, presumably due to infiltration. This could also be observed on the boxing leading to consumer unit on the basement stairs, air leakage was detected through the unit although it had warmed significantly by the time it emerged.
Additional air infiltration was detected at junctions and penetrations behind the kitchen units and appliances, and around the door and frame in the basement lobby.



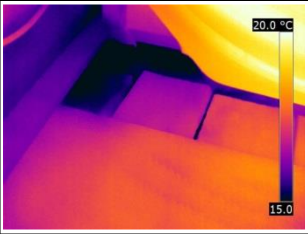


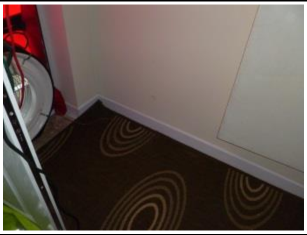
Lounge
As in the basement, air leakage could be observed around the windows where the security screens had been removed, around the trickle vents and into the intermediate floor void.
Significant air ingress was detected around the floor perimeter, most noticeably at the exposed floorboards and under the skirting and on the external wall at the junction of the floor and vertical plastic ducting.



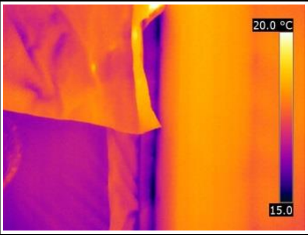
Hall & Stairs
Significant air movement was detected at the threshold, at the floor/party wall junction and through the timber floor; this was visible through the hall carpet.
Air movement was also observed around the door frame.







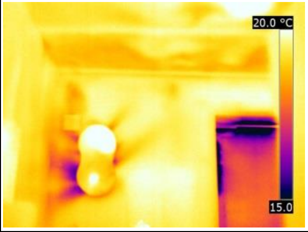




Bathroom

The most apparent infiltration paths were around the ventilation unit, which had been temporarily sealed for the test, and at the window, through the closed trickle vent and around the casement.

Air leakage into the intermediate floor void was again observed, this was most clearly seen below the area of cold roof space.

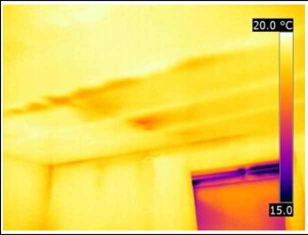



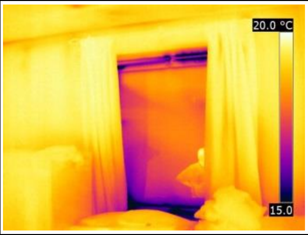


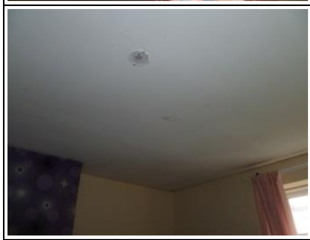
1st Floor Bedroom

As in the bathroom, air movement into the intermediate floor void could be clearly observed under thermal imaging.

Again, infiltration around the window was highly obvious. Air movement up through the floor was not possible to view with the thermal camera due to the occupant's belongings, but there was some lifting of the carpet under dwelling depressurisation although the emerging air was at or near room temperature so did not show up under thermography.




Landing & Stairs

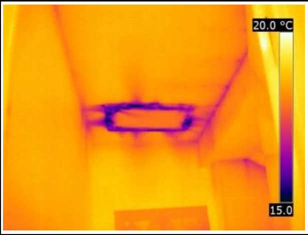
The door to the roof void at the front of the dwelling was not accessible at the time of the test to check for airtightness as it was obscured by the occupant's belongings. Any issues at the ceiling were also impossible to detect due to the heat emitted from the landing light.

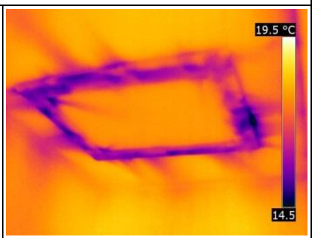
Indirect leakage into the service riser on the landing was clearly visible.

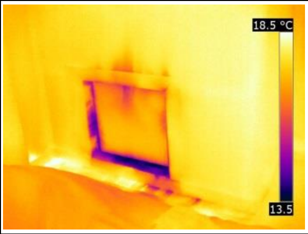
2nd Floor Bedroom

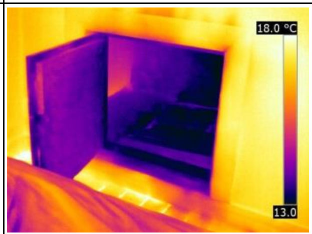
Significant air leakage was detected around the hatches to the loft space and the cold roof space at the front of the property. The door to the roof space was not draught-stripped and part of the insulation attached to the door had come off. Looking through the open door it was possible to see how warm the party wall was in the roof space, possibly due to thermal bridging from the bedroom below.

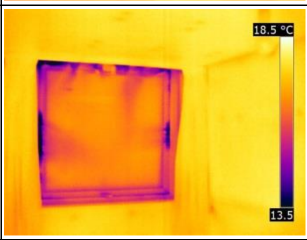
Other air paths included direct leakage at the window and central light fitting.

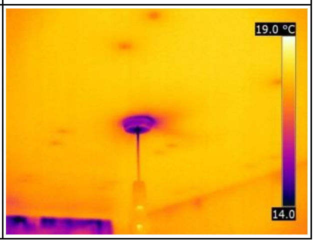












I-07

The pressurisation test was performed using depressurisation only as the occupants were present at the time of testing, and blowing cold air into the dwelling to pressurise it may have caused them discomfort.

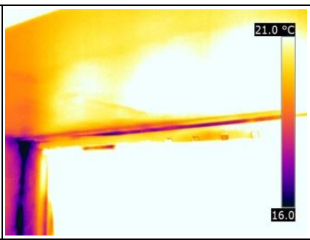
Test conditions for both tests were very similar and the air permeability of the dwelling (under depressurisation only) had reduced from 11.42 to 10.53 $m^3/(h.m^2)$ @ 50Pa between the tests. This change is small and is commensurate with increases in measured airtightness due to redecoration alone (including caulking and newly or re-applied mastic sealants); as such it is felt that the IWI and loft insulation installed has had little effect on the overall airtightness of the dwelling. This is perhaps unsurprising as leakage paths in the basement, through trickle vents and via the intermediate floor voids formed a major part of the air leakage identified in the previous test and appeared to be unaffected by the retrofit measures introduced in the other areas of the property.

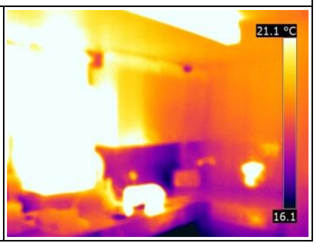
Leakage detection reported on below was again performed under depressurisation using thermography, at approximately -45 Pa.

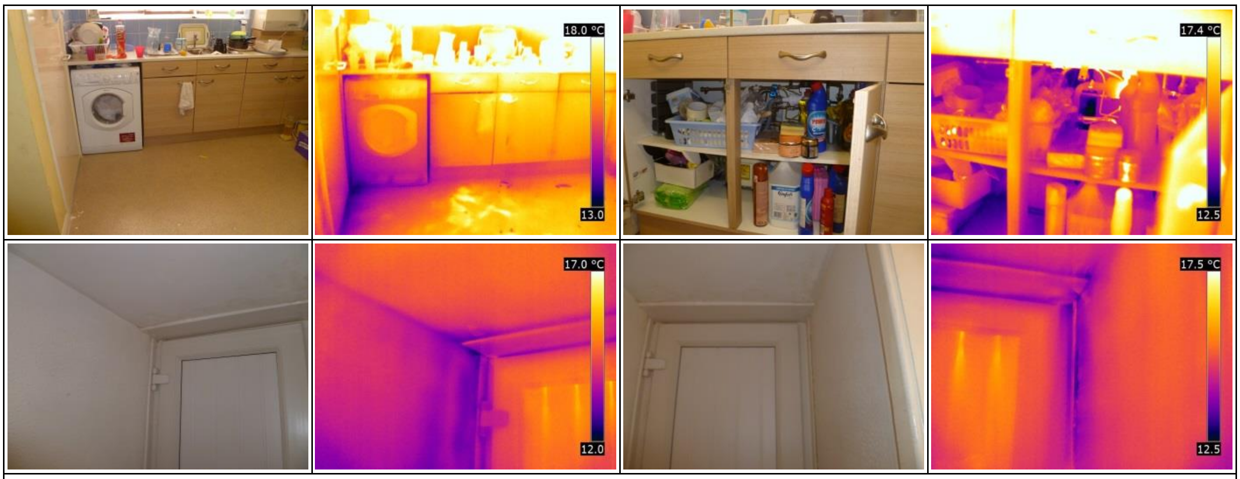
Leakage Detection

Basement

There was little change from the leakage detection performed for the previous test, with air leakage detected around the trickle vents, behind the kitchen units, around external wall penetrations and around the lobby door and frame.







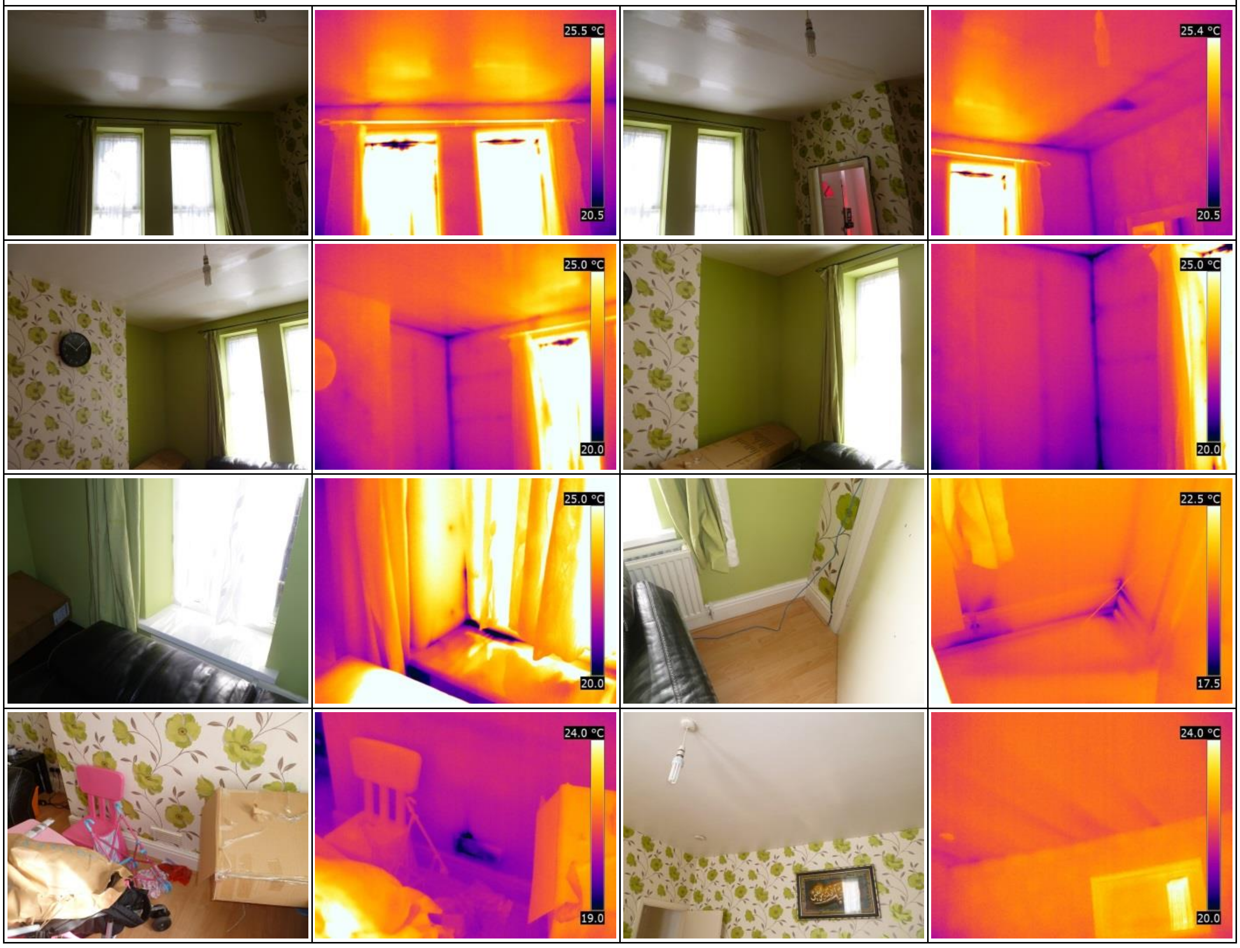
Lounge

Air leakage was again detected at the window, at the trickle vents and sill, although there was a reduction in leakage around the window frames.

On both the external and party walls air movement was detected around the IWI boards, but leakage previously observed around the vent in the external wall appeared to have been eliminated.

Other areas of infiltration included the floor perimeter and the vent on the chimney breast.

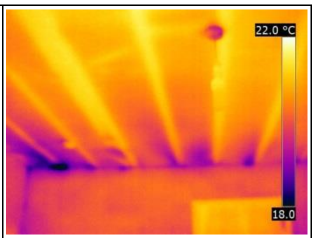
On the rear party wall, cooler air previously seen being drawn into the intermediate floor void around the built in joists had reduced significantly.




From previous test: 07-Feb-2014

From previous test: 07-Feb-2014


From previous test: 07-Feb-2014

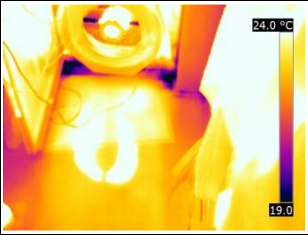


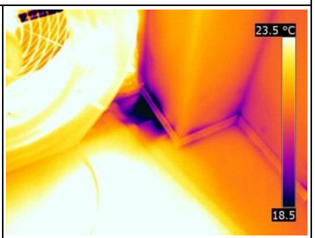
From previous test: 07-Feb-2014

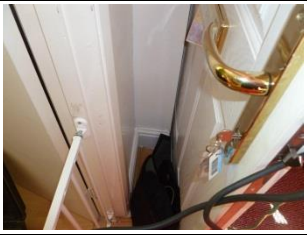
Hall & Stairs

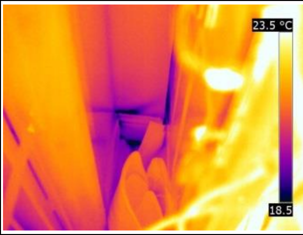
Infiltration was detected around the floor perimeter, particularly at the threshold and the junction with the stairs.

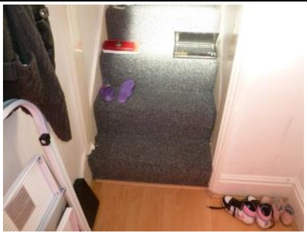
Around the front door and window there had been a noticeable improvement in airtight performance, but air movement into the intermediate floor void above the door appeared unchanged.



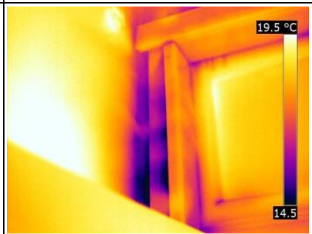









From previous test: 07-Feb-2014

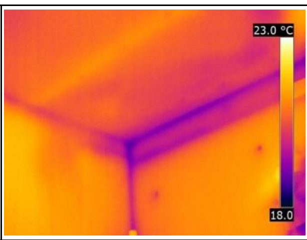


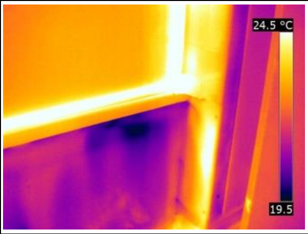
From previous test: 07-Feb-2014

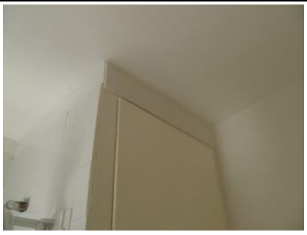
Bathroom

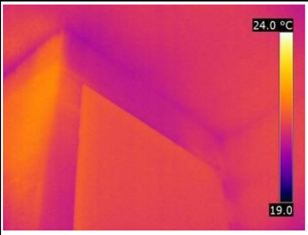
Infiltration was again observed into the intermediate floor void, and at the intermittent extract fan and trickle vent.

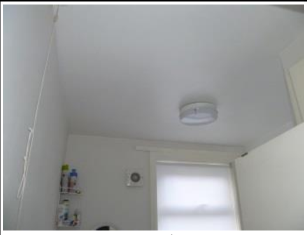
Air emerging from around the bath panel and from the airing cupboard was similar in quantity of flow but at very different temperatures, the air coming out from around the airing cupboard had warmed to near room temperature whereas that escaping from around the bath panel was substantially cooler.

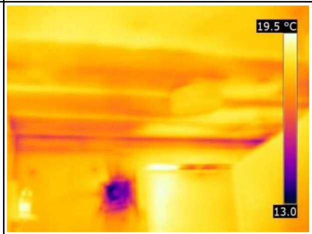






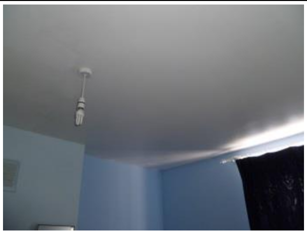


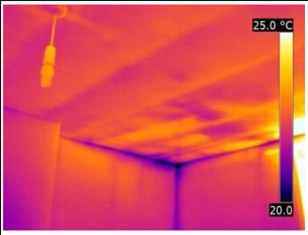

From previous test: 07-Feb-2014

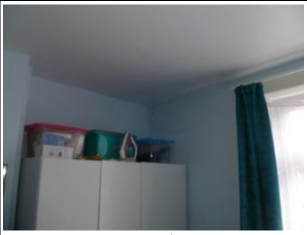


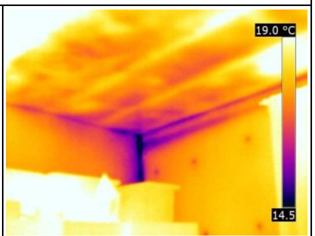
From previous test: 07-Feb-2014

1st Floor Bedroom
Air leakage previously detected at the window architrave and frame perimeter appeared to have been reduced, although intense sunlight made this impossible to confirm with thermal imaging.
Some air movement around the IWI panels could be detected, although this also showed an improvement from the previous test.
Some air was detected coming in through the floor as the carpet was lifting under depressurisation, but this was at room temperature so did not show up through thermal imaging.

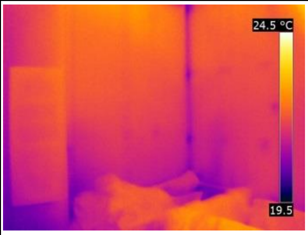




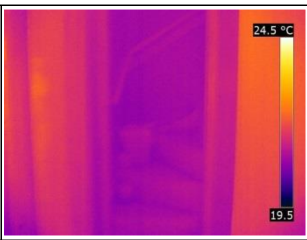

From previous test: 07-Feb-2014

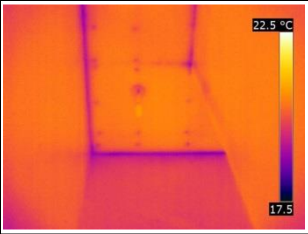


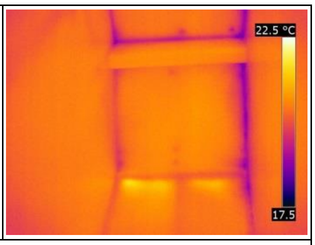
From previous test: 07-Feb-2014



Stairs & Landing
Air could be felt leaking in around the stairs to the 2nd floor, but this was emerging at room temperature.
The ceiling above the stairs showed some cooler and warmer areas but no obvious signs of air being drawn in under depressurisation.



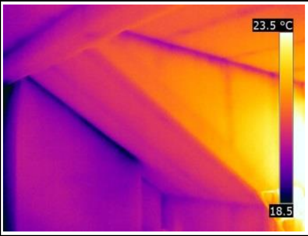



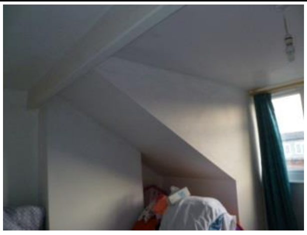



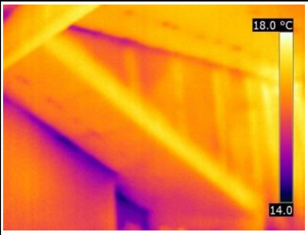
2nd Floor Bedroom

Cooler air had previously been detected being drawn down from the loft space into partition wall voids, around the access hatch to the cold roof at the front of the house and at the floor perimeter, this was all still apparent even though some (most noticeably around the access hatch) had been reduced.

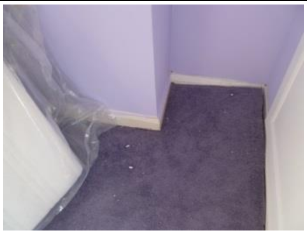
Air leakage through the intermediate floor actually appeared to be worse than previously observed; with the carpet lifting throughout the room, especially where there were holes in the floor, and joints between floorboards visible through the carpet. Along the rear wall junction with the floor the air emerging was still cool enough to show clearly in the thermal images.



From previous test: 07-Feb-2014



From previous test: 07-Feb-2014



From previous test: 07-Feb-2014

From previous test: 07-Feb-2014






From previous test: 07-Feb-2014
17.5 °C
12.5
From previous test: 07-Feb-2014
From previous test: 07-Feb-2014
18.5 °C
14.4
From previous test: 07-Feb-2014
23.0 °C
18.0
23.0 °C
18.0
24.5 °C
19.5
23.0 °C
18.0

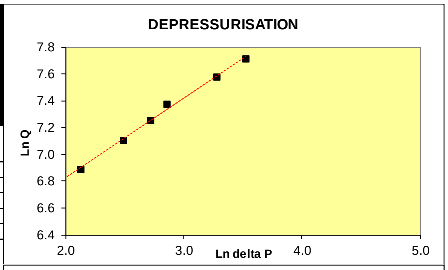
Results Spreadsheets

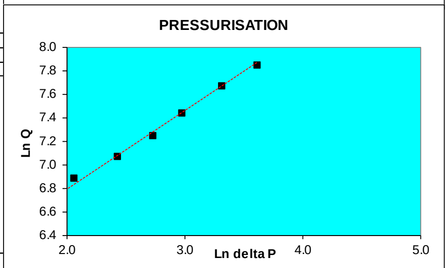
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

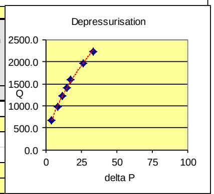
date:	07/02/2104		Version 16	22 October 2013
test house address:				
company:	leeds fed			
house type:	b2b terrace			
tester:	DMS, DG			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	9.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	10.2	°C		
outdoor humidity (%rh)	66.5	%RH		
indoor humidity (%rh)	68	%RH		
outdoor barometric pressure	984.5	mbar or hPa	Calculated Outdoor Air Density	1.21 kg/m³
indoor barometric pressure	984.6	mbar or hPa	Calculated Indoor Air Density	1.21 kg/m³
temperature corr. fact. depress.	0.996		description of main construction details:	
temperature corr. fact. press.	1.004			
wind speed (m/s):	2			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	4.9	m		
house depth:	4.4	m		
house height:	10.4	m		
floor area:	21.6	m²		
volume:	215	m³		
envelope area including floor:	233	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	3034.54	m³/h		
Mean Air Leakage at 50Pa =	14.11	h⁻¹		
Mean Air Permeability at 50 Pa =	13.02	m/h or m³h/m²		
Equivalent Leakage Area =	0.123	m² at	10	Pa

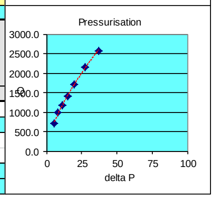
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	a	33.8	2246	2237.7	OK	33.8	3.520	7.713	2883.51	12.38	13.41
Approx 57 Pa	a	26.5	1962	1954.7	OK	26.5	3.277	7.578	r^2	0.998	
Approx 49 Pa	b	17.4	1605	1599.1	OK	17.4	2.856	7.377	C_{env}	281.017	m³/h.Pa*n*
Approx 41 Pa	b	15.1	1423	1417.7	OK	15.1	2.715	7.257	n	0.594	
Approx 33 Pa	b	12	1226	1221.5	OK	12	2.485	7.108			
Approx 25 Pa	b	8.4	988	984.3	OK	8.4	2.128	6.892	C_L (corrected)	282.066	m³/h.Pa*n*
Approx 20 Pa	b	4.4	678	675.5	OK	4.4	1.482	6.515			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa	a	36.9	2563	2572.5	OK	36.9	3.608	7.853	3185.57	13.67	14.82
Approx 57 Pa	a	27.4	2145	2153.0	OK	27.4	3.311	7.675	r^2	0.994	
Approx 49 Pa	b	19.6	1698	1704.3	OK	19.6	2.976	7.441	C_{env}	232.938	m³/h.Pa*n*
Approx 41 Pa	b	15.3	1402	1407.2	OK	15.3	2.728	7.249	n	0.668	
Approx 33 Pa	b	11.3	1171	1175.4	OK	11.3	2.425	7.069			
Approx 25 Pa	b	7.8	979	982.6	OK	7.8	2.054	6.890	C_L (corrected)	233.361	m³/h.Pa*n*
Approx 20 Pa	b	5.8	717	719.7	OK	5.8	1.758	6.579			



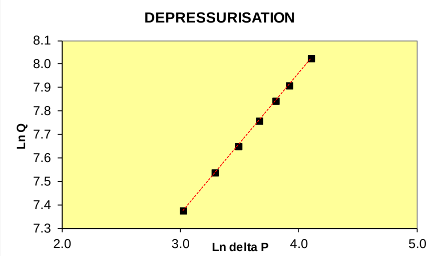


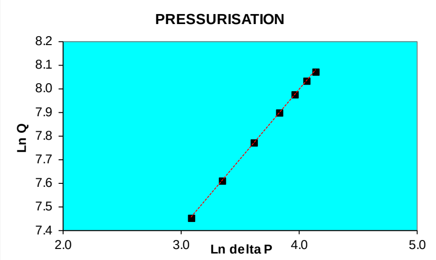




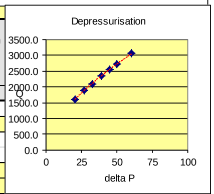
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	07/04/2104		Version 16	22 October 2013
test house address:	:			
company:	leeds fed			
house type:	b2b terrace			
tester:	DMS, DG			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	10.7	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	16.5	°C		
outdoor humidity (%rh)	86.7	%RH		
indoor humidity (%rh)	67	%RH		
outdoor barometric pressure	999.5	mbar or hPa	Calculated Outdoor Air Density	1.22 kg/m^3
indoor barometric pressure	999.6	mbar or hPa	Calculated Indoor Air Density	1.20 kg/m^3
temperature corr. fact. depress.	0.980		description of main construction details:	
temperature corr. fact. press.	1.020			
wind speed (m/s):	0			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	4.9	m		
house depth:	4.4	m		
house height:	10.4	m		
floor area:	21.6	m^2		
volume:	215	m^3		
envelope area including floor:	233	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	2770.39	m^3/h		
Mean Air Leakage at 50Pa =	12.89	h^{-1}		
Mean Air Permeability at 50 Pa =	11.89	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.119	m^2 at	10	Pa

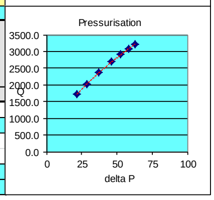




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^{3}h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	60.7	3123	3059.1	OK	60.7	4.106	8.026	2733.56	11.73	12.71
Approx 57 Pa	a	50.4	2781	2724.1	OK	50.4	3.920	7.910	r^2	1.000	
Approx 49 Pa	a	44.9	2601	2547.8	OK	44.9	3.804	7.843	C_{env}	258.834	m^3/h.Pa*n*
Approx 41 Pa	a	39.2	2391	2342.1	OK	39.2	3.669	7.759	n	0.601	
Approx 33 Pa	a	32.9	2141	2097.2	OK	32.9	3.493	7.648			
Approx 25 Pa	a	27	1917	1877.8	OK	27	3.296	7.538	C_L (corrected)	260.675	m^3/h.Pa*n*
Approx 20 Pa	a	20.6	1631	1597.6	OK	20.6	3.025	7.376			

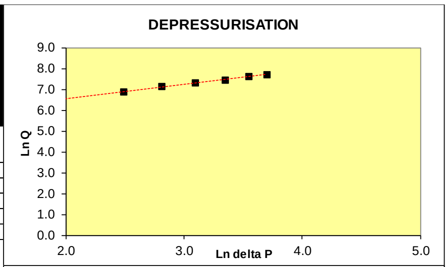


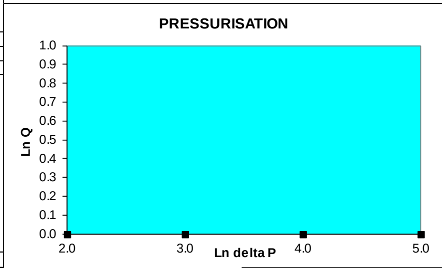
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^{3}h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	63.1	3139	3204.5	OK	63.1	4.145	8.072	2807.22	12.05	13.06
Approx 57 Pa	a	58.1	3017	3080.0	OK	58.1	4.062	8.033	r^2	1.000	
Approx 49 Pa	a	52.9	2849	2908.5	OK	52.9	3.968	7.975	C_{env}	280.278	m^3/h.Pa*n*
Approx 41 Pa	a	46.3	2633	2688.0	OK	46.3	3.835	7.897	n	0.589	
Approx 33 Pa	a	37.3	2324	2372.5	OK	37.3	3.619	7.772			
Approx 25 Pa	a	28.5	1978	2019.3	OK	28.5	3.350	7.611	C_L (corrected)	279.943	m^3/h.Pa*n*
Approx 20 Pa	a	21.9	1688	1723.2	OK	21.9	3.086	7.452			



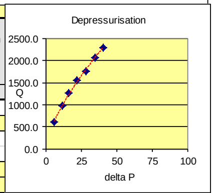
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	07/02/2104		Version 16	22 October 2013	
test house address:					
company:	leeds fed				
house type:	b2b terrace				
tester:	DMS, DG				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	9.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	18.6	°C			
outdoor humidity (%rh)	66.5	%RH			
indoor humidity (%rh)	53.7	%RH			
outdoor barometric pressure	984.5	mbar or hPa	Calculated Outdoor Air Density	1.21	kg/m^3
indoor barometric pressure	984.8	mbar or hPa	Calculated Indoor Air Density	1.17	kg/m^3
temperature corr. fact. depress.	0.968		description of main construction details:		
temperature corr. fact. press.	1.033				
wind speed (m/s):	2				
baseline pressure diff (Pa) (+/-)		Pa			
house width:	4.9	m			
house depth:	4.4	m			
house height:	10.4	m			
floor area:	21.6	m^2			
volume:	215	m^3			
envelope area including floor:	233	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =		m^3/h			
Mean Air Leakage at 50Pa =		h^{-1}			
Mean Air Permeability at 50 Pa =		m/h or m^3h/m^2			
Equivalent Leakage Area =		m^2 at	10	Pa	

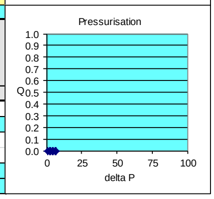




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	40.5	2360	2281.3	OK	40.5	3.701	7.733	2661.99	11.42	12.38
Approx 57 Pa	a	34.8	2137	2065.8	OK	34.8	3.550	7.633	r^2	0.999	
Approx 49 Pa	a	28.3	1822	1761.3	OK	28.3	3.343	7.474	C_{env}	179.012	m^3/h.Pa*n*
Approx 41 Pa	b	22	1603	1549.6	OK	22	3.091	7.346	n	0.689	
Approx 33 Pa	b	16.6	1308	1264.4	OK	16.6	2.809	7.142			
Approx 25 Pa	b	12	1007	973.4	OK	12	2.485	6.881	C_L (corrected)	179.523	m^3/h.Pa*n*
Approx 20 Pa	b	6.1	643	621.6	OK	6.1	1.808	6.432			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa											
Approx 57 Pa									r^2		
Approx 49 Pa									C_{env}		m^3/h.Pa*n*
Approx 41 Pa									n		
Approx 33 Pa											
Approx 25 Pa									C_L (corrected)		m^3/h.Pa*n*
Approx 20 Pa											



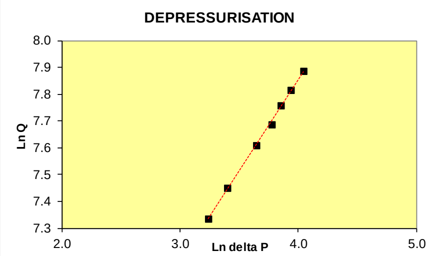
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

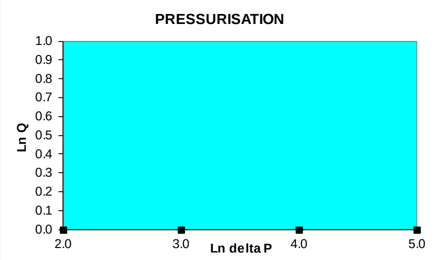
date:	10/04/2014	Version 16	22 October 2013
test house address:	:		
company:	leeds fed		
house type:	b2b terrace		
tester:	DMS, DG, MF		
test reference number:		Blower Door & Gauge Used	Model 3 with DG700

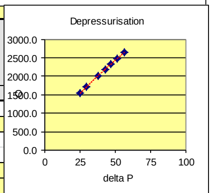
outdoor temp (°C)	11.3	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically
indoor temp (°C)	21.9	°C	
outdoor humidity (%rh)	59.8	%RH	
indoor humidity (%rh)	40.4	%RH	
outdoor barometric pressure	1016.5	mbar or hPa	Calculated Outdoor Air Density: 1.24 kg/m^3
indoor barometric pressure	1016.7	mbar or hPa	Calculated Indoor Air Density: 1.20 kg/m^3
temperature corr. fact. depress.	0.964	WARNING!!	description of main construction details:
temperature corr. fact. press.	1.037	Extreme Test	Repeat test following intervention - with loft hatch fully closed
wind speed (m/s):	2.6	Conditions	
baseline pressure diff (Pa) (+/-)		Pa	
house width:	4.9	m	
house depth:	4.4	m	
house height:	10.4	m	
floor area:	21.6	m^2	
volume:	215	m^3	
envelope area including floor:	233	m^2	
Pressure Difference for ELA	10	Pa	
RESULTS:			
Q50 Mean Flow at 50Pa =		m^3/h	
Mean Air Leakage at 50Pa =		h^{-1}	
Mean Air Permeability at 50 Pa =		m/h or m^3h/m^2	
Equivalent Leakage Area =		m^2 at	10 Pa

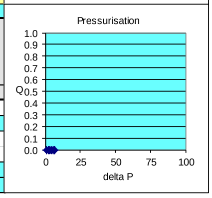
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	56.9	2762	2660.7	OK	56.9	4.041	7.886	2453.57	10.53	11.41
Approx 57 Pa	a	51.3	2572	2477.7	OK	51.3	3.938	7.815	r^2	0.999	
Approx 49 Pa	a	47.1	2428	2339.0	OK	47.1	3.852	7.757	C_{env}	166.352	$m^3/h.Pa^n$
Approx 41 Pa	a	43.5	2261	2178.1	OK	43.5	3.773	7.686	n	0.685	
Approx 33 Pa	a	38.2	2092	2015.3	OK	38.2	3.643	7.609			
Approx 25 Pa	a	30	1786	1720.5	OK	30	3.401	7.450	C_L (corrected)	168.129	$m^3/h.Pa^n$
Approx 20 Pa	a	25.6	1592	1533.6	OK	25.6	3.243	7.335			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a				OUT OF RANGE						
Approx 57 Pa	a				OUT OF RANGE				r^2		
Approx 49 Pa	b				OUT OF RANGE				C_{env}		$m^3/h.Pa^n$
Approx 41 Pa	b				OUT OF RANGE				n		
Approx 33 Pa	b				OUT OF RANGE						
Approx 25 Pa	b				OUT OF RANGE				C_L (corrected)		$m^3/h.Pa^n$
Approx 20 Pa	b				OUT OF RANGE						









Dwelling I-08, before and after retrofit

31st October 2014

General Comments:

West-facing, 2 bedroom, 2½ storey, semi-detached house with cellar and ground floor extension to rear.

Main house is solid-walled, timber roof to main house, flat roof to dormer, bay and ground floor extension. IWI on front façade, EWI on rear and gable walls and on ground floor extension. Unsure of construction of rear extension. Temporary glazing panels and front door at time of test, some 1st floor boards removed awaiting treatment, temporary sealing to base of cellar door to emulate potential future draught-stripping.

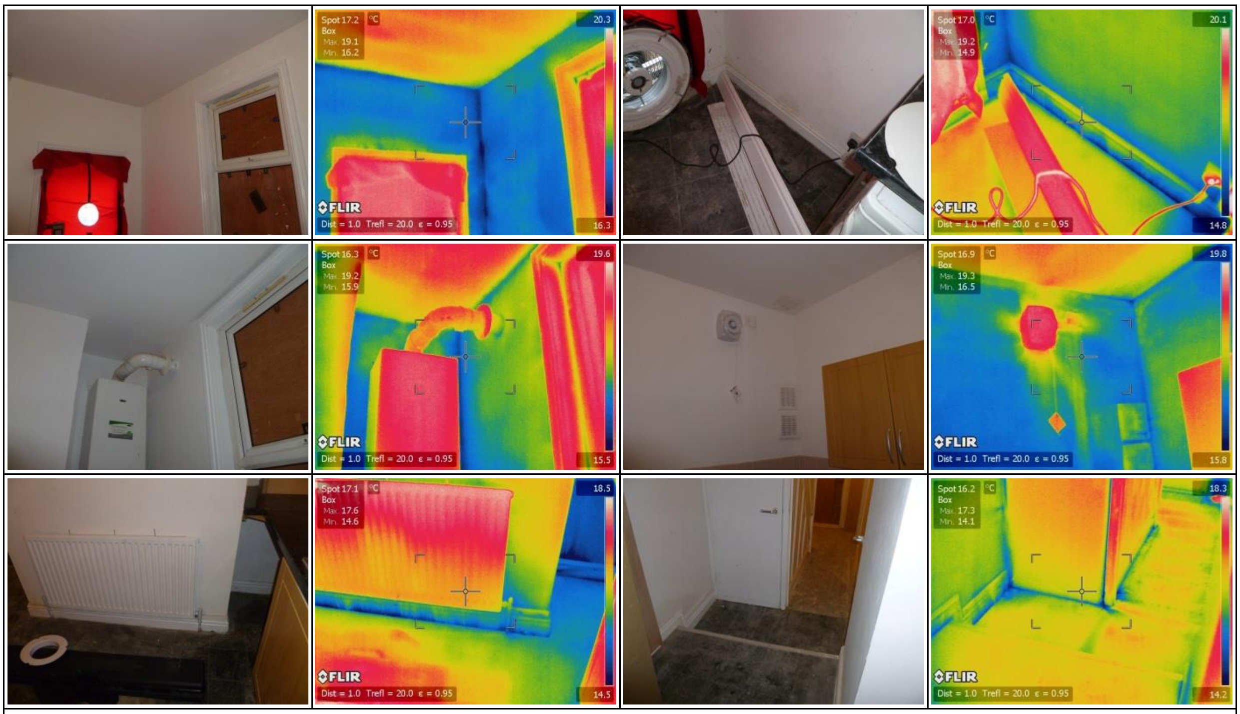
Leakage detection was performed under dwelling depressurisation at around -57Pa.

Pressure Test Results

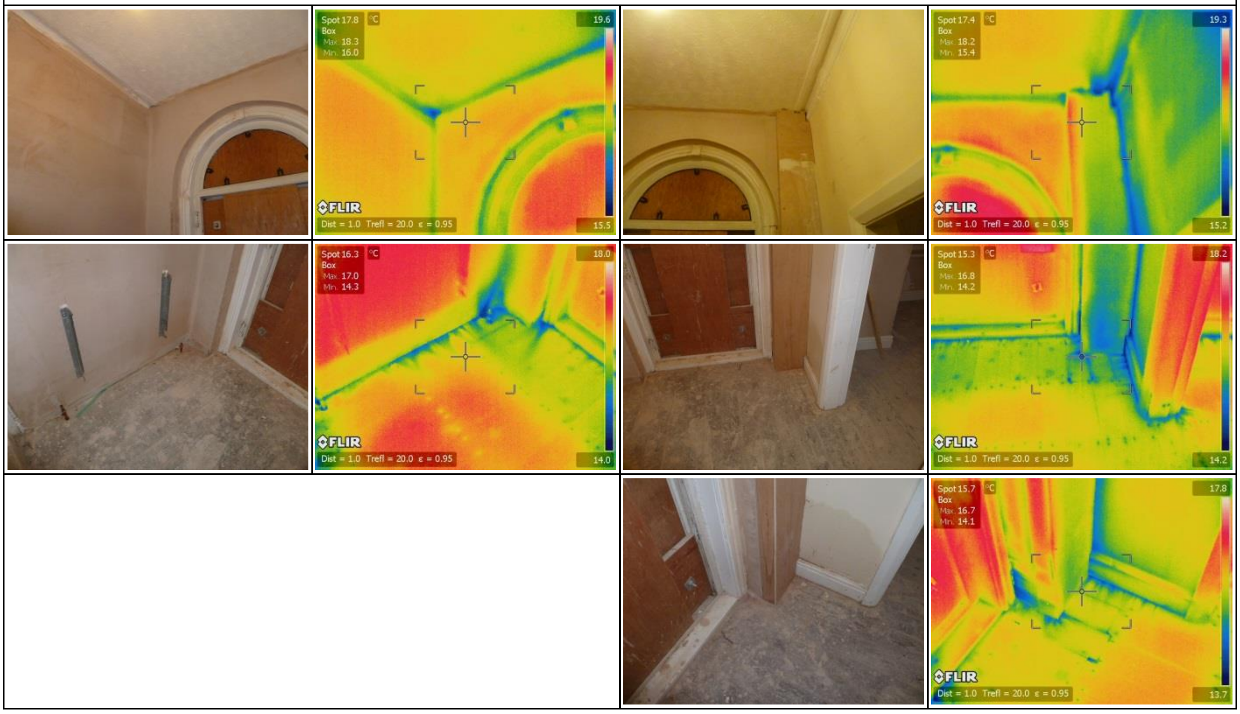
Date	Pressurisation		Depressurisation		Mean	
	Permeability	Air Change Rate	Permeability	Air Change Rate	Permeability	Air Change Rate
	$m^3/(h.m^2)$@50Pa	h^{-1}@50Pa	$m^3/(h.m^2)$@50Pa	h^{-1}@50Pa	$m^3/(h.m^2)$@50Pa	h^{-1}@50Pa
13-Aug-14	12.66	12.99	12.16	12.47	12.41	12.73
31-Oct-14	10.61	10.88	9.99	10.24	10.30	10.56
31-Oct-14	With tape removed from base of cellar door				10.83	11.10

Leakage Detection:

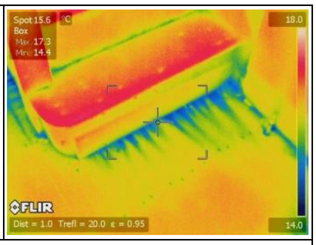
Kitchen
With only a 3⁰ difference between internal and external temperature and 3 hours of heating the internal environment it was not possible to view all infiltrating air using a thermal camera. The external walls with EWI installed were still a couple of degrees cooler than the kitchen ceiling due to their different thermal mass characteristics. However, cooler air (colder than the external air) could be observed being drawn in at the rear floor/wall junction, presumably from the cellar.
Sealing around wall penetrations was variable, with the boiler flue exhibiting no air leakage, but air was observed being drawn in around the extraction fan at the external air temperature.
Air was also observed being drawn up from the cellar at the floor perimeter on its junctions with internal walls and particularly around the cellar door (where temporary sealing was implemented to emulate draught-stripping at the foot of the door but not around the other 3 sides).



Hall
No infiltration was observed at the junction of the intermediate floor where IWI had been installed apart from around the unfinished boxing to the right of the door. It was unclear where this air was entering the boxing, although as air entering the hall from the top of the boxing was warmer than at the bottom it suggests that it too was being drawn up from beneath the ground floor.
The ground floor perimeter appeared to be far more problematic, with noticeable infiltration at all floor/wall junctions and at the base of the stairs.



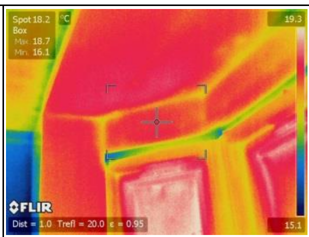




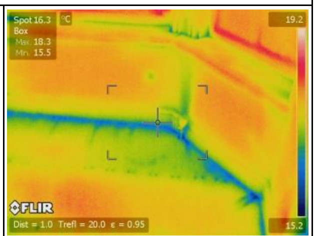
Lounge

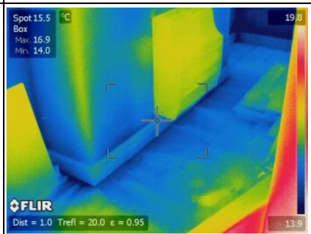
Again, around the IWI on the front of the house the junctions with the intermediate floor performed well, junctions with the ground floor not so well.

The external gable wall performed particularly badly around the chimney breast, with air emerging from the floor wall junction obviously cooler than air being drawn in around the gas fire itself. The rest of the gable wall displayed less air movement at the floor junction, comparable to that seen at the base of the two internal walls in the lounge.

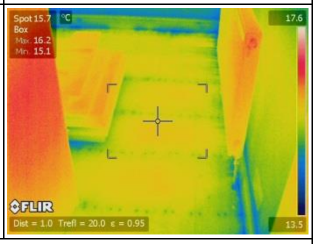







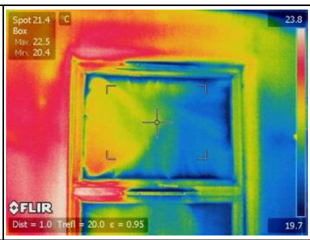



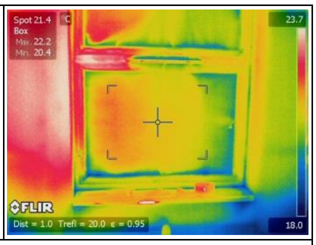


First Floor

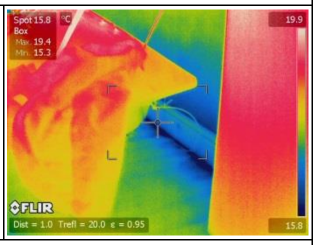
Air leakage around the front wall and IWI was not detectable using the thermal camera due in part to the lack of internal/external temperature differential (as can be seen by the temperature of the infiltration around the window), but also because there was very little airflow. Air emerging at the party wall and externally insulated wall junctions with the intermediate floor was both more prolific and cooler at point of emergence.









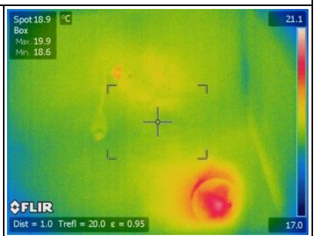
Second Floor

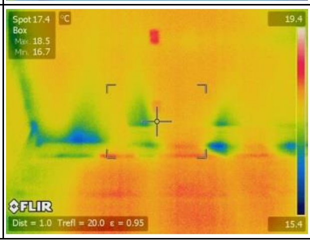
Air movement was detected around the ventilation unit, although barely visible with the thermal camera due to the lack of temperature differential. However, visible holes around the ceiling penetrations for the landing light and smoke alarms did not display and air leakage.

Leakage was also detected at the floor wall junctions at the knee wall on the front of the dwelling and around the chimney breast on the gable wall but to a much lesser degree on the rear wall.

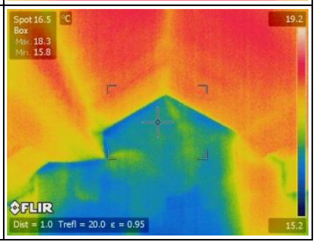
No air leakage was detected at the sloping ceilings and its junctions, the dormer also appeared to perform well with only a small amount of air movement around the light fixing in the dormer roof.

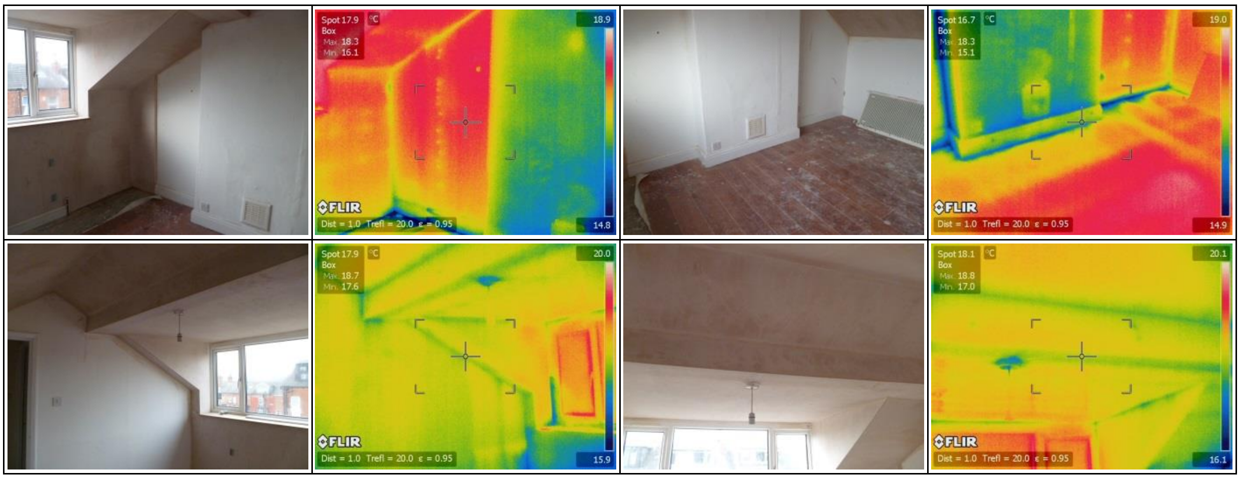










Additional Comments:

16.3% WME on front wall

17.8% WME on gable wall LHS of chimney breast

16.8% WME on gable wall RHS of chimney breast

17.3% WME on rear wall

External photos










Gaps between wall and EWI?







EPS wall beads leaking out of wall vents at rear of building?



Cellar photos



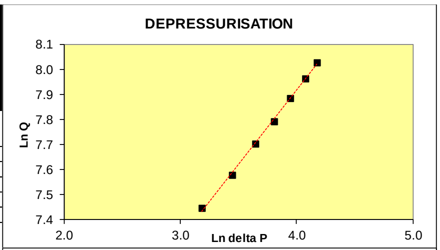


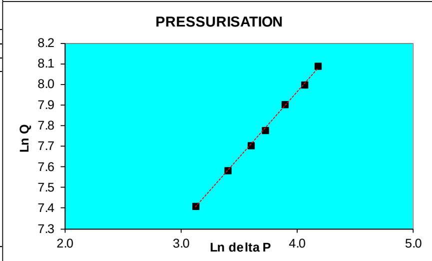



Pressure Test Spreadsheets:

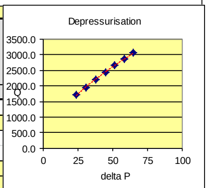
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	13/08/2014		Version 16a	19 February 2014	
test house address:					
company:	Canopy				
house type:	End-Terrace				
tester:	D. Glew F. Thomas				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	17.7	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	19	°C			
outdoor humidity (%rh)	72	%RH			
indoor humidity (%rh)	66.7	%RH			
outdoor barometric pressure	992	mbar or hPa	Calculated Outdoor Air Density	1.18	kg/m³
indoor barometric pressure	993.3	mbar or hPa	Calculated Indoor Air Density	1.18	kg/m³
temperature corr. fact. depress.	0.996		description of main construction details:		
temperature corr. fact. press.	1.004				
wind speed (m/s):	3				
baseline pressure diff (Pa) (+/-)		Pa			
house width:	5.13	m			
house depth:	7.63	m			
house height:	8.24	m			
floor area:	33.31	m²			
volume:	207.73	m³			
envelope area including floor:	213	m²			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	2643.44	m³/h			
Mean Air Leakage at 50Pa =	12.73	h^{-1}			
Mean Air Permeability at 50 Pa =	12.41	m/h or m³h/m²			
Equivalent Leakage Area =	0.109	m² at	10	Pa	

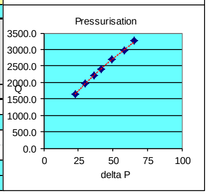




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	65.1	3080	3070.2	OK	65.1	4.176	8.030	2589.47	12.16	12.47
Approx 57 Pa	a	58.9	2885	2875.9	OK	58.9	4.076	7.964	r^2	0.998	
Approx 49 Pa	a	51.8	2671	2662.5	OK	51.8	3.947	7.887	C_{env}	258.982	m³/h.Pa*n*
Approx 41 Pa	a	45	2434	2426.3	OK	45	3.807	7.794	n	0.590	
Approx 33 Pa	a	38.2	2223	2216.0	OK	38.2	3.643	7.703			
Approx 25 Pa	a	31.4	1964	1957.8	OK	31.4	3.447	7.580	C_L (corrected)	257.344	m³/h.Pa*n*
Approx 20 Pa	a	24.1	1722	1716.5	OK	24.1	3.182	7.448			

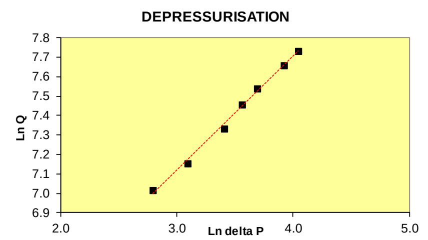


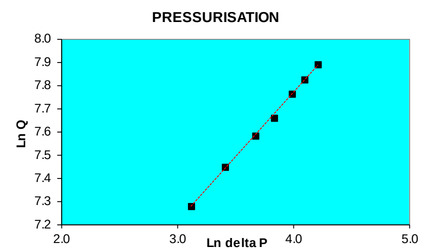
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	65.4	3248	3258.3	OK	65.4	4.181	8.089	2697.41	12.66	12.99
Approx 57 Pa	a	58.5	2963	2972.4	OK	58.5	4.069	7.997	r^2	0.999	
Approx 49 Pa	a	49.2	2693	2701.6	OK	49.2	3.896	7.902	C_{env}	224.398	m³/h.Pa*n*
Approx 41 Pa	a	41.4	2382	2389.6	OK	41.4	3.723	7.779	n	0.637	
Approx 33 Pa	a	36.7	2214	2221.0	OK	36.7	3.603	7.706			
Approx 25 Pa	a	30.1	1960	1966.2	OK	30.1	3.405	7.584	C_L (corrected)	222.885	m³/h.Pa*n*
Approx 20 Pa	a	22.8	1649	1654.2	OK	22.8	3.127	7.411			



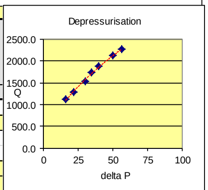
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	31/10/2014		Version 16a	19 February 2014
test house address:				
company:	Canopy			
house type:	End-Terrace			
tester:	D. Glew DMS			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	16.5	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	19.4	°C		
outdoor humidity (%rh)	72.5	%RH		
indoor humidity (%rh)	71.5	%RH		
outdoor barometric pressure	1022.6	mbar or hPa	Calculated Outdoor Air Density	1.22 kg/m³
indoor barometric pressure	1022.6	mbar or hPa	Calculated Indoor Air Density	1.21 kg/m³
temperature corr. fact. depress.	0.990		description of main construction details:	
temperature corr. fact. press.	1.010			
wind speed (m/s):	1.6			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	5.13	m		
house depth:	7.63	m		
house height:	8.24	m		
floor area:	33.31	m²		
volume:	207.73	m³		
envelope area including floor:	213	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	2194.22	m³/h		
Mean Air Leakage at 50Pa =	10.56	h^{-1}		
Mean Air Permeability at 50 Pa =	10.30	m/h or m³h/m²		
Equivalent Leakage Area =	0.098	m² at	10	Pa

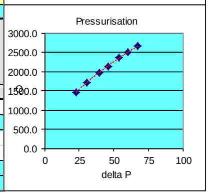




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	57	2303	2278.1	OK	57	4.043	7.731	2127.99	9.99	10.24
Approx 57 Pa	a	50.4	2144	2120.8	OK	50.4	3.920	7.660	r^2	0.996	
Approx 49 Pa	a	40.1	1900	1879.4	OK	40.1	3.691	7.539	C_{env}	210.798	m³/h.Pa*n*
Approx 41 Pa	a	35.1	1752	1733.0	OK	35.1	3.558	7.458	n	0.589	
Approx 33 Pa	b	30.2	1549	1532.2	OK	30.2	3.408	7.334			
Approx 25 Pa	b	22	1293	1279.0	OK	22	3.091	7.154	C_L (corrected)	212.500	m³/h.Pa*n*
Approx 20 Pa	b	16.4	1126	1113.8	OK	16.4	2.797	7.016			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	67.5	2645	2674.0	OK	67.5	4.212	7.891	2260.45	10.61	10.88
Approx 57 Pa	a	60	2475	2502.1	OK	60	4.094	7.825	r^2	0.999	
Approx 49 Pa	a	53.8	2324	2349.4	OK	53.8	3.985	7.762	C_{env}	255.541	m³/h.Pa*n*
Approx 41 Pa	a	46.1	2100	2123.0	OK	46.1	3.831	7.661	n	0.556	
Approx 33 Pa	a	39.5	1944	1965.3	OK	39.5	3.676	7.583			
Approx 25 Pa	b	30.4	1699	1717.6	OK	30.4	3.414	7.449	C_L (corrected)	256.525	m³/h.Pa*n*
Approx 20 Pa	b	22.6	1435	1450.7	OK	22.6	3.118	7.280			



Dwellings I-09 before and I-10 after retrofit

Date of Tests: 27th February 2014

Tested by: Dominic Miles-Shenton, David Glew & Felix Thomas

Compiled by: Dominic Miles-Shenton

Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa	r^2	Air Permeability $m^3/(h.m^2)$ @ 50Pa	Air Change Rate h^{-1} @ 50Pa
I-09	27-Feb-14	17.74	19.54	0.984					
I-10	27-Feb-14	12.53	12.56	0.997					

The pressurisation tests were performed using depressurisation only as the occupants (including children and/or vulnerable adults) were present at the time of testing, and blowing cold air into the dwellings to pressurise them may have caused them significant discomfort.

Leakage detection in both properties was performed under depressurisation using thermography, at approximately -45 Pa.

The air permeability of both properties under depressurisation only is greater than is currently acceptable for new build dwellings under the Building Regulations (10 $m^3/(h.m^2)$ @ 50Pa).

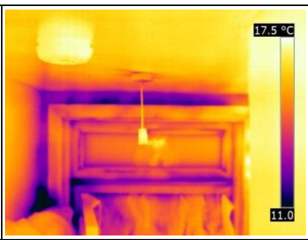
 I-09

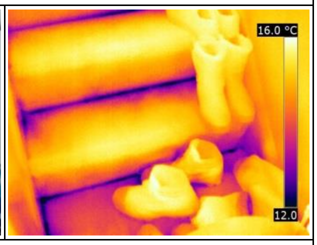
The air permeability measured through depressurisation of 17.74 $m^3/(h.m^2)$ @ 50Pa is greater than is currently acceptable for new build dwellings under the Building Regulations. Depressurisation of the dwelling pulls window casements into the seals, so pressurisation may have resulted in a higher value being obtained.

Leakage detection was performed under depressurisation (approx. -45 Pa) throughout. The internal/external ΔT was sufficient to allow this, The thermal images below show infiltrating air at a range of temperatures, the cooler air represents more direct leakage paths the warmer infiltrating air shows more complex indirect paths; they do not necessarily portray the magnitude of airflow (e.g. air infiltration around the bath panel was very severe, but does not show up as clearly in the thermal images as the air has already warmed up somewhat by the time it emerges).

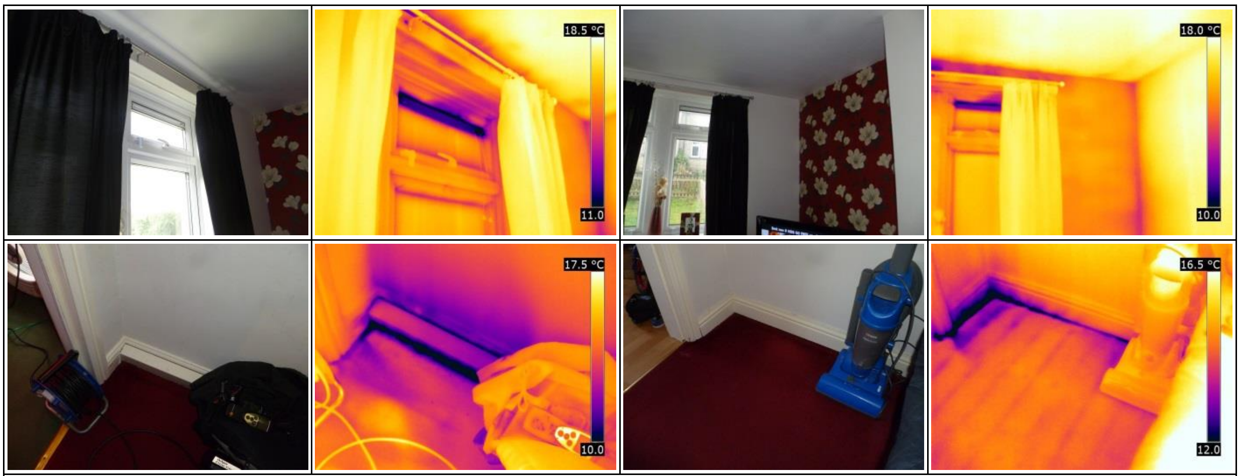
Leakage Detection & Observations

Hall and Stairs
Under dwelling depressurisation there was significant air leakage around the door architrave, this actually created a whistling sound at pressures of -30Pa and below. Substantial infiltration was also observed from underneath the suspended timber ground floor. This lifted the carpet in the hall and could be seen emerging from the floor/wall junctions and at the step/riser and stringer junctions on the lower half of the stairs, no such infiltration was observed at the upper half of the stairs where they ran over the kitchen cupboard instead of the ground floor void.



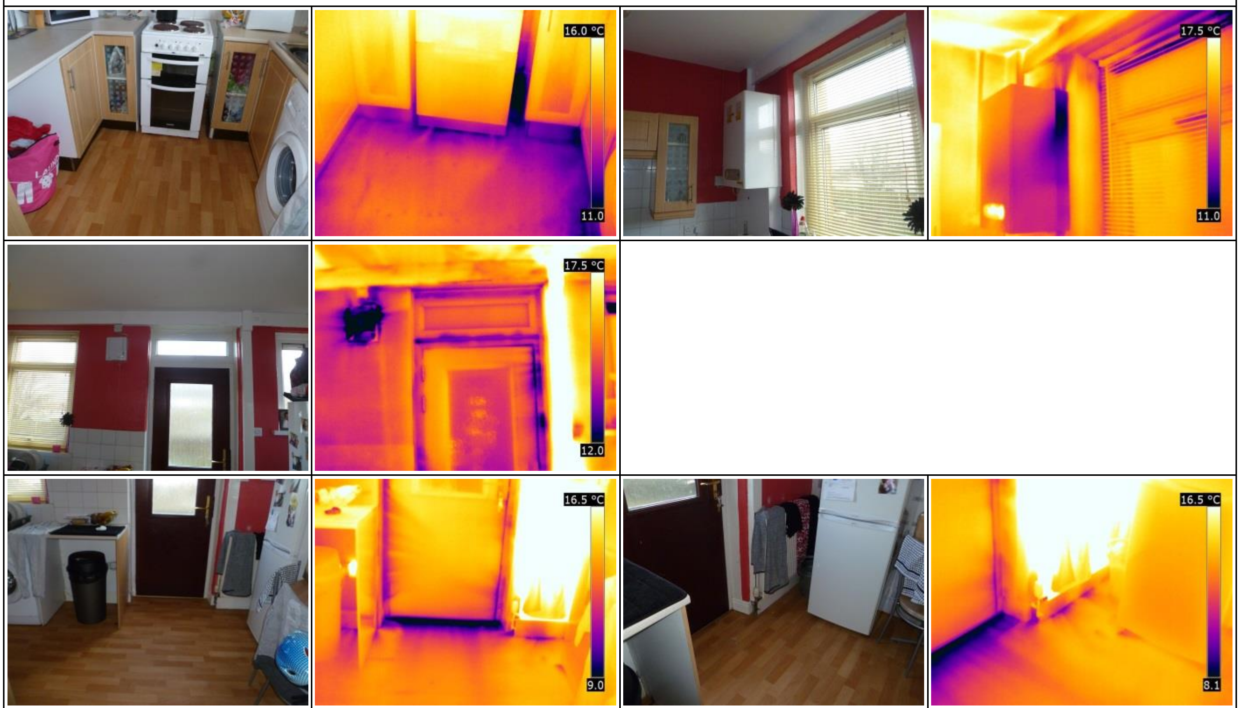


Living Room
The trickle vents were all closed for the purposes of the pressure test, but closing them did not stop airflow through them. Significant infiltration was again observed being drawn up from the ground floor void, this emerged at the room perimeter but could be seen on the thermal images coming up from between the floorboards underneath the carpet, this was particularly severe at the external wall junction around the boxing for services



Kitchen

Cooler air was seen emerging from behind the kitchen units and appliances, this may again be related to infiltration through the suspended ground floor or around service penetrations. Other areas of leakage that stood out were around the boiler flue, around the intermittent extract fan (this was temporarily sealed for the test, the leakage was from between the unit and the external wall), around the door (particularly the threshold) and at the floor perimeter.

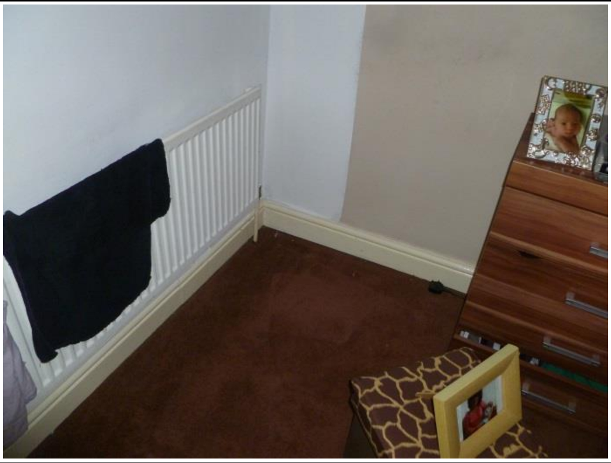
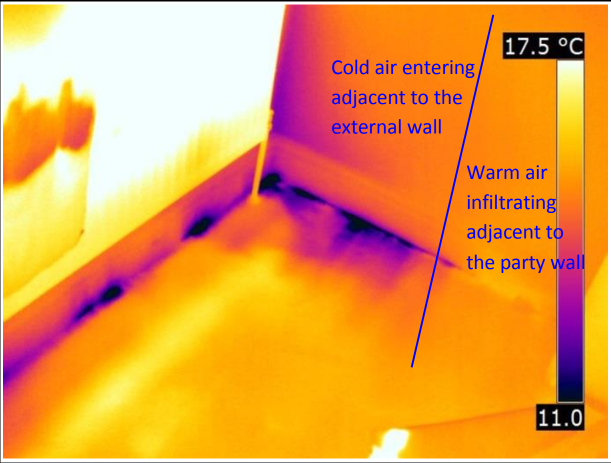


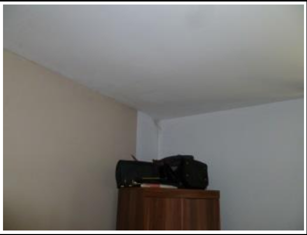
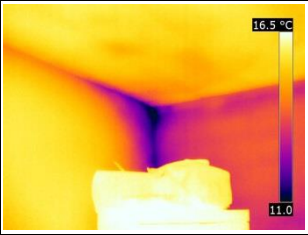
Front Bedroom

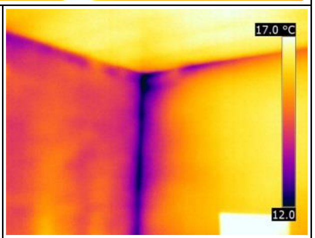
As was observed with the ground floor, significant infiltration was observed from the intermediate floor. Very cold air was being drawn in at the external wall junctions with the intermediate floor, on the party wall there was still air being drawn into the room, but it was at room temperature. The thermal imaging also revealed some compartmentalisation of different temperatures between joists in the floor void and air movement between the floorboards visible through the carpet.

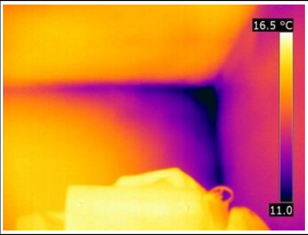
Although not an airtightness issue, the top corners of the front façade displayed particularly low surface temperatures where the side walls were external rather than separating walls. It is perhaps unsurprising that some surface mould was visible here.

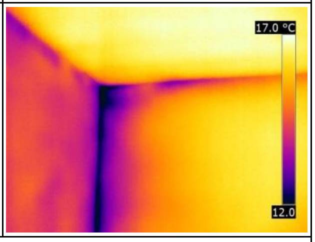


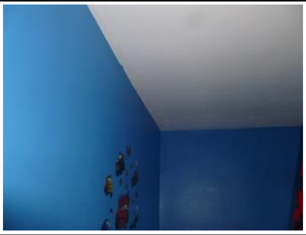
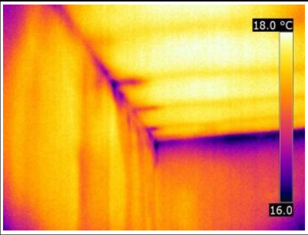



Rear Bedroom

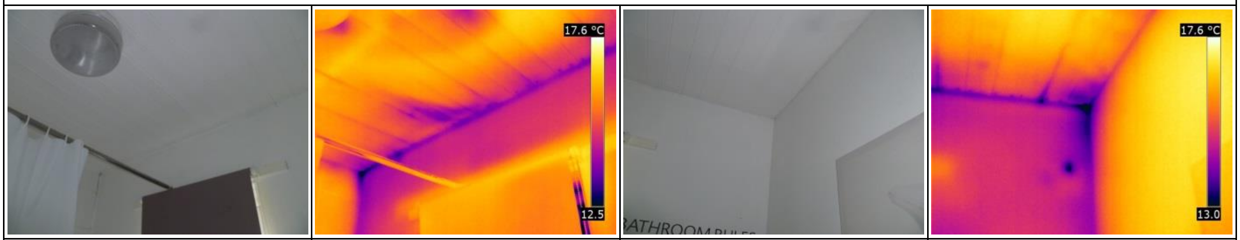
Some cooler air could be observed being drawn down into the internal partition wall between the bedrooms although this was minor compared to other leakage paths observed, and surface temperatures were well above those observed on the external wall.

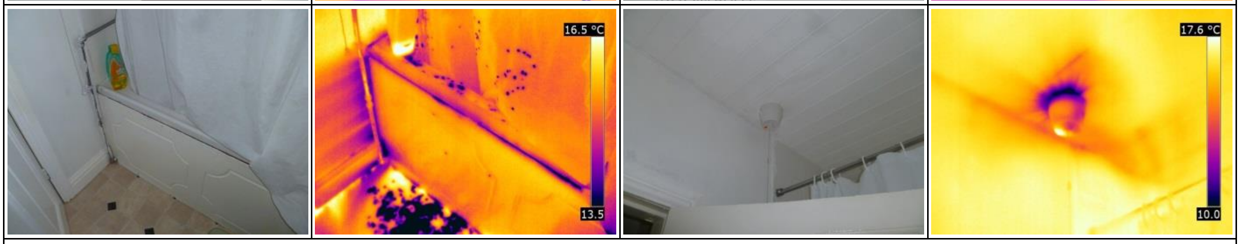





Bathroom

There were signs of either missing insulation or air being drawn in under the insulation at the rear eaves above the bathroom; this was not air entering the habitable space. Infiltration into the living space was rife around the bath panel, although it is unclear whether this was up from the intermediate floor void or from around unsealed service penetrations. Air movement was also detected from the loft void around the bathroom light switch.





Landing

The landing had no external walls and displayed little signs of air movement apart from some infiltration between the loft door and hatch.


I-10

The air permeability measured through depressurisation of 12.53 $m^3/(h.m^2)$ @ 50Pa is again greater than is currently acceptable for new build dwellings under the Building Regulations. Leakage detection on this property showed similar air infiltration paths and magnitude to the previous dwelling at Farfield Road with the exception of the performance of the ground floor; this property had a solid ground floor which was airtight throughout, as opposed to the very leaky suspended timber ground floor of the previous dwelling. Testing was again performed under depressurisation only, pressurisation may have resulted in a higher value being obtained.

Leakage detection was performed under depressurisation (approx. -45 Pa) throughout. The internal/external ΔT was substantially less than in the previous dwelling, and should be born in mind if comparisons between thermal images from this dwelling and the previous one are to be made.

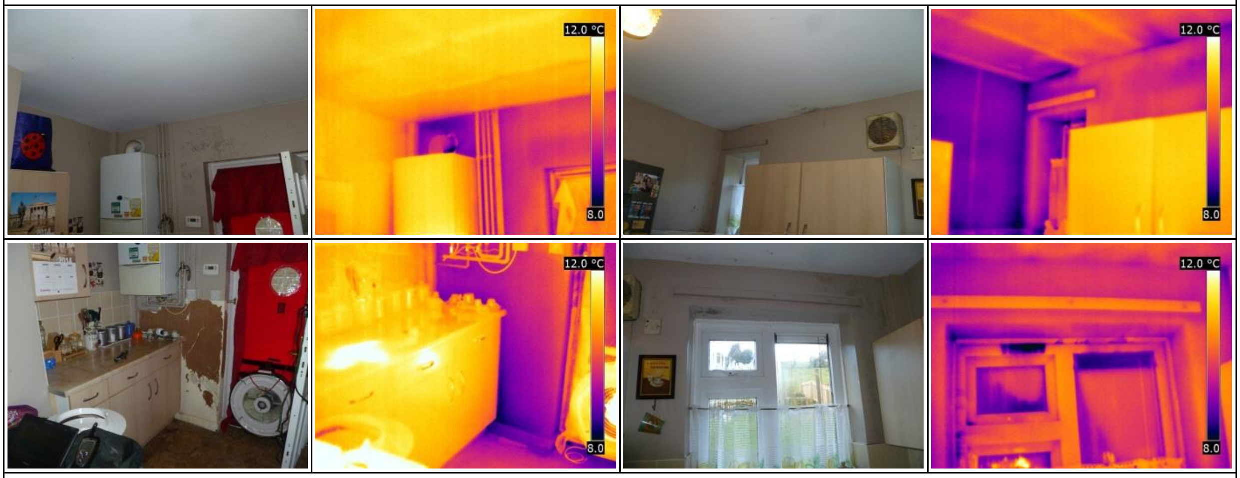
Leakage Detection & Observations

Kitchen

The external wall adjacent to the rear door appeared to display particularly low surface temperatures, although there was some dampness associated with it which will have suppressed IR emittance causing slightly lower readings on the thermal image these near-external temperatures are still a cause for concern.

Air could be seen being drawn into the intermediate floor void, causing areas which were cooler than the rear external wall so would be the first places where condensation would form – particularly as the occupants did not use the intermittence extraction fan and this was where they used their kettle.

There was also some air leakage around the kitchen window frame and at the trickle vent.

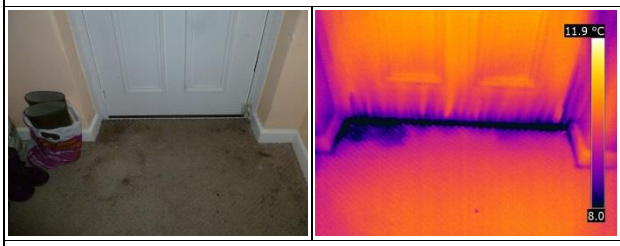


Dining Room

The ground floor junction with the external wall appeared very cold. Air was observed being drawn in through and underneath an unused gas fire.

Hall & Stairs

Significant air leakage was detected at the front door threshold, the rest of the door and the stairs showed little if any air movement.



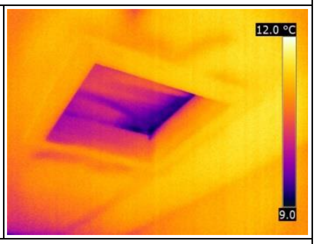
Living Room

As at the rear of the property, air was drawn into the intermediate floor void, shown here as cooler areas between the floor joists with the coolest sections nearest to the gable wall.


Front Bedrooms

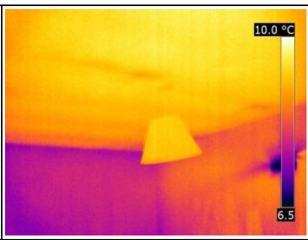
As expected, both external walls display a significantly cooler temperature than the ceiling, which displays a good even temperature with no obvious gaps in the loft insulation even at the eaves or the often missed section between the end joist and the wall. As in the previous property, there was air movement between the loft door and hatch.

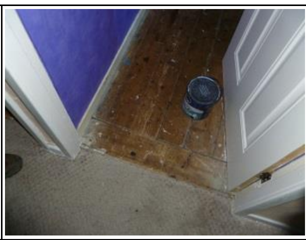
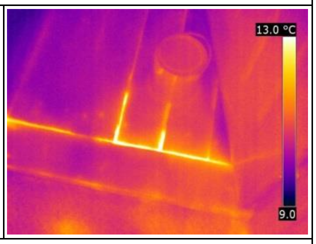




Rear Bedroom

As in the front bedrooms the loft insulation appeared to be evenly laid and the external and gable walls substantially cooler. This bedroom had no fitted carpet and substantial air movement was detected coming into the room from between the floorboards; this was at a temperature not much lower than the room temperature throughout most of the room, but where heating/DHW pipes ran through the floor void this showed up in the thermal images as warmer air emanating from the intermediate floor void.

Bathroom & WC

In the bathroom there were signs of cooler areas at the eaves, it was not possible to determine whether this was due to air movement around the insulation or missing/thin insulation. Substantial air movement was detected coming up from the intermediate floor void through the numerous gaps in the cylinder cupboard floor, and cold air emerging at the external wall junction with the bathroom floor at the room perimeter.

In the WC there was also some air movement around the trickle vent and window, but the eaves issue observed in the adjacent bathroom were not immediately obvious.



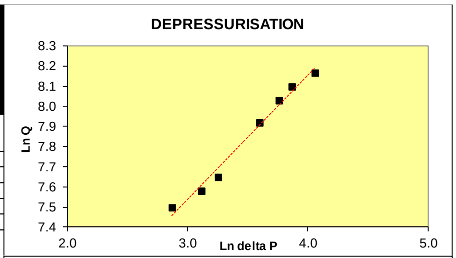
Landing
As in the previous property, the landing was central to the house with no external wall junctions and very little could be observed with the thermal camera, although some air movement around electrical penetrations was detected where cables had been chased into the internal blockwork and not sealed allowing air to enter from the loft space.

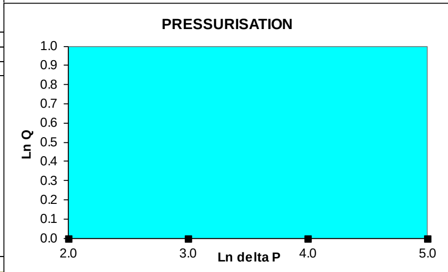
External Observations
Numerous external vents and airbricks were observed in the outer leaf stonework which did not correspond to internally visible ventilation. These may aid airflow into the external wall cavity and result in greater windwashing of the structure, assisted by the exposed location. Unfilled perpends in the external wall may also contribute to over-ventilation of the external wall cavity.
If gaps around the built-in intermediate floor joists connect the floor void directly to this cavity it may explain some of the leakage observed in this (and the previous) dwelling.

Results Spreadsheets

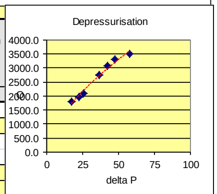
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	27/02/2014		Version 16a 19 February 2014	
test house address:				
company:				
house type:	Stone terrace			
tester:	DMS, DG, FT			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	6.2	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	20	°C		
outdoor humidity (%rh)	81	%RH		
indoor humidity (%rh)	50	%RH		
outdoor barometric pressure	985	mbar or hPa	Calculated Outdoor Air Density	1.22 kg/m^3
indoor barometric pressure	985.1	mbar or hPa	Calculated Indoor Air Density	1.17 kg/m^3
temperature corr. fact. depress.	0.953	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.049	Extreme Test	Prior to cavity fill	
wind speed (m/s):	1	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house width:	4.53	m		
house depth:	7.096	m		
house height:	5.28	m		
floor area:	32.145	m^2		
volume:	169.725	m^3		
envelope area including floor:	187.06	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =		m^3/h		
Mean Air Leakage at 50Pa =		h^{-1}		
Mean Air Permeability at 50 Pa =		m/h or m^3h/m^2		
Equivalent Leakage Area =		m^2 at	10	Pa

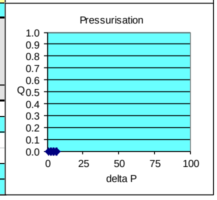




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	58.1	3695	3516.0	OK	58.1	4.062	8.165	3319.17	17.74	19.56
Approx 57 Pa	a	47.8	3457	3289.5	OK	47.8	3.867	8.098	r^2	0.984	
Approx 49 Pa	a	42.9	3234	3077.3	OK	42.9	3.759	8.032	C_{env}	297.974	$m^3/h.Pa^n$
Approx 41 Pa	a	36.6	2889	2749.0	OK	36.6	3.600	7.919	n	0.614	
Approx 33 Pa	a	26	2207	2100.1	OK	26	3.258	7.650			
Approx 25 Pa	a	22.5	2058	1958.3	OK	22.5	3.114	7.580	C_L (corrected)	300.329	$m^3/h.Pa^n$
Approx 20 Pa	a	17.6	1898	1806.0	OK	17.6	2.868	7.499			

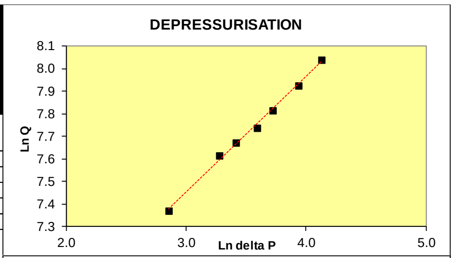


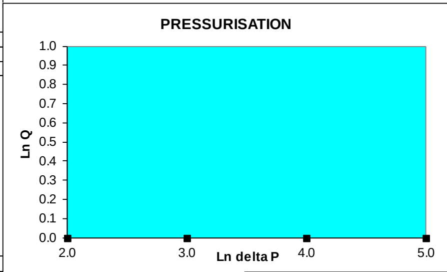
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa											
Approx 57 Pa									r^2		
Approx 49 Pa									C_{env}		$m^3/h.Pa^n$
Approx 41 Pa									n		
Approx 33 Pa											
Approx 25 Pa									C_L (corrected)		$m^3/h.Pa^n$
Approx 20 Pa											



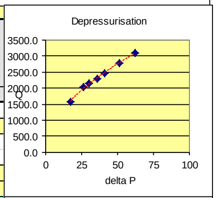
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	27/02/2014		Version 16a	19 February 2014
test house address:				
company:				
house type:	end terrace			
tester:	DMS, DG, FT			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	7.4	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	12.1	°C		
outdoor humidity (%rh)	65.8	%RH		
indoor humidity (%rh)	75.7	%RH		
outdoor barometric pressure	978.5	mbar or hPa	Calculated Outdoor Air Density	1.21 kg/m³
indoor barometric pressure	978.4	mbar or hPa	Calculated Indoor Air Density	1.19 kg/m³
temperature corr. fact. depress.	0.984		description of main construction details:	
temperature corr. fact. press.	1.017		Prior to cavity wall fill	
wind speed (m/s):	2.2			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	6.355	m		
house depth:	6.844	m		
house height:	5.054	m		
floor area:	43.49362	m²		
volume:	219.81676	m³		
envelope area including floor:	220.403	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =		m³/h		
Mean Air Leakage at 50Pa =		h⁻¹		
Mean Air Permeability at 50 Pa =		m/h or m³h/m²		
Equivalent Leakage Area =		m² at	10	Pa

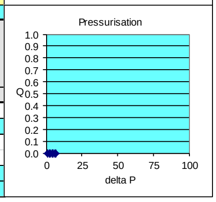




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	a	62.2	3159	3101.9	OK	62.2	4.130	8.040	2760.63	12.53	12.56
Approx 57 Pa	a	51.4	2821	2770.0	OK	51.4	3.940	7.927	r^2	0.997	
Approx 49 Pa	a	41.4	2521	2475.5	OK	41.4	3.723	7.814	C_{env}	369.830	m³/h.Pan
Approx 41 Pa	a	36.2	2333	2290.8	OK	36.2	3.589	7.737	n	0.513	
Approx 33 Pa	a	30.4	2187	2147.5	OK	30.4	3.414	7.672			
Approx 25 Pa	a	26.6	2063	2025.7	OK	26.6	3.281	7.614	C_L (corrected)	371.604	m³/h.Pan
Approx 20 Pa	a	17.4	1617	1587.8	OK	17.4	2.856	7.370			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa											
Approx 57 Pa									r^2		
Approx 49 Pa									C_{env}		m³/h.Pan
Approx 41 Pa									n		
Approx 33 Pa											
Approx 25 Pa									C_L (corrected)		m³/h.Pan
Approx 20 Pa											



Dwelling I-10 after and I-15 before retrofit

Date of Tests: 13th March 2014

Tested by: Dominic Miles-Shenton, David Glew & Felix Thomas

Compiled by: Dominic Miles-Shenton

Test Results:

Property	Date	Depressurisation Only			Pressurisation Only			Mean	
		Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa	r^2	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa	r^2	Air Permeability m³/(h.m²) @ 50Pa	Air Change Rate h⁻¹ @ 50Pa
I-09	27-Feb-14	17.74	19.54	0.984					
I-10	27-Feb-14	12.53	12.56	0.997					
	13-Mar-14	8.32	8.34	0.996					
I-15	13-Mar-14	10.42	8.94	0.997	10.66	9.14	0.997	10.54	9.04

The repeat pressurisation test on 80 Longroyd Crecsent was again performed using depressurisation only as the occupants (including children and/or vulnerable adults) were present at the time of testing, this test followed the filling of the external wall cavities with injected foam insulation.

The pressurisation test on 4 Quarry Close was performed prior to any intervention under both pressurisation and depressurisation.

Leakage detection in both properties was performed under depressurisation using thermography, at approximately -50 Pa.


I-10

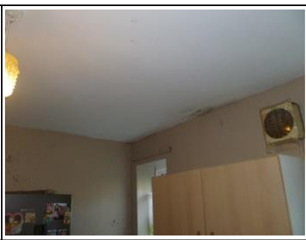
The air permeability measured through depressurisation following the external wall cavity fill had reduced from 12.53 to 8.32 $m^3/(h.m^2)$ @ 50Pa. Leakage detection on this property showed similar air infiltration paths to the previous test on this dwelling; however, leakage through the intermediate floor appeared to be at significantly reduced rates.

Leakage detection was performed under depressurisation (approx. -50 Pa) throughout. The internal/external ΔT was only 4°C so only direct infiltration paths were clearly observable, with much of the air emerging from longer or more complex leakage paths already warmed to the ambient room temperature.

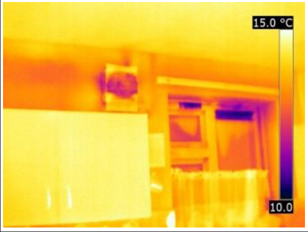
Thermal images from the previous pressurisation test are shown beneath those from this test where comparisons between observations before and after the intervention are noteworthy.

Leakage Detection & Observations

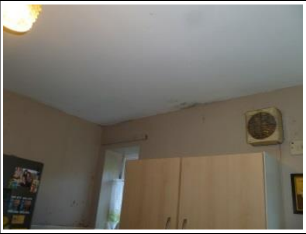
Kitchen
The dampness associated with external wall adjacent to the rear door appeared to have diminished somewhat since the previous test; the greater increase over external temperatures observed at the wall surface here are due in part to the reduction in moisture level at the wall surface even though the internal relative humidity was actually higher for the re-test.
The temperatures of the internal surfaces of the external walls appeared significantly higher than was observed in the previous test, although the external temperature was only 1.2°C higher for the re-test and the central heating was not operating for either test. Some thermal bridges had also become more obvious due to the increased performance of the plane elements around them, such as the lintel of the blocked-up window on the rear wall.
Air that was previously seen being drawn into the intermediate floor void now appeared to have been effectively eliminated.
The previously observed air leakage around the window frames, extract fan and trickle vents remained unchanged between both tests.



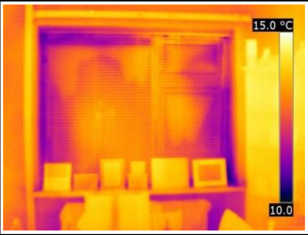



From 27-Feb-2014:

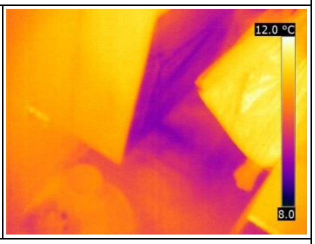

Dining Room

Air leakage in the Dining Room showed no change, with cooler air still observed being drawn in through and underneath an unused gas fire.


From 27-Feb-2014:



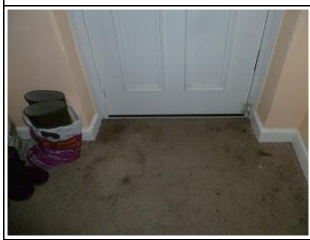
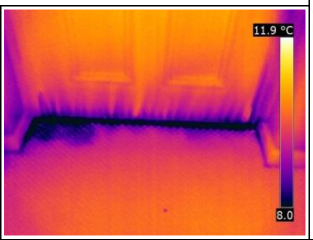


Hall & Stairs

Again, there was no significant change in the air leakage in the Hall. The most significant infiltration was again detected at the front door threshold.



From 27-Feb-2014:

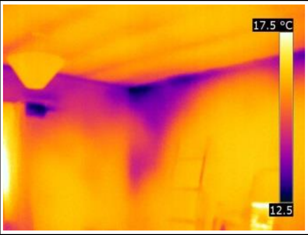
Living Room

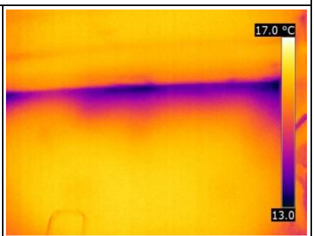
As at the rear of the property, air observed previously being drawn into the intermediate floor void from the external wall cavity appeared to have been effectively eliminated and the surface temperature of the external walls was noticeably higher than previously observed.
Air leakage through and around the temporarily sealed gas fire remained.

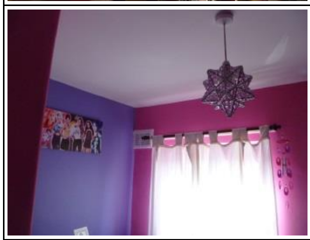
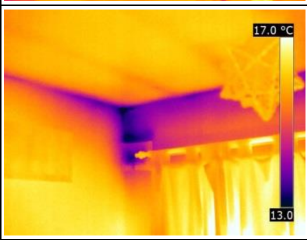


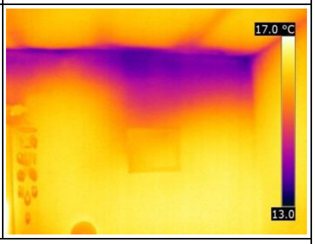
From 27-Feb-2014:

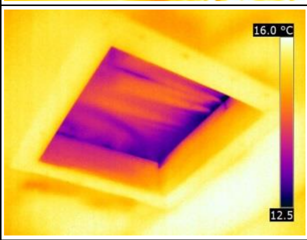

Front Bedrooms
At the previous test both external walls display a significantly cooler temperature than the insulated ceiling, now all three elements were relatively isothermal and thermal bridging was now apparent as the plane element thermal transmission has been considerably reduced.
The SouthWest top corner of the gable wall displays an extended cooler area. It is unclear whether this is due to the insulation not filling right up into the junction or whether the cooler area is due to higher moisture (hence, greater thermal transmittance) compared to the areas around it, possibly due to ingress or residual moisture.
There air movement between the loft door and hatch was unchanged.

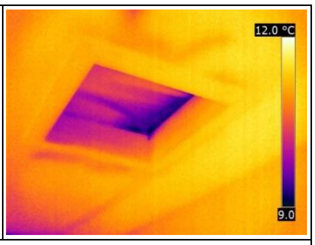



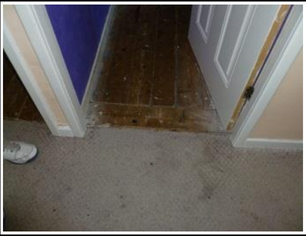
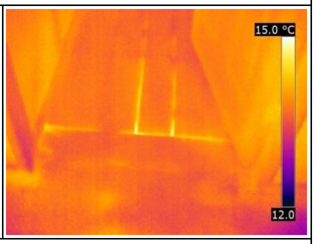
From 27-Feb-2014:



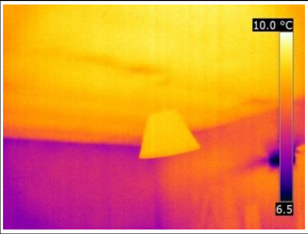


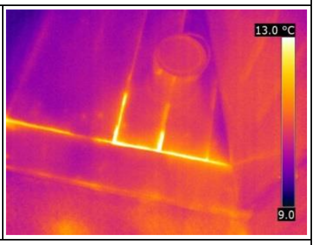
Rear Bedroom

As in the front bedrooms, the inner surfaces of the external walls were now at the same temperature as the insulated ceiling and thermal bridging at the junction had become increasingly distinguishable. Air leakage around the window and vent were similar to the previous pressurisation test although infiltration up through gaps between the floorboards appeared noticeably reduced.

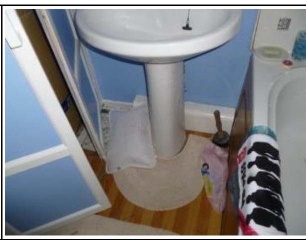

From 27-Feb-2014:

Bathroom & WC

In the bathroom the most prominent change between the two tests was the reduced infiltration up through the floor in the cylinder cupboard; where infiltration was now detected being drawn down from the loft. It is assumed that the air leakage from the loft was overlooked previously due to it being masked by the severity of the air coming up from the intermediate floor.

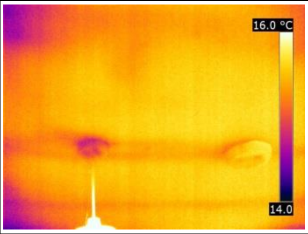






From 27-Feb-2014:



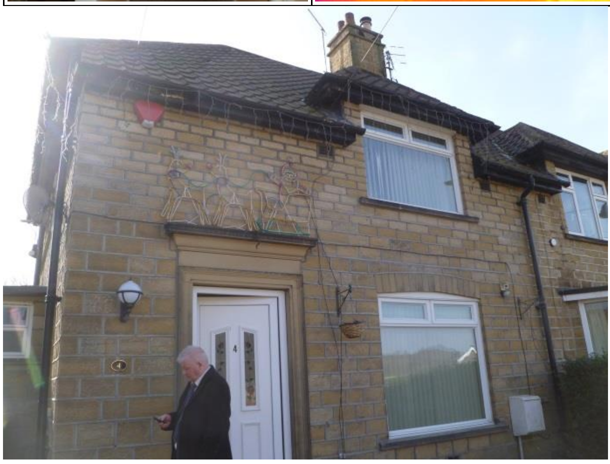
Landing
The small amount of air movement previously detected around electrical penetrations from the loft space remained unchanged between the two tests.



From 27-Feb-2014:




I-15

The air permeability measured through depressurisation of 10.54 $m^3/(h.m^2)$ @ 50Pa is only marginally greater than is currently acceptable for new build dwellings under the Building Regulations, and fairly typical for a solid-floored, wet-plastered property of this age and condition.

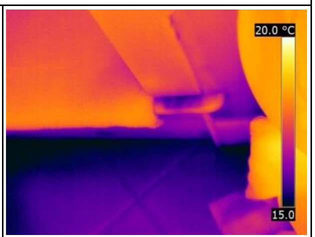
Leakage detection was performed under depressurisation (approx. -50 Pa) throughout, but only of limited success. The internal/external ΔT was only 4^o so only direct infiltration paths were clearly observable, with much of the air emerging from longer or more complex leakage paths, and even from the loft space, had already warmed to the ambient room temperature, and bright sunlight on the SouthEast and SouthWest façades restricting any thermal imaging further.

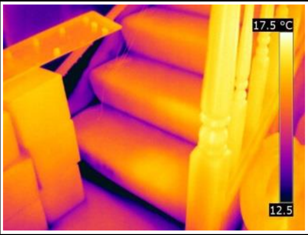
Leakage Detection & Observations

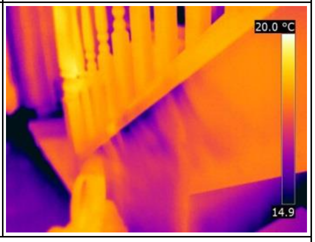
Hall and Stairs

Even with a small internal/external ΔT cooler air could be observed entering the living space from around the lower few steps of the staircase and the cupboard on the external corner at the bottom of the stairs. Air leakage through the stairs appeared limited to where there was a void beneath the staircase, but came through junctions with all other elements and joints within the staircase itself.






Lounge

The external wall appeared significantly colder than the internal partition wall and party wall. Cooler air appeared to be drawn into the intermediate floor void from the external wall cavity.

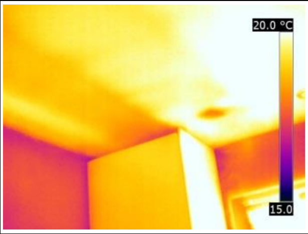


Kitchen/Diner

Thermal imaging here was particularly affected by bright sunlight and reflection; however, it still appeared that there was some air being drawn into the intermediate floor void, as observed at the front of the dwelling.

The cavity wall between the kitchen and side extension was noticably cooler than the other internal walls, although not quite as cold as the external walls.

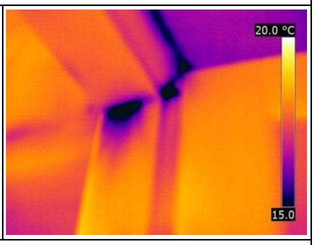
Behind the refridgerator the internal wall showed signs of cooler air being drawn into it, even though the heat dissipator from the back of the appliance would have been expected to make this area warmer.


Side Extension

Infiltration was observed around the door frame between the kitchen and side extension, possibly coming from the cavity within the wall.





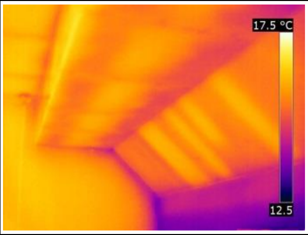
Landing

Air was observed being drawn in from the loft around the lofthatch.

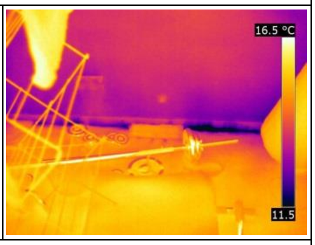

Bedroom 3 (Front/Gable Wall)

The coldest air detected entering the dwelling was from the roof void adjacent to this bedroom, particularly at the junction of the floor and the knee wall.

Usually in ceilings cooler joists indicate insulation is present between them, warmer joists imply no insulation; at the dropped soffit and sloping ceiling here, the timbers are cooler in some places and warmer in others. It is unclear whether this is due to air movement or other effects such as being only partially or inconsistently insulated.





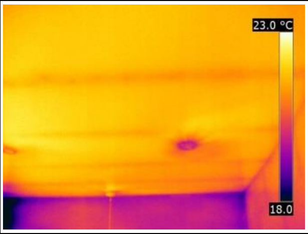
Bedroom 1 (Front/Party Wall)

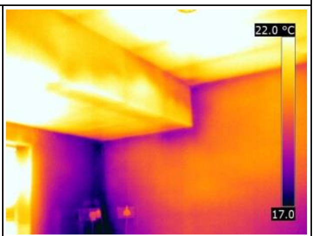
Again there are unexplained effects at the dropped soffit and sloping ceiling as observed in Bedroom 3. Also, there are very much cooler areas around the small dormer cheeks near the window head. Infiltration was detected at the unsealed chased out cables on the party wall.

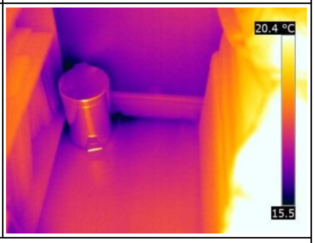
Bedroom 2 (Rear/Party Wall)

Varying amounts of infiltration was observed around the recessed lights and again there was something happening at the dropped soffit with it displaying a range of surface temperatures which cannot all be attributable to solar gain/reflection.

Significantly cooler areas were observed at the party wall junction with the external wall than were observed in the rest of the room; it is unclear whether this is just a transient effect (with solar gain heating the rest of the room first and stagnant cold air remaining here) or whether it is due to some other influence.



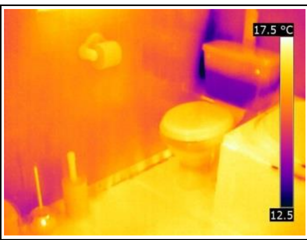


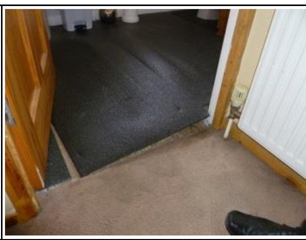


Bathroom

Air infiltration through the intermediate floor was enough to lift the floor covering, but the emerging air was not cool enough to show on a thermal image.

Direct sunlight on the SouthEast facing roof shows up in the thermal image as warmer areas of possibly un-insulated areas of sloping ceiling; here the dropped soffit displays opposing thermal gradients to those seen on the front and rear of the house which have received either no or significantly less direct solar insolance over the period prior to the pressurisation test.

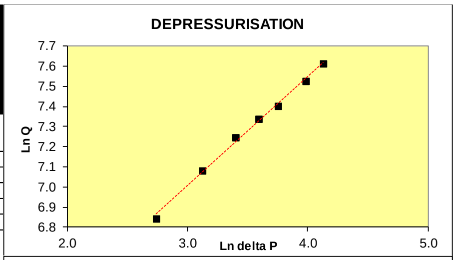


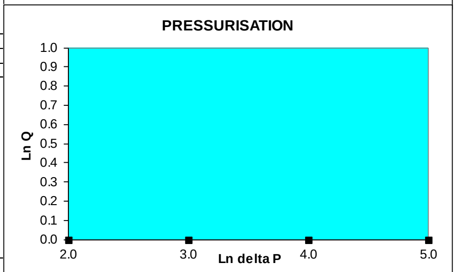


Results Spreadsheets

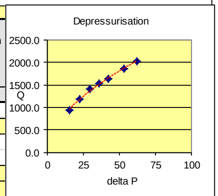
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	13/03/2014		Version 16a	19 February 2014
test house address:	8			
company:				
house type:	end terrace			
tester:	DMS, FT			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	8.6	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	12.6	°C		
outdoor humidity (%rh)	72.6	%RH		
indoor humidity (%rh)	79.5	%RH		
outdoor barometric pressure	1006.2	mbar or hPa	Calculated Outdoor Air Density	1.24 kg/m³
indoor barometric pressure	1006.3	mbar or hPa	Calculated Indoor Air Density	1.22 kg/m³
temperature corr. fact. depress.	0.986		description of main construction details:	
temperature corr. fact. press.	1.014		Post cavity wall fill	
wind speed (m/s):	1.2			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	6.355	m		
house depth:	6.844	m		
house height:	5.054	m		
floor area:	43.49362	m²		
volume:	219.81676	m³		
envelope area including floor:	220.403	m²		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =		m³/h		
Mean Air Leakage at 50Pa =		h⁻¹		
Mean Air Permeability at 50 Pa =		m/h or m³h/m²		
Equivalent Leakage Area =		m² at	10	Pa

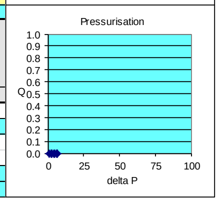




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Depressurisation Only (m³h/m²)	Air Leakage Depressurisation Only (h⁻¹)
Approx 65 Pa	a	62.3	2052	2020.8	OK	62.3	4.132	7.611	1832.80	8.32	8.34
Approx 57 Pa	a	53.6	1884	1855.4	OK	53.6	3.982	7.526	r^2	0.996	
Approx 49 Pa	a	42.6	1664	1638.7	OK	42.6	3.752	7.402	C_{env}	218.261	m³/h.Pa*n*
Approx 41 Pa	b	36.2	1562	1538.3	OK	36.2	3.589	7.338	n	0.540	
Approx 33 Pa	b	29.9	1422	1400.4	OK	29.9	3.398	7.245			
Approx 25 Pa	b	22.7	1207	1188.7	OK	22.7	3.122	7.081	C_L (corrected)	221.603	m³/h.Pa*n*
Approx 20 Pa	b	15.5	954	939.5	OK	15.5	2.741	6.845			

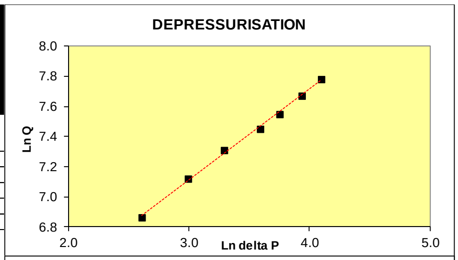


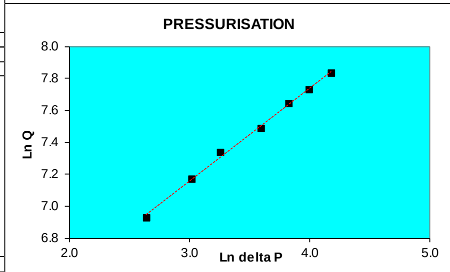
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m³/h)	Permeability Pressurisation Only (m³h/m²)	Air Leakage Pressurisation Only (h⁻¹)
Approx 65 Pa											
Approx 57 Pa									r^2		
Approx 49 Pa									C_{env}		m³/h.Pa*n*
Approx 41 Pa									n		
Approx 33 Pa											
Approx 25 Pa									C_L (corrected)		m³/h.Pa*n*
Approx 20 Pa											



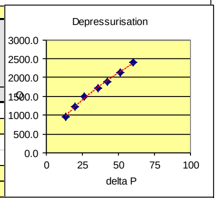
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	13/03/2014		Version 16a	19 February 2014
test house address:				
company:				
house type:				
tester:	DMS, FT			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	13.6	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	17.6	°C		
outdoor humidity (%rh)	63	%RH		
indoor humidity (%rh)	50.1	%RH		
outdoor barometric pressure	1012	mbar or hPa	Calculated Outdoor Air Density	1.22 kg/m^3
indoor barometric pressure	1011.9	mbar or hPa	Calculated Indoor Air Density	1.21 kg/m^3
temperature corr. fact. depress.	0.986		description of main construction details:	
temperature corr. fact. press.	1.014		Pre cavity fill	
wind speed (m/s):	0.4			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	6006	m		
house depth:	7050	m		
house height:	5164	m		
floor area:	93	m^2		
volume:	239	m^3		
envelope area including floor:	205	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	2160.48	m^3/h		
Mean Air Leakage at 50Pa =	9.04	h^{-1}		
Mean Air Permeability at 50 Pa =	10.54	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.094	m^2 at	10	Pa

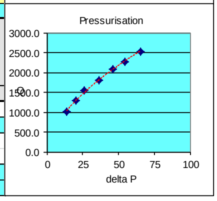




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^{3}h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	60.3	2434	2400.0	OK	60.3	4.099	7.783	2136.27	10.42	8.94
Approx 57 Pa	a	51.3	2172	2141.7	OK	51.3	3.938	7.669	r^2	0.997	
Approx 49 Pa	a	42.8	1928	1901.1	OK	42.8	3.757	7.550	C_{env}	201.490	m^3/h.Pan
Approx 41 Pa	a	36.3	1744	1719.7	OK	36.3	3.592	7.450	n	0.601	
Approx 33 Pa	b	26.9	1516	1494.8	OK	26.9	3.292	7.310			
Approx 25 Pa	b	19.9	1251	1233.5	OK	19.9	2.991	7.118	C_L (corrected)	203.149	m^3/h.Pan
Approx 20 Pa	b	13.6	969	955.5	OK	13.6	2.610	6.862			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^{3}h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	65.3	2489	2524.2	OK	65.3	4.179	7.834	2184.70	10.66	9.14
Approx 57 Pa	a	54.5	2243	2274.7	OK	54.5	3.998	7.730	r^2	0.997	
Approx 49 Pa	a	46	2061	2090.2	OK	46	3.829	7.645	C_{env}	225.762	m^3/h.Pan
Approx 41 Pa	a	36.4	1769	1794.0	OK	36.4	3.595	7.492	n	0.579	
Approx 33 Pa	b	25.9	1517	1538.5	OK	25.9	3.254	7.339			
Approx 25 Pa	b	20.4	1285	1303.2	OK	20.4	3.016	7.173	C_L (corrected)	226.382	m^3/h.Pan
Approx 20 Pa	b	14	1006	1020.2	OK	14	2.639	6.928			



Dwelling I-13, after retrofit

Date of Test 09th March 2015

Test Conducted by Dominic Miles-Shenton

Melanie Smith

Felix Thomas

Results Spreadsheet

MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	09/03/2015	Version 16c	04 November 2014
test house address:			
company:	LATCH		
house type:	b2b mid-terrace		
tester:	DMS, FT, MS		
test reference number:		Blower Door & Gauge Used	Model 3 with DG700

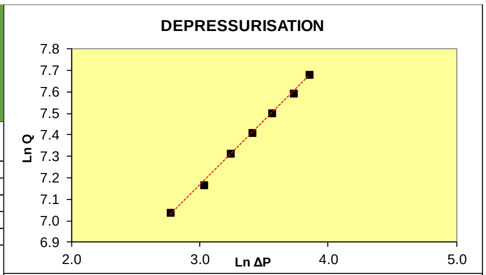
outdoor temp (°C)	8.4	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN m3/h - When using the DG700 gauge run baseline pressure adjustment for minimum 30s with fan switched on but not rotating
indoor temp (°C)	18.6	°C	
outdoor humidity (%rh)	67.8	%RH	
indoor humidity (%rh)	75.6	%RH	
outdoor barometric pressure	1011.5	mbar or hPa	Calculated Outdoor Air Density 1.25 kg/m^3
indoor barometric pressure	1011.6	mbar or hPa	Calculated Indoor Air Density 1.20 kg/m^3
temperature corr. fact. depress.	0.965	WARNING!!	description of main construction details:
temperature corr. fact. press.	1.036	Extreme Test	
wind speed (m/s):	2.1	Conditions	
baseline pressure diff (Pa) (+/-)		Pa	
house width:	5.36	m	
house depth:	5.02	m	
house height:	8.4	m	
floor area:	76	m^2	
volume:	208.6	m^3	
envelope area including floor:	223.4	m^2	
Pressure Difference for ELA	10	Pa	

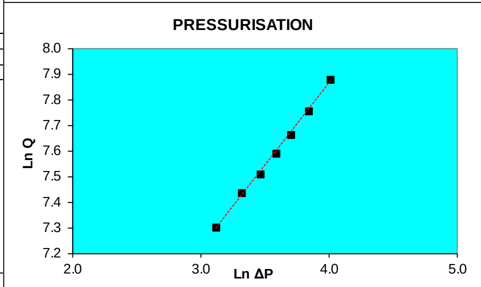
RESULTS:

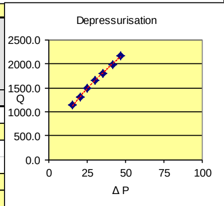
Q50 Mean Flow at 50Pa =	2356.12	m^3/h
Mean Air Leakage at 50Pa =	11.29	h^{-1}
Mean Air Permeability at 50 Pa =	10.55	m/h or m^3h/m^2
Equivalent Leakage Area =	0.098	m^2 at 10 Pa

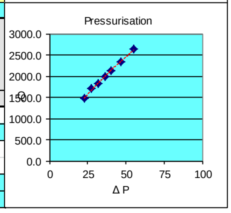
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only ($m^3/(h.m^2)$)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	0	47.3	2250	2164.4	OK	47.3	3.857	7.680	2260.33	10.12	10.84
Approx 57 Pa	0	41.7	2067	1988.4	OK	41.7	3.731	7.595	r^2	0.999	
Approx 49 Pa	0	35.3	1880	1808.5	OK	35.3	3.564	7.500	C_{env}	218.438	$m^3/h.Pa^n$
Approx 41 Pa	0	30.3	1720	1654.6	OK	30.3	3.411	7.411	n	0.593	
Approx 33 Pa	0	25.6	1560	1500.7	OK	25.6	3.243	7.314			
Approx 25 Pa	0	20.7	1351	1299.6	OK	20.7	3.030	7.170	C_L (corrected)	221.954	$m^3/h.Pa^n$
Approx 20 Pa	0	16	1187	1141.9	OK	16	2.773	7.040			

PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only ($m^3/(h.m^2)$)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	0	55.4	2543	2643.5	OK	55.4	4.015	7.880	2451.91	10.98	11.75
Approx 57 Pa	0	46.5	2246	2334.8	OK	46.5	3.839	7.756	r^2	0.998	
Approx 49 Pa	0	40.5	2050	2131.0	OK	40.5	3.701	7.664	C_{env}	200.391	$m^3/h.Pa^n$
Approx 41 Pa	0	36.3	1906	1981.3	OK	36.3	3.592	7.592	n	0.640	
Approx 33 Pa	0	31.9	1755	1824.4	OK	31.9	3.463	7.509			
Approx 25 Pa	0	27.7	1635	1699.6	OK	27.7	3.321	7.438	C_L (corrected)	200.427	$m^3/h.Pa^n$
Approx 20 Pa	0	22.7	1425	1481.3	OK	22.7	3.122	7.301			





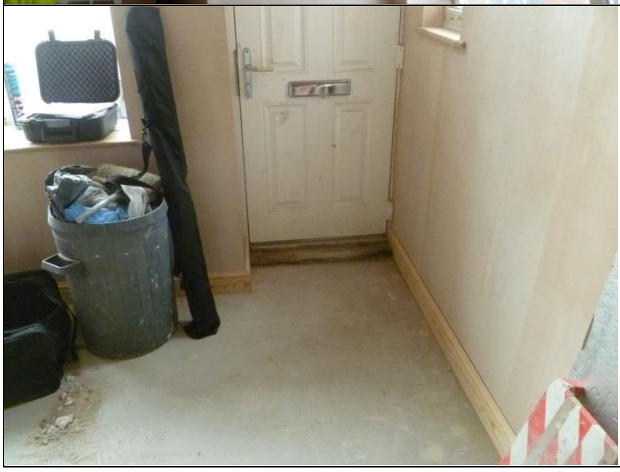
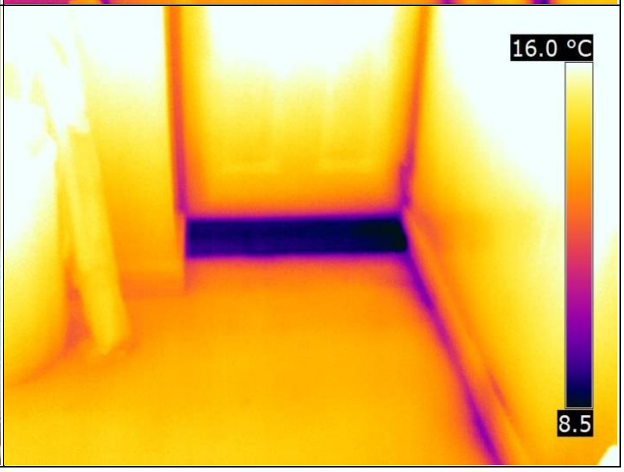


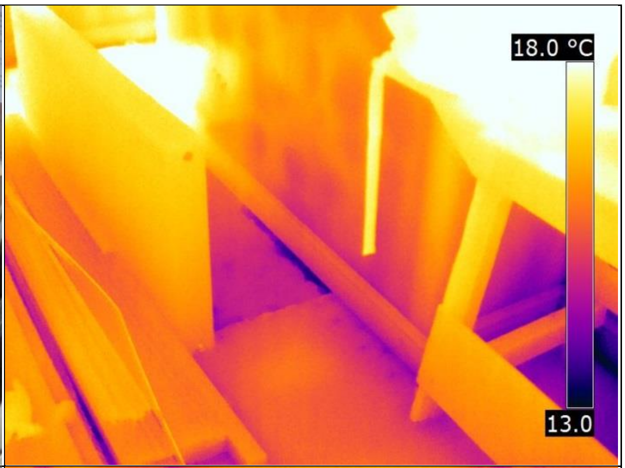


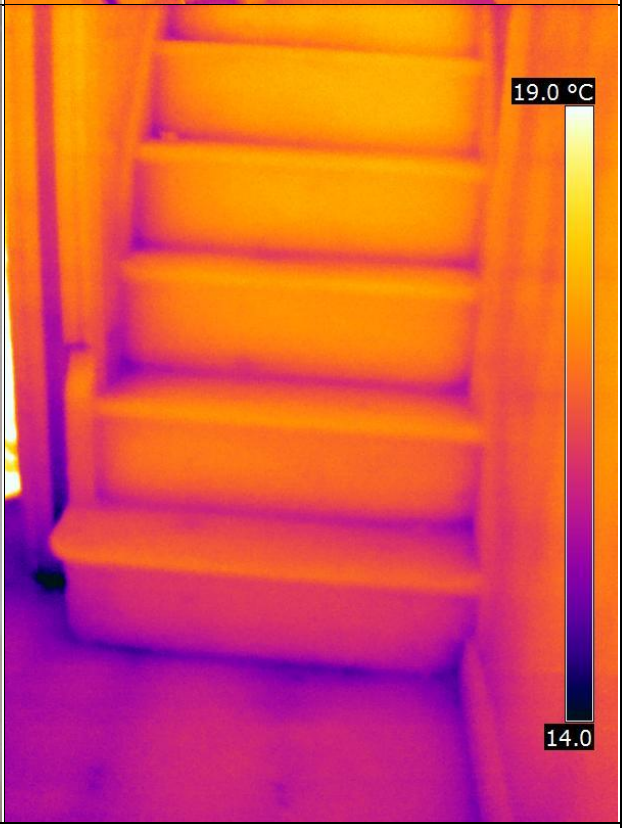
Thermal Imaging

(prior to pressurisation test)

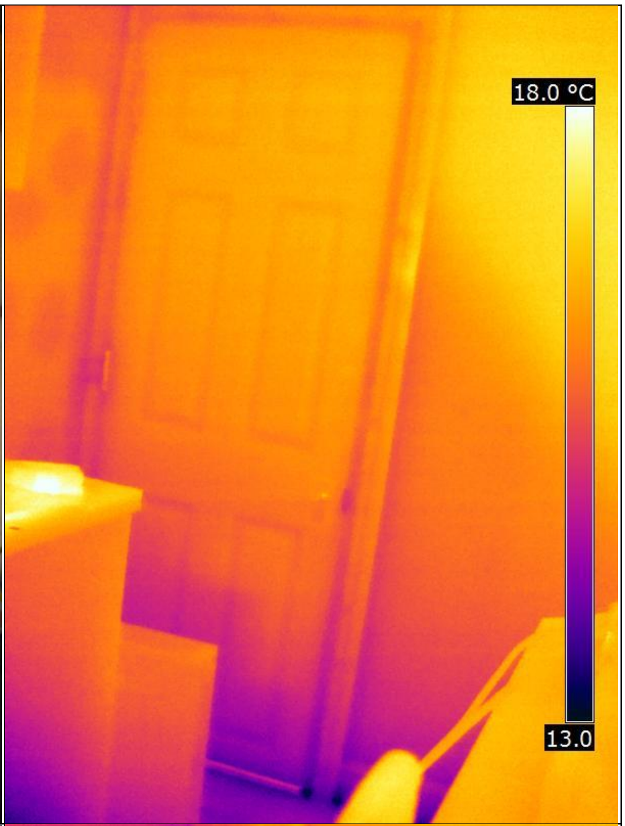

Living Room:

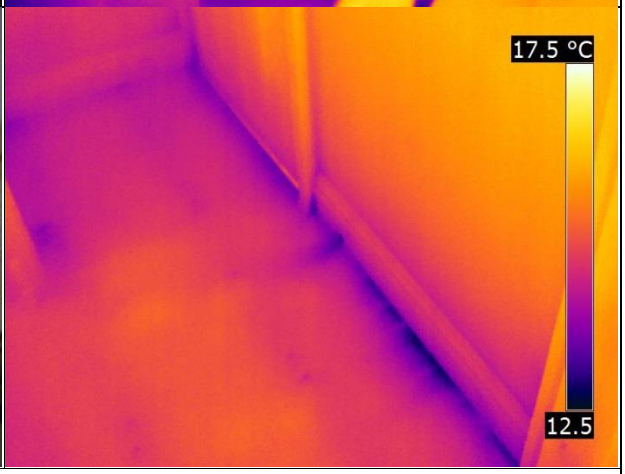






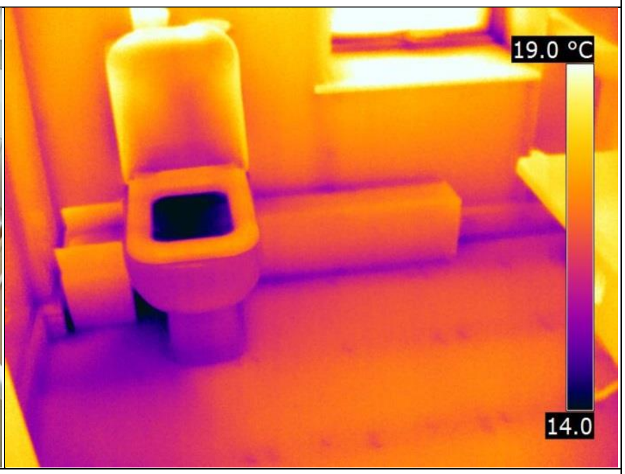


Kitchen:





Bathroom:

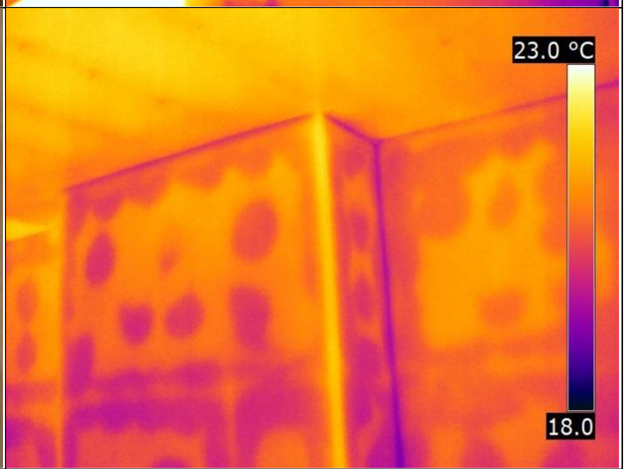


1st Floor Bedroom:

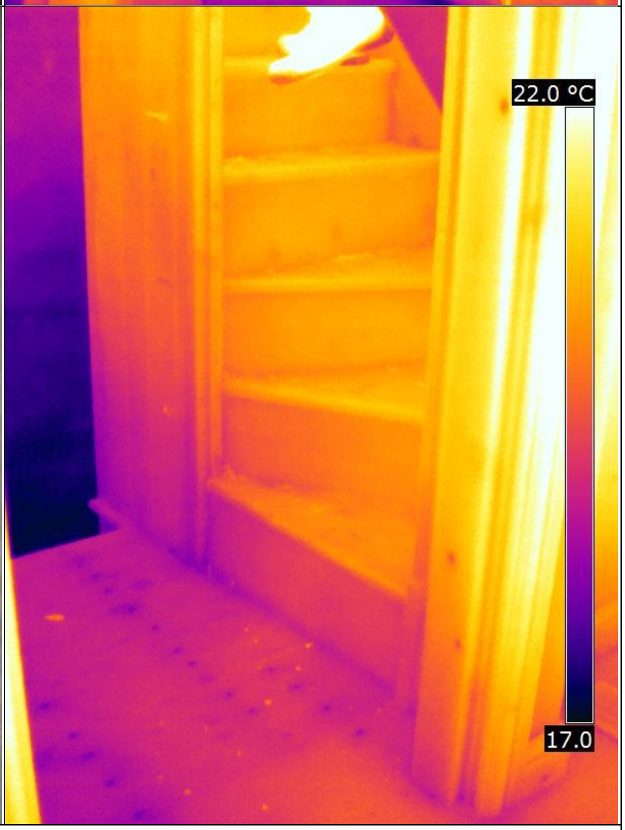


24.0 °C
19.0

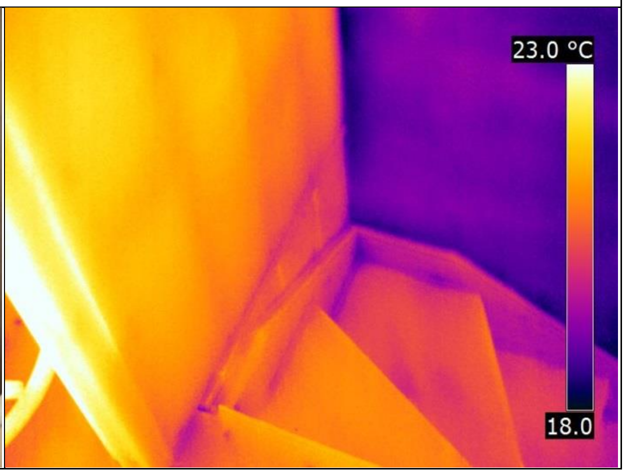

22.0 °C
17.0


23.0 °C
18.0


23.0 °C
18.0



2nd Floor Bedroom:





27.4 °C
20.0

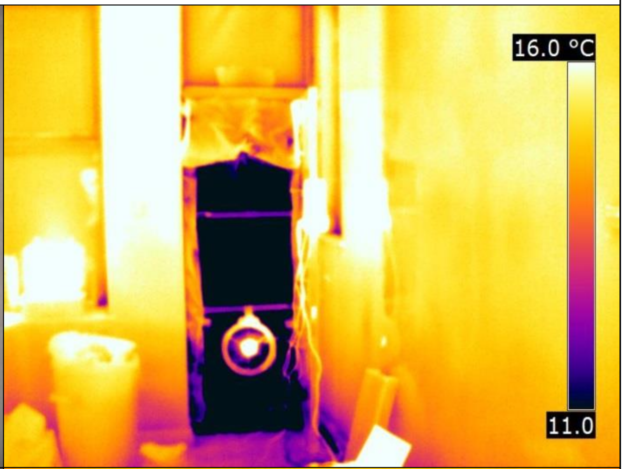

26.5 °C
19.0

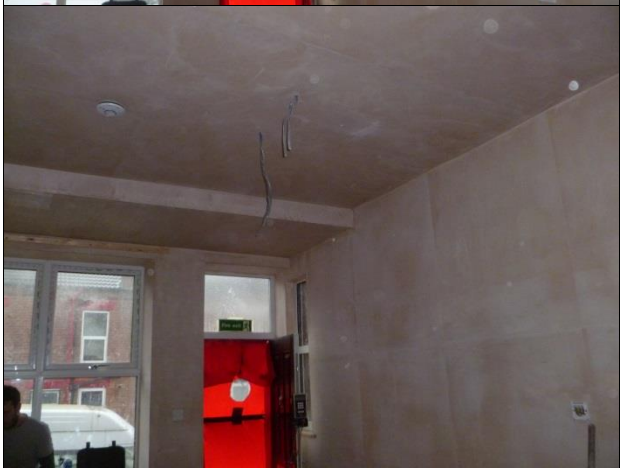

25.5 °C
20.5

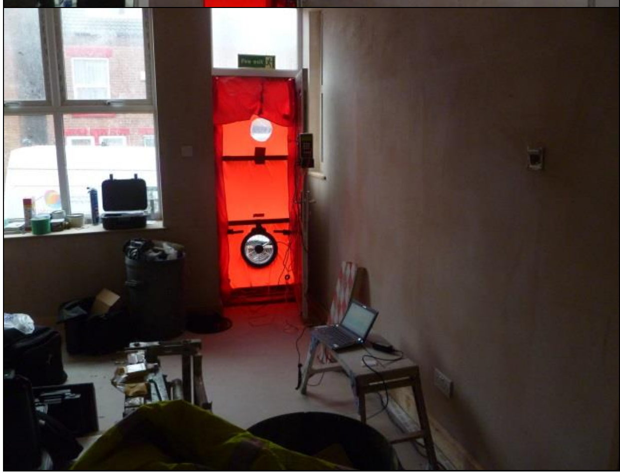
Thermal Imaging Leakage Detection

(under dwelling depressurisation)

Living Room:

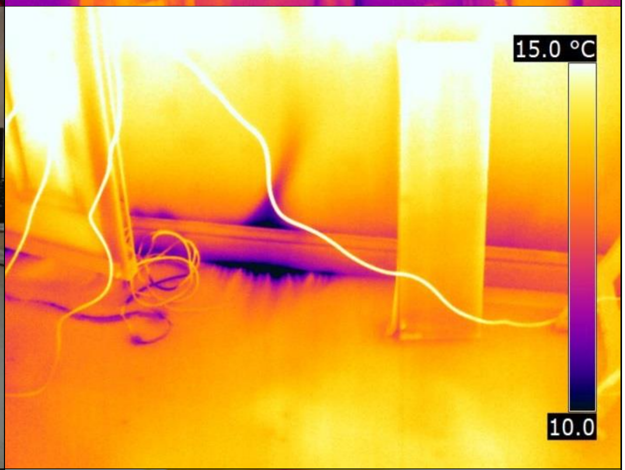








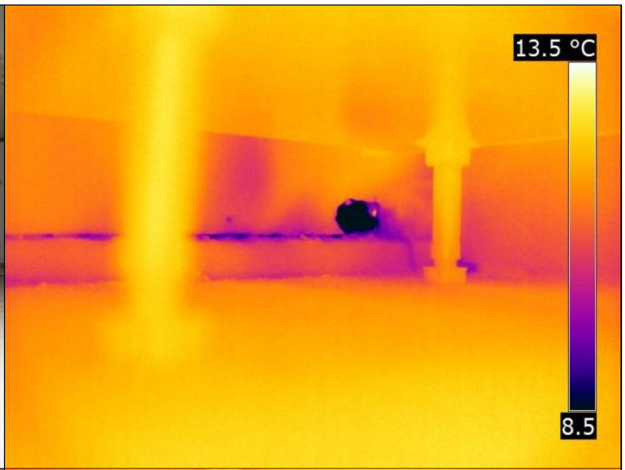
18.4 °C
13.5


15.0 °C
10.0

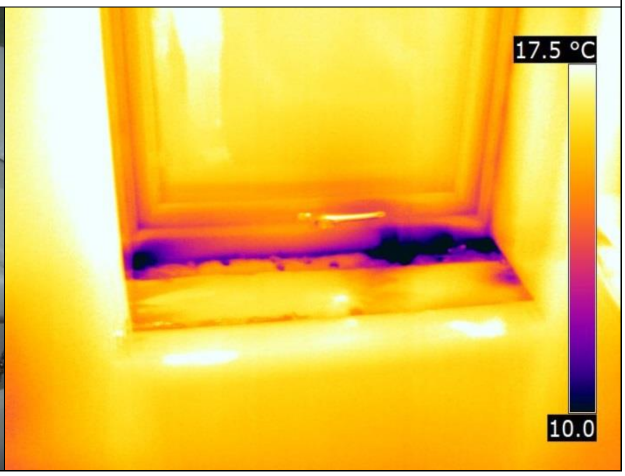

16.5 °C
11.5

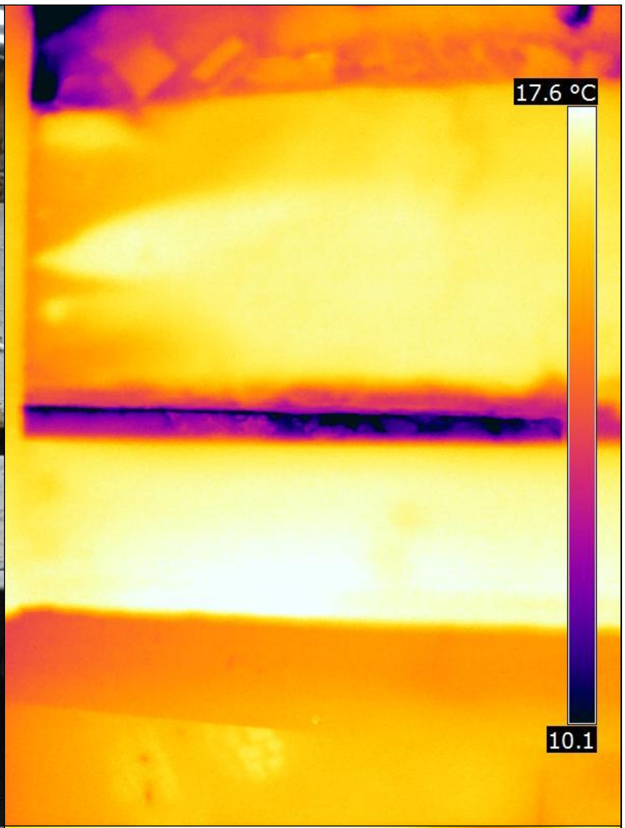

16.5 °C
11.5

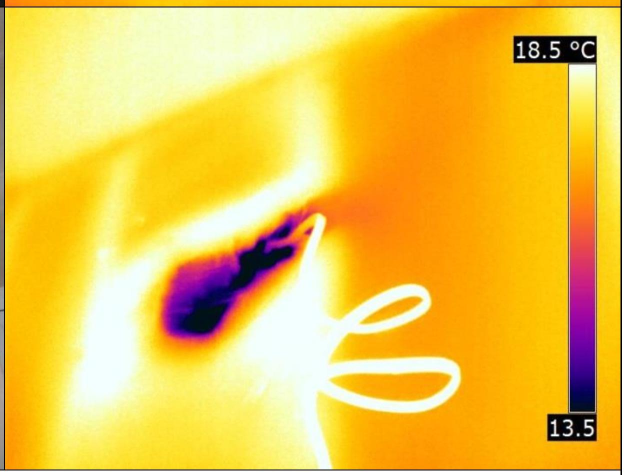
Kitchen:



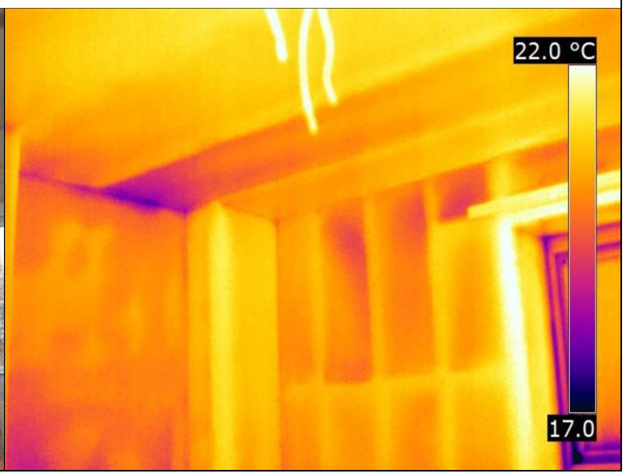
Bathroom:

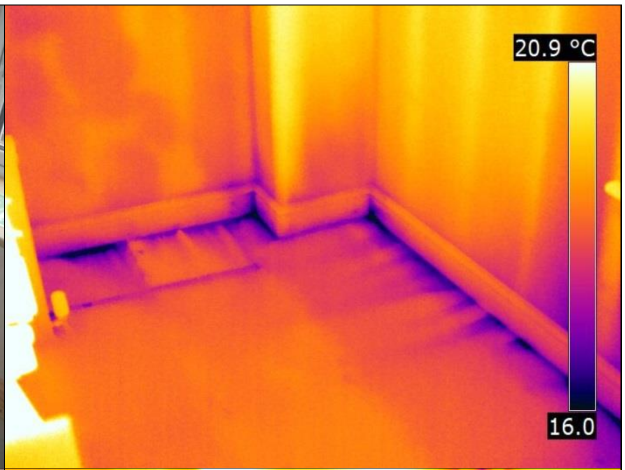






1st Floor Bedroom:

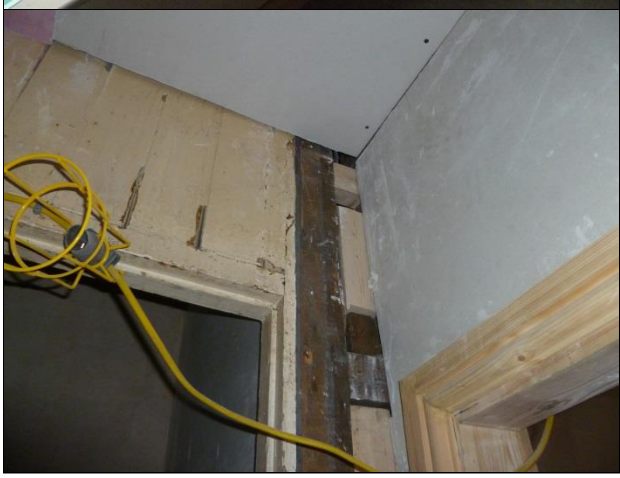




20.9 °C
16.0

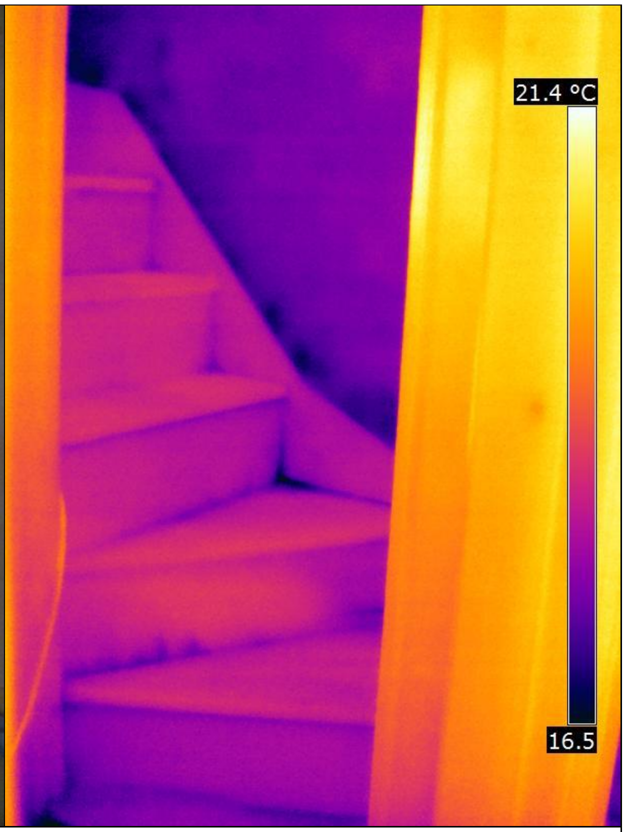
Fire
exit

20.5 °C
15.5

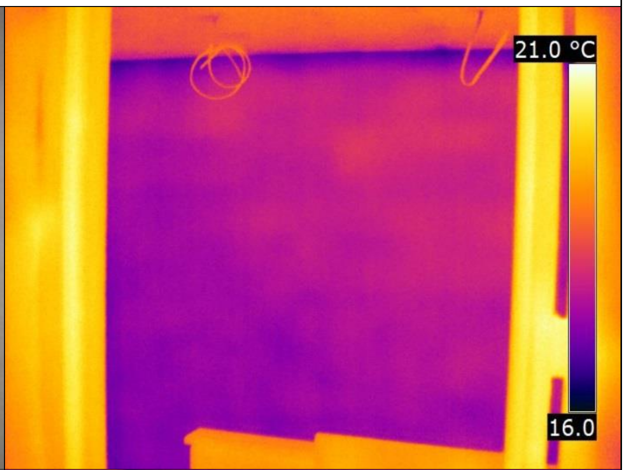
Fire
exit

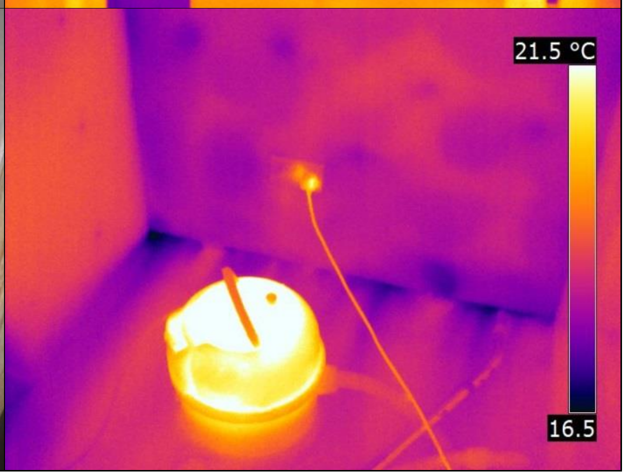
19.0 °C
14.0


21.0 °C
16.0



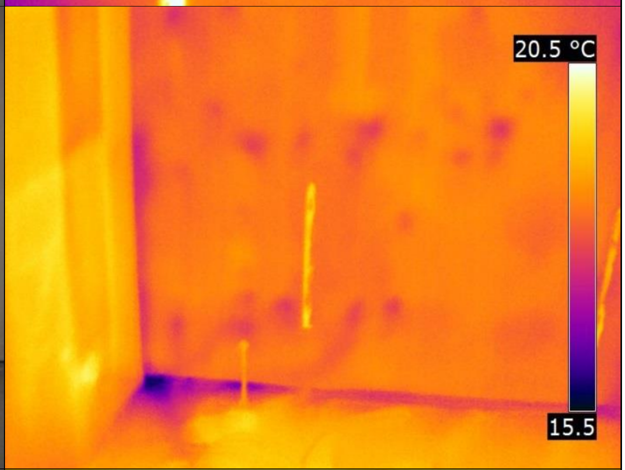
2nd Floor Bedroom






20.0 °C
14.8
19.5 °C
14.5
20.4 °C
15.3
20.0 °C
15.0


21.0 °C
16.0


20.5 °C
15.5


21.0 °C
15.9

Dwelling I-14, near air barrier completion

18th February 2013

Dr Anne Stafford, Dominic Miles-Shenton, David Farmer, Matthew Peat

Result:

Depressurisation Only		Pressurisation Only		**Mean**	
Air Permeability	Air Leakage Rate	Air Permeability	Air Leakage Rate	**Air Permeability**	**Air Leakage Rate**
$m^3/(h.m^2)$ @ 50Pa	h^{-1} @ 50Pa	$m^3/(h.m^2)$ @ 50Pa	h^{-1} @ 50Pa	**$m^3/(h.m^2)$ @ 50Pa**	**h^{-1} @ 50Pa**
6.79	8.70	6.91	8.86	**6.85**	**8.78**

* Figures are based on roughly calculated envelope area and internal volumes, as accurate surveyed measurements were not available at the time.

Main Leakage Paths:

Leakage detection was performed under both pressurisation (using a smoke puffer) and depressurisation (using infra-red thermal imaging). In general the property performed well, far in advance of current Building Regulations requirements for new-build properties. The newly installed internal insulation appeared to be sealed well, with only a few issues highlighted. The most serious air leakage observed appeared to be through party elements and into the cellar rather than through the refurbished external wall.

Leakage Detection with Smoke Puffer, main leakage points:

Into separating walls via unfilled perpends and where woodwork had been removed from walls and not yet repaired.

Leakage around the door to the cellar.

Leakage around the front door and threshold.

Leakage through gaps between ground floor boards, and a penetration into the ground floor in the kitchen.

Air movement into gaps around the chimney breast.

Leakage around floor perimeters, under the insulation at numerous points around the property.

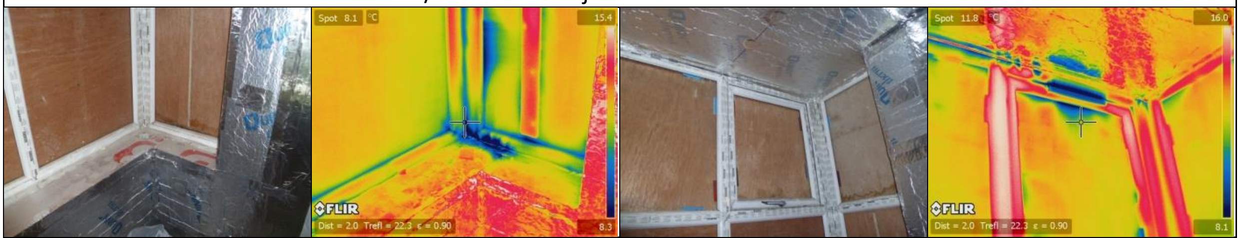
Air movement at trickle ventilators, between the vents and the frames in many cases and through some vents which did not fully close.

Air leakage at the openings on the ground floor, around the temporary plywood glazing panels.

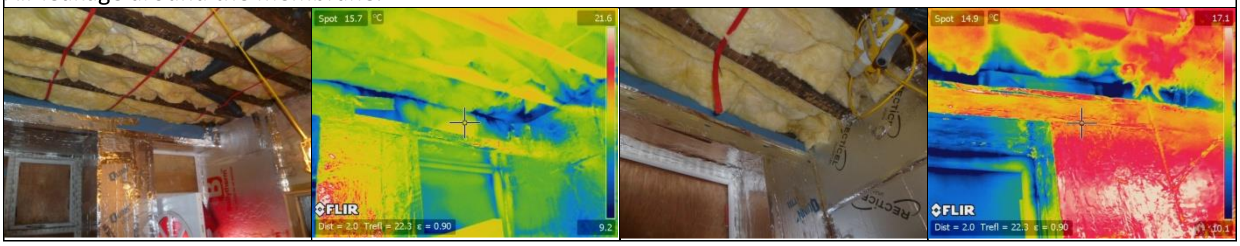
The top 2 items listed above appeared to be the worst performing details.

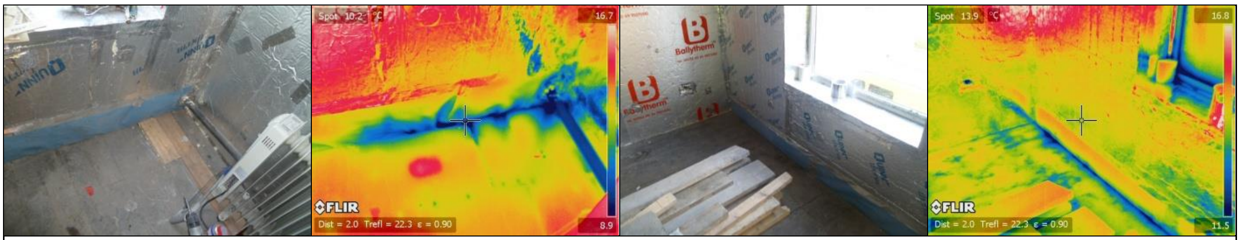
Leakage Detection with Thermal Imaging, main leakage paths:

Downstairs Windows:
Significant air leakage was detected both around the temporary glazing panels and the trickle ventilators, there was also infiltration detected at the sill/frame corner junction.

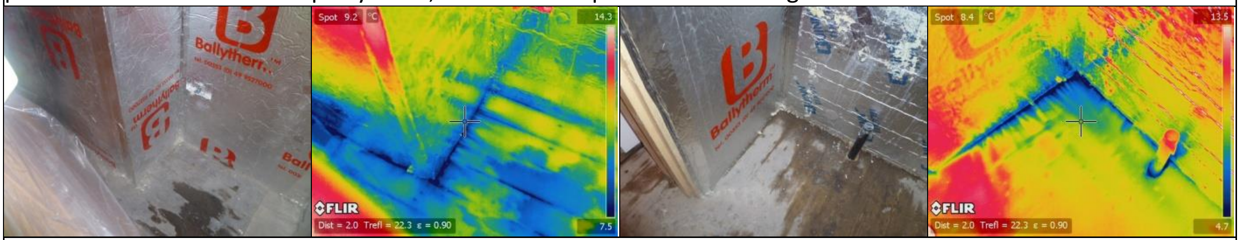


Bay Roof/Intermediate Floor Perimeter:
Air leakage around the membrane.





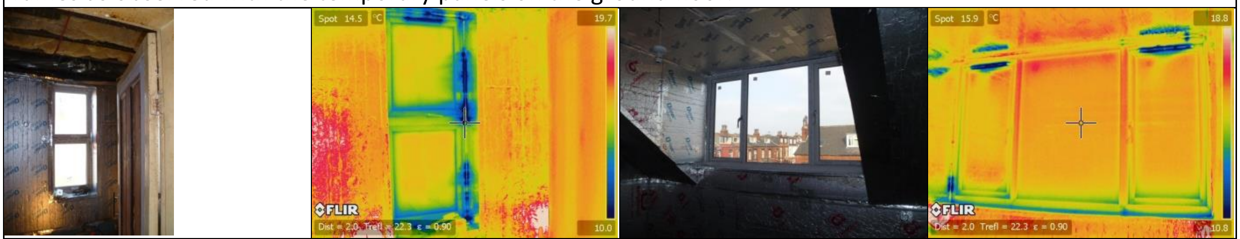
Timber Ground Floor:
Air leakage was detected both through gaps between the floor boards and at the floor perimeter in a number of places on both external and party walls, and around a penetration through the floor.



Cellar :
Leakage around the cellar door, which was temporarily sealed (albeit fairly ineffectually), and around the kitchen floor.

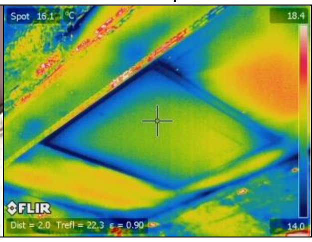
Stairs:
Infiltration observed at a number of points on the stairs, this was most obvious on the ground floor stairs where the infiltrating air was coolest.

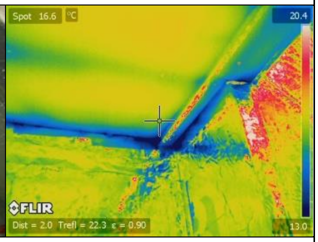
Upper Floors Windows:
Trickle vents again and some areas of leakage around the frames, no leakage between the glazing panels and frames as observed with the temporary panels on the ground floor.



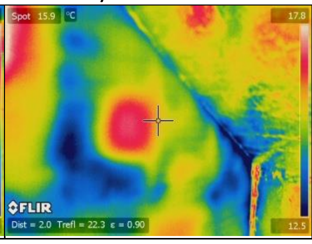
Party Elements:
Some leakage from through party walls was visible using thermography, but in most instances the temperature of the incoming air was not significantly cooler enough for leakage detection through thermography even though there was substantial infiltration.

Top Floor Ceiling:
Through proprietary loft hatch and at some patches at ceiling/wall junctions.





Top Floor Partition Wall:
Cooler air observed being drawn down into the internal wall cavity



Pressurisation Test Spreadsheet:

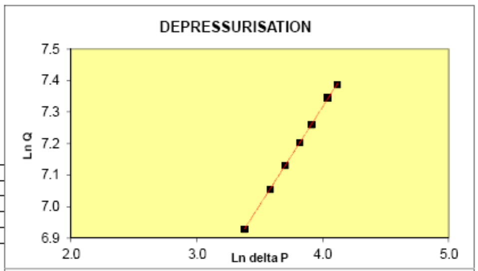
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

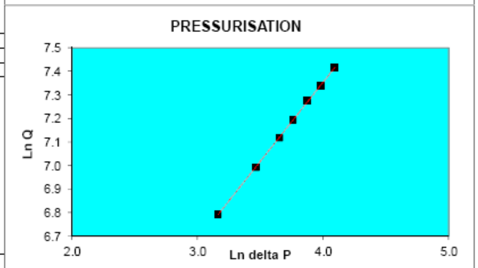
Centre for the Built Environment

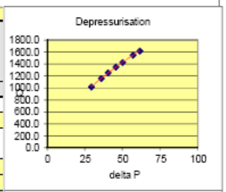
date:	18/02/2013		Version 15f	02 July 2010	
test house address:					
company:	Canopy Housing				
house type:					
tester:	AS, DF, MP, DMS				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	6.1	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	15.7	°C			
outdoor humidity (%rh)	64.5	%RH			
indoor humidity (%rh)	82.5	%RH			
outdoor barometric pressure	1028.5	mbar or hPa	Calculated Outdoor Air Density	1.28	kg/m^3
indoor barometric pressure	1028.4	mbar or hPa	Calculated Indoor Air Density	1.23	kg/m^3
temperature corr. fact. depress.	0.967		description of main construction details:		
temperature corr. fact. press.	1.034				
wind speed (m/s):	2				
baseline pressure diff (Pa) (+/-)		Pa			
house width:	5.8	m			
house depth:	3.98	m			
house height:	7.64	m			
floor area:	23.06	m^2			
volume:	167.57	m^3			
envelope area including floor:	214.68	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	1471.01	m^3/h			
Mean Air Leakage at 50Pa =	8.78	h^{-1}			
Mean Air Permeability at 50 Pa =	6.85	m/h or m^3h/m^2			
Equivalent Leakage Area =	0.059	m^2 at	10	Pa	

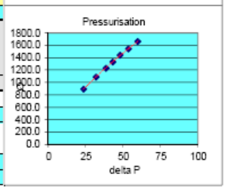
DEPRESSURISATION	RING (O=open or A,B,C,D,E)	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	B	61.5	1676	1615.0	OK	61.5	4.119	7.387	1458.00	6.79	8.70
Approx 57 Pa	B	56.9	1607	1548.5	OK	56.9	4.041	7.345	r^2	1.000	
Approx 49 Pa	B	50.1	1475	1421.3	OK	50.1	3.914	7.259	C_{env}	123.959	$m^3/h.Pa^n$
Approx 41 Pa	B	45.6	1395	1344.2	OK	45.6	3.820	7.204	n	0.624	
Approx 33 Pa	B	40.5	1297	1249.8	OK	40.5	3.701	7.131			
Approx 25 Pa	B	36	1202	1158.2	OK	36	3.584	7.055	C_L (corrected)	127.012	$m^3/h.Pa^n$
Approx 20 Pa	B	29.4	1060	1021.4	OK	29.4	3.381	6.929			

PRESSURISATION	RING (O=open or A,B,C,D,E)	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	B	60	1598	1658.4	OK	60	4.094	7.414	1484.03	6.91	8.86
Approx 57 Pa	B	53.6	1484	1540.1	OK	53.6	3.982	7.340	r^2	1.000	
Approx 49 Pa	B	48.1	1390	1442.5	OK	48.1	3.873	7.274	C_{env}	106.184	$m^3/h.Pa^n$
Approx 41 Pa	B	43.1	1281	1329.4	OK	43.1	3.764	7.192	n	0.672	
Approx 33 Pa	B	38.6	1189	1233.9	OK	38.6	3.653	7.118			
Approx 25 Pa	B	32	1048	1087.6	OK	32	3.466	6.992	C_L (corrected)	107.151	$m^3/h.Pa^n$
Approx 20 Pa	B	23.7	859	891.5	OK	23.7	3.165	6.793			









Dwelling E-42, before and after DIY sealing

Address:

Test Conducted on: 14th May 2015

Test Conducted by: D Glew, D Miles-Shenton; Centre for the Built Environment, Leeds Sustainability Institute, Leeds Beckett University.

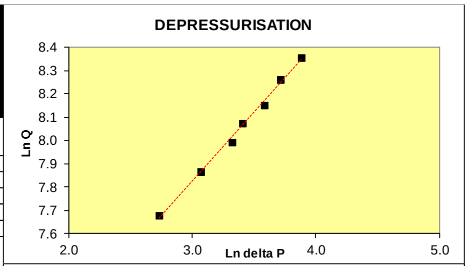
Results:

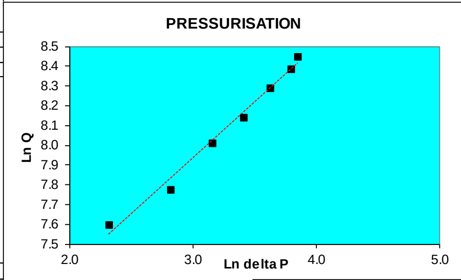
Date	Depressurisation Only			Pressurisation Only			Mean	
	Air Permeability	Air Leakage Rate	Correlation Coefficient	Air Permeability	Air Leakage Rate	Correlation Coefficient	Air Permeability	Air Leakage Rate
	$m^3/(h.m^2)$@50Pa	ach^{-1}@50Pa	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}@50Pa	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}@50Pa
19-Feb-2015	15.58	16.44	0.990	17.66	19.63	0.997	16.62	17.53
14-May-2015	12.46	13.15	0.996	13.43	14.17	0.988	12.95	13.66

Results Spreadsheet:

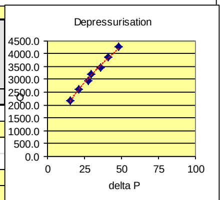
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	19/02/2015		Version 16a	19 February 2014
test house address:				
company:	DECC			
house type:	Semi 1930s			
tester:	DG			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	13	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically	
indoor temp (°C)	19.1	°C		
outdoor humidity (%rh)	57.6	%RH		
indoor humidity (%rh)	46.5	%RH		
outdoor barometric pressure	1000.7	mbar or hPa	Calculated Outdoor Air Density	1.21 kg/m^3
indoor barometric pressure	1000.7	mbar or hPa	Calculated Indoor Air Density	1.19 kg/m^3
temperature corr. fact. depress.	1.032		description of main construction details:	
temperature corr. fact. press.	1.021			
wind speed (m/s):	0.1			
baseline pressure diff (Pa) (+/-)		Pa		
house width:	9.256	m		
house depth:	10.342	m		
house height:	7.267	m		
floor area:	64.248	m^2		
volume:	328	m^3		
envelope area including floor:	346	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	4479.96	m^3/h		
Mean Air Leakage at 50Pa =	13.66	h^{-1}		
Mean Air Permeability at 50 Pa =	12.95	m/h or m^3h/m^2		
Equivalent Leakage Area =	0.198	m^2 at	10	Pa

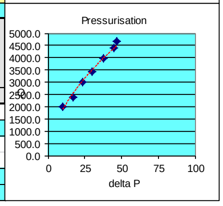




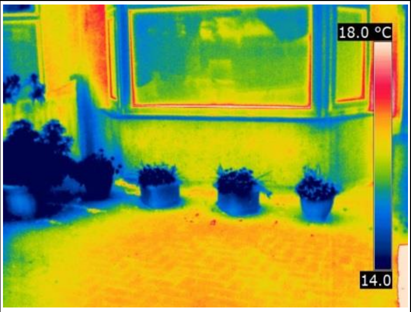
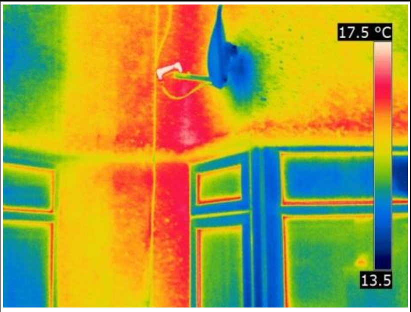
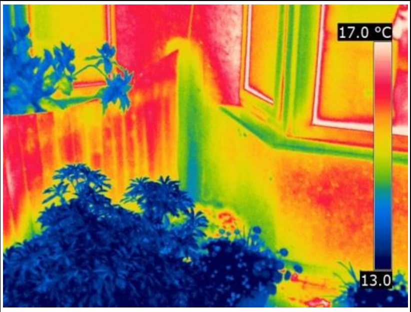
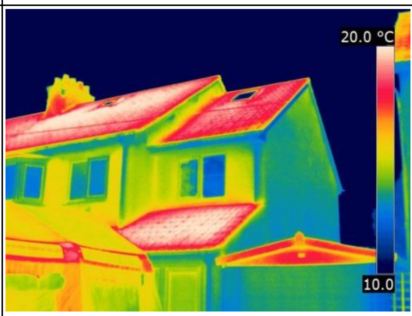
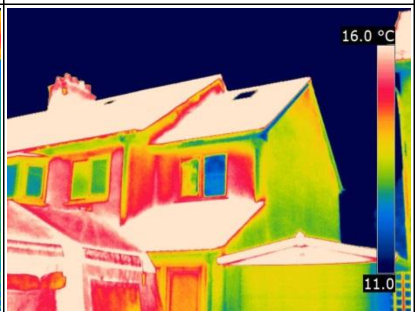
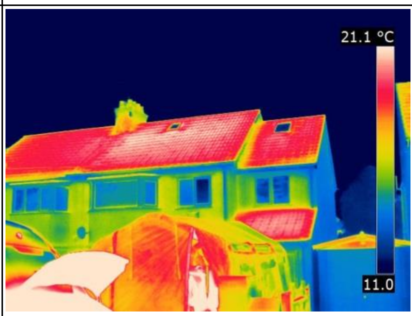
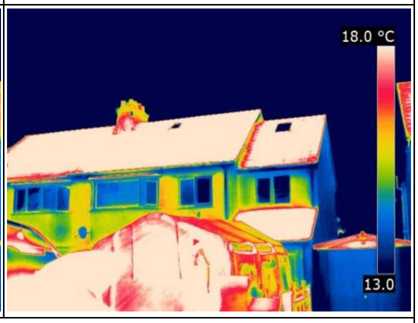
DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	48.5	4347	4253.6	OK	48.5	3.882	8.356	4312.13	12.46	13.15
Approx 57 Pa	a	41.1	3954	3869.0	OK	41.1	3.716	8.261	r^2	0.996	
Approx 49 Pa	a	36	3544	3467.9	OK	36	3.584	8.151	C_{env}	425.158	$m^3/h.Pa^n$
Approx 41 Pa	a	30.1	3277	3206.6	OK	30.1	3.405	8.073	n	0.591	
Approx 33 Pa	a	27.7	3026	2961.0	OK	27.7	3.321	7.993			
Approx 25 Pa	a	21.5	2669	2611.7	OK	21.5	3.068	7.868	C_L (corrected)	427.224	$m^3/h.Pa^n$
Approx 20 Pa	a	15.4	2206	2158.6	OK	15.4	2.734	7.677			



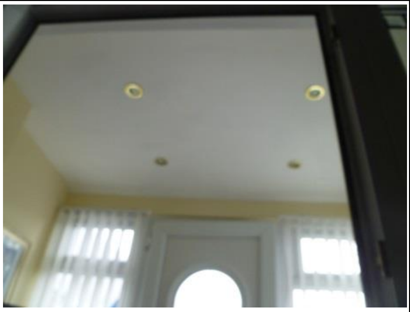
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	47	4567	4667.3	OK	47	3.850	8.448	4647.79	13.43	14.17
Approx 57 Pa	a	44.7	4301	4395.4	OK	44.7	3.800	8.388	r^2	0.988	
Approx 49 Pa	a	37.7	3902	3987.7	OK	37.7	3.630	8.291	C_{env}	513.545	$m^3/h.Pa^n$
Approx 41 Pa	a	30.2	3368	3442.0	OK	30.2	3.408	8.144	n	0.564	
Approx 33 Pa	a	23.5	2947	3011.7	OK	23.5	3.157	8.010			
Approx 25 Pa	a	16.8	2334	2385.2	OK	16.8	2.821	7.777	C_L (corrected)	511.340	$m^3/h.Pa^n$
Approx 20 Pa	a	10.2	1956	1998.9	OK	10.2	2.322	7.600			

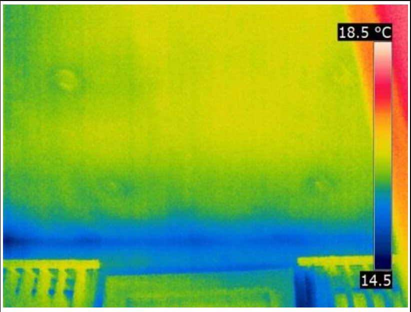


Images:

External		
Prior to test		
		
		
		
		
		
Hall		

Prior to test





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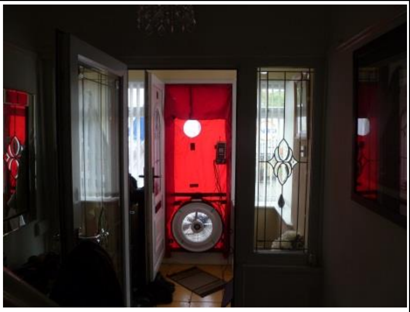
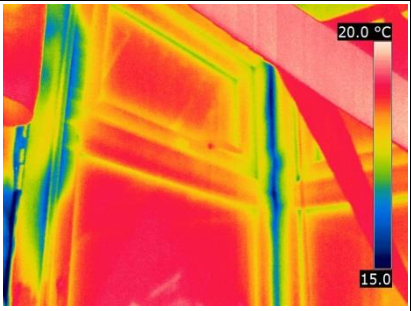
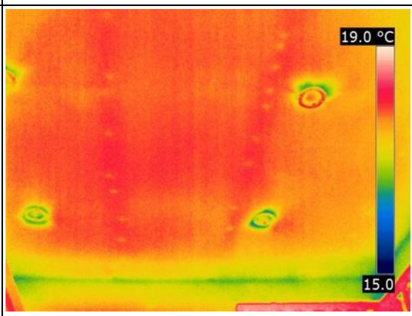
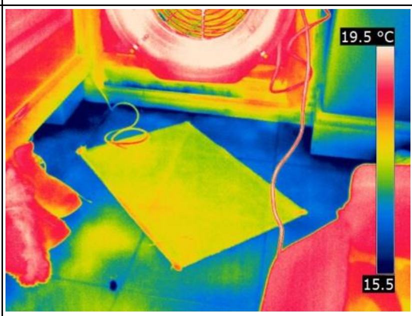


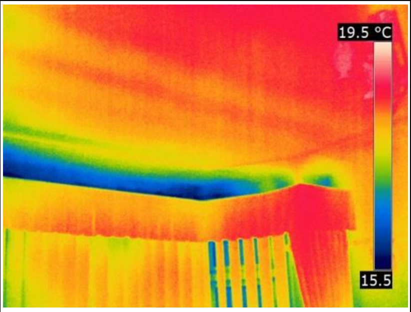


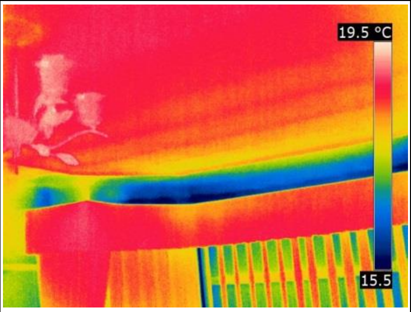




Front Living Room

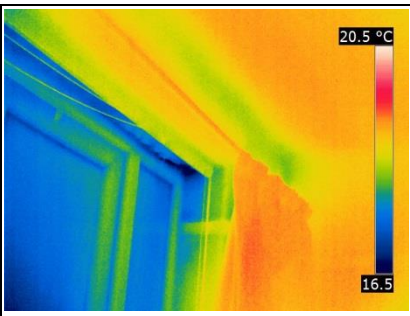
Under depressurisation

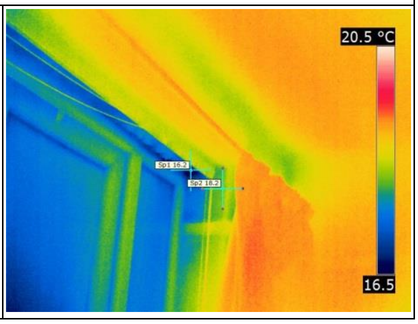


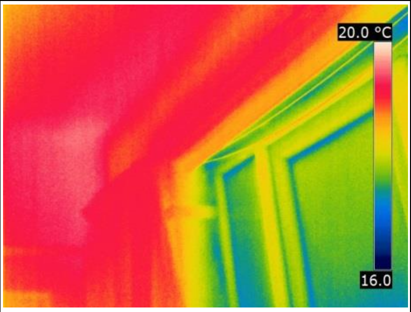


Rear Living Room

Prior to test







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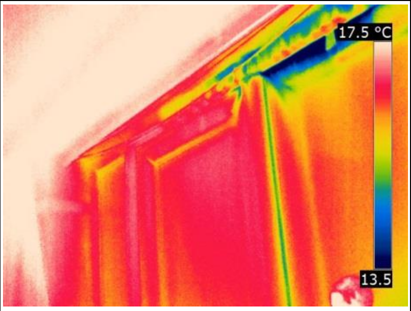
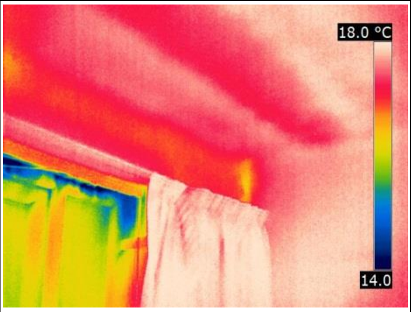
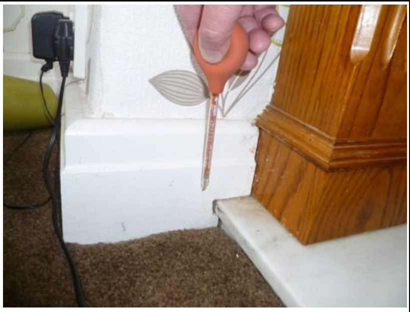


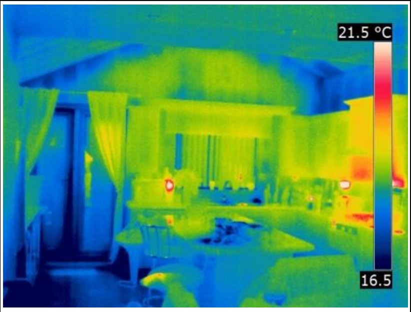


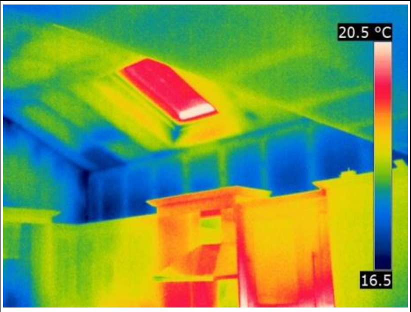
Under pressurisation

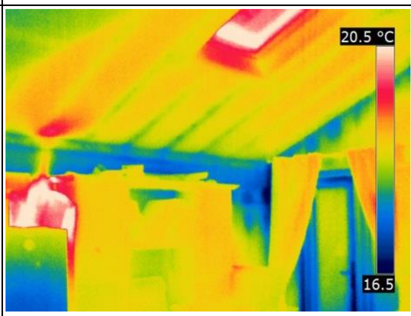


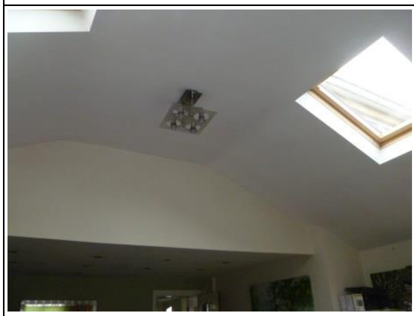
Kitchen

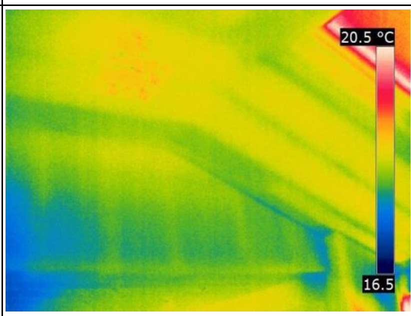
Prior to test

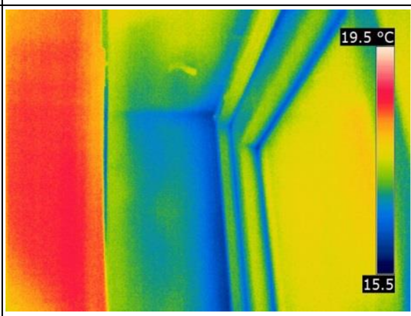


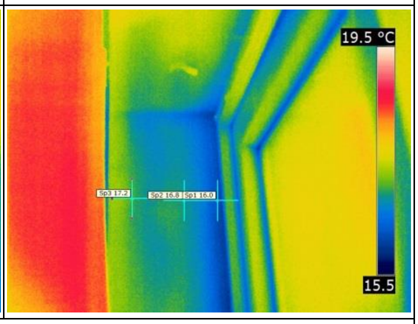












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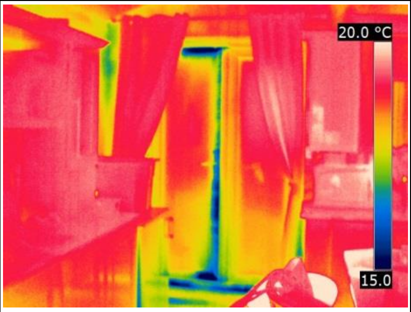
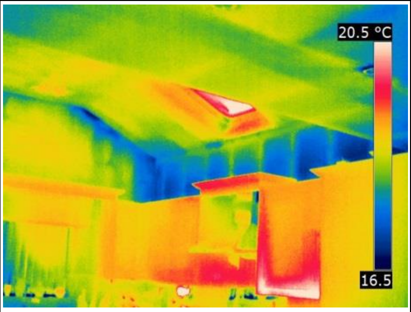
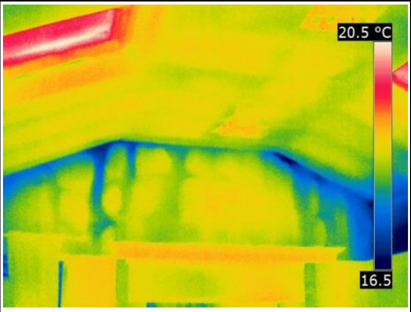
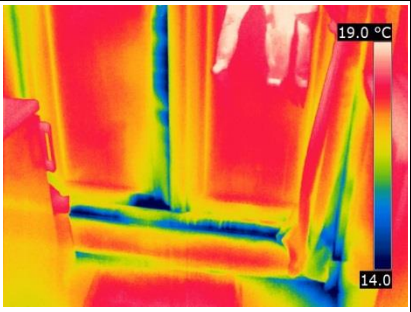
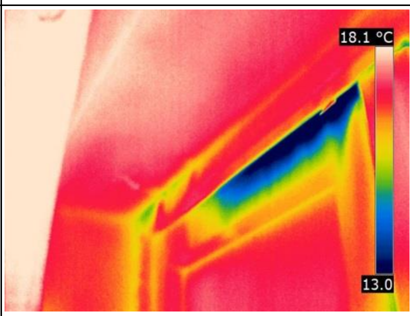
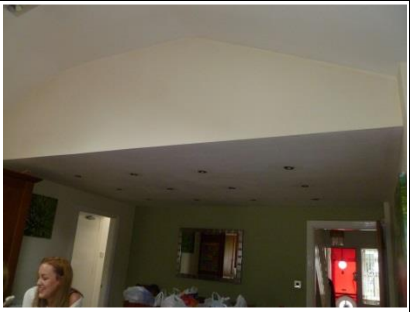
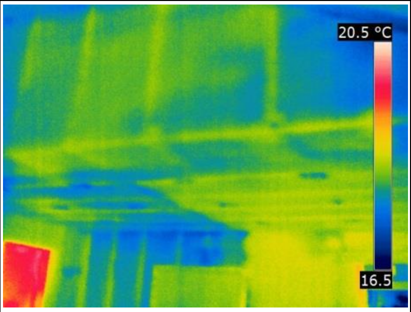
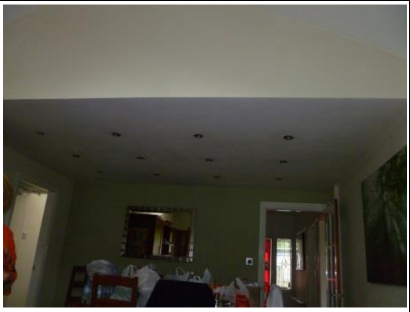
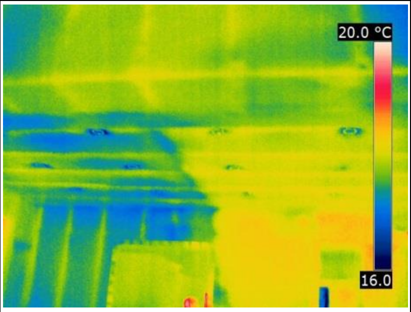
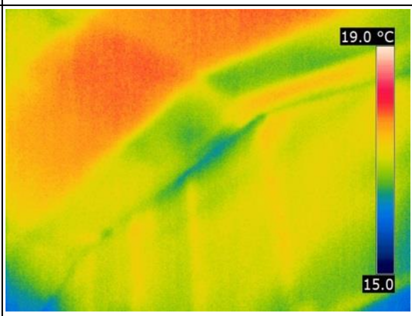
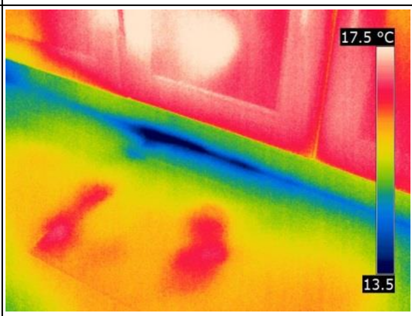
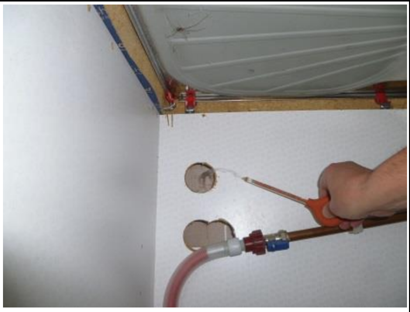
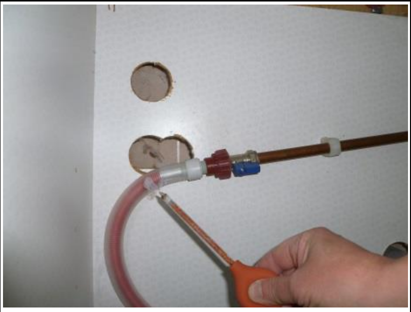
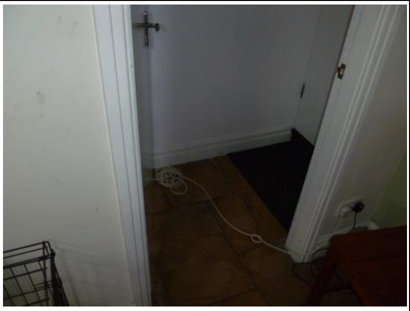
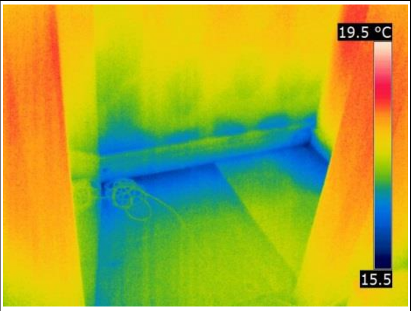
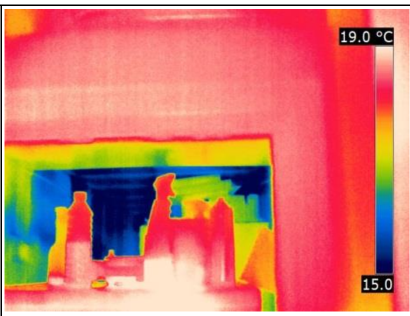
	 20.0 °C 15.0	
	 20.5 °C 16.5	
	 20.5 °C 16.5	
	 19.0 °C 14.0	
	 18.1 °C 13.0	

		
		
		
		
Under pressurisation		
		



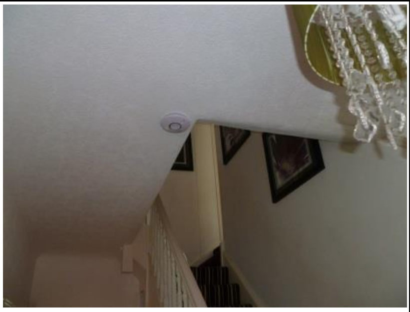



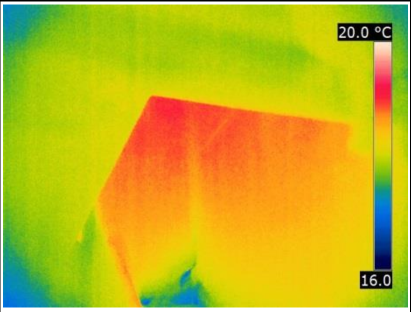


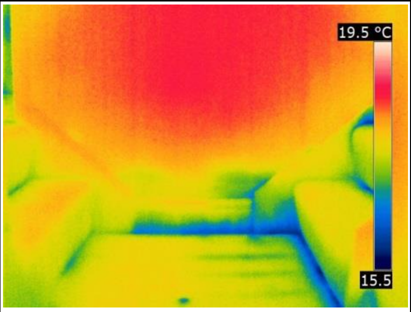
		
		
Ground Floor Side Extension		
Prior to test		
		
Under depressurisation		
		
Under pressurisation		
		

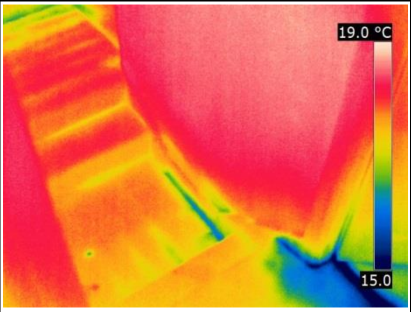
1^st Floor Landing

Under depressurisation



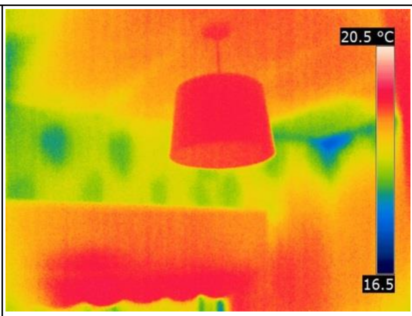






Rear Bedroom (Gable Wall)

Prior to test



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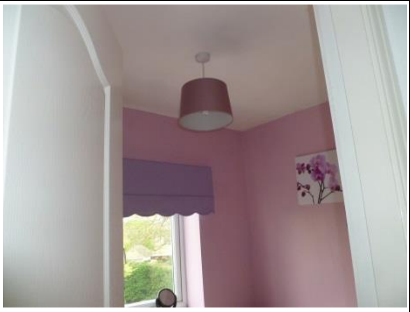
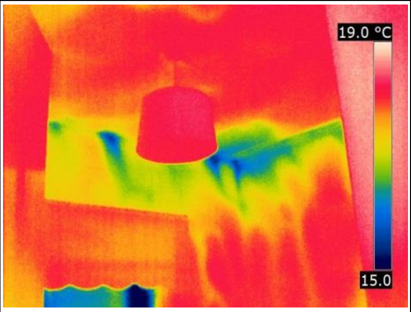
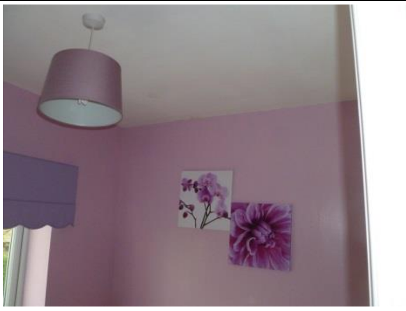
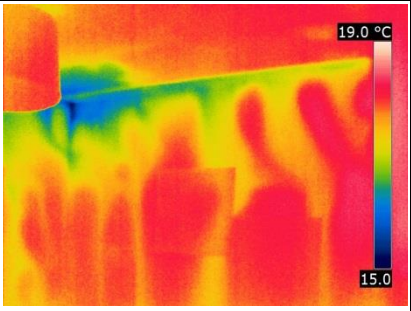
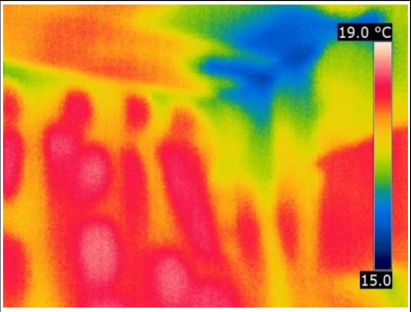


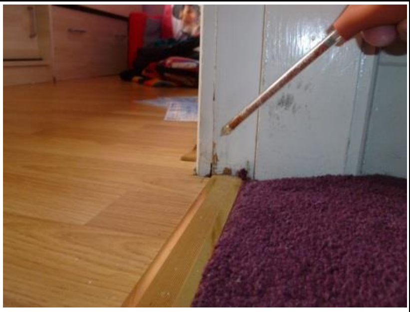


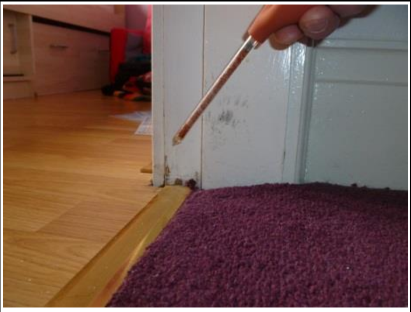






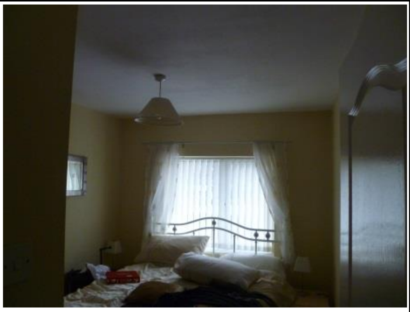
Under pressurisation

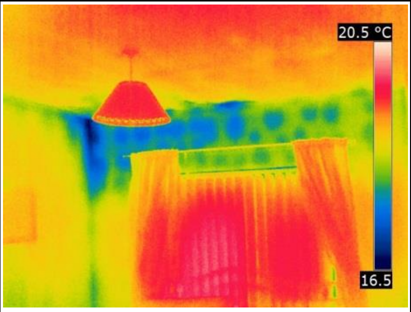




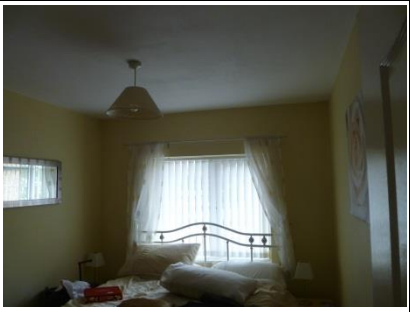
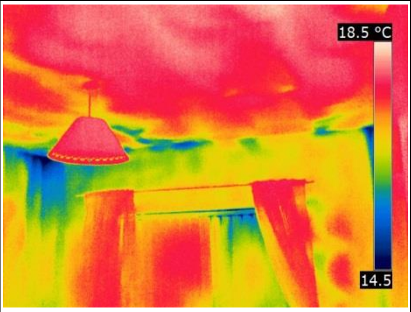
Front Bedroom (Gable Wall)

Prior to test



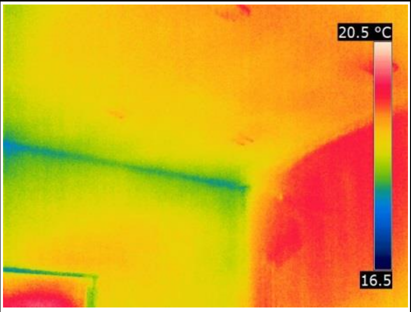


Under depressurisation

Bathroom

Prior to test

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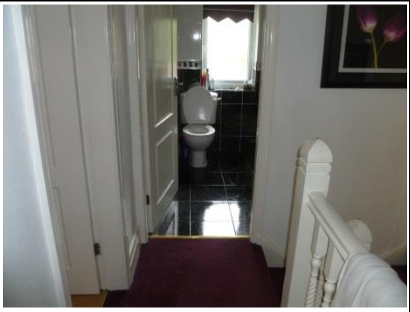
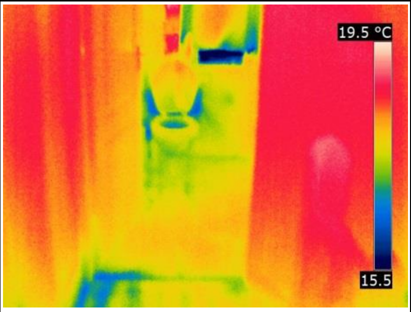
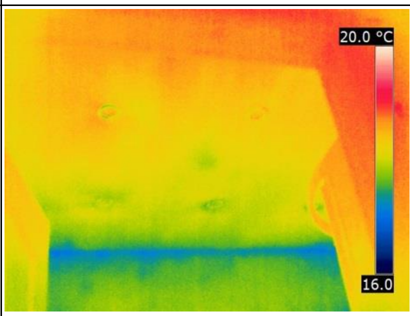
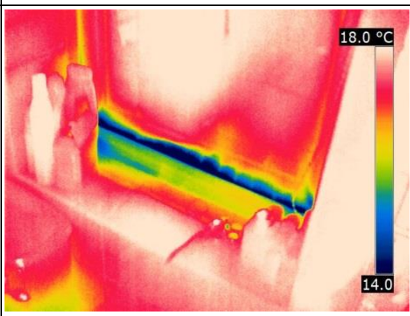
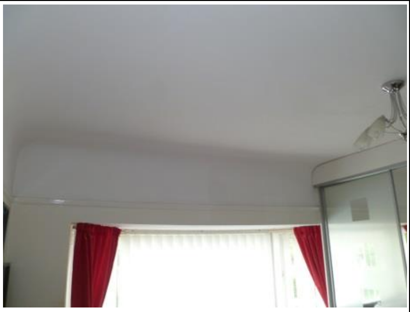
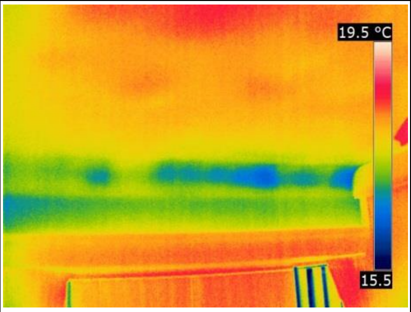
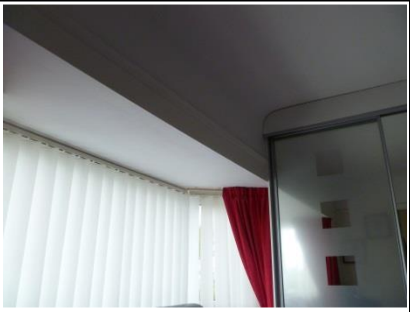
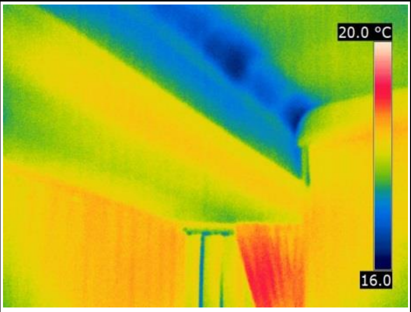
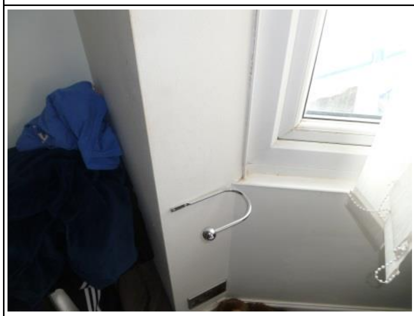
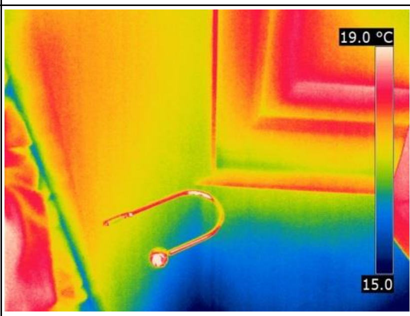
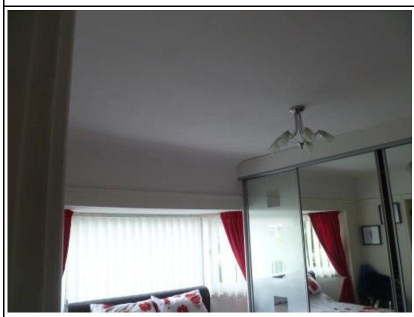
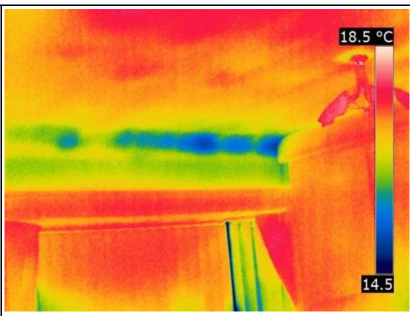
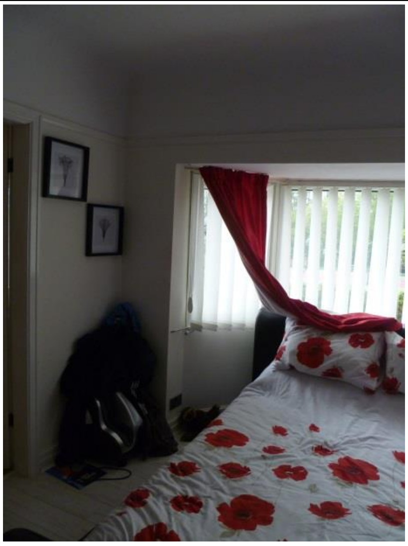
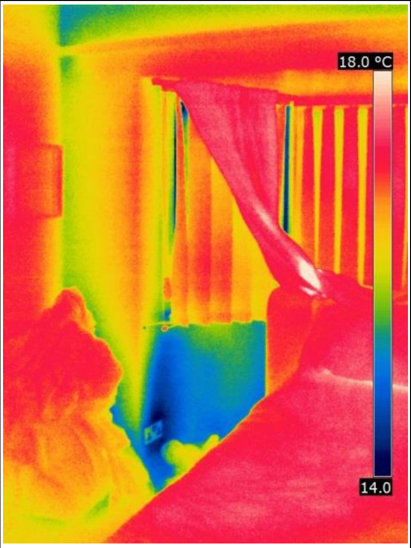
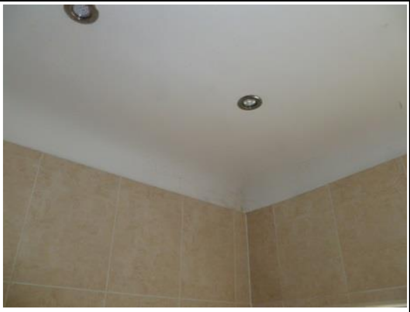
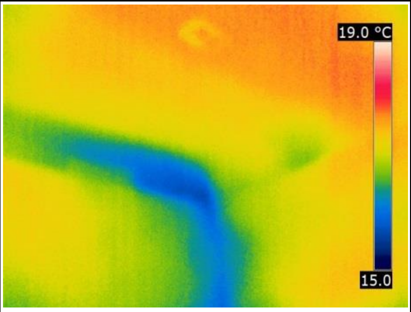
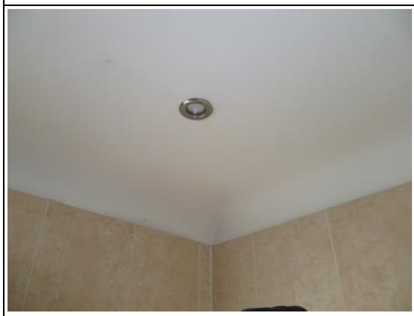
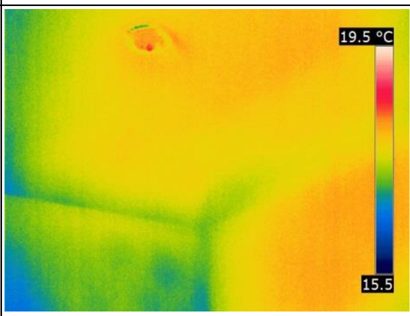



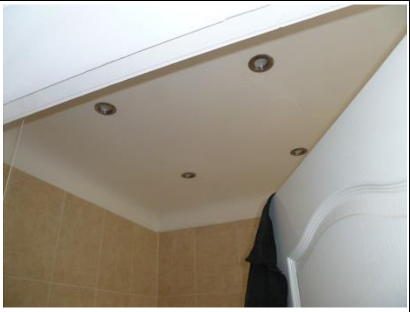
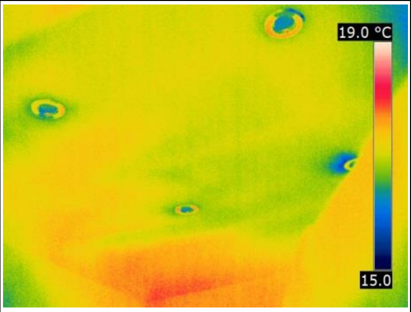
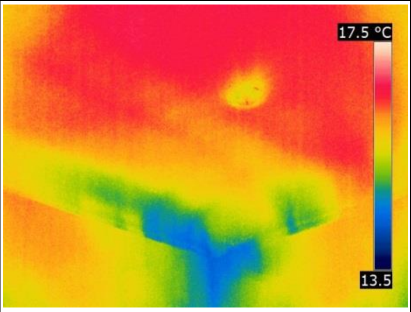
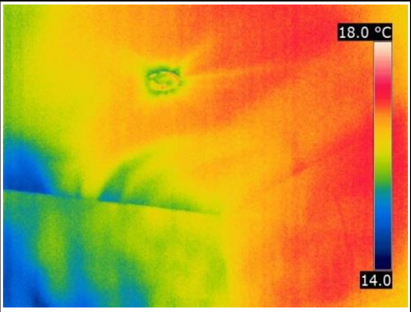
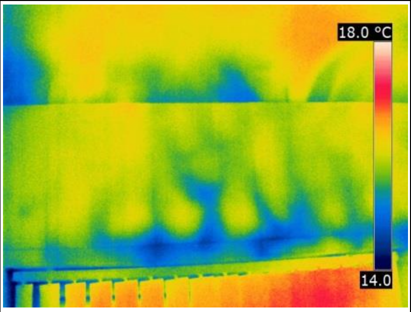



Under Pressurisation

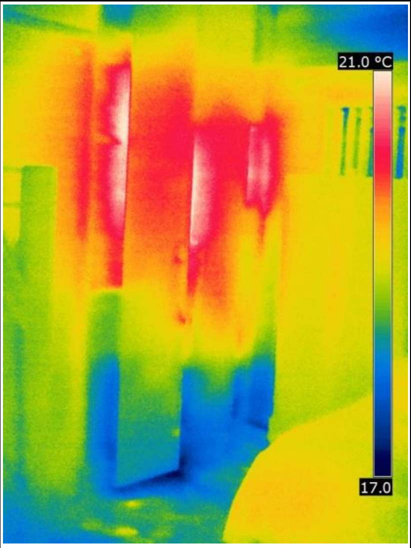
		
Front Bedroom (Party Wall)		
Prior to test		
		
		
		
Under depressurisation		
		

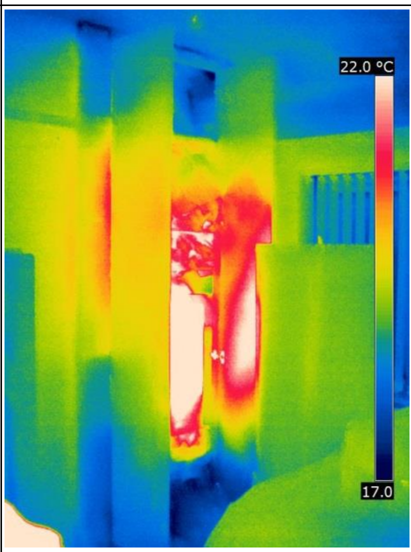
		
		
En suite		
Prior to test		
		
		
Under depressurisation		

		
		
		
		
Under pressurisation		
		

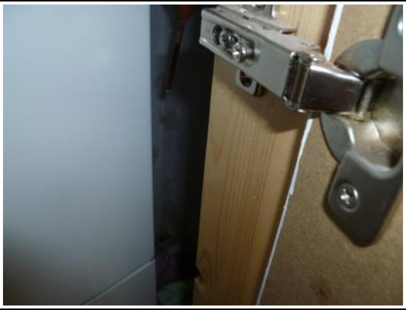
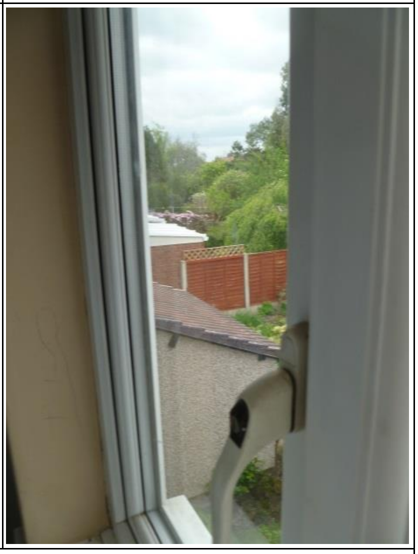
Rear Bedroom (Party Wall)

Under depressurisation



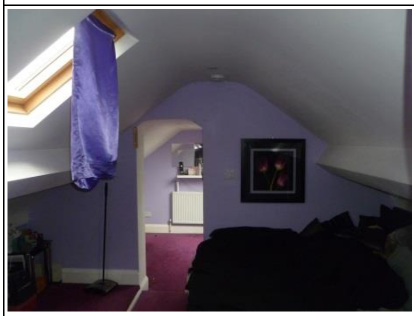
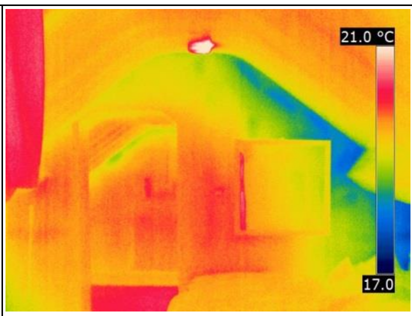


Under pressurisation

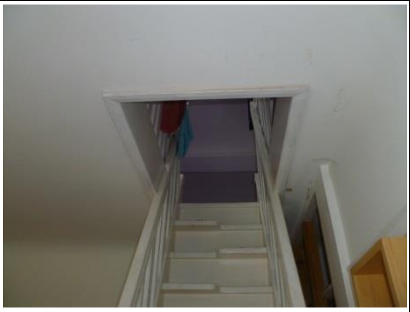
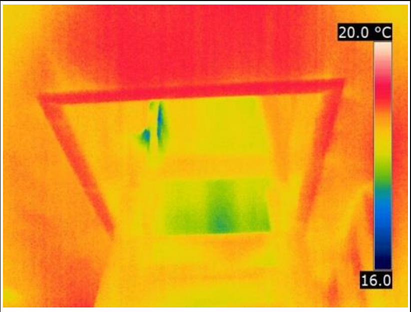
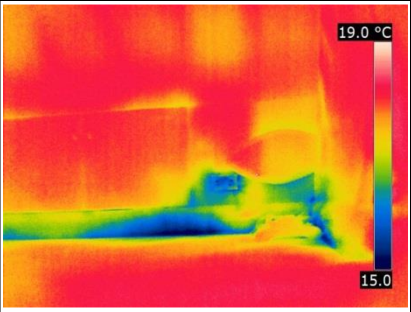
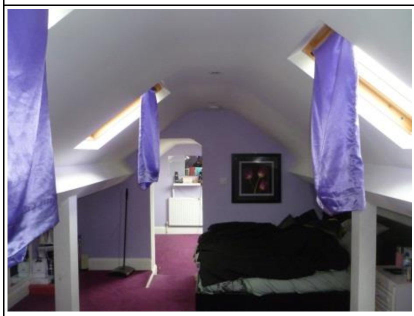
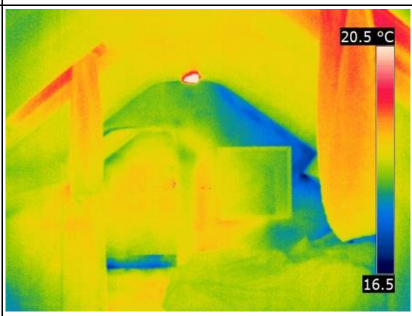
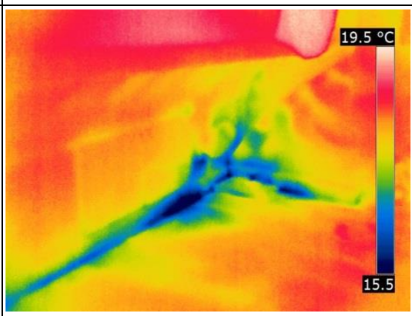
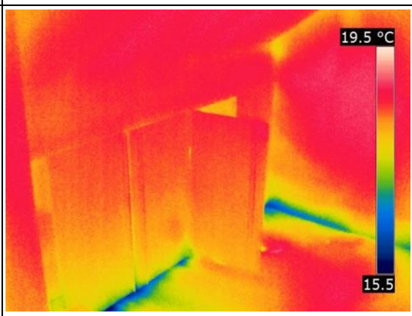
		
		
		

2nd Floor Bedroom

Prior to test

Under depressurisation

	20.0 °C 16.0	
	19.0 °C 15.0	
	20.5 °C 16.5	
	19.5 °C 15.5	
	19.5 °C 15.5	

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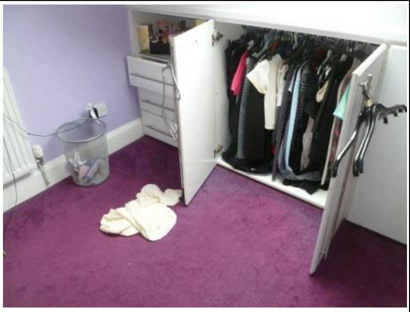
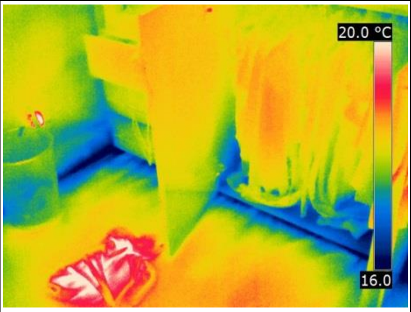
<tr><td></td><td>
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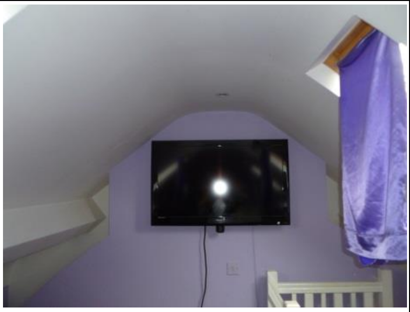
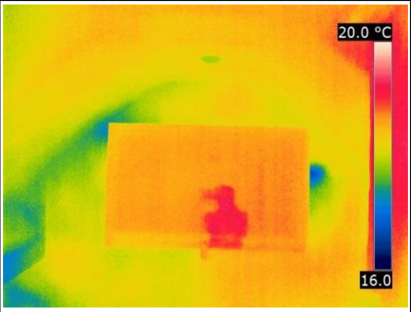
<tr><td></td><td>
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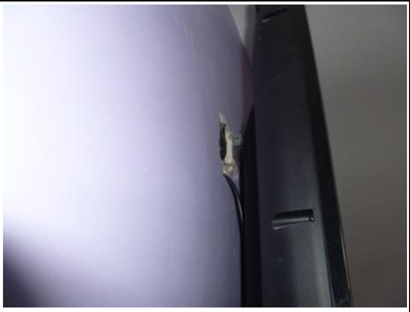
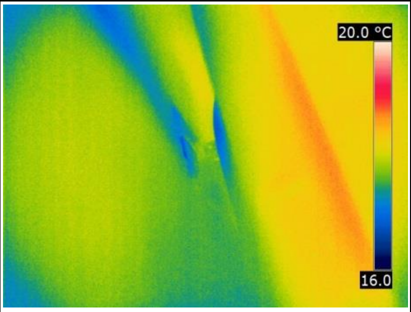
<tr><td></td><td>
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<tr><td colspan="3">Under pressurisation</td></tr>
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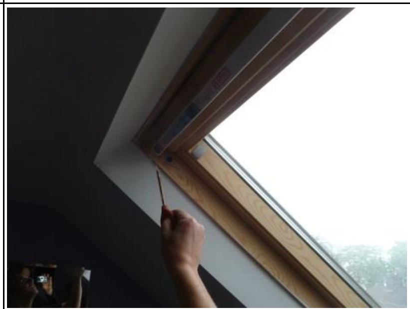
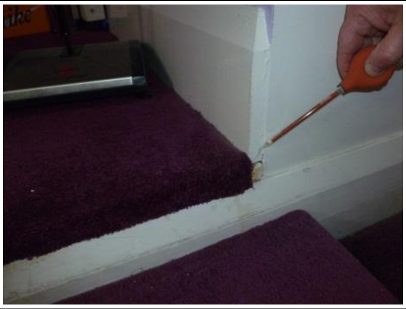
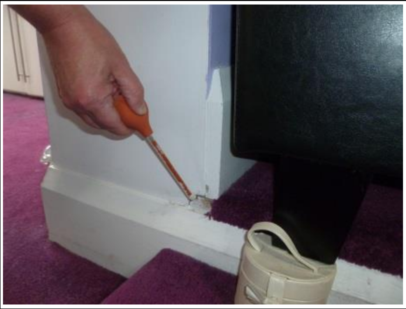
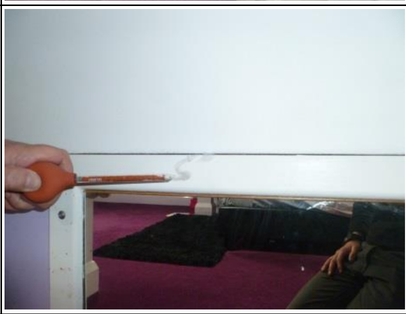








Dwelling E-42 after external paint sealing

Test Conducted on: 4th March 2016

Test Conducted by: D Miles-Shenton; Centre for the Built Environment, Leeds Sustainability Institute, Leeds Beckett University.

Results:

Date	Depressurisation Only			Pressurisation Only			Mean	
	Air Permeability	Air Leakage Rate	Correlation Coefficient	Air Permeability	Air Leakage Rate	Correlation Coefficient	Air Permeability	Air Leakage Rate
	$m^3/(h.m^2)$@50Pa	ach^{-1}@50Pa	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}@50Pa	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}@50Pa
19-Feb-2015	15.58	16.44	0.990	17.66	19.63	0.997	16.62	17.53
14-May-2015	12.46	13.15	0.996	13.43	14.17	0.988	12.95	13.66
04-Mar-2016	12.31	12.98	0.998	13.16	13.88	0.992	12.73	13.43

The airtightness of the dwelling had increased since the previous test, although not by a significant amount. The leakage detection displayed very similar air leakage paths to those previously identified under both pressurisation and depressurisation.

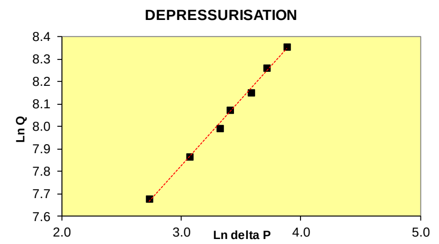
The thermal images below have been set at temperature spans of either 5°C, 7.5°C or 10°C for ease of comparison.

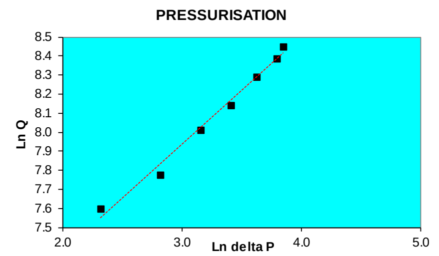
Leakage detection was performed at -50 Pa for thermal imaging under depressurisation and +50 Pa for smoke detection under pressurisation. Thermal images captured prior to the test were done so under natural conditions, under no induced pressure; where the ground floor was an infiltration zone (with external air entering the dwelling) and the attic an exfiltration zone (internal air exiting the dwelling).

Results Spreadsheets:

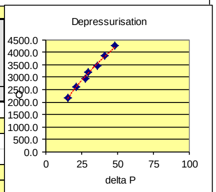
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	19/02/2015		Version 16a	19 February 2014	
test house address:	[illegible]				
company:	DECC				
house type:	Semi 1930s				
tester:	DG				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	13	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN M3/HR - When using the DG700 gauge you do not need to input a baseline pressure difference as this is calculated by the gauge and the readings adjusted automatically		
indoor temp (°C)	19.1	°C			
outdoor humidity (%rh)	57.6	%RH			
indoor humidity (%rh)	46.5	%RH			
outdoor barometric pressure	1000.7	mbar or hPa	Calculated Outdoor Air Density	1.21	kg/m^3
indoor barometric pressure	1000.7	mbar or hPa	Calculated Indoor Air Density	1.19	kg/m^3
temperature corr. fact. depress.	1.032		description of main construction details:		
temperature corr. fact. press.	1.021				
wind speed (m/s):	0.1				
baseline pressure diff (Pa) (+/-)		Pa			
house width:	9.256	m			
house depth:	10.342	m			
house height:	7.267	m			
floor area:	64.248	m^2			
volume:	328	m^3			
envelope area including floor:	346	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	4479.96	m^3/h			
Mean Air Leakage at 50Pa =	13.66	h^{-1}			
Mean Air Permeability at 50 Pa =	12.95	m/h or m^3h/m^2			
Equivalent Leakage Area =	0.198	m^2 at	10	Pa	

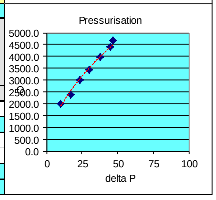




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3h/m^2)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	48.5	4347	4253.6	OK	48.5	3.882	8.356	4312.13	12.46	13.15
Approx 57 Pa	a	41.1	3954	3869.0	OK	41.1	3.716	8.261	r^2	0.996	
Approx 49 Pa	a	36	3544	3467.9	OK	36	3.584	8.151	C_{env}	425.158	$m^3/h.Pa^n$
Approx 41 Pa	a	30.1	3277	3206.6	OK	30.1	3.405	8.073	n	0.591	
Approx 33 Pa	a	27.7	3026	2961.0	OK	27.7	3.321	7.993			
Approx 25 Pa	a	21.5	2669	2611.7	OK	21.5	3.068	7.868	C_L (corrected)	427.224	$m^3/h.Pa^n$
Approx 20 Pa	a	15.4	2206	2158.6	OK	15.4	2.734	7.677			



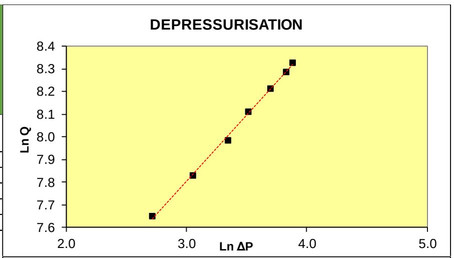
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m3/h)	ADJUSTED FLOW (m3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3h/m^2)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	47	4567	4667.3	OK	47	3.850	8.448	4647.79	13.43	14.17
Approx 57 Pa	a	44.7	4301	4395.4	OK	44.7	3.800	8.388	r^2	0.988	
Approx 49 Pa	a	37.7	3902	3987.7	OK	37.7	3.630	8.291	C_{env}	513.545	$m^3/h.Pa^n$
Approx 41 Pa	a	30.2	3368	3442.0	OK	30.2	3.408	8.144	n	0.564	
Approx 33 Pa	a	23.5	2947	3011.7	OK	23.5	3.157	8.010			
Approx 25 Pa	a	16.8	2334	2385.2	OK	16.8	2.821	7.777	C_L (corrected)	511.340	$m^3/h.Pa^n$
Approx 20 Pa	a	10.2	1956	1998.9	OK	10.2	2.322	7.600			

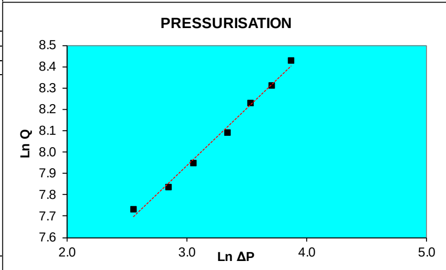


MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

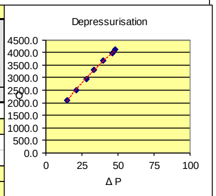
date:	04/03/2016	Version 16c	04 November 2014
test house address:			
company:	DECC		
house type:	Extended 1930s semi		
tester:	DMS		
test reference number:	3	Blow er Door & Gauge Used	Model 3 w ith DG700

outdoor temp (°C)	3.4	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN m3/h - When using the DG700 gauge run baseline pressure adjustment for minimum 30s w ith fan sw itched on but not rotating		
indoor temp (°C)	17.4	°C			
outdoor humidity (%rh)	84.9	%RH			
indoor humidity (%rh)	63.4	%RH			
outdoor barometric pressure	1008	mbar or hPa	Calculated Outdoor Air Density	1.27	kg/m^3
indoor barometric pressure	1008	mbar or hPa	Calculated Indoor Air Density	1.20	kg/m^3
temperature corr. fact. depress.	0.952	WARNING!!	description of main construction details:		
temperature corr. fact. press.	1.051	Extreme Test			
w ind speed (m/s):	3.4	Conditions			
baseline pressure diff (Pa) (+/-)		Pa			
house w idth:	9.256	m			
house depth:	10.342	m			
house height:	7.267	m			
floor area:	64.248	m^2			
volume:	328	m^3			
envelope area including floor:	346	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	4406.24	m^3/h			
Mean Air Leakage at 50Pa =	13.43	h^{-1}			
Mean Air Permeability at 50 Pa =	12.73	m/h or m^3h/m^2			
Equivalent Leakage Area =	0.205	m^2 at	10	Pa	

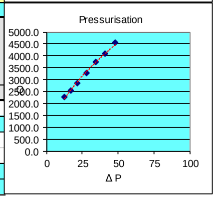




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only ($m^3/(h.m^2)$)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	a	48.7	4354	4134.9	OK	48.7	3.886	8.327	4258.87	12.31	12.98
Approx 57 Pa	a	46.2	4171	3961.1	OK	46.2	3.833	8.284	r^2	0.998	
Approx 49 Pa	a	40.3	3884	3688.5	OK	40.3	3.696	8.213	C_{env}	427.542	$m^3/h.Pa^n$
Approx 41 Pa	a	33.6	3505	3328.6	OK	33.6	3.515	8.110	n	0.582	
Approx 33 Pa	a	28.4	3091	2935.4	OK	28.4	3.346	7.985			
Approx 25 Pa	a	21.3	2648	2514.7	OK	21.3	3.059	7.830	C_L (corrected)	437.310	$m^3/h.Pa^n$
Approx 20 Pa	a	15.1	2211	2099.7	OK	15.1	2.715	7.650			



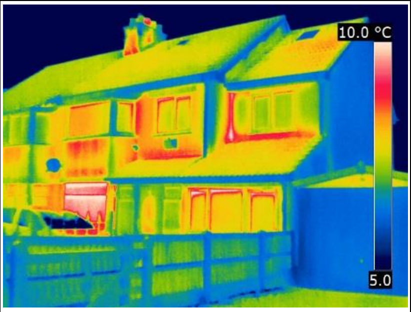
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa)	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only ($m^3/(h.m^2)$)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	a	48.2	4341	4571.0	OK	48.2	3.875	8.427	4553.60	13.16	13.88
Approx 57 Pa	a	41	3869	4074.0	OK	41	3.714	8.312	r^2	0.992	
Approx 49 Pa	a	34.3	3558	3746.5	OK	34.3	3.535	8.229	C_{env}	563.031	$m^3/h.Pa^n$
Approx 41 Pa	a	28.3	3105	3269.5	OK	28.3	3.343	8.092	n	0.534	
Approx 33 Pa	a	21.3	2692	2834.6	OK	21.3	3.059	7.950			
Approx 25 Pa	a	17.3	2406	2533.5	OK	17.3	2.851	7.837	C_L (corrected)	563.657	$m^3/h.Pa^n$
Approx 20 Pa	a	12.9	2168	2282.9	OK	12.9	2.557	7.733			



Images:

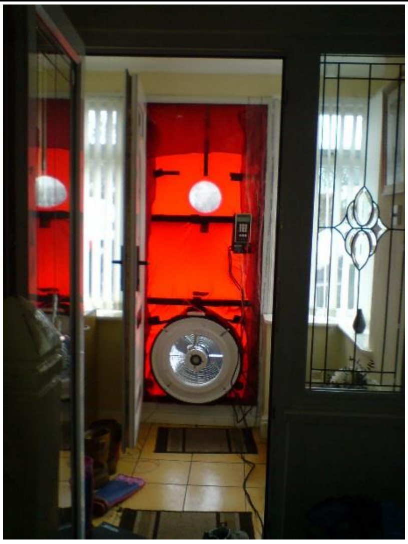
External

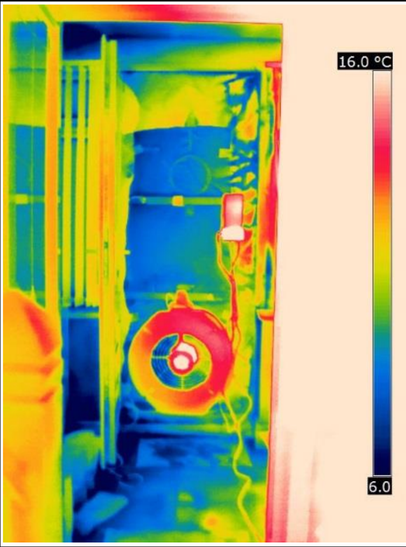
Prior to test

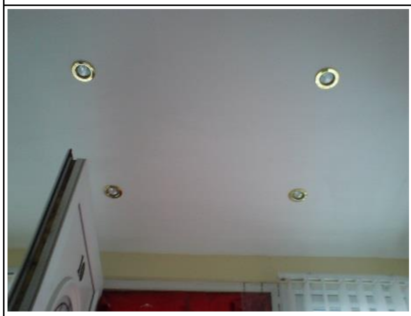


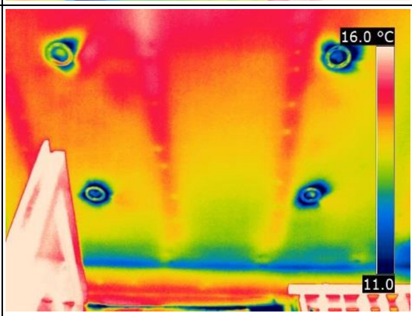
Hall

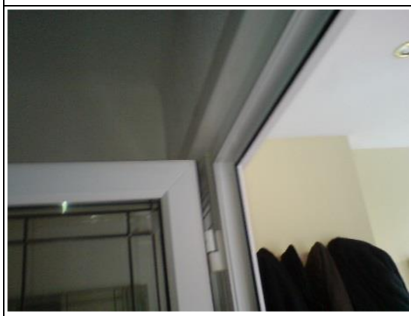
Under depressurisation

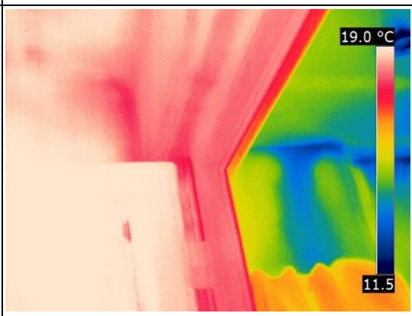






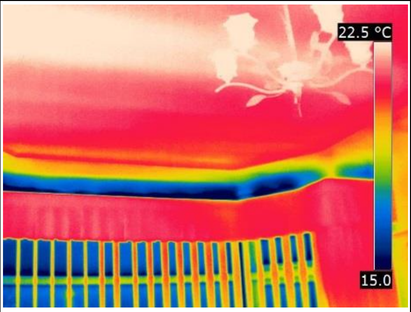




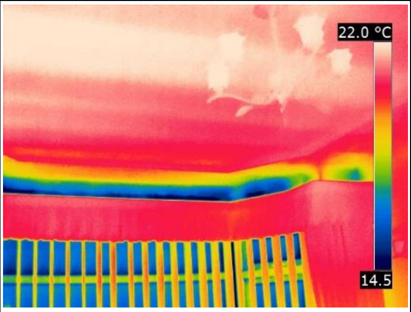


Front Living Room

Prior to test

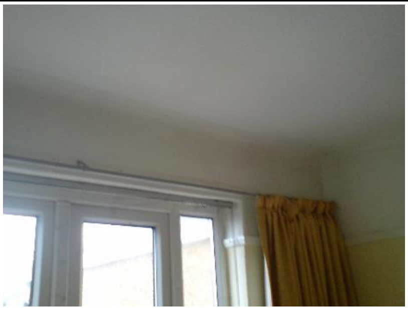


Under depressurisation



Rear Living Room

Prior to test



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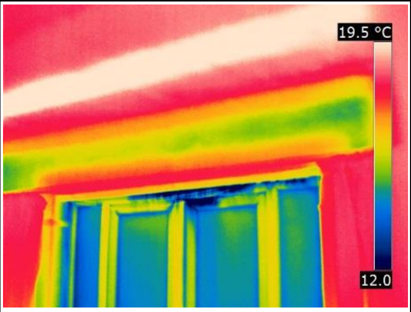

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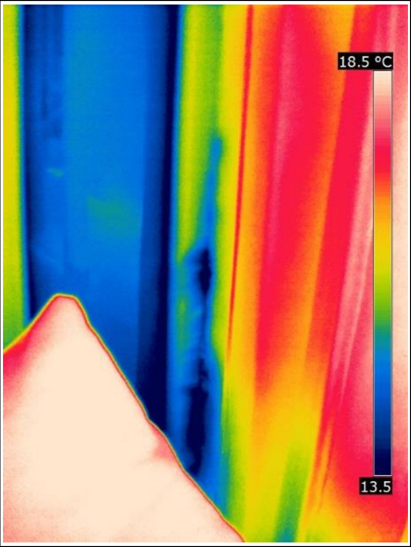
<tr><td></td><td>
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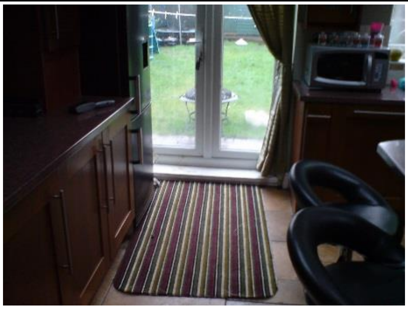
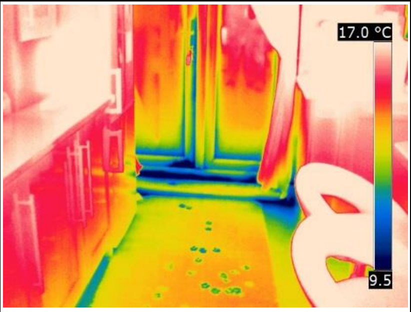
<tr><td></td><td>
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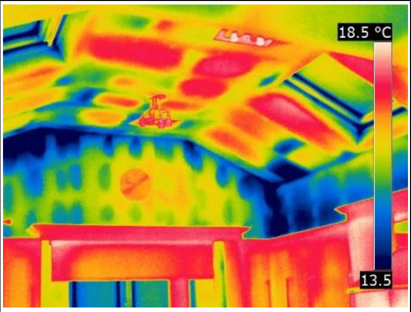
<tr><td></td><td>
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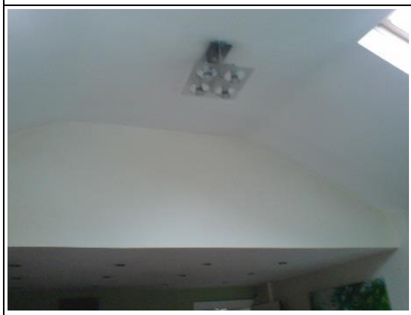
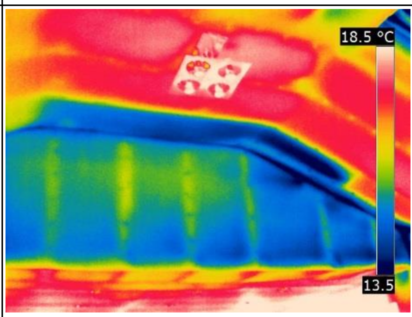
<tr><td></td><td>
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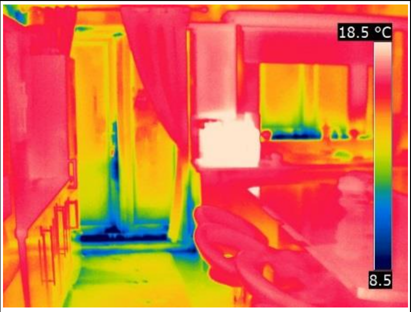
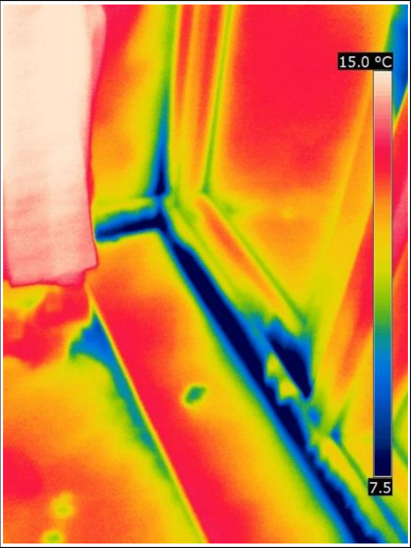
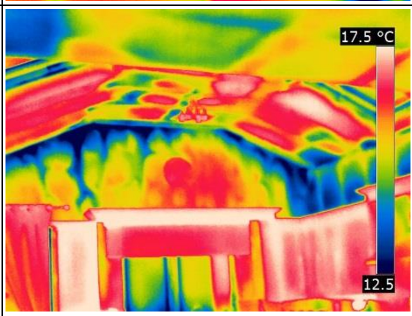
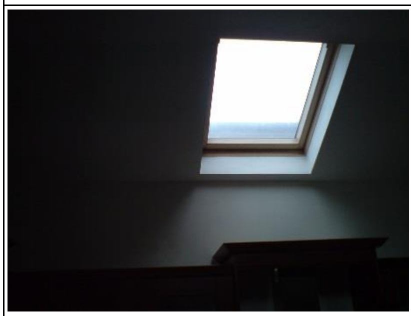
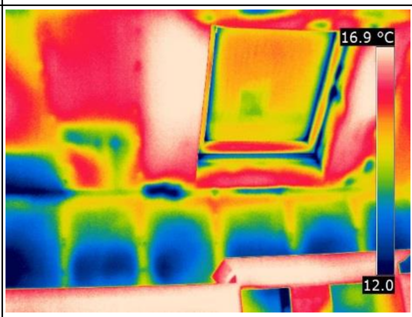
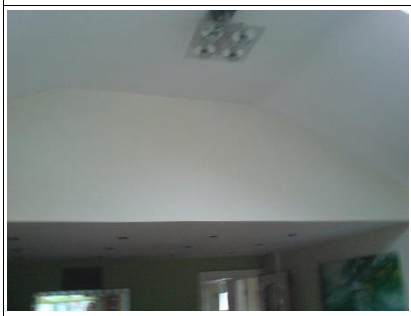
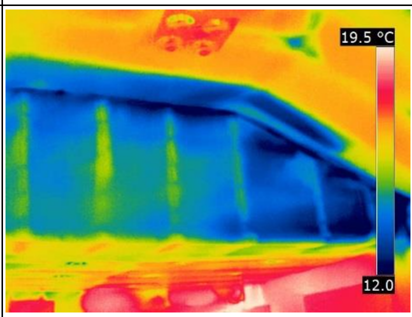
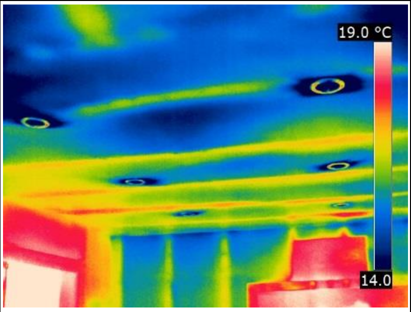
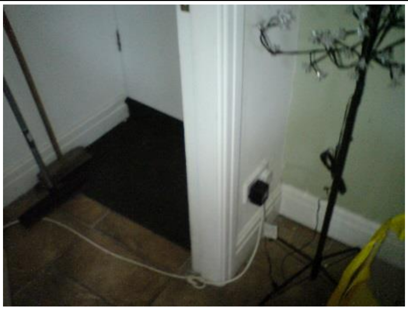
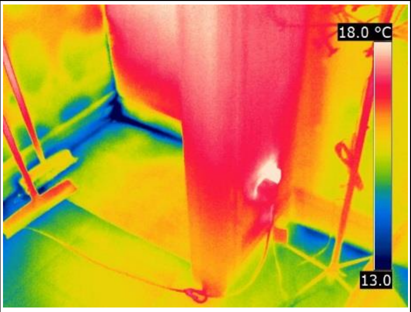
	18.5 °C 8.5	
	15.0 °C 7.5	
	17.5 °C 12.5	
	16.9 °C 12.0	
	19.5 °C 12.0	



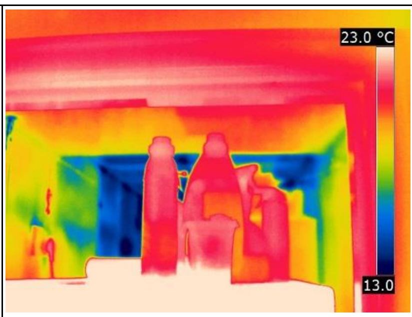


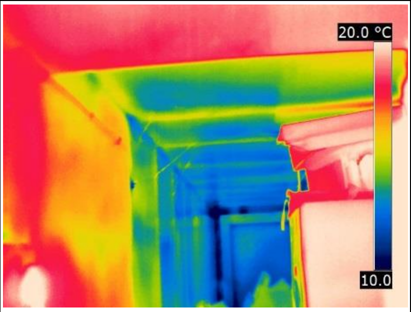
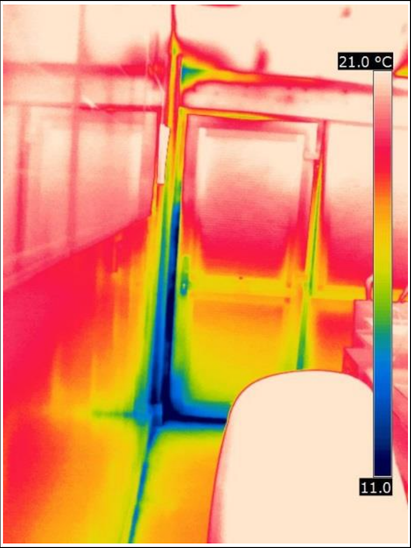
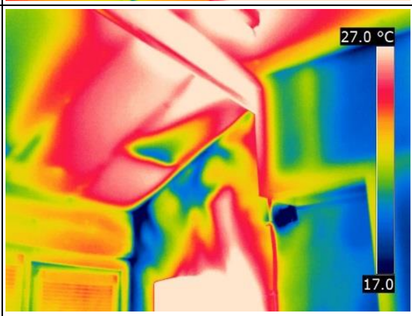
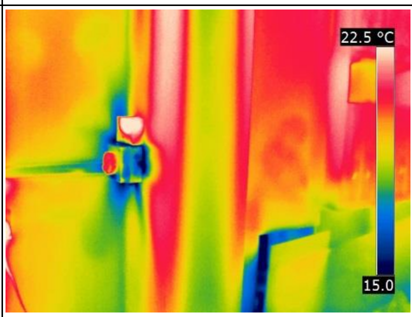


Under pressurisation

Ground Floor Side Extension

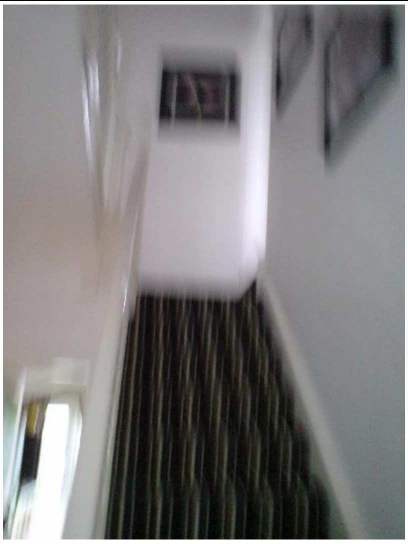
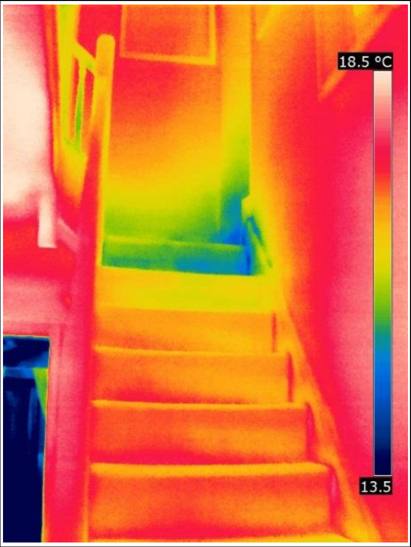
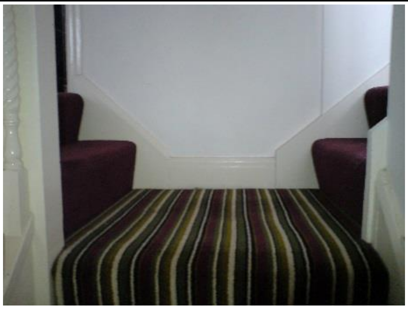
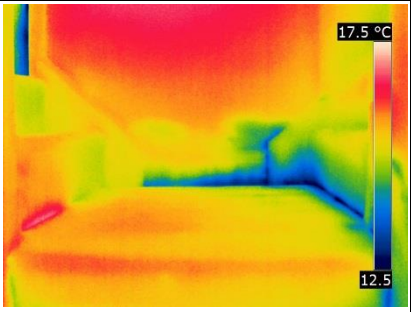
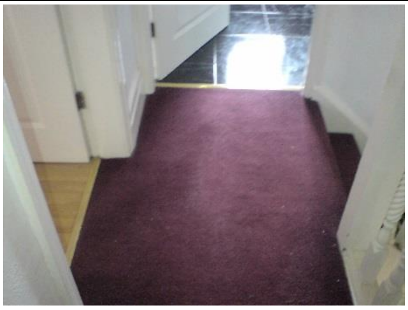
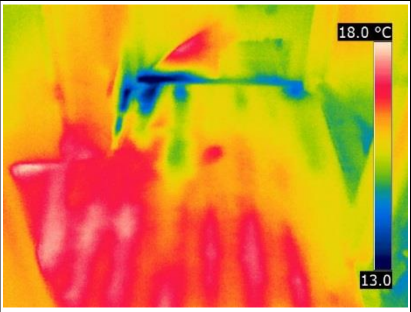
Under depressurisation



		
		
		
		
Under pressurisation		
		

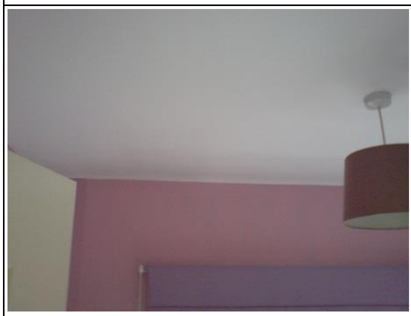
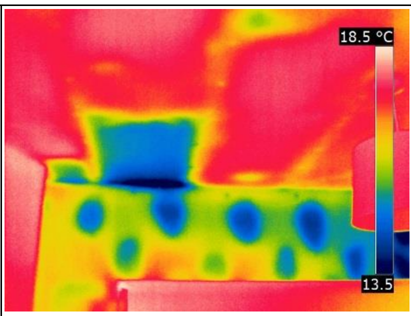
1st Floor Landing

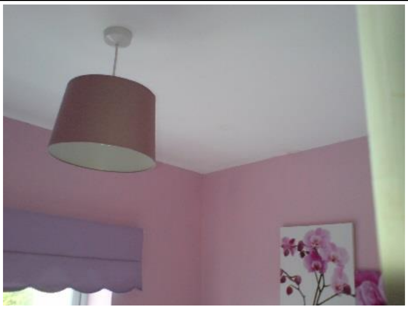
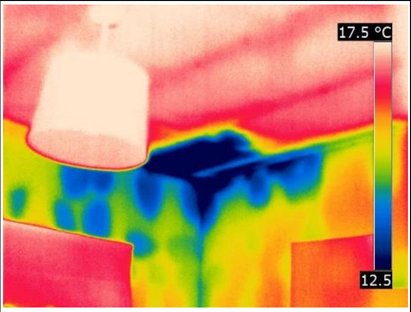
Under depressurisation

Rear Bedroom (Gable Wall)

Prior to test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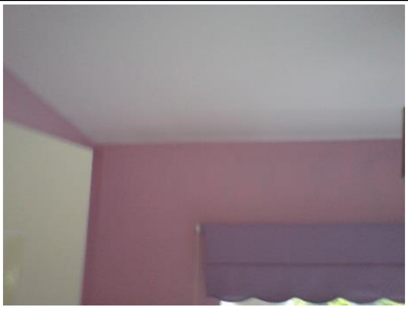
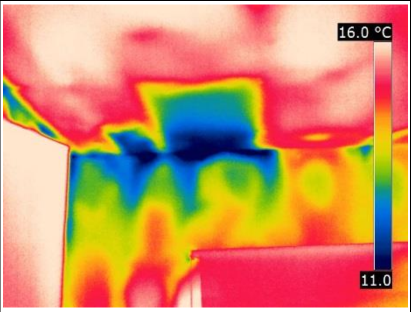
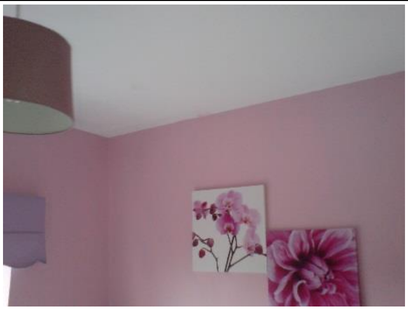
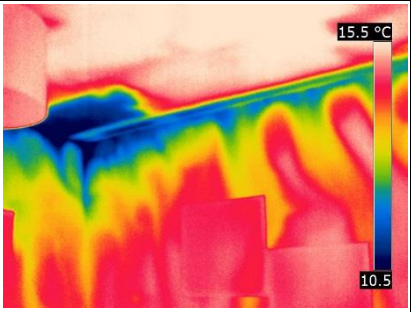
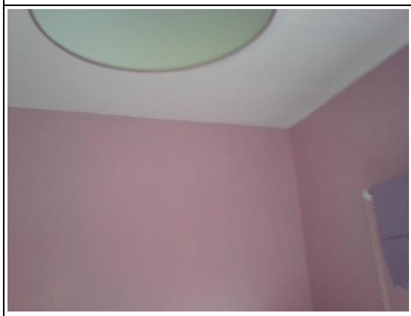
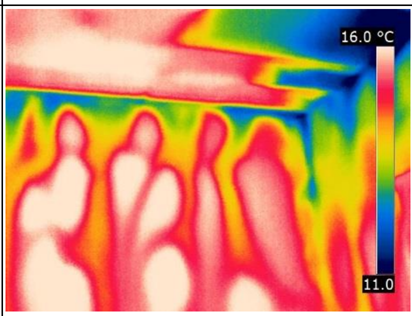
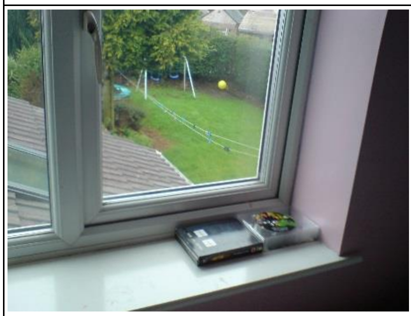
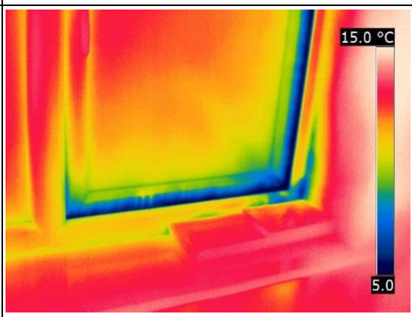
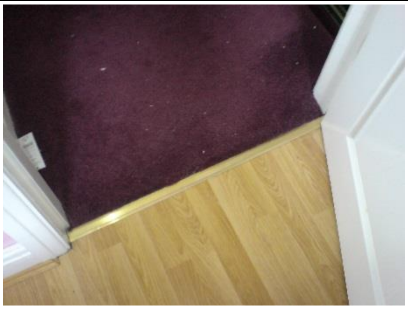
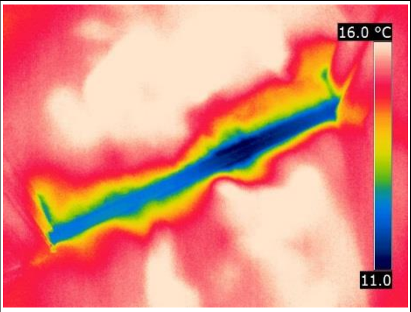
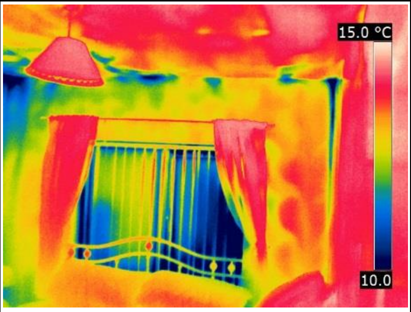
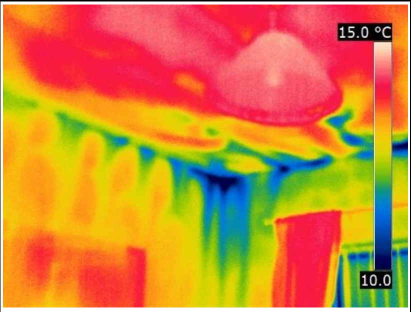
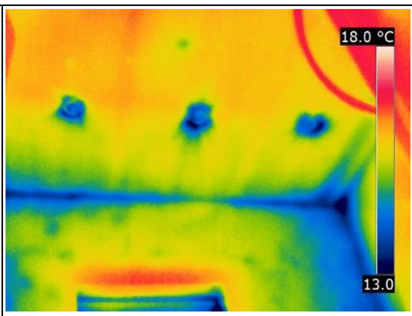
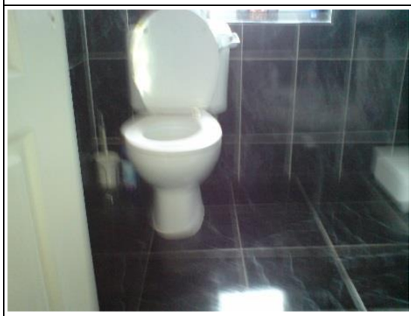
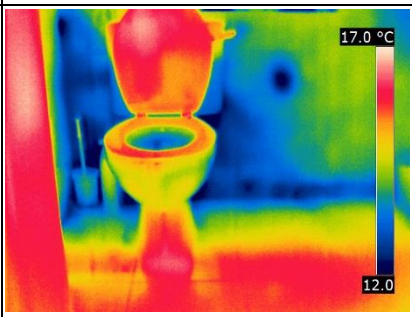
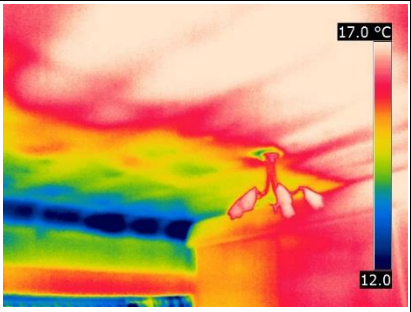
		
		
		
		

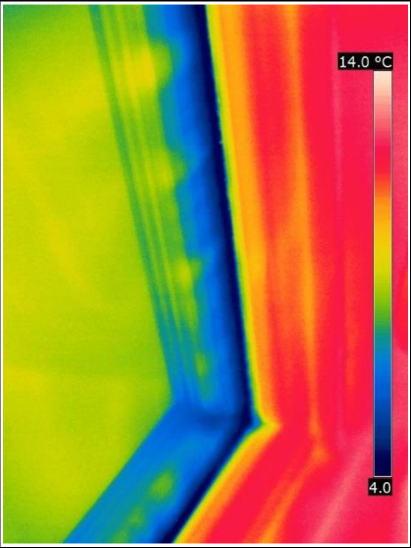
		
Front Bedroom (Gable Wall)		
Under depressurisation		
		
		
Bathroom		
Under depressurisation		
		
		

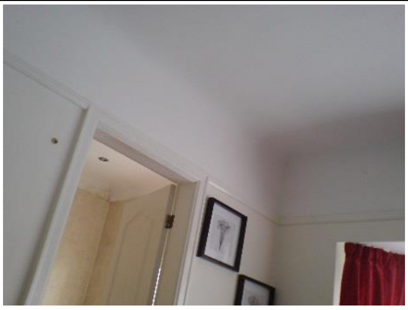
Front Bedroom (Party Wall)

Prior to test

Under depressurisation

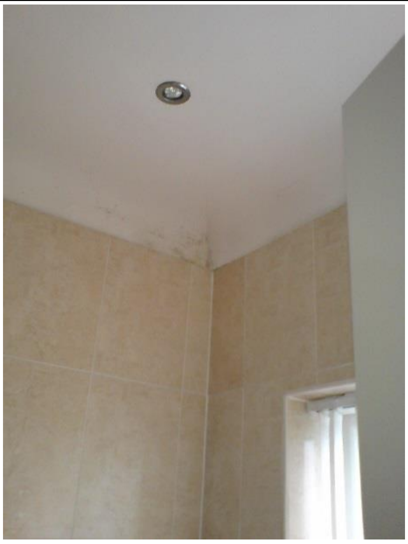


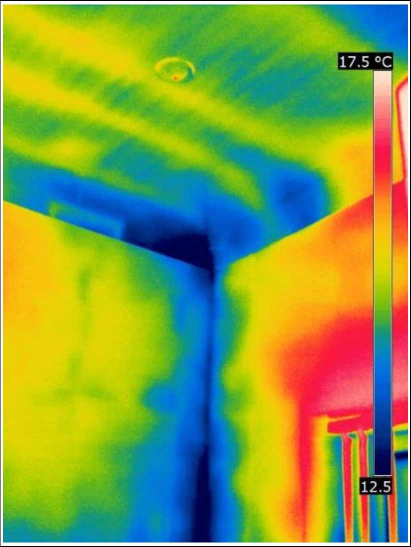




En suite

Prior to test





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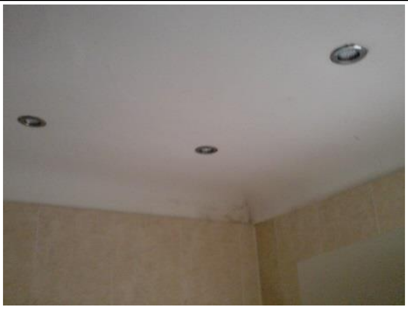
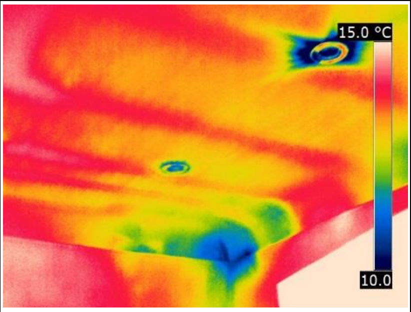
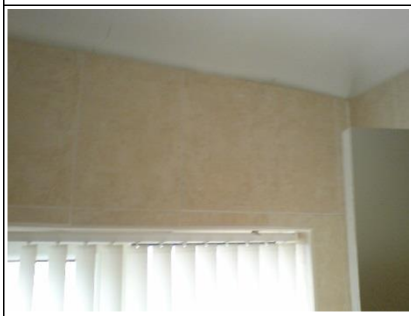
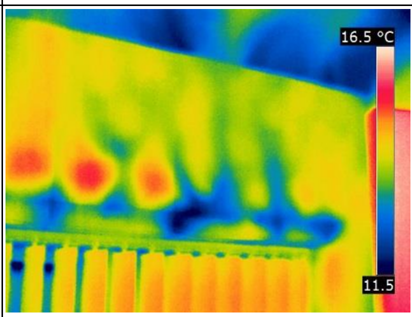


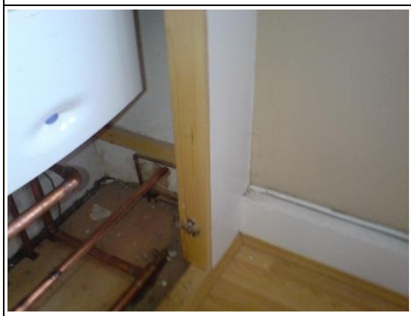


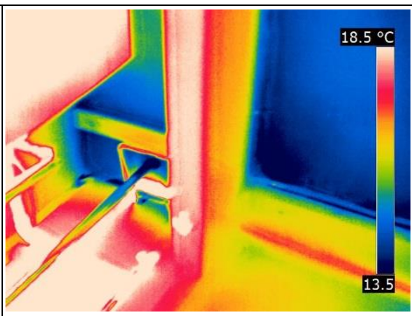




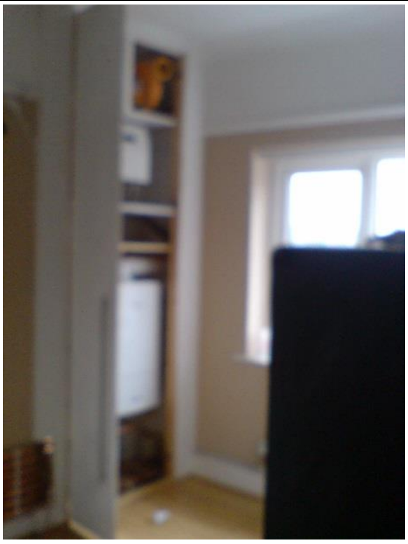
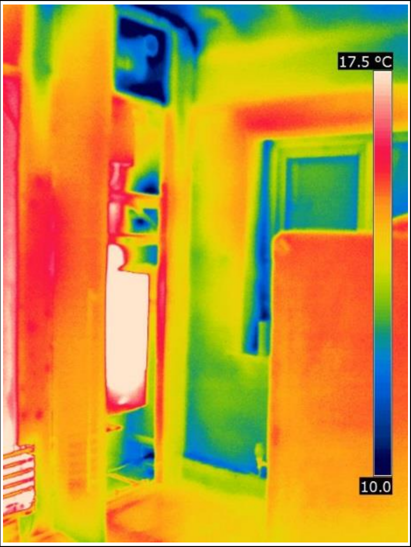
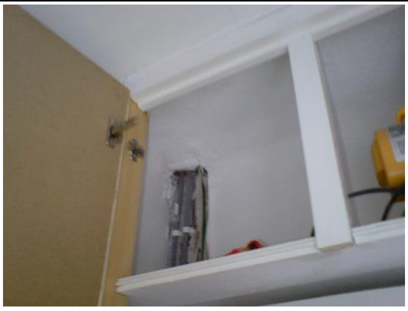
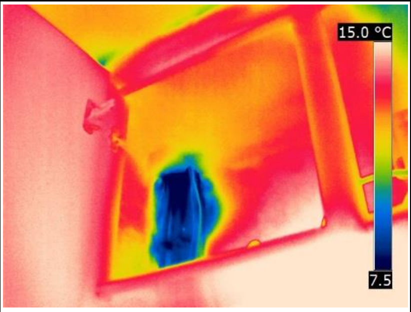
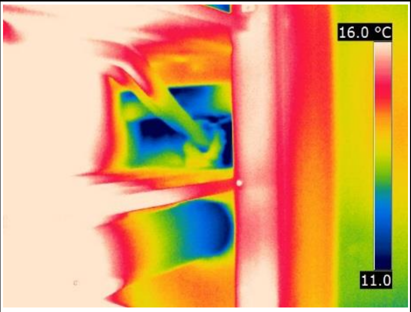
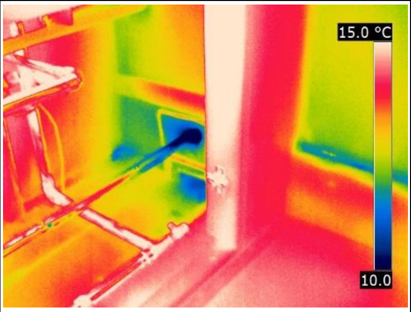
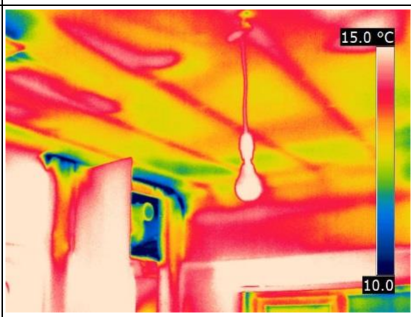
Rear Bedroom (Party Wall)

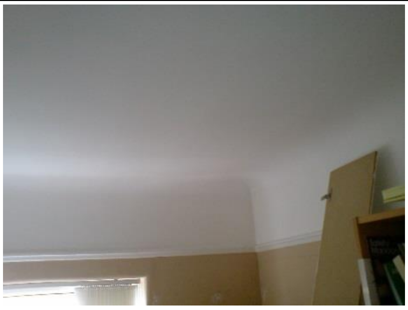
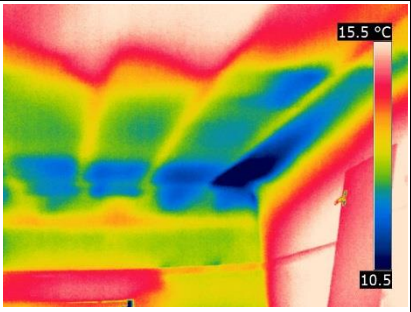
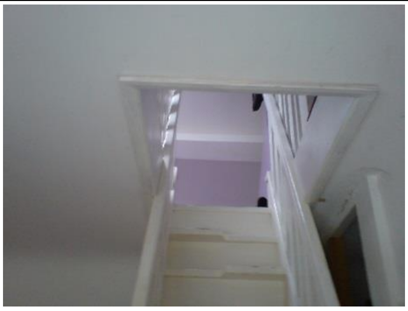
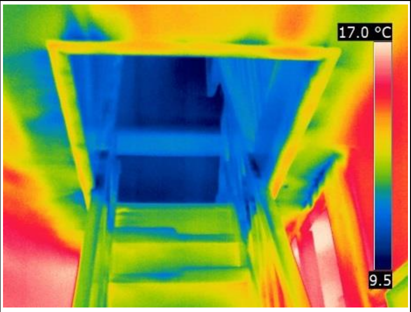
Prior to test





Under depressurisation

	17.5 °C 10.0	
	15.0 °C 7.5	
	16.0 °C 11.0	
	15.0 °C 10.0	
	15.0 °C 10.0	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	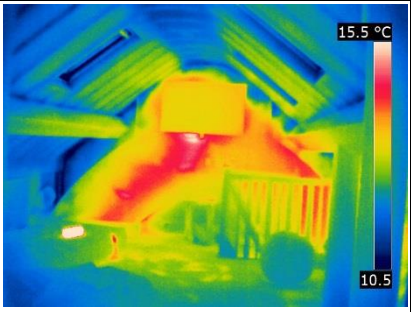	
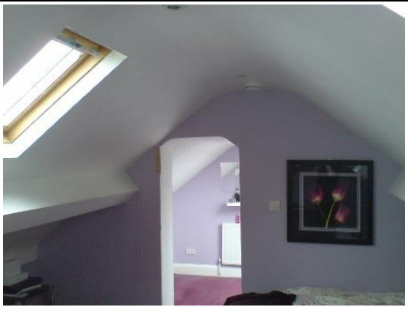		
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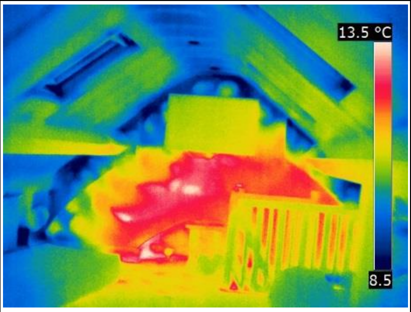
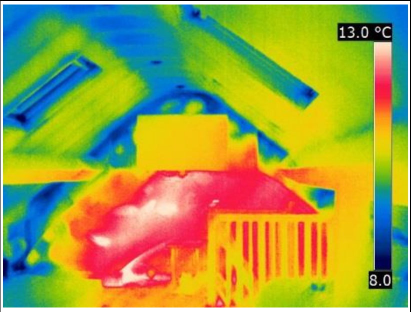
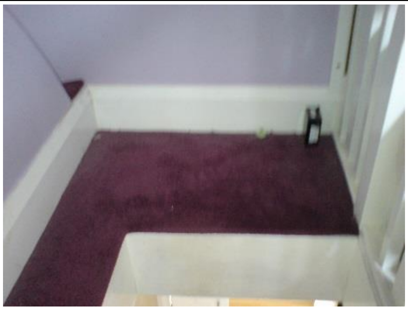
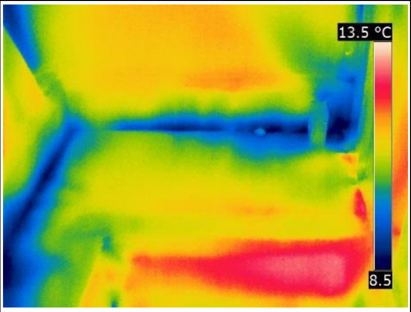
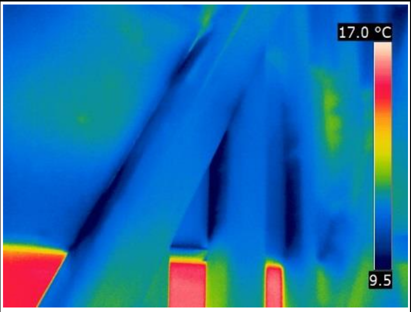
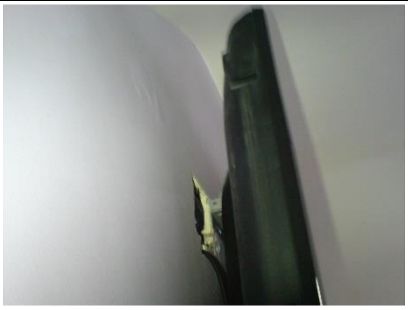
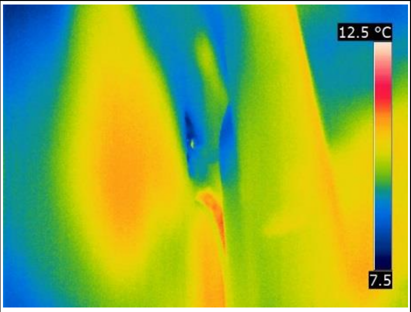
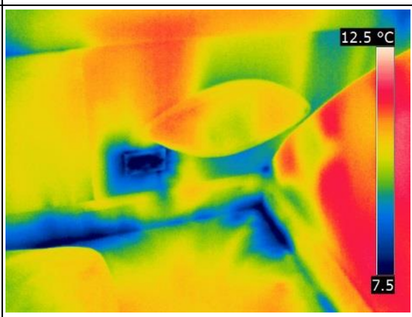
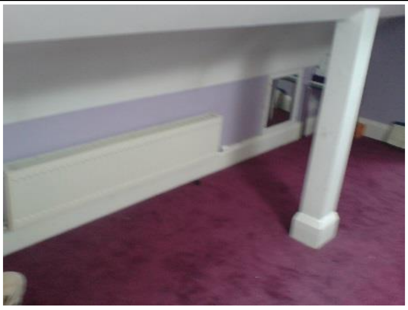
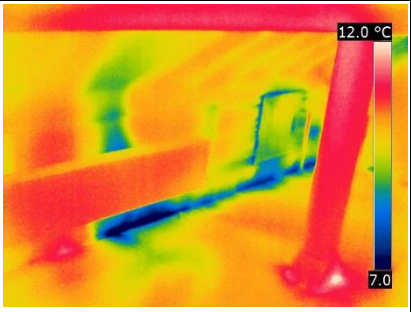
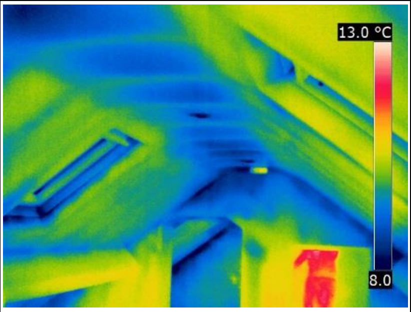
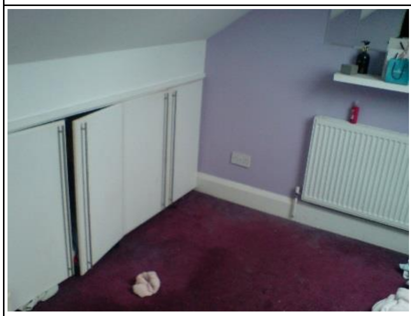
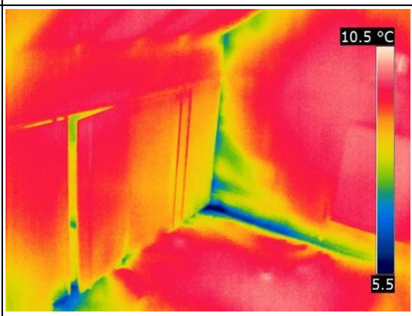
		

	 13.0 °C 8.0	
	 13.5 °C 8.5	
	 17.0 °C 9.5	
	 12.5 °C 7.5	
	 12.5 °C 7.5	

	12.0 °C 7.0	
	13.0 °C 8.0	
	10.5 °C 5.5	

Appendix C. Design review C-01

Leeds Core Cities Monitoring and Evaluation Project: Renovations of Brick Built Solid Wall Terrace Properties - Design Review Report 01

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March 2013

Table of Contents

Introduction

1. This report outlines the results of a design review that was undertaken on the approach devised for renovating brick built solid wall terrace properties in Leeds. The design review was undertaken as part of the Leeds Core Cities Monitoring and Evaluation project and is linked to the Green Deal Go Early Initiative.

Description of Developments

2. The terrace properties for renovation were predominantly constructed in the late Victorian or Edwardian eras. The original construction methods encountered were nine inch solid brick external walls with plaster internal finish, single brick load bearing internal walls, timber stud partitions with lath and plaster and pitched timber roof with slate covering. The original windows would have been timber sliding sash but many of these had been replaced in recent decades with PVCu casement windows. The renovation projects were all managed by social housing providers with the physical works undertaken by volunteers as part of community action schemes. In some instances contractors were employed to carry out the works.

Method

3. The review has been undertaken on the design approach devised for the renovation of brick built terrace properties. The review is based upon the design information that has been made available for the subject dwellings. This includes: architectural design drawings and a design strategy in the form of a guidance manual. This is referred to throughout the report as the Guidance Manual (Leeds Action to Create Homes (LATCH), 2012). Communication has also taken place with the Client Project Managers for each of the development properties and the Contractor that devised the general insulation and airtightness strategy.

Layout and Form

4. The properties varied between developments but typical layouts and form are shown in Figures 1 and 2.

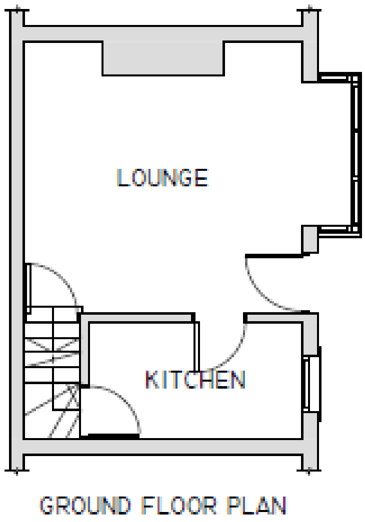

Figure 1 Example Plans

Figure 2 Example Elevation

Building Fabric

Insulation Strategy

5. The retrofit insulation strategy is detailed as follow:

   a. External Walls – The external walls are internally insulated using 150 mm or 100 mm foil faced Polyisocyanurate (PIR) boards. The insulation is fixed using expanding foam as adhesive and secondary proprietary plastic insulation fixings. The walls are dry lined with plasterboard fixed to the insulation with panel adhesive. Gypsum fibreboard is used where fittings will be hung from the walls in kitchens and bathrooms. Where joists run parallel to external walls, the gap between the joist and the masonry is insulated with either rigid insulation board or expanding foam depending on the space available. Internal masonry walls that are connected to the external walls are insulated locally to the junction where practical.

b. Suspended Ground Floors – Mineral wool insulation is fitted between joists with additional support straps fixed below. In some instances 25 mm PIR board has been specified instead of the support straps.

c. Party Walls and Chimney Breasts – The design strategy treats party walls (also known as separating walls) and chimney breasts as heat loss elements. The design information provided specifies that PIR insulation boards are to be fixed to the party walls and chimney breasts at a thickness to accommodate architectural elements, for example, staircases and door jambs against adjacent walls.

d. Roof (Sloping Ceiling) – PIR insulation board is fixed to the underside of rafters with proprietary insulation fixings. The design information stipulates that PIR boards are to be shaped to ensure a proper fit at junctions between elements in different planes.

e. Roof (Flat Ceiling) – Two layers of mineral wool are used to insulate roofs at flat ceiling level. The design calls for an overall insulation thickness of 400 mm with one 200 mm layer between the ceiling joists and another 200 mm layer over the top at 90 degrees. The design also includes details for insulated loft hatches and the provision of storage platforms.

f. Bay and Dormer Windows – The walls or cheeks and roof to bay and dormer windows are insulated with PIR board of a thickness to suit the feature. Boards are shaped at junctions to ensure a proper fit at junctions.

g. Windows and Doors – The design presents a variety of options for the treatment of windows and doors to suit cost and maintenance considerations. These range from the refurbishment of existing windows and the fitting of secondary glazing to complete replacement.

h. No U-value calculations were provided for the design review. However, the Contractor that devised the general insulation strategy indicated that a U-value of 0.15 W/m^2K was expected where 150 mm of PIR is installed to external walls. It was also stated that the U-value would change to 0.25 W/m^2K where 100 mm of PIR is installed.

Thermal Bridging

6. It is evident from inspection of the design information that some consideration had been given to the limiting of thermal bridging. However, no calculations

were made available during the design review to demonstrate that junctions had been formally assessed.

Moisture

7. The internal insulation strategy acknowledged the need to prevent the driving of moisture into the building fabric from the internal conditioned environment. Great emphasis was placed on ensuring the provision of a continuous vapour control layer and air barrier. However, the hygrothermal behaviour of the renovated fabric was not fully evaluated. Any potential risk associated to moisture transfer should have been assessed using hygrothermal simulation because of the existing masonry construction present. The concern with solid wall construction where internal wall insulation is applied is the potential for transport mechanisms to draw moisture from the external environment into the inner layers where it can accumulate. The creation of a vapour barrier prevents moisture within the fabric from evaporating internally and the insulation cools the fabric beyond the insulating layer reducing the outwards drying effect.

Airtightness

8. The design set a general airtightness target to achieve less than 10 $m^3/h.m^2$ @ 50 Pa. This is the same level of performance set by the Building Regulations (HM Government, 2010) as the threshold for new build dwellings.

9. The design uses a drawing with a continuous red line to indicate the position of the air barrier. This is an example of good practice because it clearly communicates an overview of the airtightness strategy.

10. The information provided shows that a number of different approaches are used to improve the airtightness of suspended ground floors after any defective floor boards have been replaced and all old service penetrations are filled. The floors can be overlaid with pre-shrunk hardboard with all joints sealed. Alternatively, each joint between the existing floor boards can be individually sealed. This approach relies on the good quality application of a large quantity of sealant which is very labour intensive. Where PIR boards are fixed to the underside of the floor joists all joints are taped. In all cases the floor edges are sealed to the surrounding masonry walls using expanding foam or sealant to suit the width of any gaps.

11. The Guidance Manual (LATCH, 2012) calls for the patch repointing of masonry where required. This is to reduce air leakage paths through the fabric of existing walls.

12. Air bricks that are not needed to ventilate the building fabric or supply combustion air to appliances are to be sealed. The Guidance Manual (LATCH, 2012) suggests considering the removal of any appliance that requires an air brick to supply combustion air. The proposed method for sealing air bricks is to fill with mineral fibre and internally board or plaster over.

13. The foil faced insulation forms the principal air barrier to the walls. All joints and the heads of mechanical fixings are taped using proprietary foil tape. Membranes taped to the insulation are used at intermediate floors to ensure continuity of the air barrier between storeys. The installation of the membranes requires the cutting back of floorboards to the last joist parallel to the wall.

14. Service penetrations through the air barrier are to be sealed using expanding foam or sealant. Proprietary grommets are also required to seal new service penetrations.

15. Where existing doors and windows are to be retained the elements are refurbished. Repairs and adjustments are undertaken to ensure that the doors and windows are in proper working order. An enhancement is also made to specifically improve the level of airtightness by applying draught stripping.

Ventilation

16. Ventilation strategies differ between development properties. Some incorporate mechanical ventilation heat recovery (MVHR), whereas others have natural supply with mechanical extract. Options are also presented in the Guidance Manual (LATCH, 2012) for continuous mechanical extract ventilation (MEV) or intermittent extract fans.

17. All habitable rooms are to have opening windows irrespective of the type of mechanical ventilation installed.

18. The design approach seeks to ensure that the building fabric is adequately ventilated where required and proposes strategies to coordinate with the thermal upgrading. Baffles made from rigid insulation are used to maintain ventilation to under floor voids where the joist depth is to be filled with mineral wool. Chimneys are ventilated at the top and bottom outside of the thermal envelope to prevent the build up of moisture. This approach ensures that the creation of a thermal bypass is avoided because the chimney is thermally separated from the conditioned rooms.

Services

19. Where an MVHR system is to be installed the Guidance Manual (LATCH, 2012) sets the following requirements:
    a. The system must have a designated electrical circuit.
    b. Boost switches are to be located in the kitchen and bathroom.
    c. All ductwork is to be acoustically insulated.
    d. No windows should be fitted with trickle ventilators.

e. The system must be commissioned with flow measurements taken at both background and boost settings to check compliance with the system design.
f. Occupants must be provided with clear guidance on the effective use of the system.
g. The need for annual maintenance is highlighted.

20. The insulating of water tanks in roof spaces is outlined. The design stipulates that no insulation is to be fitted below a water tank to enable some heat transfer to occur and prevent freezing. PIR insulation boards are fixed to the sides and lid. Continuity with the loft insulation is sought to prevent the creation of a bypass.

21. Outline specifications and basic system schematics are given for the space heating and domestic hot water (DHW) installations. The design documentation expresses the importance of providing energy efficient space heating and DHW systems with effective control. The main components specified are as follows:
    a. Vaillant ecoTEC Plus 831 combi boiler with weather compensation controls
    b. Honeywell programmable room thermostats for two zones
    c. Stelrad Compact radiators with thermostatic radiator valves

22. The design recognises that existing space heating and DHW systems may be retained. Where this is the case, recommendations are given to improve energy efficiency. For example, the need to insulate pipework and hot water storage cylinders is identified.

23. The Guidance Manual (LATCH, 2012) draws attention to health and safety considerations. The potential of finding asbestos containing materials used in existing lagging is highlighted. The possibility that an existing property may have a lead service pipe is identified. The importance of replacing this is communicated and instruction is given on how to take action.

24. Basic advice is provided on minimising water consumption. Low flow taps, dual flush toilets and A++ rated washing machines and dishwashers are all water saving measures identified.

25. Rainwater harvesting is proposed as an option for supplying water to the washing machine and toilet. The Guidance Manual (LATCH, 2012) indicates that the water storage tank and pumping equipment could be located in the basement. The provision of a water tank would necessitate sufficient access to place the item and this is likely to present a significant logistical challenge in many terrace properties.

26. The treatment of existing electrical wiring is described and the need to avoid surround cables with insulation is explained. The documentation identifies the need for all electrical work to be undertaken by a competent person. Instruction is given for the provision of power sockets, light switches and communication points recessed into the new wall insulation.

27. The provision of energy efficient lighting is predominately addressed in the Guidance Manual (LATCH, 2012) with the recommendation to fit low energy replacement lamps to existing fittings. However, some measures are considered where a complete new electrical installation is to be undertaken. These include the use of light sensitive passive infrared sensor controlled lighting to the circulation spaces and the installation of real-time energy monitors. The Guidance Manual (LATCH, 2012) encourages the use of task lighting to reduce energy demand and specifies that power sockets should be positioned close to where task lighting would likely be needed. The need to consider the additional requirements when installing light fittings to bathrooms or fire rated elements is highlighted.

28. The treatment of recessed down lights to insulated ceilings is addressed by the Guidance Manual (LATCH, 2012). Boards spanning between ceiling joists are recommended to support the insulation above the light fitting and create an air void to prevent overheating.

Energy Performance and Carbon Dioxide (CO_2) Emissions Calculations

29. Full renovation of existing domestic properties should be informed by energy performance and CO_2 emissions calculations. These can be used to make comparison between the existing property and the improved dwelling. No energy performance and CO_2 emissions calculations were made available during the design review. The assessment tool RdSAP is intended to support the Green Deal and the Energy Performance Certificate (EPC) output from it forms part of the Green Deal Advice Report (BRE, 2012). Therefore, these assessments will form an important part of future domestic renovation projects.

Project Information

30. The project information provided presents a basic level of information and guidance on the design and physical work activities for the renovation of brick built solid wall terrace properties. The Guidance Manual (LATCH, 2012) conveys health and safety issues, the materials and tools needed and the methods of work to be undertaken. The document is well illustrated with photographs and diagrams. Overall the basic principles for the upgrading of brick built solid wall terrace properties are effectively communicated.

31. Each page of the Guidance Manual (LATCH, 2012) has a unique Quick Response (QR) code (see Figure 3) for use with smart phones installed with a generic QR code reader application. This feature provides the reader of the information with direct access to an electronic copy of the contents of the page. This is a good use of technology to enhance access to project information and it could easily be extended to include drawings and other design documents.

D027
WALL INSULATION
Insulating walls with PIR board

Figure 3 QR Code (LATCH, 2012)

32. The project information contains some prescriptive and performance specification on the drawings and in the Guidance Manual (LATCH, 2012) but this is too general. The conventional production information set containing drawings, a schedule of work and a reference specification that is typical for small scale renovation works should be created to convey project specific information and minimise the potential for misinterpretation of the design intent. The presentation and coordination of design information should follow the guidance set out by the Construction Project Information Committee (2003).

Summary

33. The strategy devised to create low energy and consequently low carbon dwellings by renovating brick built solid wall terrace properties represents significant upgrading works. However, the information provided for this design review suggests that the proposals have not been thoroughly assessed as part of the design process. Energy performance and CO_2 emissions calculations should be used to compare the existing dwelling with a prediction made for any improvements proposed. In addition, the upgrading of individual elements should be assessed for suitability. For example, the hygrothermal behaviour of the renovated building fabric elements should be investigated using appropriate methods. Thermal bridges should be formally assessed where possible.

34. The design strategy takes a holistic approach to airtightness. The information provided for review demonstrates that attention has been paid to detail and a substantial effort has been made to achieve airtightness levels comparable with the regulations for new build properties.

35. The approach to upgrading is pragmatic and the Guidance Manual (LATCH, 2012) communicates the principles well at strategic level and functions partially as a collection of method statements. However, each individual project should have a set of production information specific to the project consisting of drawings, a schedule of work and a reference specification, all of which should be coordinated to industry standards. This would filter out information which is not relevant to the project and allow those undertaking the works to focus on the matters affecting the project.

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HM Government. (2010) *Approved Document L1A: Conservation of Fuel and Power in New Dwellings*. The Building Regulations 2000. London: NBS.

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Appendix D. Co heating report C-01

DECC Green Deal Project

Dwelling C-01: Thermal Performance Testing

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March 2016

TABLE OF CONTENTS

1 Introduction

This report provides the results and analysis of an investigation by a research team from the Centre of the Built Environment (CeBE) at Leeds Beckett University into the pre- and post-retrofit fabric thermal performance of dwelling C-01 in the DECC Green Deal Project. Dwelling C-01 was subject a full house retrofit intended to improve its thermal performance.

2 Test house construction

Latch (Leeds Action to Create Homes) provided the test house C-01 (Figure 1), which is a 2.5 storey (plus basement) back-to-back[1] mid-terrace circa 1900.

Figure 1: Image of the test house

Table 1 provides details of the test house construction and retrofit measures.

Table 1: Test house construction and retrofit measures

Element	Construction (as found)	Retrofit measures
External wall	Solid wall. 225 mm (9 inch) brick stretcher Flemish bond with five stretcher courses to one Flemish course with a ~20 mm plaster internal finish	Internal wall insulation (IWI). Thermal laminate plasterboard comprising 150 mm PIR (λ 0.022) with 12.5 mm plasterboard (λ 0.19)
Roof	Pitch timber roof with slate covering, with 50 x 75 mm rafters at 400 mm centres with lath and plaster finish. The loft is within the thermal envelope and classed as a basic roof room in the RdSAP 2009 methodology. The loft space is separated from the	Ridge soffit: 150 mm PIR (λ 0.022) Sloping ceiling: 100 mm PIR (λ 0.022)

[1] A back-to-back is commonly a terrace house which shares a rear party wall with the house behind it.

	external environment by a sloping ceiling. A lath and plaster knee wall with timber studs (various sizes at irregular intervals) separates the conditioned loft space from an unheated space in the region of the eaves junction. A hardboard soffit separates the conditioned space from the unheated space below ridge level.	Knee wall: 150 mm PIR (λ 0.022)
Ground floor	Suspended timber floor above unheated basement. Comprises timber floor boards on 60 x 175 mm floor joists running parallel to the external wall at mean centres of 420 mm, boarded out on the underside; the floor joists are supported between party walls by a load-bearing internal wall.	175 mm glass mineral wool (λ 0.04) between joists. Underside of floor sealed with 12.5 mm plasterboard (λ 0.19)
Party walls	Solid brick wall (225 mm) with ~10mm wet plaster finish.	None
Fenestrations	uPVC window and door units with double glazing.	None

3 Methodology

3.1 Experimental design

A two stage test programme was designed to measure the improvement in thermal performance resulting from the full-retrofit, the test stages were designated as:

1. Pre-retrofit.
2. Post-retrofit.

The following measurements of thermal performance were taken at each stage of the test programme to assess the effectiveness of the retrofit:

1. *In situ* U-values quantify the thermal transmission of test house's thermal elements.
2. Heat loss coefficient (HLC) is the whole house heat loss (fabric and ventilation) of the test house.
3. Airtightness measurement from which the background ventilation rate of the test house can be derived.

The measurements obtained in the pre-retrofit test stage formed the baseline values of thermal performance from which the effectiveness of the retrofit measures were quantified.

3.2 Methods employed

3.2.1 External environment monitoring

External air temperature, relative humidity, wind speed and wind direction was measured using a Vaisala WXT520 weather transmitter located in the garden of the test house. Solar insolation was measured using a south facing vertically orientated Kipp and Zonen CMP 3 pyranometer. External environmental and temperature measurements were logged at ten minute intervals using an Eltek Squirrel RX250AL data logger. Missing data were corrected using linear interpolation.

3.2.2 Internal environment monitoring

Internal environmental measurements (air temperature, RH, CO_2 concentration) were obtained using an Eltek monitoring system which recorded measurements at one minute intervals to an Eltek Squirrel RX250AL data logger. Missing data were corrected using linear interpolation.

- Internal air temperatures were measured using PT100 RTD temperature sensors (± 0.1 K).
- Internal surface and cavity temperatures were obtained using Type K thermocouples (± 1 K).

3.2.3 Heat loss coefficient (HLC)

Estimates of the HLC for the test house at each test stage were obtained from coheating tests undertaken in accordance with the protocol developed by Leeds Metropolitan (now Beckett) University (refer to Johnston *et al*., 2013).

- The fuzzy logic thermostatic temperature controls were set to ensure the electric resistance heaters maintained a stable internal air temperature.
- Electrical power input to the test dwelling was measured using Elster A100C energy meter which provided one pulse per Wh electrical energy delivered (± 1%).
- Power input was corrected to account for inter-dwelling heat transfer between the test dwelling and its neighbours via the party wall using the heat flux density measured on each party wall.

3.2.4 *In situ* U-value measurement

In situ U-value measurements were undertaken during the coheating tests in accordance with ISO 9869 (ISO, 1994).

- *In situ* measurements of heat flux density, from which *in situ* U-values are derived, were obtained using Hukseflux HFP01 heat flux plates (HFPs. The voltage induced by the HFPs was recorded at one minute intervals by Thermo Fisher Scientific dataTaker DT80 data loggers.
- HFPs were positioned in locations considered to be representative of the whole element, as well as other locations of interest to the research team.
- HFP positioning was informed by the use of a thermographic survey using a Flir B620 thermal imaging camera.
- HFPs were affixed to the surface of each element using thermal compound and adhesive tape.
- The elevated and stable internal temperatures experienced during the coheating test are conducive to obtaining accurate measures *in situ* U-values. Air circulation fans were used during the coheating test to ensure even distribution of temperatures throughout the test dwelling. However, care was taken to ensure that HFPs were not unduly influenced by excessive air movement by positioning fans in such a way that air was not blown directly on to the HFPs.
- To compensate for thermal inertia and storage effects, U-values were calculated using the Average Method contained within ISO 9869; which is a cumulative moving average of measured heat flux and ΔT. To remove the effects of solar radiation, roof U-values were calculated using data recorded overnight.
- Unless otherwise stated the uncertainty associated with *in situ* U-values measured at the location of each HFP is 10%. It must be noted that *in situ* U-values presented may not be representative of the thermal element as a whole, as measurement of heat flux was obtained from only a small proportion of the total party wall surface area.

3.2.5 Background ventilation rate

The background ventilation rate of the test house was derived from the fan pressurisation test air leakage rate at 50 pascals (n_{50}) using the n_{50}/20 rule (refer to Sherman, 1987). The derivation includes the correction factor for dwelling shelter factor which is contained within the SAP 2012 methodology (BRE, 2012). The fan pressurisation tests were undertaken using a blower door in accordance with ATTMA L1 (ATTMA, 2010). The uncertainty associated with this method is highly dependent upon the environmental conditions present during the test.

3.3 Test programme

Table 2 provides details of the significant events in the test programme.

Table 2: Dwelling C-01 test programme

Date	Event
26/02/2013	Pre-retrofit fan pressurisation test.

07/03/2013	Main phase of pre-retrofit thermal performance testing commences.
22/03/2013	Main phase of pre-retrofit thermal performance testing ends.
Spring – Autumn 2013	Retrofit of the test house undertaken
20/01/2014	Post-retrofit fan pressurisation test.
24/01/2014	Main phase of post-retrofit thermal performance testing commences.
02/02/2014	Main phase of post-retrofit thermal performance testing ends.

4 Results and discussion

4.1 *In situ* U-value measurements

4.1.1 External wall

Figure 3 illustrates the region of external wall that was subject to *in situ* U-value measurements. As the test house only has one external wall, of which a high proportion are openings, placement of HFPs was severely restricted.

Figure 3: Area of external wall subject to U-value measurements (marked in black)

Figure 4 illustrates the pre-retrofit external wall *in situ* U-value measured at each HFP location with a corresponding thermogram of the measurement area.

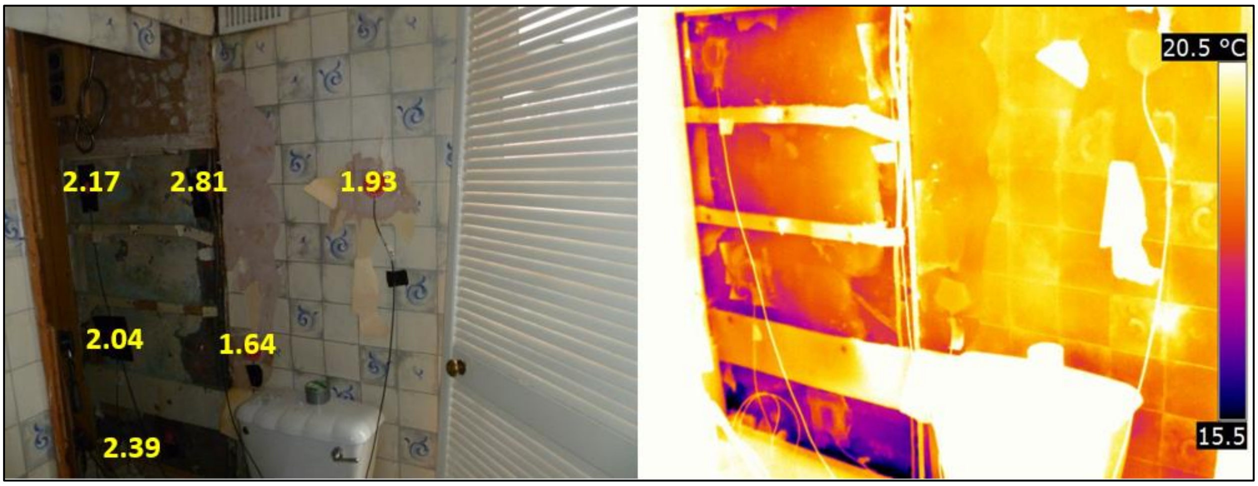

Figure 4: Annotated image and thermogram showing the pre-retrofit external wall U-value measurements

The thermogram in Figure 4 reveals a high level of thermal inconsistency across the pre-retrofit external wall, which is reflected in the large range of *in situ* U-value measurements (1.64 – 2.81 W/m^{2}K). The lowest in situ U-values were measured at locations on the smooth plaster finish; although the size of the discrepancy measured at the location of the greatest outlier cannot be explained by the reduction in resistance attributed to the missing plaster layer[2]. The highest in situ U-values were measured at locations on the exposed brickwork.

The mean of the pre-retrofit external wall *in situ* U-values is 2.16 W/m²K, this is reduced to 2.08 W/m²K when adjusted to account for the missing plaster at some measurement locations.

The pre-retrofit external wall U-value of 2.08 W/m²K is in reasonable agreement with the RdSAP assumed U-value of 2.10 W/m²K.

Figure 5 illustrates the post-retrofit external wall *in situ* U-value measured at each HFP location with corresponding thermograms of the measurement locations.

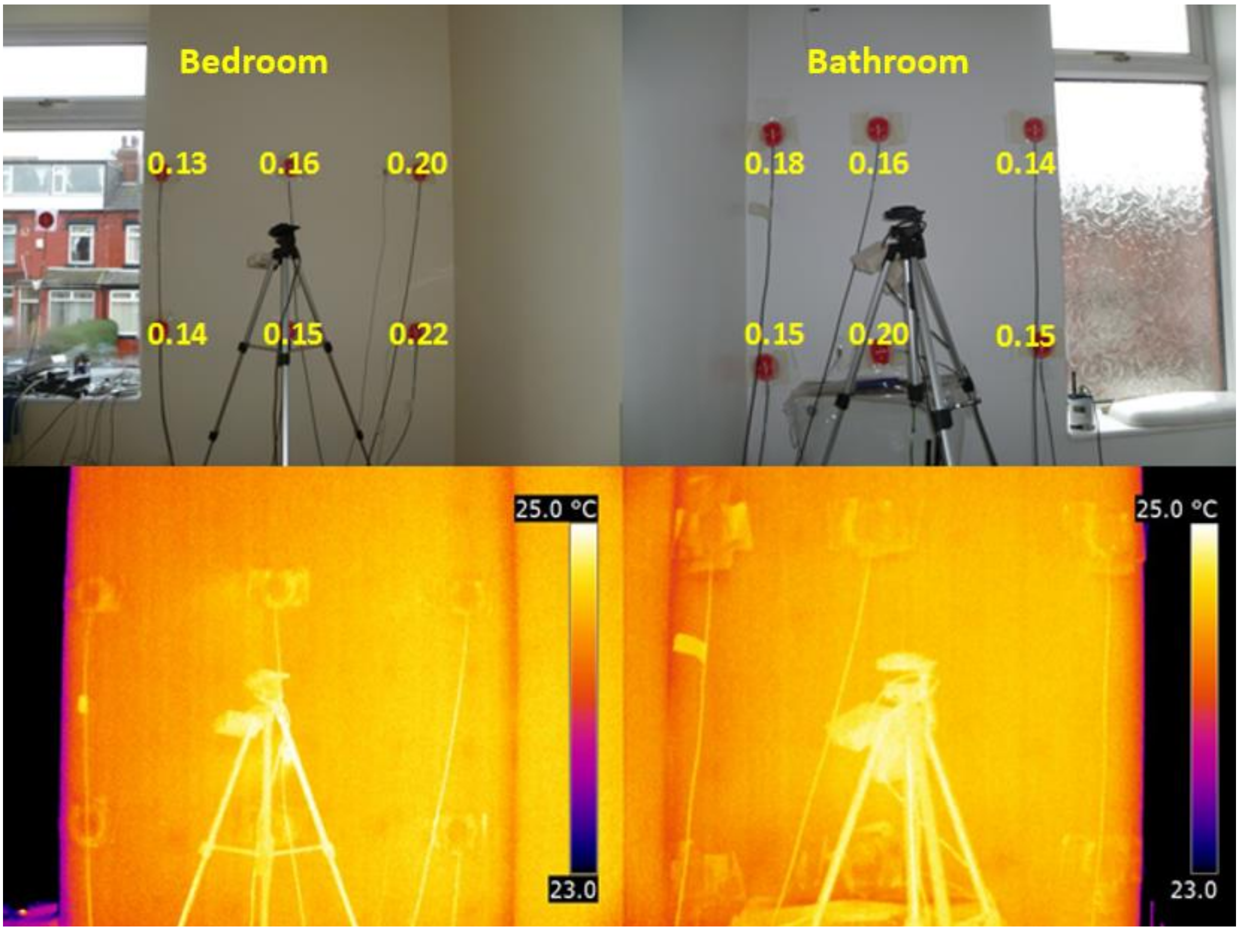

Figure 5: Annotated images and thermograms showing the post-retrofit external wall U-value measurements

The U-values measured close to the reveals are not considered representative of the majority of the external wall locations as they are affected by non-perpendicular heat flow at the jambs.

The mean of post-retrofit external wall *in situ* U-value measurements is 0.18 W/m²K[3].

The thermograms in Figure 5 suggests a very high level of thermal consistency across the measured wall; though the distribution of *in situ* U-values measured seen in Figure 6 shows this not to be the case.

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[2] The plaster coat above the toilet appears to have been applied relatively recently in the dwelling's history and is most likely gypsum based. Assuming a plaster layer depth of 20 mm and thermal conductivity of 0.51 W/mK, the addition of a layer of plaster would lower the measured U-value of 2.81 W/m²K to 2.53 W/m²K.

[3] The measurements taken at the location of HFPs close to the window reveals are not included in the calculation of the *in situ* wall U-value as the non-perpendicular heat flow at these locations should be accounted for in thermal bridging calculations.

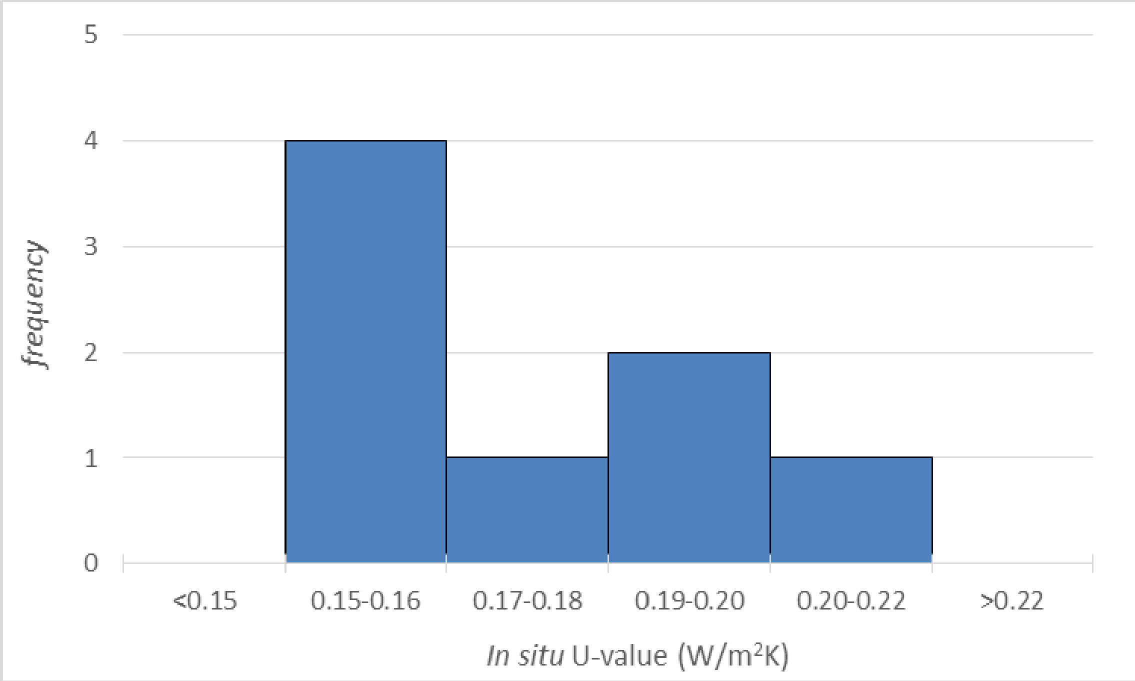

Figure 6: Frequency distribution of the post-retrofit external wall *in situ* U-values

Table 3 provides details of the calculated and measured increase in thermal performance of the external wall.

Table 3: Comparison between the calculated and measured change in external wall thermal performance

Pre-retrofit measured U-value (W/m^2K)	Pre-retrofit measured R-value (K/Wm^2)	Calculated resistance of retrofit measures (K/Wm^2)	Post-retrofit calculated R-value (K/Wm^2)	Post-retrofit calculated U-value (W/m^2K)	Post-retrofit measured U-value (W/m^2K)	Measured increase in R-value (K/Wm^2)	R-value increase performance gap (%)
2.08	0.48	6.88	7.36	0.14	0.18	5.40	26

From Table 3 it can be seen that that there was a 26% performance gap between the calculated and measured increase in thermal resistance (R-value). The reason for the discrepancy could not be ascertained using the non-destructive test methods available to the research team. There is low confidence in the pre-retrofit U-value (thus R-value); however, it is highly unlikely that magnitude of the performance gap could be explained by an incorrect estimation of the pre-retrofit R-value due to the relatively low R-value of the baseline external wall compared with retrofit materials.

Figure 7 reveals that the location at which the greatest *in situ* U-value was measured is close to a point of air infiltration which was observed when the test house was being artificially depressurised. The movement of cool air around the insulation is a possible cause of the underperformance measured.

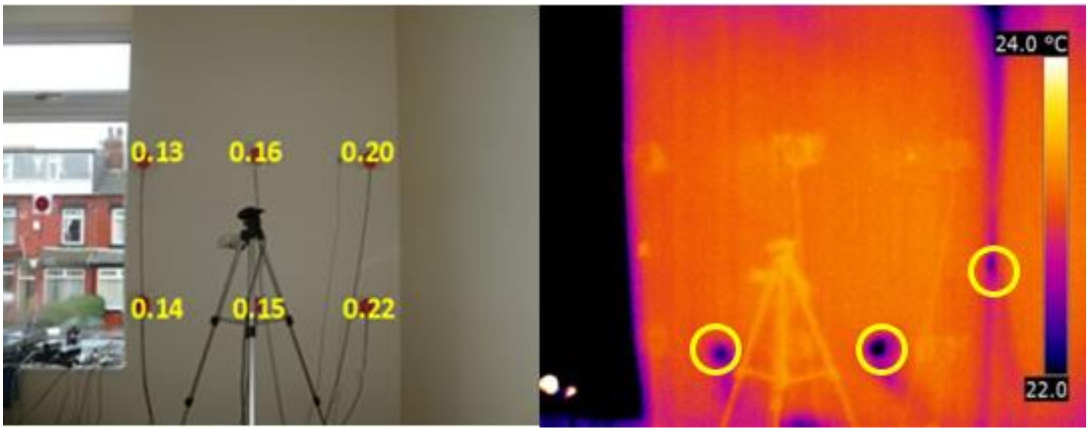

Figure 7: Proximity of the greatest post-retrofit external wall *in situ* U-value to air infiltration points observed using thermography during building depressurisation (locations circled)

4.1.2 Other thermal elements

Table 4 presents the *in situ* U-value measurements of other the thermal elements which comprise the test house.

Table 4: Pre- and post-retrofit *in situ* U-values for elements other than the external walls of the test house[4]

Thermal element	**Pre-retrofit *in situ* U-value (W/m^2K)**	**Post-retrofit *in situ* U-value (W/m^2K)**	**Calculated post-retrofit U-value target (W/m^2K)**
Ground floor	1.14	0.19	0.19
Roof (ridge soffit)	1.28	0.11	0.13
Roof (sloping ceiling)	1.52	0.32	0.19
Bay window wall	2.38	0.14	0.14
Bay window roof	0.78	0.12	0.12
Glazing (centre pane)	3.02	n/a	n/a
Loft knee wall	2.04	n/a	0.14
Dormer wall	n/a	0.12	n/a
Dormer roof	n/a	0.12	n/a
Dormer cheek	n/a	0.16	n/a

Figure 8 shows that other than the external wall, the thermal element to measure a significant underperformance was the sloping ceiling section of the roof (46%). The reason for this and the measured increase in R-value of the roof at ridge level being greater than that calculated is not known.

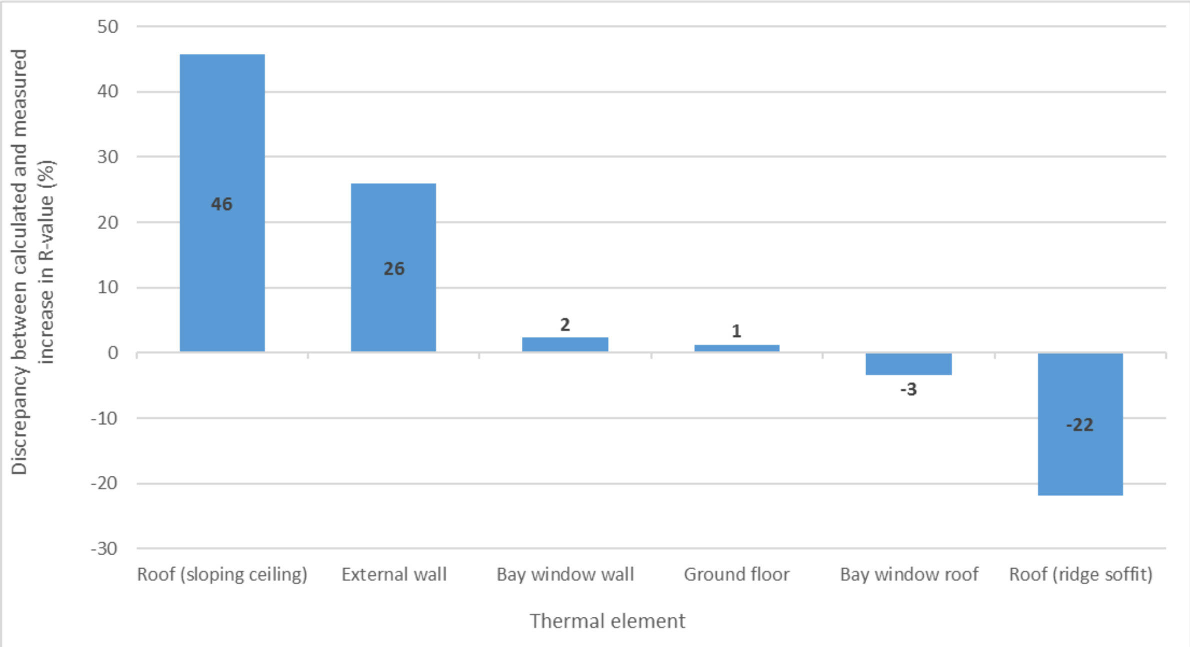

Figure 8: Percentage discrepancy between the calculated and measured increase in R-value of the test house's thermal elements

[4] The ground floor U-values provided are location specific and not applicable to the entire ground floor area.

Roof and ground floor U-values do not include thermal bridging through structural timber.

4.2 Heat loss coefficient

4.2.1 Coheating test result

The linear regression based HLC estimates derived from the coheating tests undertaken during the pre-retrofit and post-retrofit test stages are illustrated in Figure 9.

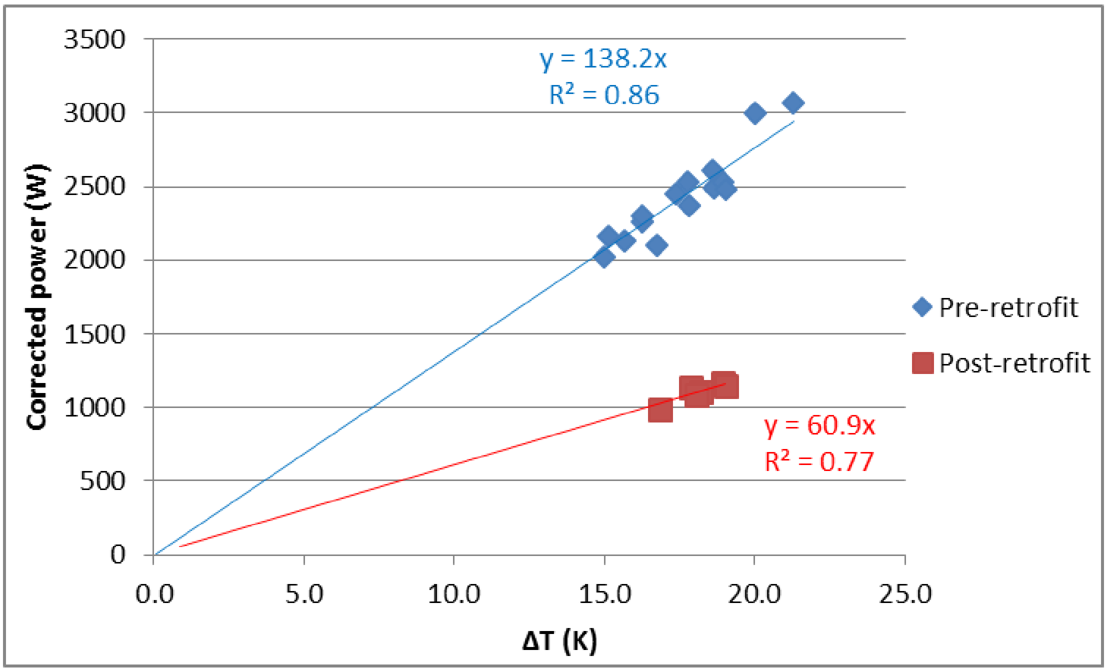

Figure 9: Linear regression HLC estimates for the test house during the pre-retrofit and post-retrofit test stages

The pre-retrofit HLC of 138.2 (± 2.8) W/K reduced to 60.9 (± 1.2) W/K post-retrofit, this represents a 56% reduction in the test house HLC. It was not possible to compare the coheating test result with a predicted HLC as a full set of thermal bridging calculations have not been completed for the test dwelling.

4.2.2 Background ventilation heat loss

Figure 10 illustrates the 62% reduction in background ventilation rate following the retrofit. For more details of the fan pressurisation tests performed on Dwelling C-01 from which the background ventilation rate was derived, please refer to Appendix B of the main report.

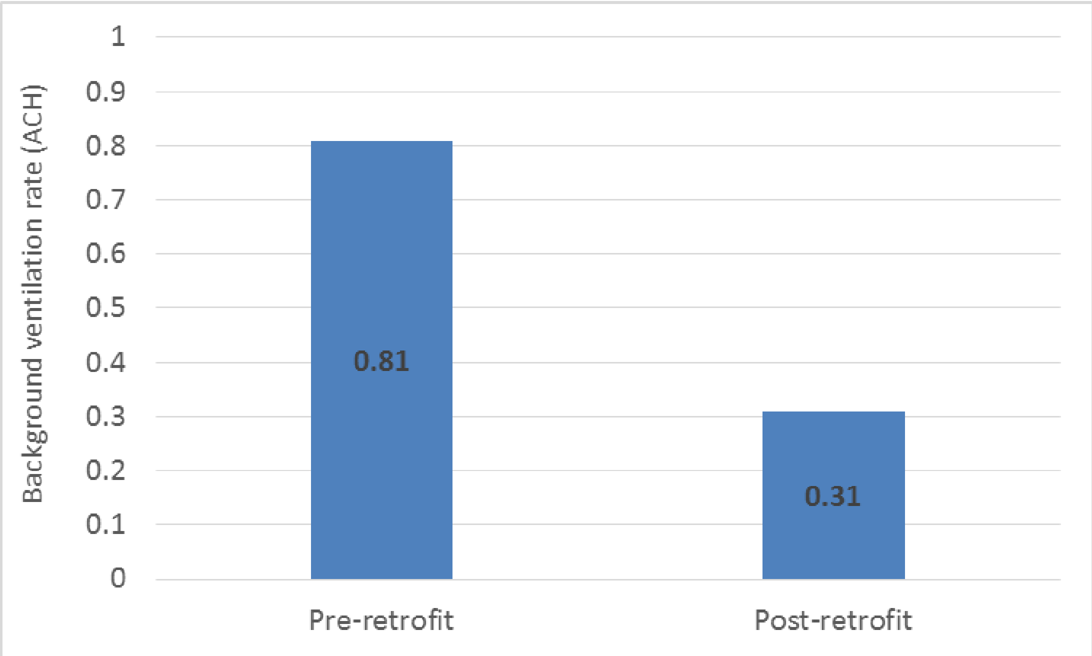

Figure 10: Pre- and post-retrofit background ventilation rate

Table 5 provides background ventilation heat loss derived from the fan pressurisation test for each of the test stages.

Table 5: Test house background ventilation heat loss derived from building pressurisation tests pre- and post-retrofit

	Test stage	
	Pre-retrofit	**Post-retrofit**
Ventilation rate [n_{50}] (ACH @ 50 Pa)	20.85	7.99
Sheltered sides [S_s]	3	3
Sheltering factor [S_f] [1-(S_s*0.075)]	0.775	0.775
Background ventilation rate [(n_{50}/20)*S_f] (ACH)	0.81	0.31
Dwelling volume (m^3)	146	146
Background Ventilation Heat Loss (W/K) [ACH*0.33*volume]	38.9	14.9

Table 6 provides details of the disaggregation of the fabric and ventilation heat loss components of the HLC measured during the pre- and post-retrofit test stages.

Table 6: Disaggregation of the HLC measured in the pre- and post-retrofit test stages into fabric and ventilation heat loss

Test stage	**Heat loss coefficient (W/K)**	**Ventilation heat loss (W/K)**	**Fabric heat loss (W/K)**
Pre-retrofit	138.2	38.9	99.3
Post-retrofit	60.9	14.9	46
Reduction on pre-retrofit (W/K)	77.3	24	53.3

Figure 11 visualises the contribution of fabric and background ventilation heat loss reductions to the overall HLC reduction.

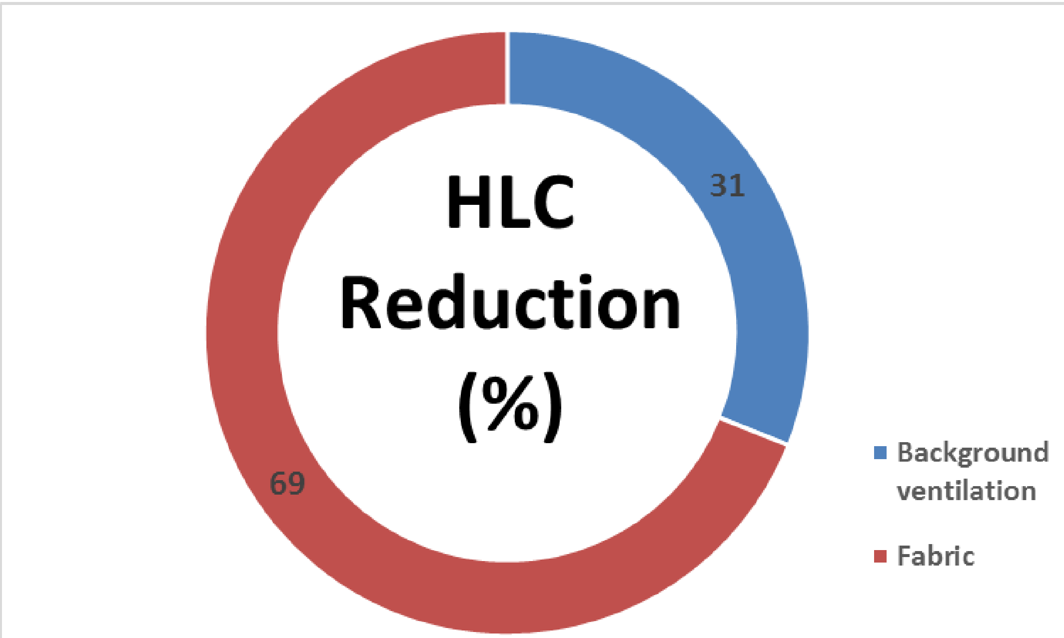

Figure 11: Contribution of the reduction in fabric and background ventilation heat loss reductions to the overall HLC reduction

5 Conclusions

The thermal performance testing demonstrated the potential for dwellings of this type to achieve significant reductions in heat loss at both a whole house and elemental level.

The fabric performance gap, previously identified in the new build sector, exists in retrofit. The retrofit was performed with high attention to detail, yet significant underperformance was measured by the external walls.

6 References

International Organization for Standardization (1994) **Thermal insulation – Building elements - In situ measurement of thermal resistance and thermal transmittance.** Geneva, Switzerland, ISO.

Johnston, D. Miles-Shenton, D. Farmer, D. and Wingfield, J. (2013 b) **Whole House Heat Loss Test Method (Coheating).** June 2013. Leeds, UK, Centre for the Built Environment, Leeds Metropolitan University.

Appendix E. Co heating report C-02

DECC Green Deal Project

Dwelling C-02: Thermal Performance Testing

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March 2016

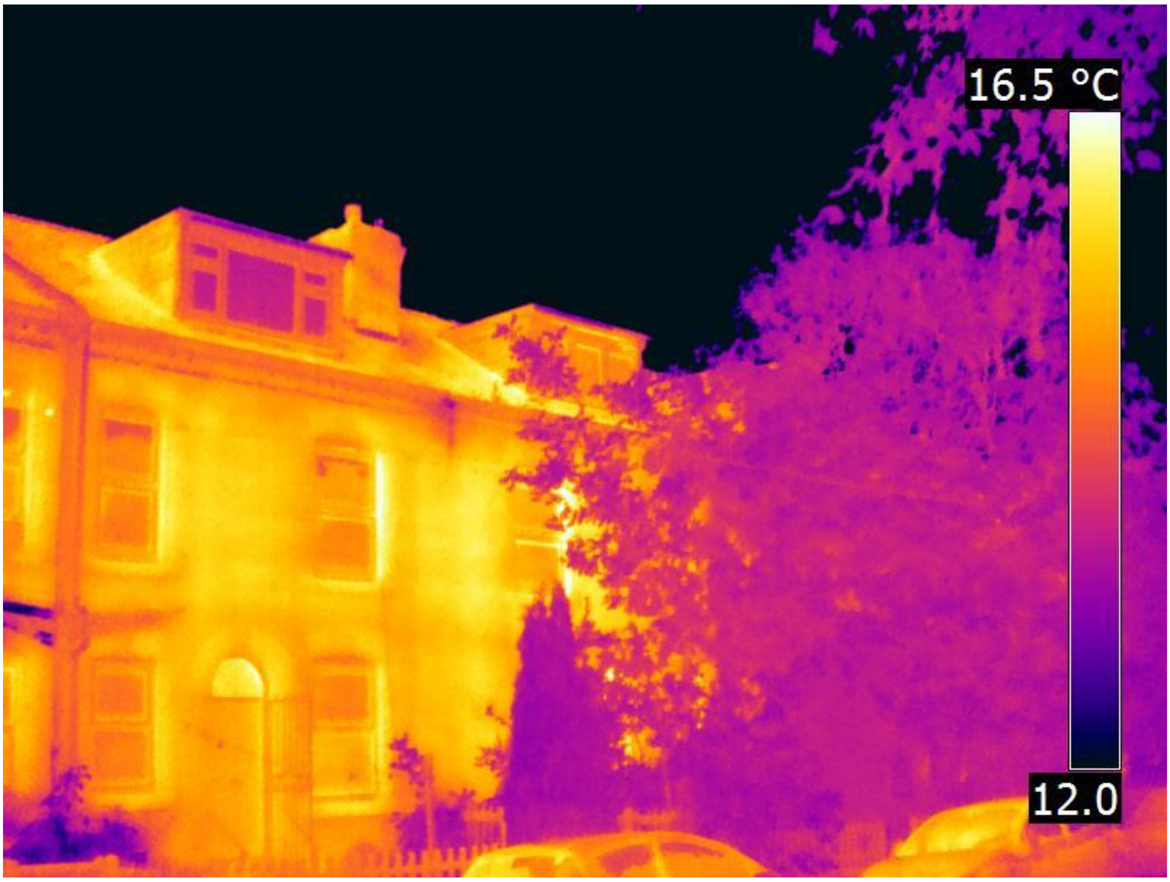


TABLE OF CONTENTS

1 Introduction

This report provides the results and analysis of an investigation by a research team from the Centre of the Built Environment (CeBE) at Leeds Beckett University into the pre- and post-retrofit fabric thermal performance of dwelling C-02 in the DECC Green Deal Project. Dwelling C-02 was subject a full house retrofit intended to improve its thermal performance.

2 Test house construction

Latch (Leeds Action to Create Homes) provided the test house C-02 (Figure 1), which is a 2.5 storey (plus basement) back-to-back[1] mid-terrace circa 1900.

Figure 1: Image of the test house

Table 1 provides details of the test house construction and retrofit measures.

Table 1: Test house construction and retrofit measures

Element	Construction (as found)	Retrofit measures
External wall	Solid wall. 225 mm (9 inch) brick stretcher Flemish bond with five stretcher courses to one Flemish course with a ~20 mm plaster internal finish	Internal wall insulation (IWI). Thermal laminate plasterboard comprising 60 mm PIR (λ 0.022) with 12.5 mm plasterboard (λ 0.19)

[1] A back-to-back is commonly a terrace house which shares a rear party wall with the house behind it.

Roof	Pitch timber roof with slate covering with dormer window. The loft is within the thermal envelope and classed as a basic roof room in the RdSAP 2009 methodology. The loft space is separated from the external environment by a sloping ceiling. A lath and plaster knee wall with timber studs (various sizes at irregular intervals) separates the conditioned loft space from an unheated space in the region of the eaves junction. A hardboard soffit separates the conditioned space from the unheated space below ridge level.	Ridge soffit: 300 mm glass mineral wool (λ 0.04) Sloping ceiling: 50 mm PIR (λ 0.022) between rafters - 25mm air gap - multi-foil insulation. Knee wall: Dormer: 50 mm PIR (λ 0.022) between rafters - 25mm air gap - multi-foil insulation.
Ground floor	Suspended timber floor above unheated basement. Comprises timber floor boards on 60 x 150 mm floor joists running parallel to the external wall, the floor joists are supported between party walls by a load-bearing internal wall which prevents access to ~ 2/3 of the basement	150 mm mineral wool (assumed λ 0.04) suspended between joists on mesh.
Party walls	Solid brick wall (225 mm) with ~10mm wet plaster finish.	None
Fenestrations	uPVC window units with double glazing. Timber front door	Replacement solid panelled composite front door

3 Methodology

3.1 Experimental design

A two stage test programme was designed to measure the improvement in thermal performance resulting from the full-retrofit, the test stages were designated as:

1. Pre-retrofit.
2. Post-retrofit.

The following measurements of thermal performance were taken at each stage of the test programme to assess the effectiveness of the retrofit:

1. *In situ* U-values quantify the thermal transmission of test house's thermal elements.
2. Heat loss coefficient (HLC) is the whole house heat loss of the test house.
3. Airtightness measurement from which the background ventilation rate of the test house can be derived.

The measurements obtained in the pre-retrofit test stage formed the baseline values of thermal performance from which the effectiveness of the retrofit measures were quantified.

3.2 Methods employed

3.2.1 External environment monitoring

External air temperature, relative humidity, wind speed and wind direction was measured using a Vaisala WXT520 weather transmitter located in the garden of the test house. Solar insolation was measured using a south facing vertically orientated Kipp and Zonen CMP 3 pyranometer. External environmental and temperature measurements were logged at ten minute intervals using an Eltek Squirrel RX250AL data logger. Missing data were corrected using linear interpolation.

3.2.2 Internal environment monitoring

Internal environmental measurements (air temperature, RH, CO_2 concentration) were obtained using an Eltek monitoring system which recorded measurements at one minute intervals to an Eltek Squirrel RX250AL data logger. Missing data were corrected using linear interpolation.

- Internal air temperatures were measured using PT100 RTD temperature sensors (± 0.1 K).
- Internal surface and cavity temperatures were obtained using Type K thermocouples (± 1 K).

3.2.3 Heat loss coefficient (HLC)

Estimates of the HLC for the test house at each test stage were obtained from coheating tests undertaken in accordance with the protocol developed by Leeds Metropolitan (now Beckett) University (refer to Johnston *et al*., 2013).

- The fuzzy logic thermostatic temperature controls were set to ensure the electric resistance heaters maintained a stable internal air temperature.
- Electrical power input to the test dwelling was measured using Elster A100C energy meter which provided one pulse per Wh electrical energy delivered (± 1%).
- Power input was corrected to account for inter-dwelling heat transfer between the test dwelling and its neighbours via the party wall using the heat flux density measured on each party wall.

3.2.4 *In situ* U-value measurement

In situ U-value measurements were undertaken during the coheating tests in accordance with ISO 9869 (ISO, 1994).

- *In situ* measurements of heat flux density, from which *in situ* U-values are derived, were obtained using Hukseflux HFP01 heat flux plates (HFPs. The voltage induced by the HFPs was recorded at one minute intervals by Thermo Fisher Scientific dataTaker DT80 data loggers.
- HFPs were positioned in locations considered to be representative of the whole element, as well as other locations of interest to the research team.
- HFP positioning was informed by the use of a thermographic survey using a Flir B620 thermal imaging camera.
- HFPs were affixed to the surface of each element using thermal compound and adhesive tape.
- The elevated and stable internal temperatures experienced during the coheating test are conducive to obtaining accurate measures *in situ* U-values. Air circulation fans were used during the coheating test to ensure even distribution of temperatures throughout the test dwelling. However, care was taken to ensure that HFPs were not unduly influenced by excessive air movement by positioning fans in such a way that air was not blown directly on to the HFPs.
- To compensate for thermal inertia and storage effects, U-values were calculated using the Average Method contained within ISO 9869; which is a cumulative moving average of measured heat flux and ΔT. To remove the effects of solar radiation, roof U-values were calculated using data recorded overnight.
- Unless otherwise stated the uncertainty associated with *in situ* U-values measured at the location of each HFP is 10%. It must be noted that *in situ* U-values presented may not be representative of the thermal element as a whole, as measurement of heat flux was obtained from only a small proportion of the total party wall surface area.

3.2.5 Background ventilation rate

The background ventilation rate of the test house was derived from the fan pressurisation test air leakage rate at 50 pascals (n_{50}) using the n_{50}/20 rule (refer to Sherman, 1987). The derivation includes the correction factor for dwelling shelter factor which is contained within the SAP 2012 methodology (BRE, 2012). The fan pressurisation tests were undertaken using a blower door in accordance with ATTMA L1 (ATTMA, 2010). The uncertainty associated with this method is highly dependent upon the environmental conditions present during the test.

3.3 Test programme

Table 2 provides details of the significant events in the test programme.

Table 2: Dwelling C-02 test programme

Date	Event
30/09/2013	Initial pre-retrofit fan pressurisation test.

02/10/2013	Main phase of pre-retrofit thermal performance testing commenced.
20/10/2013	Main phase of pre-retrofit thermal performance testing ended.
21/10/2013	Second pre-retrofit fan pressurisation test.
	Retrofit of the test house undertaken
02/04/2014	Initial post-retrofit fan pressurisation test.
03/04/2014	Main phase of post-retrofit thermal performance testing commenced.
10/04/2014	Main phase of post-retrofit thermal performance testing ended.
11/04/2014	Saint-Gobain QUB test period commenced
14/04/2014	Saint-Gobain QUB test period ended.
14/04/2014	Final post-retrofit fan pressurisation test.

4 Results and discussion

4.1 *In situ* U-value measurements

Figure 2 illustrates the region of external wall that was subject to U-value measurements. As the test house only had one external wall, of which a high proportion are openings, placement of HFPs was restricted.

Figure 2: Area of external wall subject to U-value measurements (black regions – pre-retrofit, white region – post-retrofit)

Figure 3 illustrates the pre-retrofit external wall *in situ* U-value measured at each HFP location on the ground floor with a corresponding thermogram of the measurement area.

Figure 3: Annotated image and thermogram showing the ground floor pre-retrofit external wall U-value measurements

Figure 4 illustrates the pre-retrofit external wall *in situ* U-value measured at each HFP location on the first floor with a corresponding thermogram of the measurement area.

Figure 4: Annotated image and thermogram showing the first floor pre-retrofit external wall U-value measurements

The mean pre-retrofit external wall U-value of 1.57 W/m²K is substantially lower than the RdSAP assumed U-value of 2.10 W/m²K.

The frequency distribution in Figure 5 suggests that the mean external *in situ* U-value of 1.57 W/m²K is reasonably representative of the sample area.

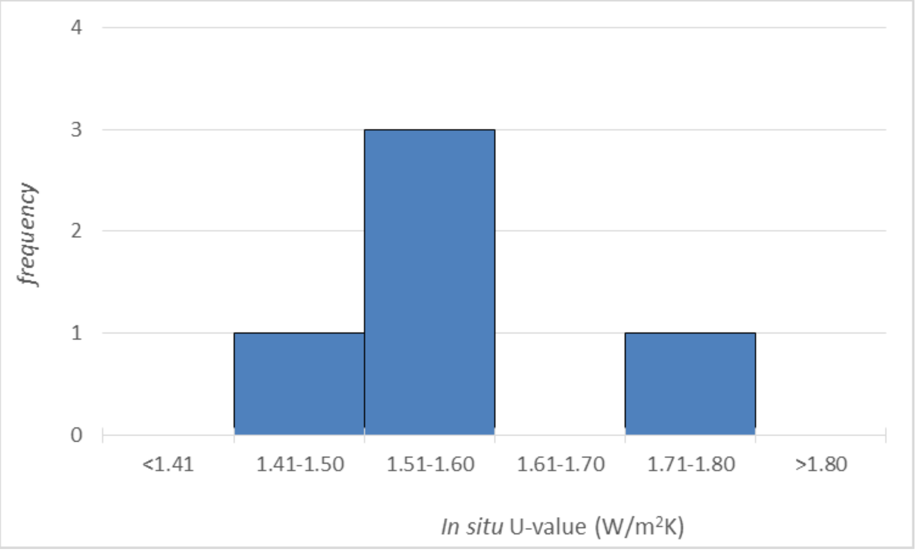


Figure 5: Frequency distribution of the pre-retrofit external wall *in situ* U-values

Figure 6 illustrates the post-retrofit external wall *in situ* U-value measured at each HFP location with corresponding thermogram of the measurement location.

Figure 6: Annotated image and thermogram showing the post-retrofit external wall U-value measurements

The mean of post-retrofit external wall *in situ* U-value measurements is 0.31 W/m²K.

The thermogram in Figure 6 shows a high level of thermal consistency across the measurement area post-retrofit, which was also observed pre-retrofit (Figure 4). Figure 7 shows the post-retrofit external wall *in situ* U-values to be normally distributed. A Shapiro-Wilks test also suggested that the sample is normally distributed (p-0.953). The distribution suggests that the mean external wall *in situ* U-value of 0.31 W/m²K is representative of the measurement area.

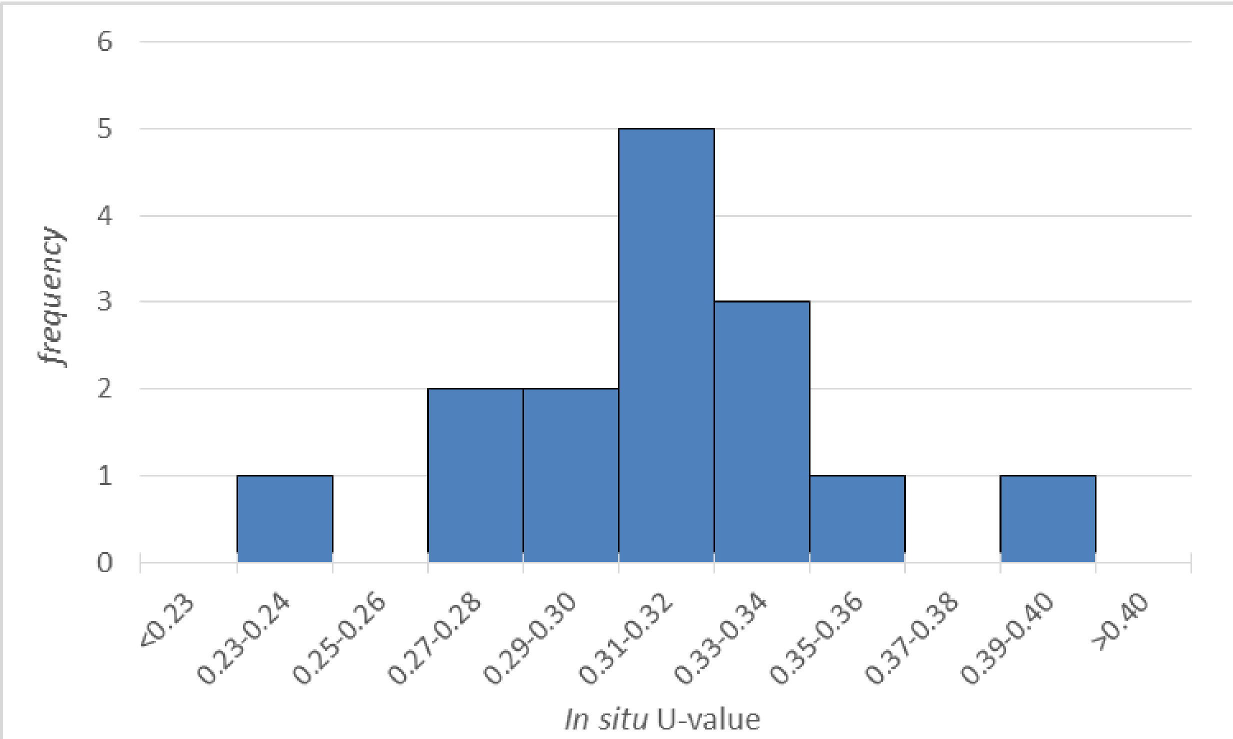


Figure 7: Frequency distribution of the post-retrofit external wall *in situ* U-values

Table 3 provides details of the calculated and measured increase in thermal performance of the external wall.

Table 3: Comparison between the calculated and measured change in external wall thermal performance

Pre-retrofit external wall U-value (W/m^2K)	Pre-retrofit external wall R-value (K/Wm^2)	Calculated resistance of retrofit measures (K/Wm^2)	Post-retrofit external wall calculated R-value (K/Wm^2)	Post-retrofit external wall calculated U-value (W/m^2K)	Post-retrofit external wall-value (W/m^2K)	Measured increase in R-value (K/Wm^2)	R-value performance gap (%)
1.57	0.64	2.78[2]	3.44	0.29	0.31	2.59	7

From Table 3 it can be seen that that there was a 7% performance gap between the calculated and measured increase in R-value which is within the uncertainty associated with the measurement.

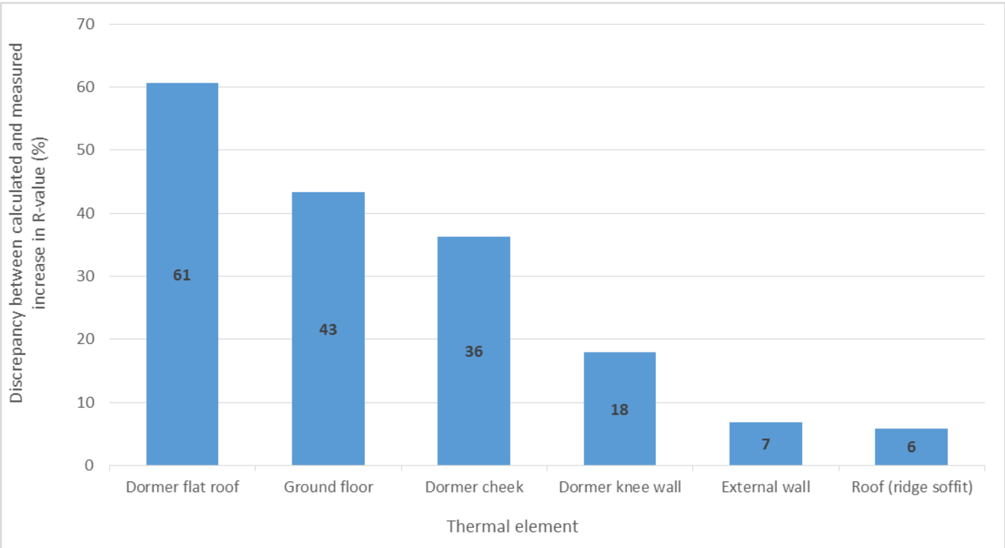
4.1.1 Other thermal elements

Table 4 presents the in situ U-value measurements of other the thermal elements which comprise the test house. All of the measurements undertaken on the roof components pre-retrofit were substantially below the RdSAP value of 2.30 W/m^2K.

Table 4: Pre- and post-retrofit in situ U-values for elements other than the external walls of he test house[3]

Thermal element	**Pre-retrofit *in situ* U-value (W/m^2K)**	**Post-retrofit *in situ* U-value (W/m^2K)**	**Calculated post-retrofit U-value target (W/m^2K)**
Ground floor[4]	1.00	0.32	0.21
Roof (ridge soffit)	0.34	0.10	0.10
Dormer knee wall	0.59	0.27	0.24
Dormer cheek	0.41	0.25	0.20
Dormer flat roof	1.48	0.61	0.32
Roof (sloping ceiling)	n/a	0.15	n/a

Figure 8 shows that the only thermal elements retrofitted, where comparable measurements were undertaken pre- and post-retrofit, that did not measure a statistically significant performance gap were the external wall and the roof ridge soffit.



[2] Includes adjustment to account for removal of original plaster layer prior retrofit. Assumed plaster layer of ½” with λ 0.051 W/mK.

[3] The ground floor U-values provided are location specific and not applicable to the entire ground floor area.

Roof and ground floor U-values do not include thermal bridging through structural timber.

[4]It must be noted that it was only possible to insulate only ~1/3 of the ground floor due to the basement layout.

Figure 8: Percentage discrepancy between the calculated and measured increase in R-value of the test house's thermal elements

4.2 Heat loss coefficient

4.2.1 Coheating test result

The linear based HLC estimates derived from the coheating tests undertaken during the pre-retrofit and post-retrofit test stages are illustrated in Figure 9.

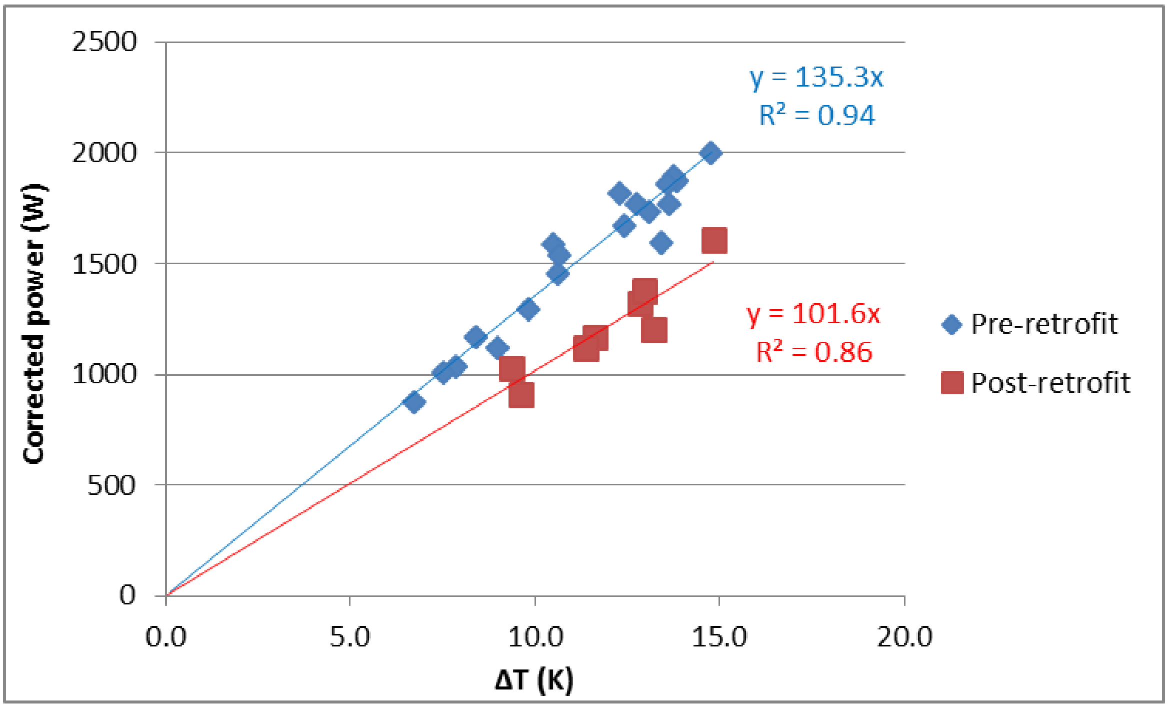


Figure 9: Linear regression HLC estimates for the test house during the pre-retrofit and post-retrofit test stages

The pre-retrofit HLC of 135.3 (± 2.5) W/K reduced to 101.6 (± 3.8) W/K post-retrofit, this represents a 25% reduction in the test house HLC. It was not possible to compare the coheating test result with a predicted HLC as a full set of thermal bridging calculations have not been completed for the test dwelling.

4.2.2 Background ventilation heat loss

Figure 10 illustrates

Figure 10: Pre- and post-retrofit background ventilation rate

Table 4 provides background ventilation heat loss derived from the fan pressurisation test for each of the test stages. A 13% reduction in background ventilation rate was achieved by the retrofit. For more details of the fan pressurisation tests performed on Dwelling C-02 from which the background ventilation rate was derived, please refer to Appendix B of the main report.

Table 4: Test house background ventilation heat loss derived from building pressurisation tests pre- and post-retrofit

	Test stage	
	Pre-retrofit	**Post-retrofit**
Ventilation rate [n_{50}] (ACH @ 50 Pa)	30.19	26.36
Sheltered sides [S_s]	3	3
Sheltering factor [S_f] [1-(S_s*0.075)]	0.775	0.775
Background ventilation rate [(n_{50}/20)*S_f] (ACH)	1.17	1.02
Dwelling volume (m^3)	145	145

Background Ventilation Heat Loss (W/K) [ACH*0.33*volume]	56	48.9

Table 5 provides details of the disaggregation of the fabric and ventilation heat loss components of the HLC measured during the pre- and post-retrofit test stages.

Table 5: Disaggregation of the HLC measured in the pre- and post-retrofit test stages into fabric and ventilation heat loss

Test stage	Heat loss coefficient (W/K)	Ventilation heat loss (W/K)	Fabric heat loss (W/K)
Pre-retrofit	135.3	56	79.3
Post-retrofit	101.6	48.9	52.7
Reduction on pre-retrofit (W/K)	33.7	7.1	26.7

Figure 10 visualises the contribution of fabric and background ventilation heat loss reductions to the overall HLC reduction.

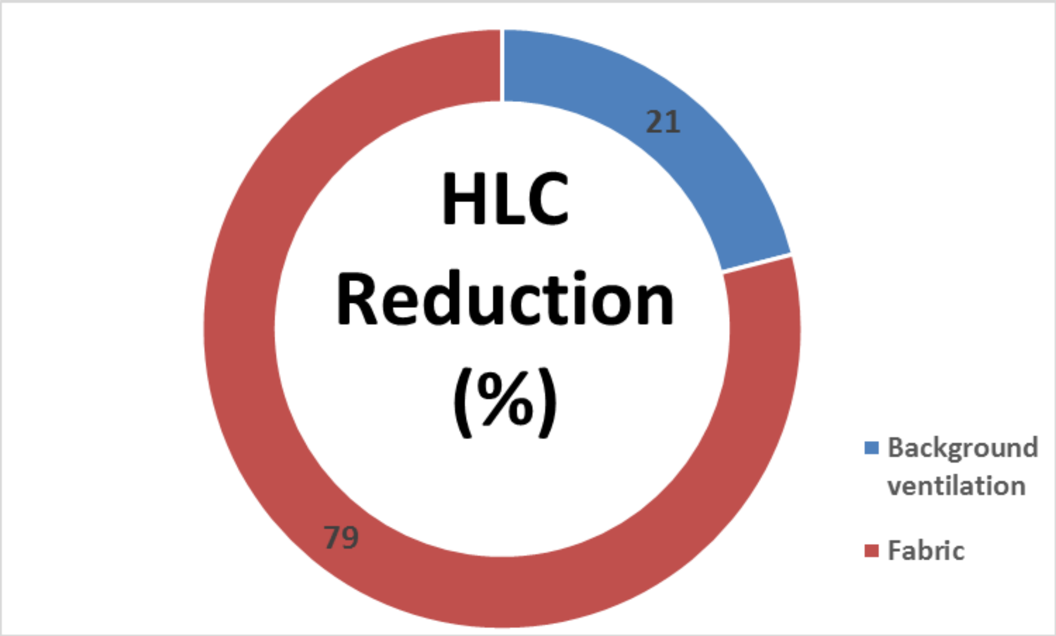


Figure 10: Contribution of the reduction in fabric and background ventilation heat loss reductions to the overall HLC reduction

5 Conclusions

The performance gap has the potential to reduce the effectiveness of retrofit. The 25% reduction in HLC of the test house could have been greater if not for the performance gap measured on the majority of the thermal elements.

The external wall and roof pre-retrofit U-values were substantially below what is predicted by RdSAP. This could result in RdSAP overestimating of heat loss of houses similar to the test house in its pre-retrofit condition.

6 References

International Organization for Standardization (1994) **Thermal insulation – Building elements - In situ measurement of thermal resistance and thermal transmittance.** Geneva, Switzerland, ISO.

Johnston, D. Miles-Shenton, D. Farmer, D. and Wingfield, J. (2013 b) **Whole House Heat Loss Test Method (Coheating).** June 2013. Leeds, UK, Centre for the Built Environment, Leeds Metropolitan University.

Appendix F. Co heating report C-03

DECC Green Deal Project

Dwelling C-03: Thermal Performance Testing.

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TABLE OF CONTENTS

1 Introduction

This report provides the results and analysis of an investigation by a research team from the Centre of the Built Environment (CeBE) at Leeds Beckett University into the heat loss from the masonry cavity party walls of dwelling C-03 in the DECC Green Deal Project. One party wall was subject to a series of retrofit measures intended to reduce heat loss attributable to the party wall thermal bypass mechanism.

2 Background

The party wall cavity convective thermal bypass mechanism (Figure 1) was identified by Socolow (1977) and Harrje *et al*. (1979), and initially measured by Sivior (1994). Research by CeBE (Wingfield *et al.*, 2007 and 2009) provided evidence that the party wall bypass was responsible for a significant proportion of the discrepancy between the predicted and measured heat loss from new build dwellings. This body of research suggested that a party wall with an unsealed and unfilled cavity has a U-value of ~0.50 W/m^{2}K; that a party wall cavity with effective edge sealing has a U-value of ~0.20 W/m^{2}K; and a fully-filled and effectively sealed party wall cavity has U-value of ~0 W/m^{2}K. These findings prompted the inclusion of party wall bypass heat losses into Part L1A of the Building Regulations (HM Government, 2010). Further research by CeBE strongly suggested that fully-filling the party wall cavity in existing dwellings can eliminate the bypass mechanism (Farmer, Miles-Shenton & Peat, 2013); however, the nature of this project meant it was not possible to confidently measure *in situ* U-values.

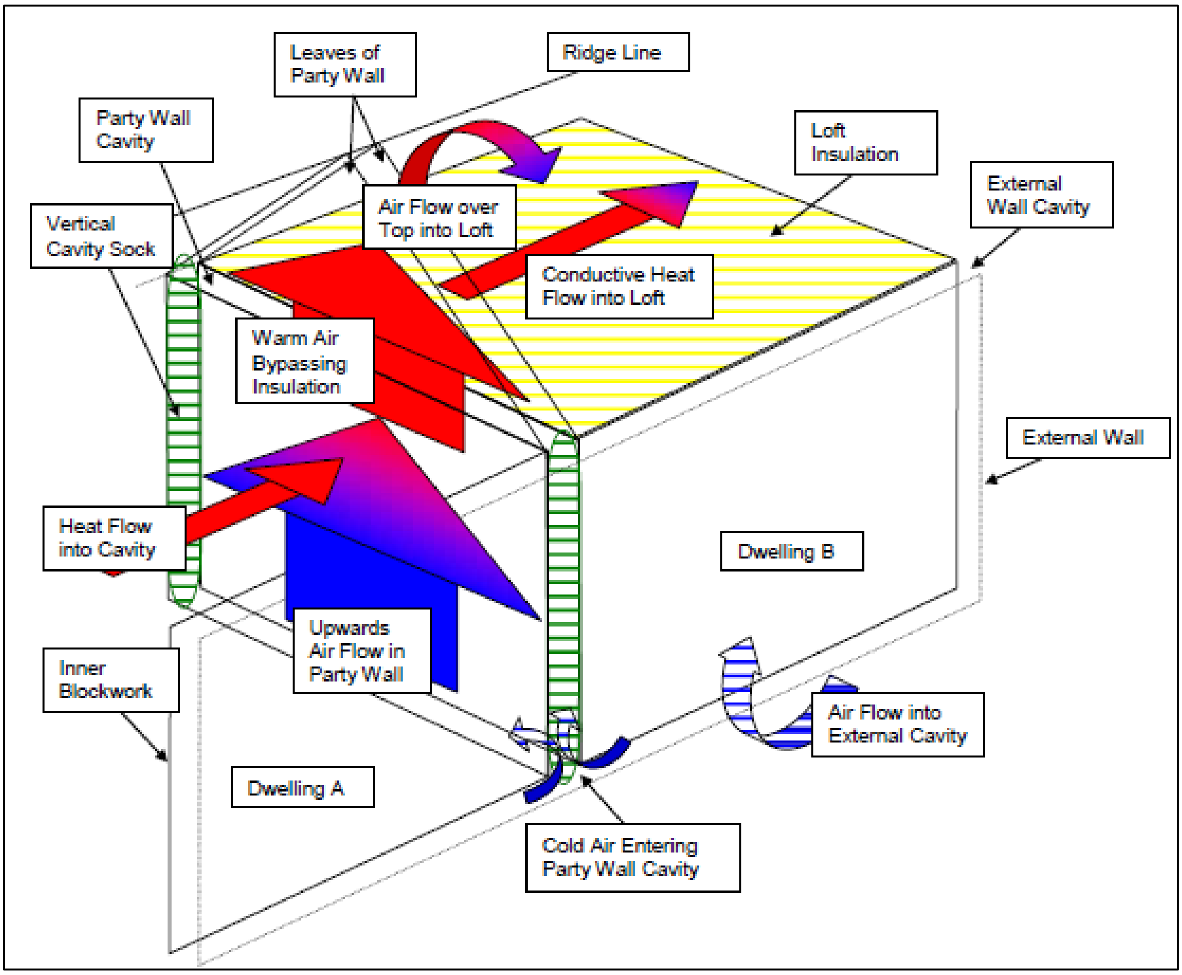


Figure 1: Schematic of the party wall bypass mechanism (Source: Wingfield *et al*., 2007)

3 Test house and party wall construction

City West Housing Trust provided the test house C-03 (Figure 2), which is a two storey mid-terrace built in 1957. Floor plans for the test house can be found in Appendix B.

Figure 2: Image of the front of the test house illustrating the location and designation of the party walls

Table 1 provides details of the test house construction.

Table 1: Test house construction

Element	Construction
Party walls	Masonry cavity (brick-50mm-brick) with wet plaster finish in both dwellings. West neighbour party wall extends from ground to ridge level. East neighbour party wall is suspended above a passageway which provides access to the rear of the house. Both party wall cavities extend to the underside of the roof.
External walls	~270 mm thick masonry cavity (brick-50mm cavity-brick) with wet plaster internal finish. Cavity filled with retrofitted blown mineral wool insulation.
Roof	Tiled, pitched cold roof. 100 mm mineral wool insulation intermittently placed between ceiling joists.
Ground floor	Solid concrete slab-on-ground with screed finish.
Fenestrations	uPVC window and door units with double glazing.

4 Methodology

4.1 Experimental design

A staged test programme was designed to measured heat loss from the test party wall in three conditions:

1. Party wall in its original condition (unfilled party wall).
2. Party wall cavity capped horizontally at first floor ceiling level using a standard cavity barrier (capped party wall).
3. Party wall cavity capped and retro-filled with blown glass mineral wool insulation (filled party wall).

The purpose of test stage one was to identify whether a convective thermal bypass was present in the party walls of the test house and to measure the heat loss attributable to it. The effectiveness of the retrofit measures detailed above was quantified from measurements taken in test stages two and three.

To quantify and characterise party wall heat loss, the following measurements of thermal performance were taken at an elemental and whole house level at each stage of the test programme:

1. *In situ* U-values.
2. Whole house heat loss (heat loss coefficient (HLC)).
3. Background ventilation rate.
4. Various temperature measurements.

As U-value measurements are location specific and can vary across the element being measured, the HLC of the test house was measured at each test stage, this enables the change in heat loss measured to be normalised over the entire party wall surface area. The background ventilation rate was measured at each test stage to enable the disaggregation of the fabric and ventilation heat loss components of the HLC.

The measurements obtained in the unfilled test stage formed the baseline values of thermal performance. The effectiveness of the retrofit measures was quantified as the change in thermal performance from the unfilled stage values.

One of the party walls was designated as a control so that any measured change in thermal performance could be ascribed to the retrofit interventions rather than any change in external environmental conditions. Thus, the control wall remained unchanged throughout the test programme. Figure 2 illustrates the identifier of each party wall.

To minimise heat flows through the party wall which could be attributed to a temperature difference between dwellings, the west neighbour adjacent to the test wall was heated to same internal temperature as test house using portable electric oil heaters. The air internal temperature of the west neighbour was also measured throughout the test programme. The east neighbour was reluctant to participate with the investigation, thus it was not possible to provide heating and monitor conditions in that space.

4.2 Methods employed

4.2.1 External environment monitoring

External air temperature, relative humidity, wind speed and wind direction was measured using a Vaisala WXT520 weather transmitter located in the garden of the test house. Solar insolation was measured using a south facing vertically orientated Kipp and Zonen CMP 3 pyranometer. External environmental and temperature measurements were logged at ten minute intervals using an Eltek Squirrel RX250AL data logger. Missing data were corrected using linear interpolation.

4.2.2 Internal environment monitoring

Internal environmental measurements (air temperature, RH, CO_2 concentration) were obtained using an Eltek monitoring system which recorded measurements at one minute intervals to an Eltek Squirrel RX250AL data logger. Missing data were corrected using linear interpolation.

- Internal air temperatures were measured using PT100 RTD temperature sensors (± 0.1 K).
- Internal surface and cavity temperatures were obtained using Type K thermocouples (± 1 K).

4.2.3 Heat loss coefficient (HLC)

Estimates of the HLC for the test house at each test stage were obtained from coheating tests undertaken in accordance with the protocol developed by Leeds Metropolitan (now Beckett) University (refer to Johnston *et al*., 2013).

- The fuzzy logic thermostatic temperature controls were set to ensure the electric resistance heaters maintained a stable internal air temperature of 22°C.
- Electrical power input to the test dwelling was measured using Elster A100C energy meter which provided one pulse per Wh electrical energy delivered (± 1%).

4.2.4 *In situ* U-value measurement

In situ U-value measurements were undertaken during the coheating tests in accordance with ISO 9869 (ISO, 1994).

- *In situ* measurements of heat flux density, from which *in situ* U-values are derived, were obtained using Hukseflux HFP01 heat flux plates (HFPs). An illustration of a HFP is provided in Figure 4. The voltage induced by the HFPs was recorded at one minute intervals by Thermo Fisher Scientific dataTaker DT80 data loggers.
- HFPs were positioned in locations considered to be representative of the whole element, as well as other locations of interest to the research team.
- HFP positioning was informed by the use of a thermographic survey using a Flir B620 thermal imaging camera.
- HFPs were affixed to the surface of each element using thermal compound and adhesive tape.
- The elevated and stable internal temperatures experienced during the coheating test are conducive to obtaining accurate measures *in situ* U-values. Air circulation fans were used during the coheating test to ensure even distribution of temperatures throughout the test dwelling. However, care was taken to ensure that HFPs were not unduly influenced by excessive air movement by positioning fans in such a way that air was not blown directly on to the HFPs.
- 24 hour U-values reported for all elements are for 24 hour time periods commencing at midnight.
- To compensate for thermal inertia and storage effects, U-values were calculated using the Average Method contained within ISO 9869; which is a cumulative moving average of measured heat flux and ΔT.
- Unless otherwise stated the uncertainty associated with *in situ* U-values measured at the location of each HFP is 10%. It must be noted that *in situ* U-values presented may not be representative of the thermal element as a whole, as measurement of heat flux was obtained from only a small proportion of the total party wall surface area.

Figure 4: HFP (inset) and HFPs *in situ* on the control party wall

4.2.5 Background ventilation rate

The background ventilation rate of the test house was estimated using the following methods:

- Derived from the fan pressurisation test air leakage rate at 50 pascals (n_{50}) using the n_{50}/20 rule (refer to Sherman, 1987). The derivation includes the correction factor for dwelling shelter factor which is contained within the SAP 2012 methodology (BRE, 2012). The fan pressurisation tests were undertaken using a blower door in accordance with ATTMA L1 (ATTMA, 2010). The uncertainty associated with this method is highly dependent upon the environmental conditions present during the test.
- CO_2 was released into the test house at each stage of the test programme. Background ventilation rates were determined based upon the period of time taken for the CO_2 concentration to decay to the background level. These were calculated in accordance with the method described within Roulet and Forandini (2002).

4.3 Test programme

Table 2 provides details of the party wall investigation test programme for dwelling C3.

Table 2: Dwelling C-03 test programme

Date	Event
19/02/2014	• Initial building pressurisation test. • Power and internal environmental temperature logging commenced.
21/02/2014	• Weather station positioned at the south of the test house and logging of external environmental conditions commenced. • HFPs installed on the party walls and logging of heat flux density commenced. • Monitoring of internal temperature in rooms adjacent to the test party wall in the west neighbouring house commenced.
24/02/2014	• Heating of the test house commenced. Thermostats set to maintain an internal air temperature of 22°C. • Placement of party wall surface temperature and cavity thermocouples.
25/02/2014	• Oil filed radiators placed in rooms adjacent to the test party wall in the west neighbouring house. Thermostats set to maintain an internal air temperature of 22˚C.
26/02/2014	• Loss of power in test house 09:12 – 10:17.
04/03/2014	• **Test party wall capped.**
05/03/2014	• Logger malfunction, no power data recorded from 16:17.
06/03/2014	• Logger issue resolved at 13:14. • Voltage range on pyranometer adjusted to prevent data loss. • Second building pressurisation test.
13/03/2014	• **Test party wall filled.**
17/03/2014	• Third building pressurisation test.
23/03/2014	• Final 24 hour analysis period.

5 Results and discussion

5.1 *In situ* measurements of heat flux and U-value

5.1.1 Heat flux plate locations

Figure 5 illustrates the location and identifier of the HFPs on the test and control party walls. The internal arrangement of the test house and presence of kitchen units prevented HFP positioning across the entire party wall at ground floor level.

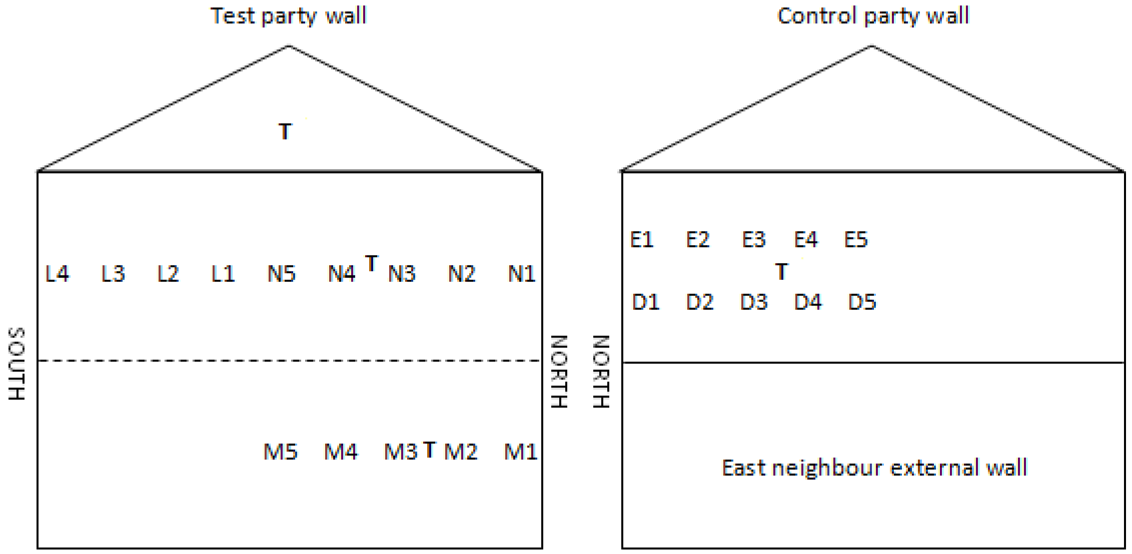


Figure 5: Schematic of HFP locations and identifiers on the party walls of the test house (T denotes location of party wall surface and cavity air temperature measurements)

5.1.2 *In situ* heat flux and temperature measurements

Figure 6 illustrates the hourly mean of heat fluxes (heat flow rate) and selected air temperatures measured throughout the test programme which relate to the test party wall.

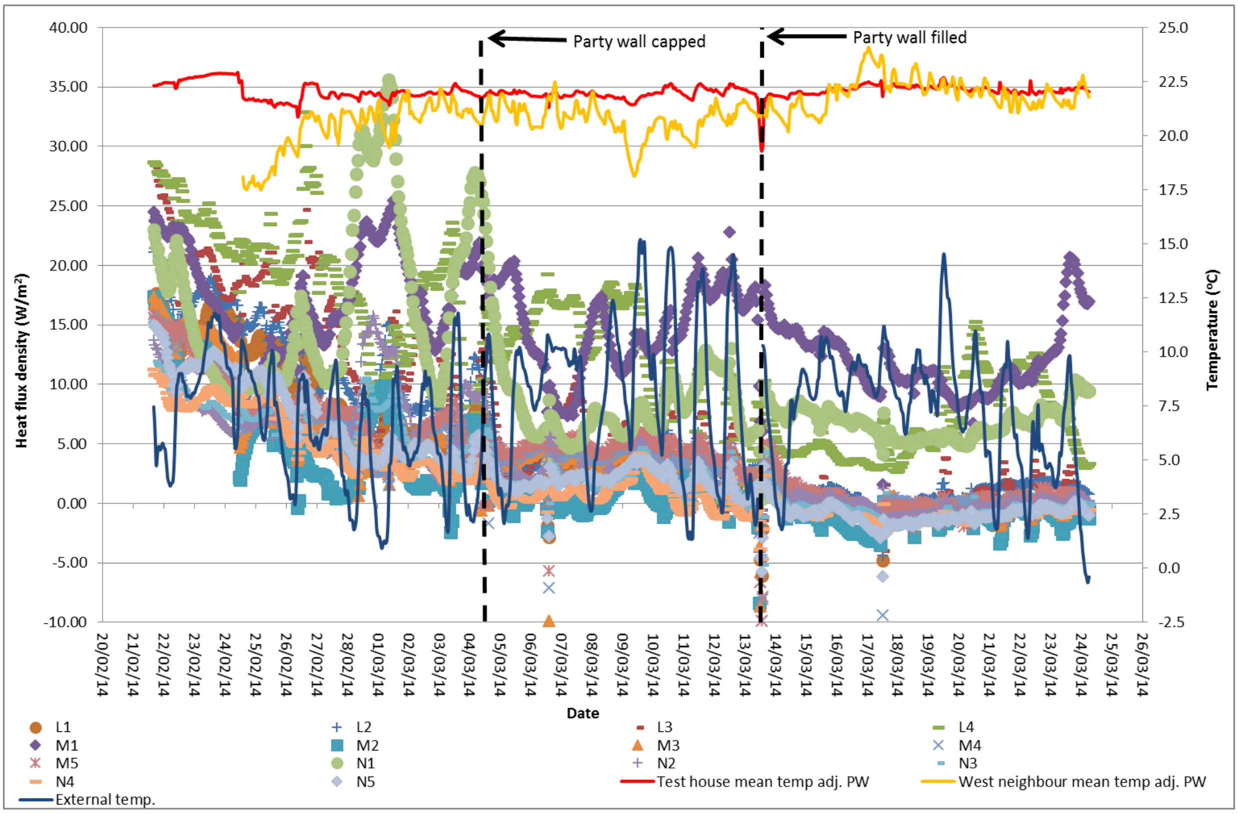


Figure 6: Measured heat fluxes and air temperatures relating to the test wall

Throughout the test programme the highest rates of heat flow were measured by the HFPs at the test wall junctions with the external walls (L4, M1, N1). This behaviour is attributed to the influence of thermal bridging at the junction and potentially air movement. Excluding the HFPs at junctions, the rate of heat flow measured into the test wall at each location reduced following each intervention. Additionally, the dispersion in the heat flows measured between HFP locations reduced, indicating more consistent behaviour across the test wall following each intervention.

Despite a downward trend in external air temperature at the beginning of the test programme, the trend in heat flow into the test wall measured was also downward. The initial part of reduction (21/02/14 – 24/02/14) is attributed to charging of the fabric, the later part (25/02/14 – 27/02/14) to a reduction in ΔT between the test house and west neighbour. During the final period of the unfilled test stage (28/02/14 – 03/03/14), the test wall exhibited behaviour which shows the rate of heat flow measured changing (following a lag period) in response to the change in the air external temperature. This response became less evident following each intervention, which indicates that the rate of the test wall heat flows measured became less dependent on external environmental conditions.

The thermal connection between the test house and west neighbour was evident during all test stages when changes in the ΔT between dwellings resulted in a change to the heat flow measured. This was most evident in the capped test stage around 09/03/14 when the air temperature in the west neighbour dropped in relation to the test house, which resulted in a measured increase in heat flow into the test wall. During the filled test stage the west neighbour air temperature rose in relation to the test house around 17/03/14, this resulted in negative heat flow being measured, which signifies heat flow into the test house.

Figure 7 illustrates the hourly mean of heat fluxes and selected air temperatures measured throughout the test programme which relate to the control party wall.

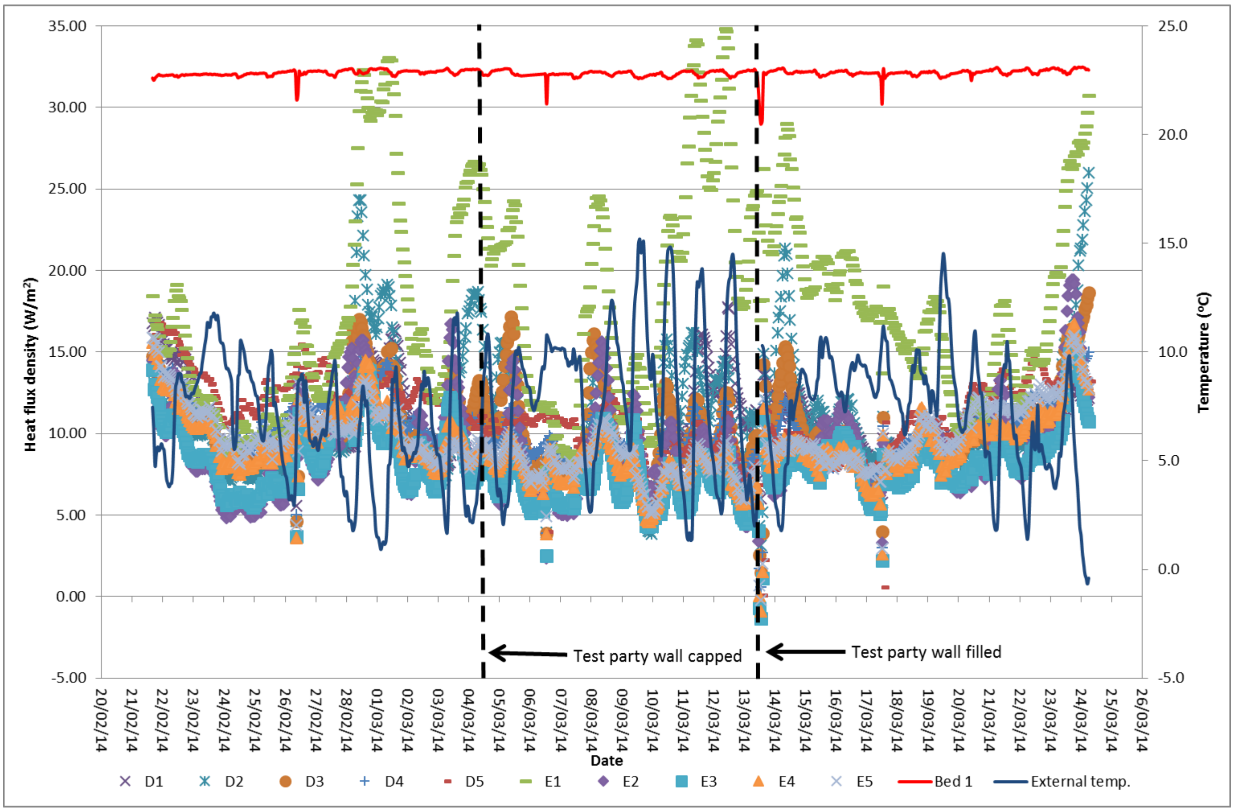


Figure 7: Measured heat fluxes and air temperatures relating to the control wall

As with the test wall, the highest rates of heat flow through the control wall were measured by HFPs at the junction with the external wall (D1, E1). These locations again showed the greatest response to change in external environmental conditions, most notably E1.

The following comparisons can be made between the behaviour of the control and test walls throughout the test programme which strongly suggest that the change in behaviour of the test wall can be attributed to the interventions made:

- The rate of heat flow measured through the control wall remained relatively consistent throughout the test programme when compared to the test wall.

- The dispersion of the heat flow measured at each HFP wall did not reduce following each intervention to the test wall.
- The heat flows measured through the control wall show a strong response to change in external air temperature throughout the entirety of the test programme.

The comparison between the control and test walls should be caveated. Primarily, the test and control walls are of differing heights and have differing construction at the base. The rate of heat flow measured through the control wall throughout most of the test programme was higher than the test wall. As the heating regime and internal temperature of the east neighbour is unknown, the higher rate of heat loss cannot confidently by attributed to differing thermal performance, it could be the case that the east neighbour was heated to a lower internal temperature than the test house. In addition, it is not known whether the internal temperature of the east neighbour remained reasonably constant throughout the test programme. Thus the reason why the control wall did not exhibit some of the behaviour changes measured on the test wall could be attributed to a change in heating regime in the east neighbour. However, it is the judgement of the research team that it is highly unlikely that the heating regime in the east neighbour varied in such a way as to invalidate comparisons made between the control and test walls.

5.1.3 24 hour *in situ* U-values

In situ U-values can be calculated for individual 24 hour periods. Individual 24 hour U-values must be treated with a degree of caution as much of the variation in 24 hour U-values observed in Figure 8 and Figure 11 could be a symptom of the steady-state calculation method failing to account for thermal inertia and change in thermal storage within the walls resulting from temperature variation in the external environment. However, 24 hour U-values do provide the opportunity to identify phenomenon in U-value data which can be masked when performing analysis using the average method contained within ISO 9869.

Figure 8 illustrates the 24 hour *in situ* U-values for the test wall throughout the entire test programme.

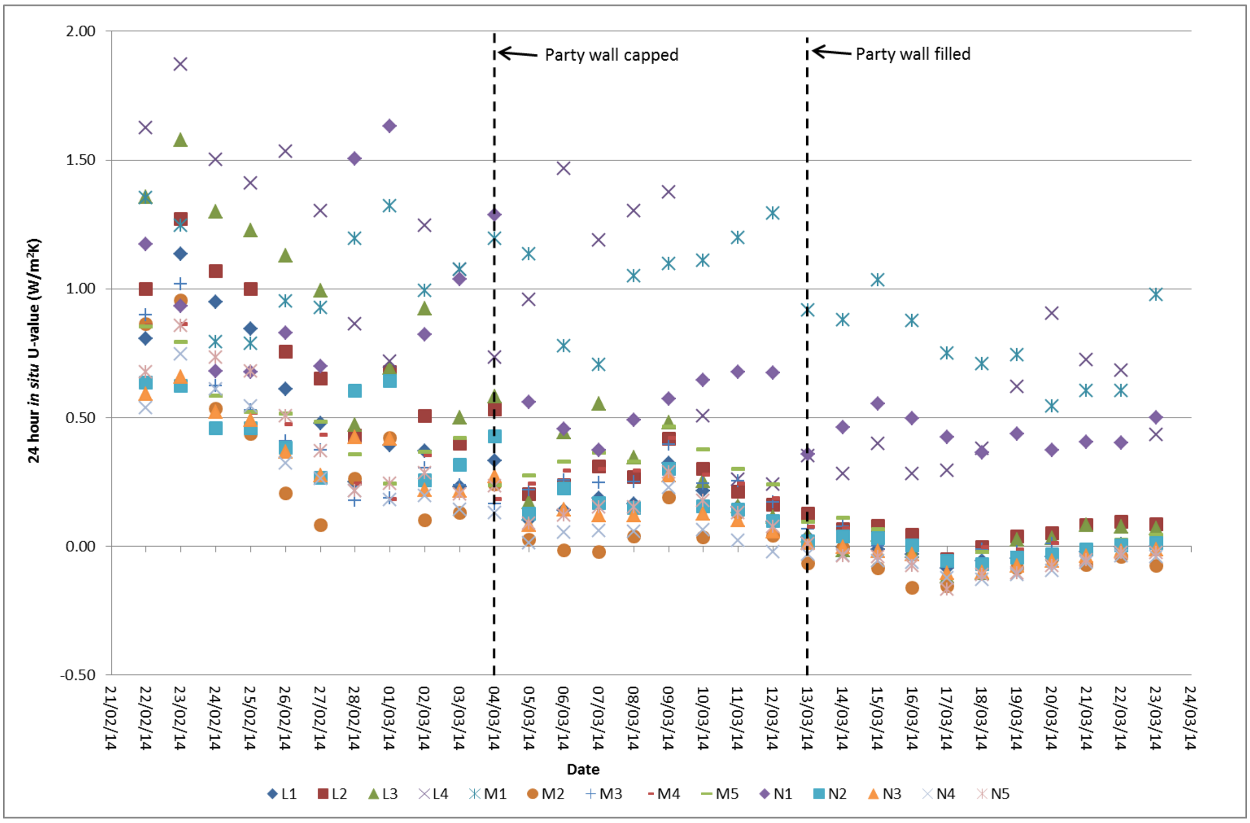


Figure 8: Test wall 24 hour *in situ* U-values

The commentary which accompanies Figure 6 can be used to interpret Figure 8. Figure 9 shows the relationship between the mean of the 24 hour *in situ* unfilled test wall U-values measured at HFPs at distances ≥ 1 m from the junction with the external walls and the ΔT between the test house and west neighbour in the 24 hour periods following commencement of heating in the west neighbour by the research team.

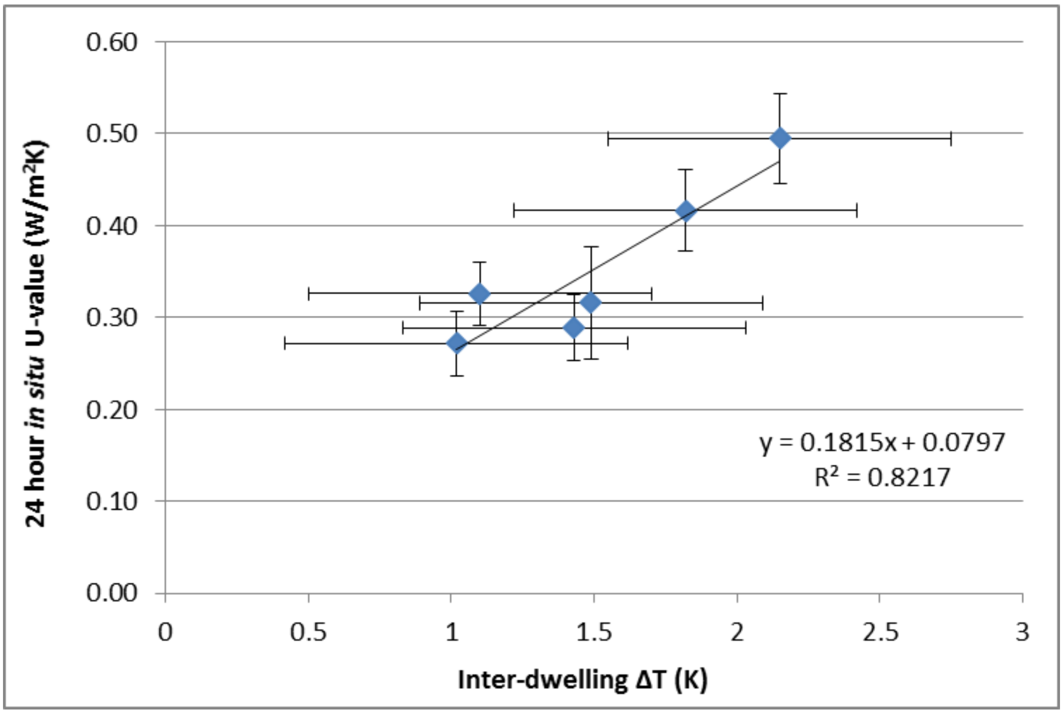


Figure 9: Inter-dwelling ΔT vs. unfilled test wall 24 hour *in situ* U-values

It can be seen in Figure 9 that there is a reasonably strong relationship between the inter-dwelling ΔT and 24 hour U-values. The 24 hour U-value stabilises around 0.30 W/m²K once the ΔT drops below 1.5 K on 28/02/14. Therefore only measured data from 28/02/14 onwards will be used to calculate the unfilled test wall *in situ* U-value. The uncertainty associated with the temperature measurements mean that it is not prudent to use the intercept value of 0.08 W/m²K as the unfilled test wall *in situ* U-value.

Figure 10 illustrates the relationship between 24 hour *in situ* U-values during each test stage and the corresponding 24 hour mean wind speed.

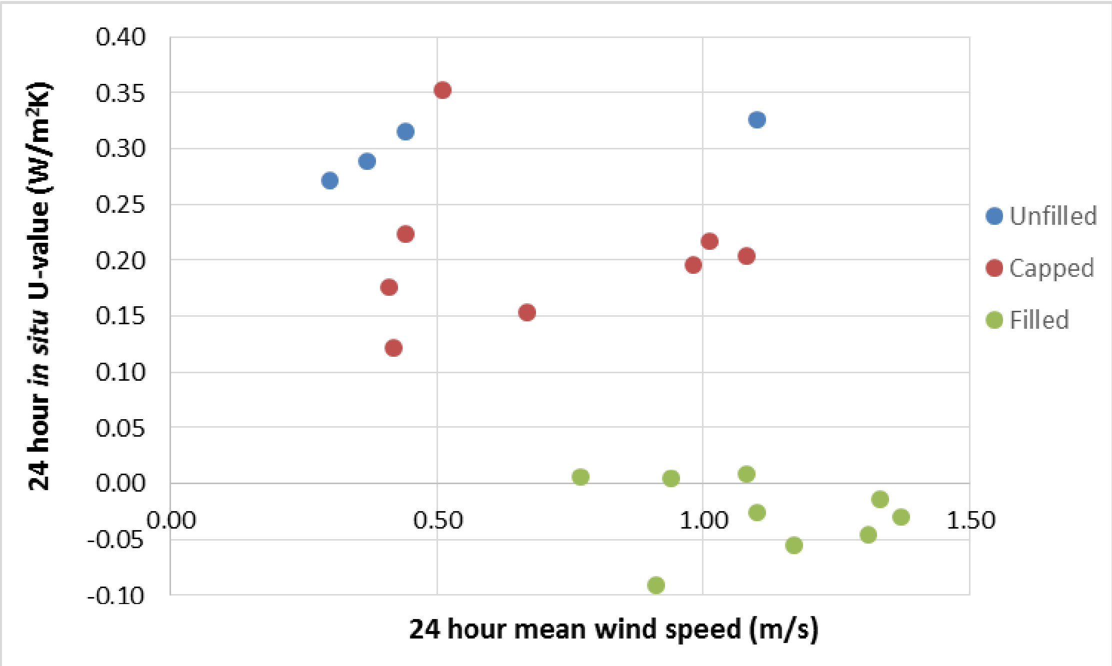


Figure 10: 24 hour mean wind speed vs. test wall 24 hour *in situ* U-values during each test stage

From Figure 10 it is evident that there is a reasonably strong positive correlation ($R^2 = 0.64$) between the 24 hour U-values measured and the mean wind speed during the same 24 hour period during the unfilled test stage. There appears to be no relationship evident following the initial intervention. This could suggest that sealing the test cavity reduced the susceptibility of the test wall to wind driven heat loss. However, the limited number and poor spread of data points mean that no firm conclusions can be drawn as to the effect of wind on the heat loss of the test wall using this analysis technique.

Figure 11 illustrates the 24 hour *in situ* U-values for the control wall throughout the entire test programme.

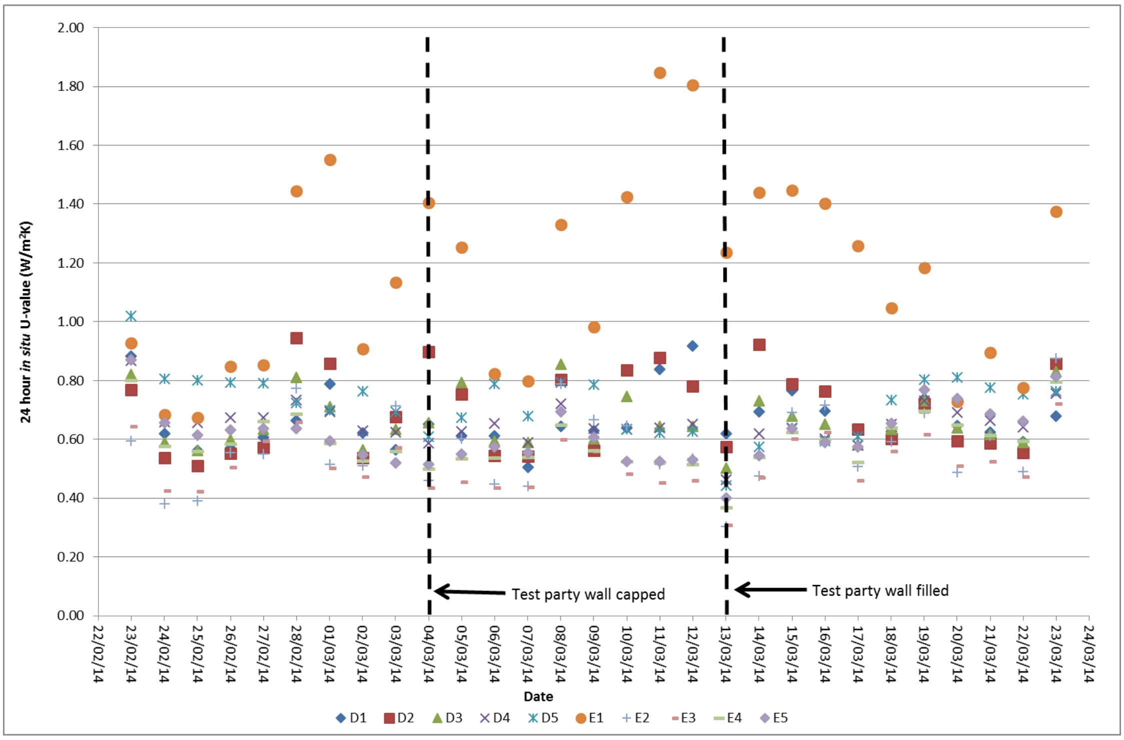


Figure 11: Control wall 24 hour *in situ* U-values

The commentary which accompanies Figure 7 can be used to interpret Figure 11.

Figure 12 plots the test wall 24 hour *in situ* U-values measured during the unfilled test stage against those measured on the control wall.

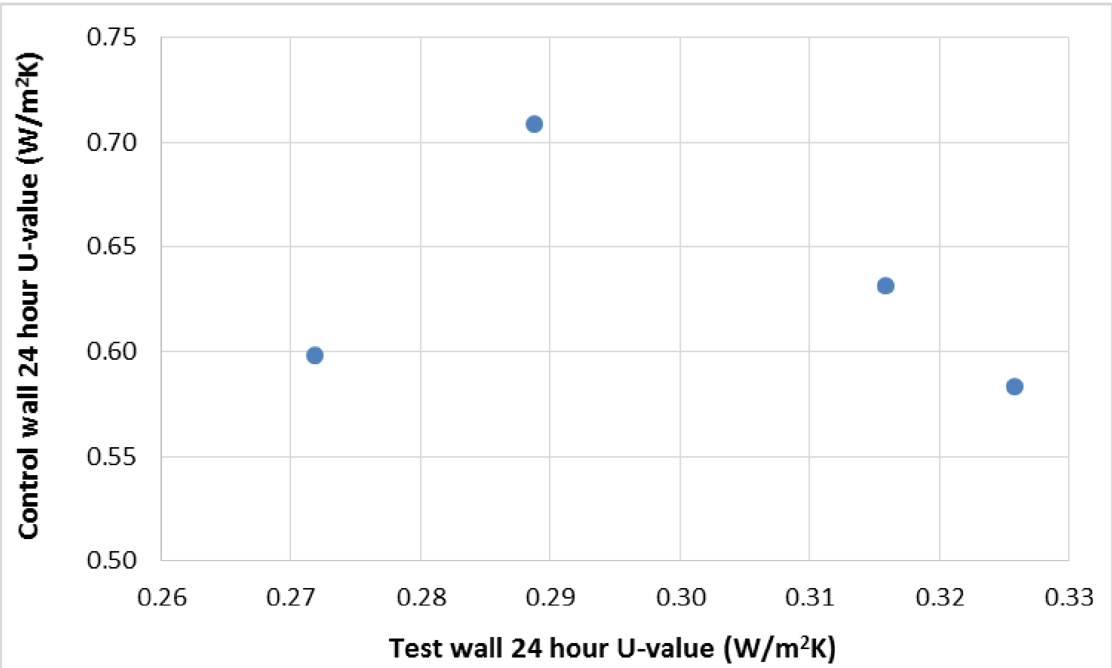


Figure 12: Test wall vs. control wall 24 hour *in situ* U-values during the unfilled test stage

Figure 12 shows there to be no correlation between the test wall and control wall 24 hour *in situ* U-values measured during the unfilled test stage. This shows that that the test and control walls react differently to changes in external environmental conditions over each 24 hour period. The absence of any relationship could also be a symptom of differing heating regimes in each neighbour. The differing reaction of the walls is not surprising given that the control wall: base is suspended in the external environment at first floor height; is a different height, most likely adjoins a neighbour with a variable heating pattern. The difference in behaviour precludes a direct statistical comparison between the two walls in the following test stages.

5.1.4 ISO 9869 *in situ* U-values

The final reported U-values in this report have been calculated using the average method contained within ISO 9869. This calculation method compensates for thermal inertia and storage effects by using a cumulative moving average of previous measured heat flux and ΔT[1].

Figure 13 illustrates the evolution of test wall *in situ* U-value measurements during the unfilled test stage.

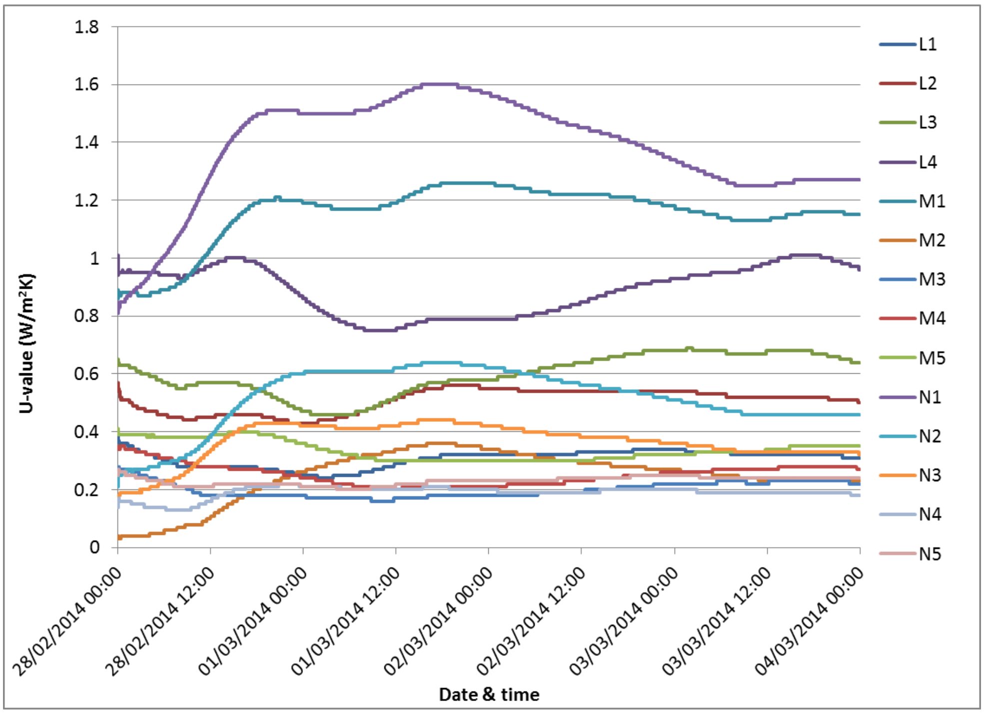
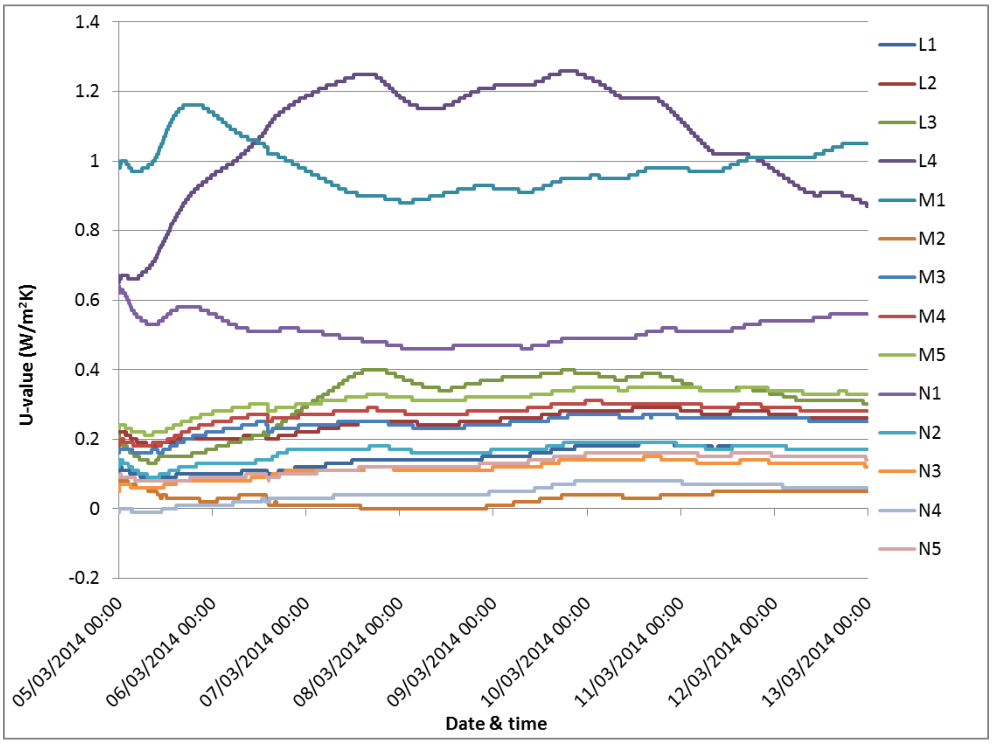


Figure 13: *In situ* U-value measurements of the unfilled test wall.

Figure 14 illustrates the evolution of test wall *in situ* U-value measurements during the capped test stage.



[1] It must be noted that most U-values quoted for locations where the HFP was located at the test wall junction with the external wall (L4, M1, N1) failed to meet the requirements set out under ISO 9869. However, these U-values are not included in the calculation of the reported *in situ* U-value due to the influence of thermal bridging.

Figure 14: *In situ* U-value measurements of the capped test wall.

Figure 15 illustrates the evolution of test wall *in situ* U-value measurements during the filled test stage.

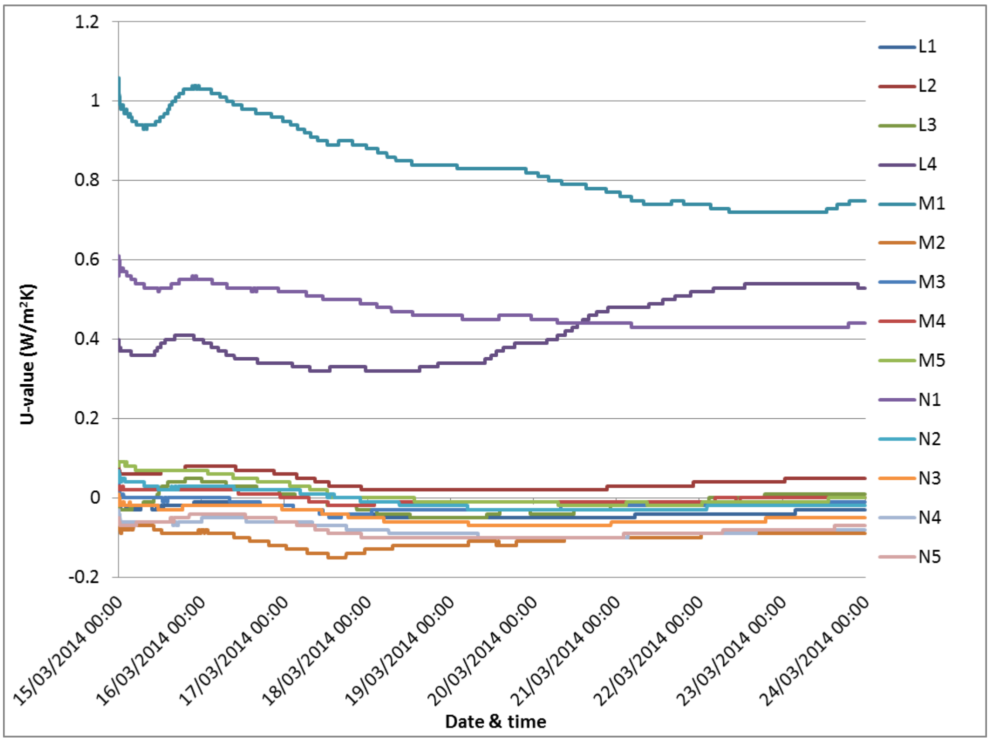


Figure 15: *In situ* U-value measurements of the capped and filled test wall.

The test wall *in situ* U-values measured at each HFP location for each of the test stages are provided in Table 3.

Table 3: Test wall *in situ* U-values at the location of each HFP[2]

HFP location	Unfilled test wall		Capped test wall		Capped & filled test wall	
	U-value (W/m^2K)	Standard deviation (W/m^2K)	U-value (W/m^2K)	Standard deviation (W/m^2K)	U-value (W/m^2K)	Standard deviation (W/m^2K)
L1	0.31	0.03	0.17	0.03	-0.03	0.01
L2	0.5	0.04	0.26	0.03	0.05	0.02
L3	0.64	0.07	0.30	0.08	0.01	0.03
L4	0.96	0.08	0.87	0.16	0.53	0.08
M1	1.15	0.10	1.05	0.07	0.75	0.10
M2	0.23	0.09	0.05	0.02	-0.09	0.02
M3	0.22	0.03	0.25	0.03	-0.01	0.01
M4	0.27	0.03	0.28	0.03	0.00	0.01
M5	0.35	0.03	0.33	0.04	0.00	0.03
N1	1.27	0.18	0.56	0.04	0.44	0.04
N2	0.46	0.10	0.17	0.02	-0.02	0.02
N3	0.32	0.06	0.12	0.02	-0.05	0.02
N4	0.18	0.02	0.06	0.02	-0.08	0.02

[2] Negative U-values are the result of the heat flow measured at the HFP location being negative (heat flow from the test wall).

N5	0.24	0.01	0.14	0.03	-0.07	0.02

Figure 16 plots the test wall *in situ* U-values measured on the first floor during each test stage level in relation to their location.

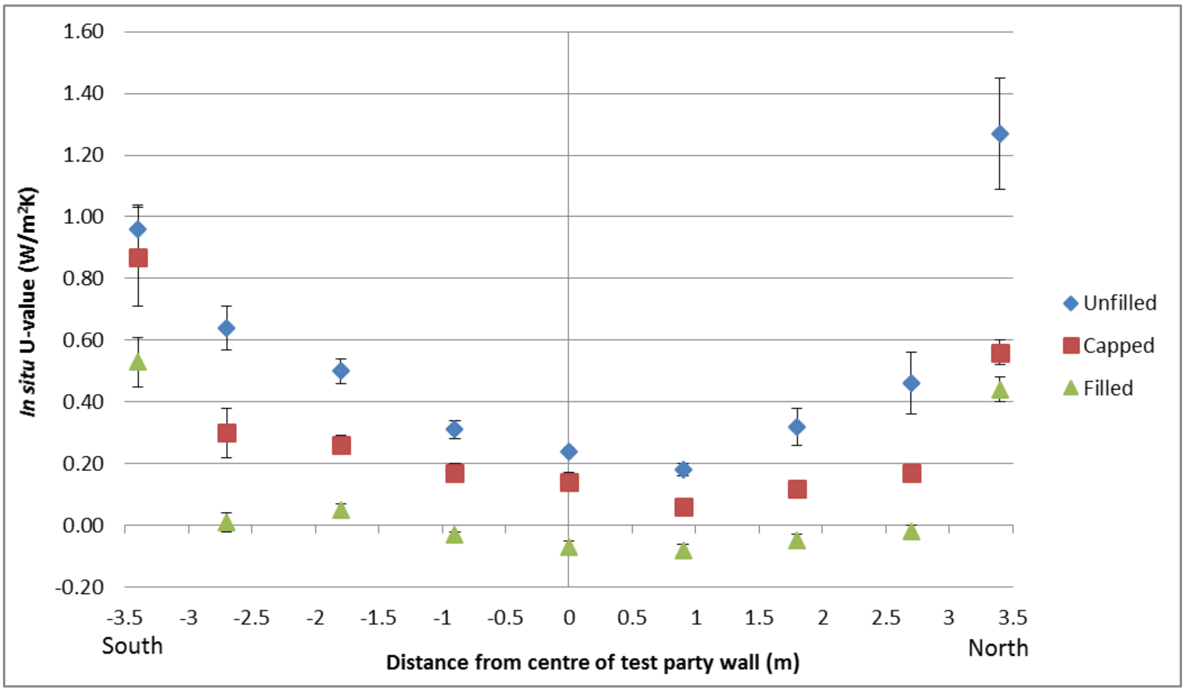


Figure 16: First floor test wall *in situ* U-values during each test stage in relation to location

Figure 16 shows how each successive intervention increases the consistency of the U-values measured across the test wall. The reduction in edge effects is most prominent at the measurement locations 700 mm from the junctions with the external walls. Heat loss across the test wall in the unfilled test stage could be described as asymmetric, with greater heat loss measured at the south of the dwelling (excluding extremities). However, each intervention resulted in the heat loss across the party wall becoming more symmetrical. The negative U-values measured in the filled test stage are thought to be caused by periods of overheating and the presence of heaters close to the party wall in the west neighbour.

Figure 17 illustrates the evolution of the control wall *in situ* U-value measurements throughout the entire test programme.

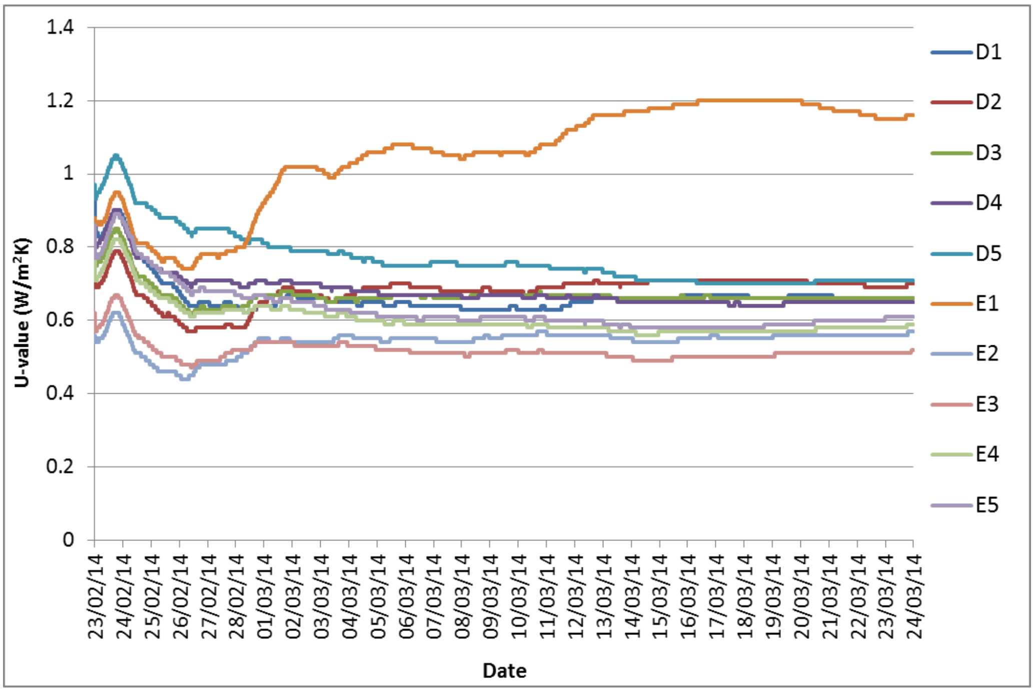


Figure 17: U-value measurements of the control wall

The control wall *in situ* U-values measured at each HFP location across the entire test programme are provided in Table 4.

Table 4: Control party wall *in situ* U-values at the location of each HFP

HFP location	U-value (W/m^2K)	Standard deviation (W/m^2K)
D1	0.66	0.05
D2	0.7	0.04
D3	0.66	0.03
D4	0.65	0.05
D5	0.71	0.07
E1	1.16	0.14
E2	0.57	0.03
E3	0.52	0.03
E4	0.59	0.05
E5	0.61	0.06
Mean > 1 m from external wall	0.62	0.03 (SE)

Table 5 provides the final *in situ* U-values derived from each test stage for the test and control walls.

The 20% greater U-value of the lower HFP array (D) could indicate air infiltration lower in the cavity, potentially at the base of the suspended party wall.

Table 5: *In situ* U-value for the test and control walls at each stage of the test programme

Test stage	Test party wall		Control party wall	
	Mean U-value >1m from junctions (W/m^2K)	Standard error (W/m^2K)	Mean U-value >1m from junctions (W/m^2K)	Standard error (W/m^2K)
Unfilled	0.30	0.03	0.63	0.03
Capped	0.20	0.03	0.61	0.04
Filled	-0.02	0.02	0.65	0.02

The U-value of -0.02 W/m^2K is considered zero for reporting purposes. The reason for the negative U-value measured has been discussed earlier.

A one-way ANOVA was used to test for differences in the *in situ* U-value of the test wall derived from the three tests. Data comprises U-values measured at distances > 1 m from junctions. There was a statistically significant difference between the three U-values derived, $F(2, 21) = 32.603$ $p = <0.001$. Gabriel post-hoc comparisons of the three groups indicate that the filled test wall (M = -0.02, 95% CI [-0.06, 0.01]) had a significantly lower U-value than the capped test wall (M = 0.20, 95% CI [0.12, 0.28]), p = <0.001 as well as the unfilled wall (M = 0.30, 95% CI [0.22, 0.38]), p=<0.001. The analysis also revealed that there was no statistically significant difference between the unfilled and capped test wall U-value (p = 0.077). It must be noted that the p-value is very close to the arbitrary value of 0.05 used to test for statistical significance. Despite this uncertainty, the U-value measurements show that the sealed and fully-filled party wall prevents heat transfer to the external environment at all locations other than the perimeter, thus the party wall U-value can be considered 0 W/m^2K.

A one-way ANOVA was used to test for differences in the *in situ* U-value of the control wall derived from the three test stages. Data comprises U-values measured at distances > 1 m from junctions. There was no statistically significant difference between the U-value derived from the three test stages, $F(2, 15) = 0.711$ $p = 0.507$. Gabriel post-hoc comparisons of the three groups indicate that the filled test stage (M = 0.65, 95% CI 0.60, 0.71]) U-value was not significantly different to the capped test stage (M = 0.61, 95%

CI [0.51, 0.70]), p = 0.566 and the unfilled test stage (M = 0.63, 95% CI [0.56, 0.70]), p=<0.931. There was no statistically significant difference between the control wall U-value during the unfilled and capped test stages (p = 0.882). This suggests that the thermal performance of the control wall was similar throughout the entire test programme. Despite the differences between the test and control walls outlined previously, the similar performance of the control wall in all test phases provides confidence that the reduction in heat loss measured from the test wall is attributable to the intervention measures.

5.2 Heat loss coefficient

5.2.1 Coheating test result

The coheating analysis uses the power input relative to the temperature differential between internal and external air (ΔT), assuming that the heat loss rate is linearly dependent upon ΔT. A successful coheating test relies upon minimising or accurately measuring all other heat transfer mechanisms that are not directly influenced by the external environment. In this instance, the major driver from heat loss through the solid ground floor is the ΔT between the internal environment and the ground below the floor. Thus, heat loss through the ground floor is effectively decoupled from the rest of the dwelling. To compensate for ground floor heat transfer, a whole floor heat transfer rate was estimated by multiplying the heat transfer rate measured on the ground floor by the total floor area; this rate was subtracted from the measured power input into the test dwelling. This procedure also compensates for the period during which solid ground floor reaches thermal capacitance. The measured *in situ* U-value of the ground floor was multiplied by the floor area and the ΔT, the resultant heat transfer rate is added back onto the corrected power.

To try to minimise the effects of thermal storage of solar radiation being carried over to the following day, the 24 hour time period used for daily test data runs from 6 a.m. to 6 a.m.

The coheating analysis for each test stage was performed using the following regression models:

1 Simple linear regression: ground floor corrected power as the dependent variable and ΔT as the independent variable.

2 Multiple linear regression: ground floor corrected power as the dependent variable with ΔT and mean daily solar insolation[3] as independent variables.

3 Multiple linear regression: ground floor corrected power as the dependent variable with ΔT, mean daily solar insolation and wind speed as independent variables.

Tables 6, 7 and 8 provide the regression statistics for each regression model for each stage of the test programme.

Table 6: Unfilled test stage coheating regression statistics for each model

Model	Independent variable(s)	Coefficient	Std. error	Statistic		95% Confidence interval	
				t	p	Lower	Upper
1	ΔT	180.011	6.220	28.940	<0.000	165.303	194.720
2	ΔT	205.073	9.030	22.710	<0.000	182.977	227.169
	Solar	-217.263	69.547	-3.124	0.20	-387.438	-47.089
3	ΔT	180.207	9.226	19.532	<0.000	156.490	203.924
	Solar	-158.918	45.711	-3.477	0.018	-276.422	-41.414
	Wind speed	333.221	99.381	3.353	0.020	77.754	588.687

Table 7: Capped test stage coheating regression statistics for each model

Model	Independent variable(s)	Coefficient	Std. error	Statistic		95% Confidence interval	
				t	p	Lower	Upper
1	ΔT	145.370	14.345	10.134	<0.000	108.494	182.246
2	ΔT	209.631	9.196	22.795	<0.000	184.097	235.164

[3] The solar coefficient provided does not represent the solar aperture as the raw voltage output from the pyranometer was used in the multiple regression analysis.

	Solar	-268.655	34.616	-7.761	0.001	-364.764	-172.547
3	ΔT	61.381	43.238	1.420	0.251	-76.221	198.983
	Solar	29.701	88.327	.336	0.759	-251.396	310.799
	Wind speed	1751.073	507.600	3.450	0.041	135.664	3366.482

Table 8: Filled test stage coheating regression statistics for each model

Model	Independent variable(s)	Coefficient	Std. error	Statistic		95% Confidence interval	
				t	p	Lower	Upper
1	ΔT	165.470	4.754	34.803	<0.000	153.248	177.691
2	ΔT	179.593	4.629	38.797	<0.000	166.741	192.445
	Solar	-105.403	28.827	-3.656	0.022	-185.438	-25.367
3	ΔT	166.401	4.789	34.749	<0.000	151.161	181.640
	Solar	-116.836	16.085	-7.264	0.005	-168.025	-65.647
	Wind speed	191.367	59.065	3.240	0.048	3.397	379.338

Only regression model one was statistically significant in the analysis of all three test stages. However, the HLC estimate it produced for the capped test stage was lower than the filled test stage; this is contrary to the findings from the *in situ* U-value measurements. Model one also fails to account for the influence of solar radiation and wind speed. Model three was found to have the most explanatory power[4], though this meant discarding the capped test stage coheating test analysis. The linear based HLC estimates derived from the coheating tests undertaken during the unfilled and filled test stages are illustrated in Figure 18.

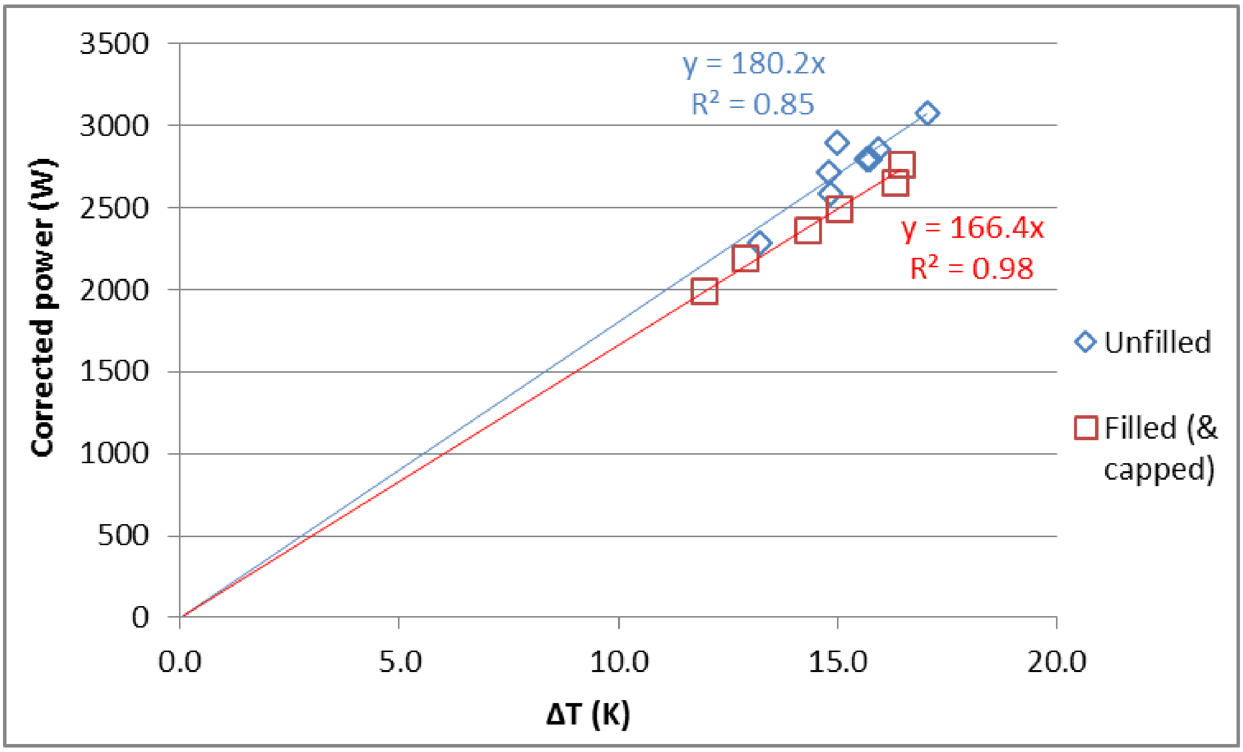


Figure 18: Linear regression HLC estimates for the test house during the unfilled and filled test stages

From Figure 18 it can be seen that the reduction in HLC following the capping and filling of the party wall was 13.8 W/K. The reduction in HLC measured can include both change to the fabric and ventilation heat losses. To isolate the change in fabric heat loss resulting from the filling and capping of the party wall, the change in background ventilation rate must be ascertained.

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[4] It must be noted that the addition of the extra two independent variables does little to alter the HLC from that obtained using model one, however the R^2 fit was improved in both models.

5.2.2 Background ventilation heat loss

Table 9 provides the results of the fan pressurisation tests undertaken at each stage of the test programme and the background ventilation rates derived from the test results. For more details of the fan pressurisation tests performed on Dwelling C-03 please refer to Appendix A of the main report.

Table 9: Fan pressurisation test results at each stage of the test programme

Test stage	Pressurisation			Depressurisation			Mean		Background ventilation rate (ACH)
	Q_{50} ($m^3/(h.m^2)$ @ 50Pa)	R^2	n	Q_{50} ($m^3/(h.m^2)$ @ 50Pa)	R^2	n	Q_{50} ($m^3/(h.m^2)$ @ 50Pa)	n_{50} (ACH @ 50 Pa)	
Unfilled	16.61	0.991	0.575	16.4	0.998	0.607	16.5	17.81	0.69
Capped	18.09	0.987	0.601	16.14	0.999	0.645	17.12	18.48	0.72
Filled	15.34	0.995	0.654	14.5	0.995	0.566	14.92	16.11	0.62

The increase in the derived background ventilation rate following the capping of the test wall was unexpected as no alteration was made to the primary air barrier. The relatively poor R^2 correlation of 0.987 from the pressurisation component of the fan pressurisation test suggests that the measurement could be spurious. The veracity of the capped stage fan pressurisation test result is also questioned as it measured the greatest percentage discrepancy between the pressurisation and depressurisation (11%).

Capping and fully filling the test wall resulted in 10% improvement in airtightness of the test house.

Figure 19 illustrates the analysis of the CO_2 concentration decay undertaken during the unfilled test stage used to verify the background ventilation rate derived from the fan pressurisation test. Table 10 provides the background ventilation rate derived from this analysis.

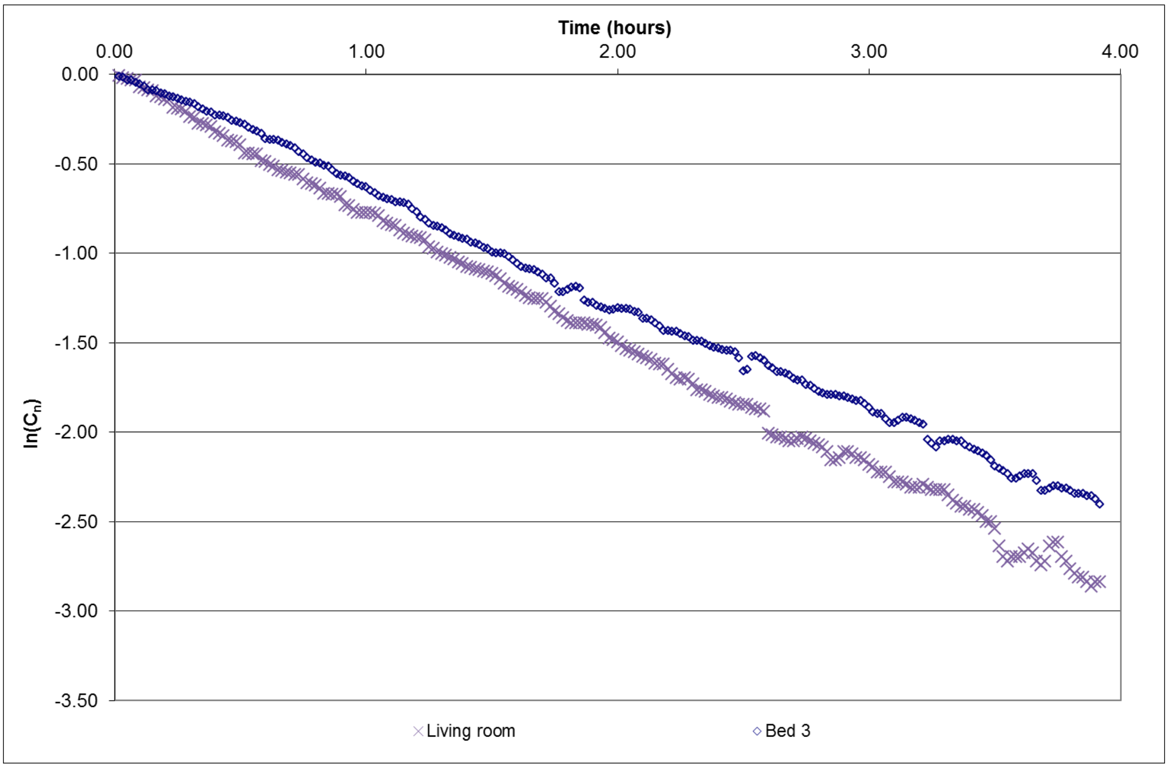

Figure 19: Logarithm of normalised CO_2 concentration vs. elapsed time for the measurement locations in the test house during the unfilled test stage

Table 10: Background ventilation rate derived from CO_2 decay for the measurement locations in the test house during the unfilled test stage

Location	Gradient (ACH)	Std. error (ACH)	R^2
Living room	0.72	< 0.01	0.998
Bed 3	0.62	< 0.01	0.997
Mean	0.67		

The background ventilation rate derived from the CO_2 decay analysis in the unfilled test stage differs from that derived from the fan pressurisation test by 3%. This suggests that there should be reasonable confidence with the background ventilation rates derived from the fan pressurisation test at stage of the test programme.

Table 11 provides background ventilation heat loss derived from the fan pressurisation test for each of the test stages.

Table 11: Test house background ventilation heat loss derived from building pressurisation tests at each stage of the test programme

	Test stage		
	Unfilled	**Capped**	**Filled**
Ventilation rate [n_{50}] (ACH @ 50 Pa)	17.81	18.48	16.11
Sheltered sides [S_s]	3	3	3
Sheltering factor [S_f] [1-(S_s*0.075)]	0.775	0.775	0.775
Background ventilation rate [(n_{50}/20)*S_f] (ACH)	0.69	0.72	0.62
Dwelling volume (m^3)	176.4	176.4	176.4
Background Ventilation Heat Loss (W/K) [ACH*0.33*volume]	40.2	41.7	36.3

Table 12 shows the disaggregation of the fabric and ventilation heat loss components of the HLC measured during the unfilled and filled test stages.

Table 12: Disaggregation of the HLC measured in the unfilled and filled test stages into fabric and ventilation heat loss

Test stage	Heat loss coefficient (W/K)	Ventilation heat loss (W/K)	Fabric heat loss (W/K)
Unfilled	180.2 ± 9.2	40.2	140
Filled	166.4 ± 4.8	36.3	130.1
Reduction on unfilled stage (W/K)	13.8	3.9	9.9
Reduction on unfilled test party wall per m^2 (W/m^2K)			0.28

As the only intervention to the test house during the test programme was the capping and filling of the test party wall, the reduction in fabric heat loss can be divided over the surface area to enable a comparison with the *in situ* U-value reduction measured. The fabric heat loss reduction of 0.28 W/m^2K derived from the coheating tests is in good agreement with the *in situ* U-value reduction of 0.30 W/m^2K.

5.3 Cavity temperature measurements

Thermocouple probes were positioned in the centre of the test and control wall cavities at the locations illustrated in Figure 5.

Figure 20 illustrates the hourly mean of the air temperatures measured adjacent to the test party wall, and within the control and test party wall cavities, throughout the test programme.

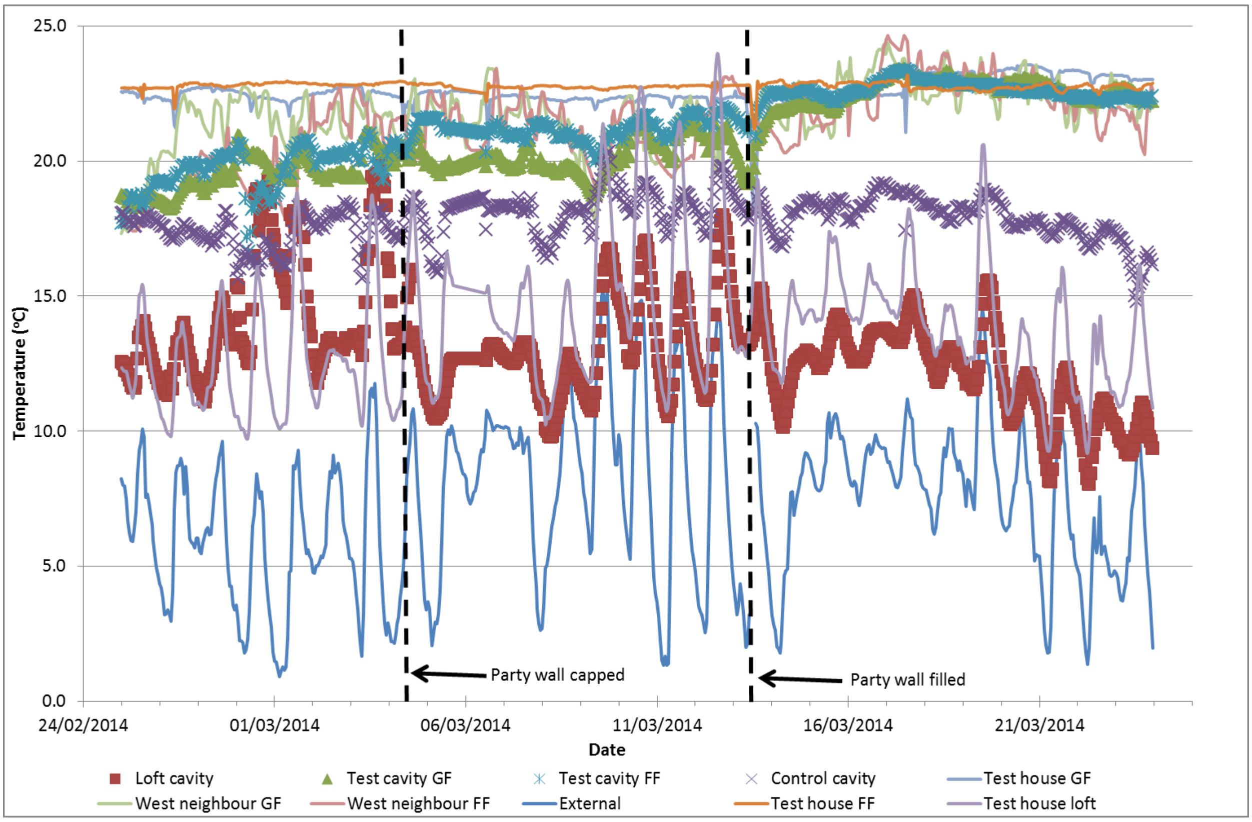

Figure 20: Hourly mean measurements of air temperatures adjacent to the test party wall and within the control and test party wall cavities

The test cavity temperature measured on the ground floor and first floor level became warmer following each intervention to the test wall. During the first two stages the ground floor cavity temperature was lower than that of the first floor; this could indicate stratification within the cavity, or the drawing in of cooler air at the base of the cavity. When the test wall was filled, the party wall cavity temperature became more consistent and was close to that of the surrounding air temperatures within the test house and west neighbour.

The air temperature of the test cavity at loft height was greater than the loft space during the unfilled test stage. It is thought that the elevated temperature in the cavity was caused by warm air rising within the test wall cavity; this suggests the presence of thermal bypass during this period. Following capping of test cavity, the loft cavity air temperature was predominately below that of the loft space. This behaviour suggests that the flow of warm air from below the roof insulation line was ceased following the capping of the test wall cavity.

The air temperature within the control wall cavity was lower than that measured in the test wall cavity during the unfilled stage. This could indicate that the internal temperature of the east neighbour was cooler than the west neighbour and/or that the suspended construction of the control wall means that it has a greater exposed surface area from which to loose heat. The control party wall cavity air temperature remained reasonably consistent throughout the test programme. The cavity air temperature was in responsive to change in the external air temperature throughout the test programme.

Figure 21 and Figure 22 show the temperature gradient across the test wall during each phase of the test programme on the ground floor and first floors respectively. The temperature gradient comprises the mean temperature measured in the test wall cavity and the air temperatures either side of the party wall.

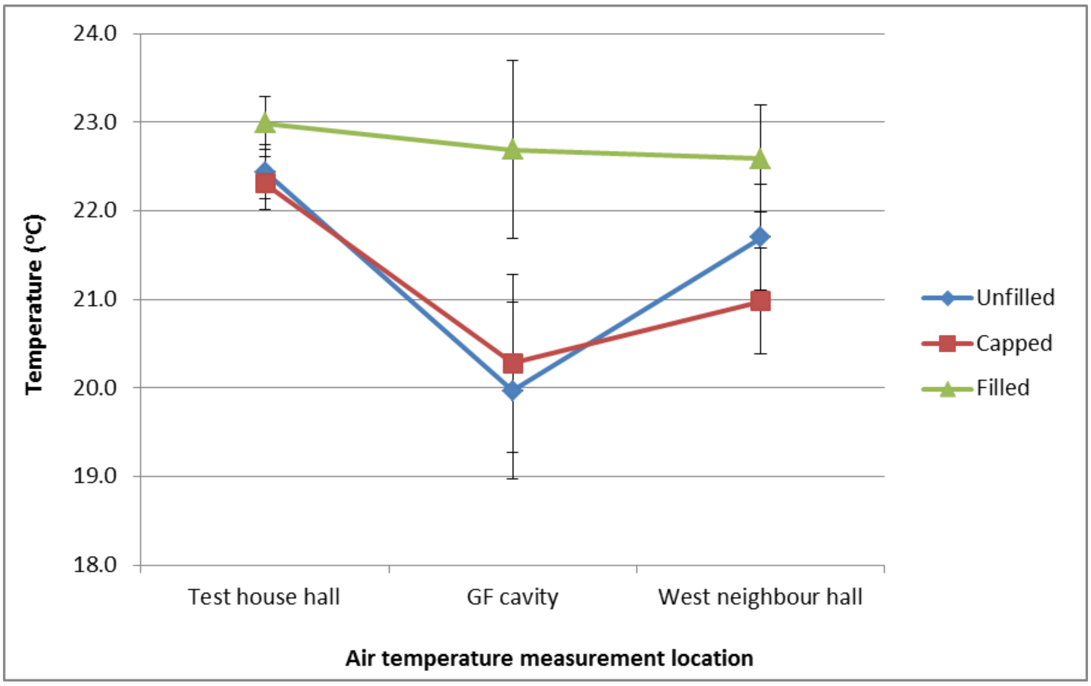

Figure 21: Air temperature measured within, and adjacent to, the test wall on the ground floor

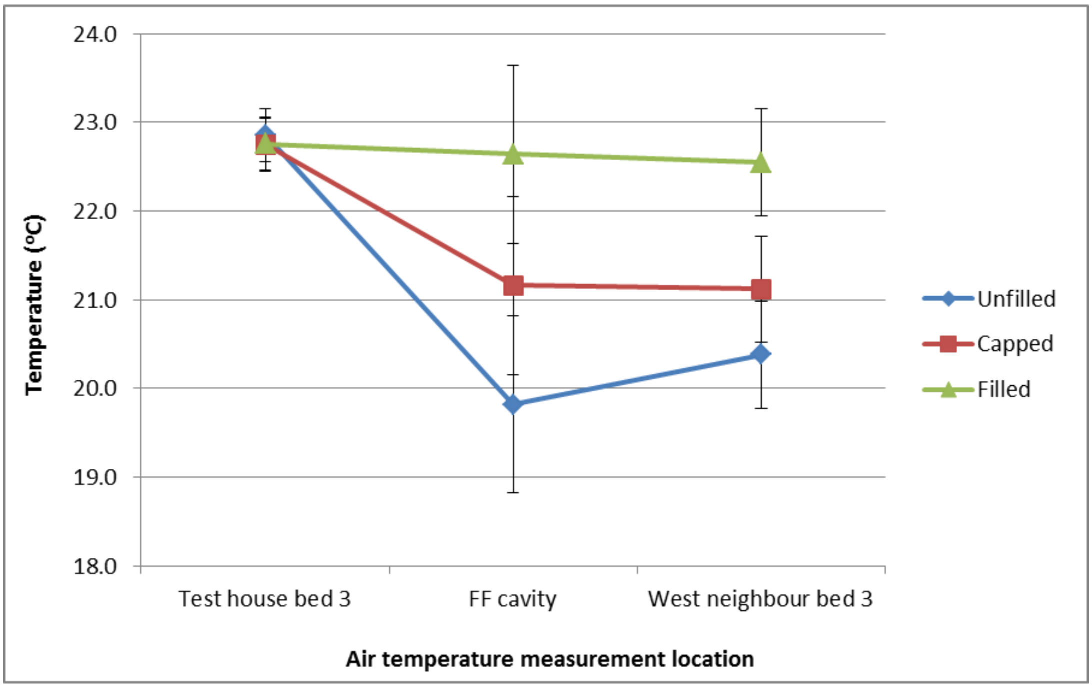

Figure 22: Air temperature measured within, and adjacent to, the test wall on the first floor

The cavity temperatures measured were lower than the habitable spaces either side of the test wall during the unfilled test stage. This indicates cooling of the cavity either through the escape of heat or the infiltration of cold air. The temperature gradient of the capped test wall suggests the cooling mechanism was reduced, but not eliminated, by this intervention.

Following filling of the party wall, the temperature gradient is close to a straight line which indicates that indicates conduction of heat between dwellings, rather than to the external environment. The elimination of the thermal bypass means that the retrofitted party wall can be considered to have a U-value of zero.

Assuming the party wall construction is similar on either side of the cavity then it can be expected that in the absence of a thermal bypass within the party wall cavity, the air temperature will be close to the mean of the air temperatures in the spaces on either side of the party wall (some differences might exist due to stratification and stack effect within an original cavity). Figure 23 illustrates the ΔT between the test cavity air temperature and the mean air temperature of the habitable spaces either side of the cavity during each test phase.

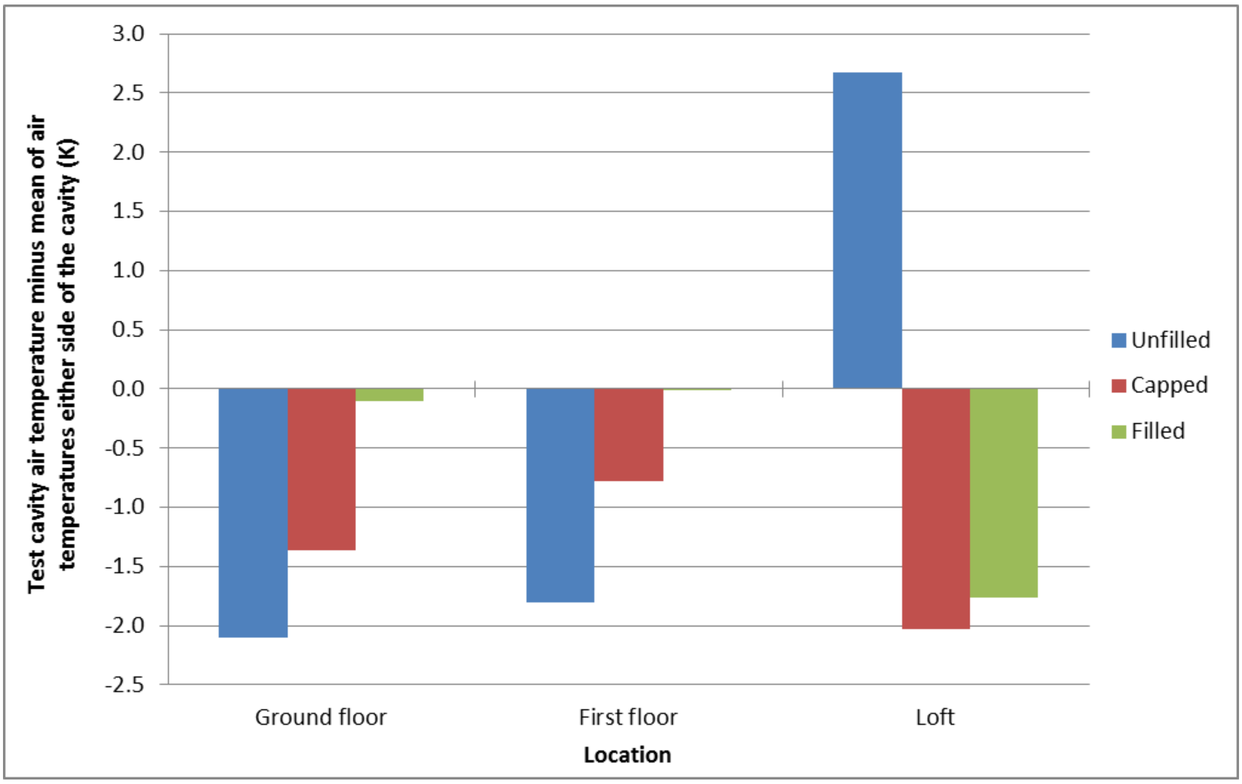

Figure 23: ΔT between air temperatures in test wall cavity and mean air temperature of internal spaces adjacent to the cavity in test house and west neighbour during each test phase[5]

The test wall cavity was cooler than the habitable spaces either side of it during the first two tests indicating the presence of a heat loss mechanism which was only eliminated after the test wall was fully filled.

The dramatic change in behaviour following intervention was in the test wall cavity at loft level. During the unfilled test stage the cavity was ~2.5 K warmer than the loft space. Following capping of the test wall cavity, the cavity was ~2K cooler than the loft space. This suggests that capping the test wall cavity prevented the passage of warm air up the cavity. In effect, the cavity was no longer behaving as a chimney.

5.4 Thermal mass

Following the party wall test period the test house continued to be heated as part of an investigation into the thermal performance of replacement loft insulation (Appendix A); during this period HFPs remained attached to the party wall. On 24/03/14 the test house experienced a power cut resulting in the loss of electrical heat input for approximately eight hours, this period demonstrated difference in the thermal mass characteristics of the test and control party walls. Figure 24 illustrates the mean of the first floor heat fluxes measured on the test and control party walls at a distance of greater than one meter from the external wall junction and associated temperature measurements in the period around the power cut.

[5] Loft air temperature measured in test house only.

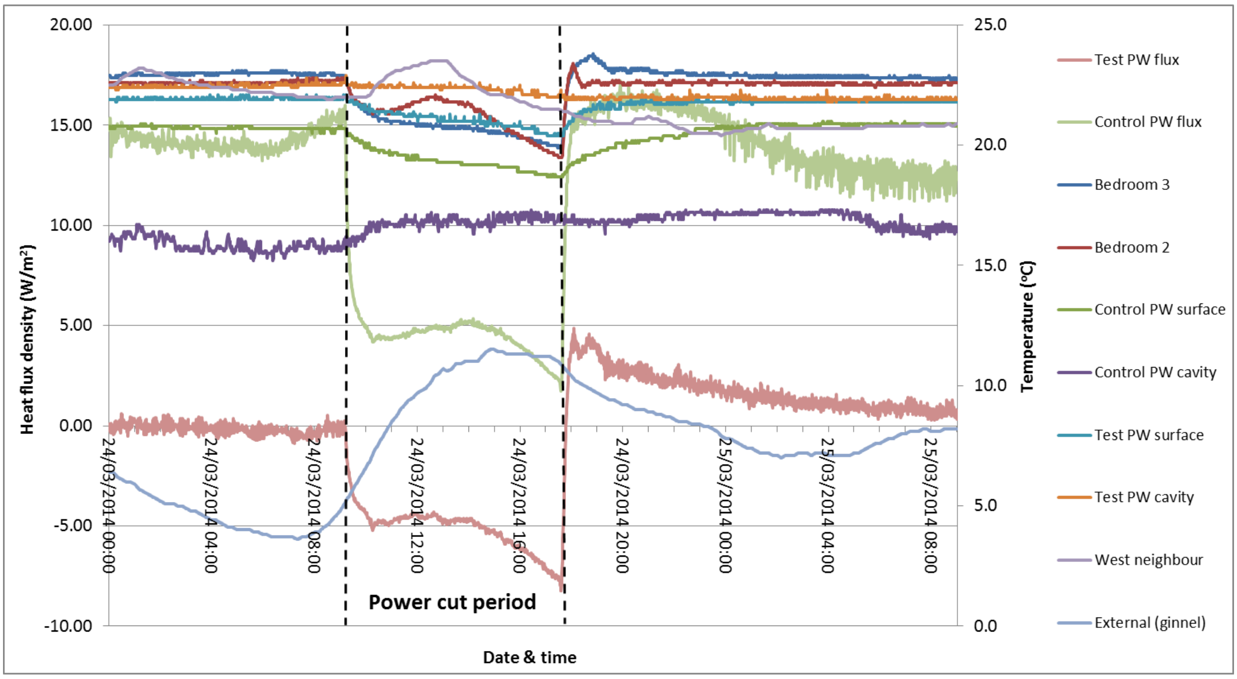

Figure 24: Heat fluxes and associated temperature measurements in the period around the power cut

Prior to the power cut, the surface temperature of the test party wall was below that of the air temperature of bedroom 3. Following the power cut, the surface temperature of the party wall reduced less rapidly than the air temperature, and after a period of approximately half an hour in duration, the air temperature had dropped to below that of the party wall surface, this continued for the remainder of the power cut period. The temperature within the filled party wall cavity remained greater than the air temperature throughout the entire power cut. Heat flow measured on the test party wall throughout this period was negative (into the building), which signifies the release of stored heat back into the bedroom 3.

The surface and cavity air temperatures of the control party wall remained lower than the air temperature of bedroom 2 throughout the entire period of the power cut. The heat flow measured on the control party wall remained positive (out of the building) throughout the entire period; though the rate of heat flow into the control party wall slowed as the ΔT between bedroom 2 and the empty cavity reduced.

The contrasting behaviour of the two party walls highlights the differing thermal mass properties of the unfilled and fully-filled masonry cavity party wall, with the fully-filled wall demonstrating a greater ability to store and release heat.

It must be noted that some of the heat flow measured into bedroom 3 from the test party wall could have also been a result of inter-dwelling heat transfer. Further investigation is required to disaggregate from the measured heat flow the contribution of stored heat release and inter-dwelling heat transfer.

6 Conclusions

There is good agreement between the reduction in U-values measured and the reduction in HLC loss following the capping and filling of the test wall. When taken in conjunction with the cavity temperature measurements, it can be stated that there is a high level of confidence that capping and fully filling the test party wall with mineral wool eliminated the thermal bypass mechanism present and resulted in a zero U-value party wall.

Though the U-value of the existing wall of 0.30 W/m^{2}K was lower than that the 0.50 W/m^{2}K predicted by RdSAP. However, the measured U-values following each intervention were consistent with new build party wall U-values contained within Part L1A of the Building Regulations. The investigation supports previous work which suggested that this retrofit measure can eliminate the thermal bypass mechanism; however it also casts uncertainty as to the magnitude of the energy savings that can be achieved with this measure.

Further research is required to establish the effect of the seal at the base and edges of a cavity party wall and the relationship between air infiltration and U-value. This work could potentially take place in a laboratory environment with adjustable apertures at the edges of a replica party wall used to control infiltration. Certain construction types could have inherent weaknesses that mean that the potential for air infiltration at the base of a party wall is greater, thus increasing the U-value. For example, a suspended timber floor construction could provide air paths from the floor void into the cavity where built-in joists penetrate the party wall.

It is highly likely that the integrity of a cavity seal at the base and edges of a party wall, which could influence the magnitude of the cavity wall bypass, cannot easily be identified an energy assessor. This could result in a misestimation of the potential energy savings that could be attributed to this retrofit measure. Thus, a greater statistical sample of party wall heat loss across the housing stock is required to ascertain the distribution of unfilled masonry cavity party wall U-values.

Fully filling a party wall cavity not only reduced the elemental U-value, it enables the utilisation of the party wall masonry thermal mass, this behaviour was evident following the power cut in the test house. This finding highlights an addition benefit of this retrofit measure that is not currently considered in energy saving calculations.

7 References

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Appendix A – Replacement loft insulation

Following the main party wall investigation the existing (pre-retrofit) loft insulation was removed and replaced (retrofit) with 300 mm of glass mineral wool quilt (λ = 0.044 W/mK). Measurements of thermal performance continued to be taken. All pre-retrofit values stated were measured during the filled test stage of the party wall investigation.

Thermography

Figure A1 shows the inconsistency with the placement of the pre-retrofit loft insulation in the test house loft above bedroom 3. It is evident in Figure A1 that the greatest heat loss observed in the thermogram corresponds with missing insulation between the second pairing of ceiling joists from the party wall.

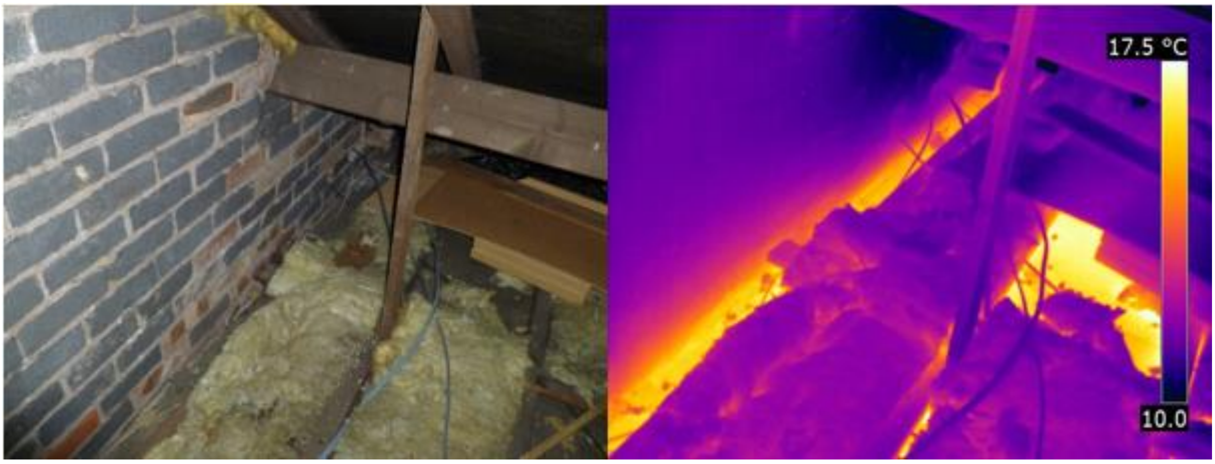


Figure A1: Image and thermogram of the loft space above bedroom 3 prior to retrofit showing poorly fitted and missing roof insulation

Figure A2 shows how the areas of missing insulation in the loft space seen in Figure A1 correspond with the cold areas of ceiling in bedroom 3. The thermal inconsistencies evident in the thermogram in Figure A2 are typical of what was observed across the first floor ceiling of the test house pre- retrofit.

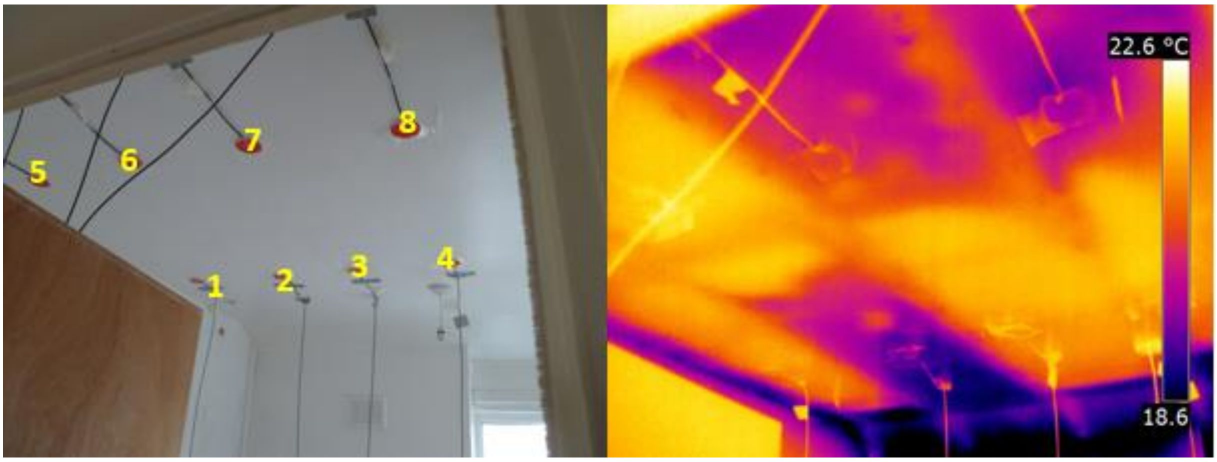


Figure A2: Image and thermogram of the ceiling in bedroom 3 prior to retrofit. Numbers 1-8 are the roof HFP identifiers.

It can be seen in Figure A3 that the retrofit loft insulation was correctly installed resulting in a higher level of thermal consistency.

Figure A3: Image and thermogram of the loft space with the retrofit loft insulation fitted

Figure A4 shows the loft space above bedroom 3. The retrofit loft insulation appeared to be correctly installed and a greater level of thermal consistency was observed.

Figure A3: Image and thermogram of the loft space above bedroom 3 with the retrofit loft insulation fitted

The 2 K temperature span in the thermogram of the ceiling in bedroom 3 seen in Figure A4 shows a high level of thermal consistency across the ceiling following the installation of the retrofit loft insulation.

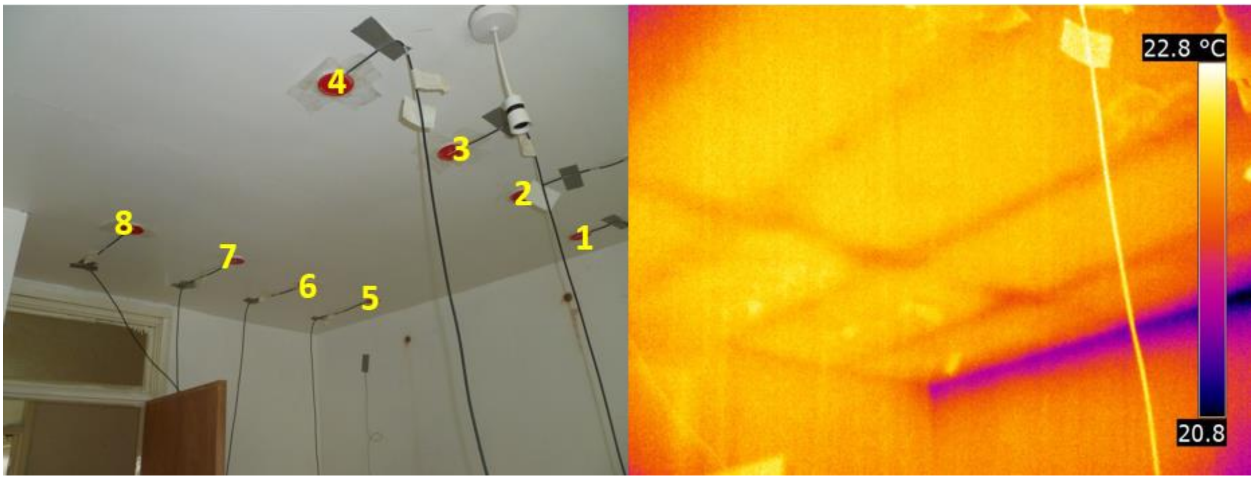


Figure A4: Image and thermogram of the ceiling in bedroom 3 post-retrofit. Numbers 1-8 are the roof HFP identifiers.

Figure A5 shows homogenous surface temperatures on the ceiling of bedroom 3 post- retrofit. This region that was previously characterised by a high level of thermal consistency, notably in the region of roof HFP2 (refer to Figure A2).

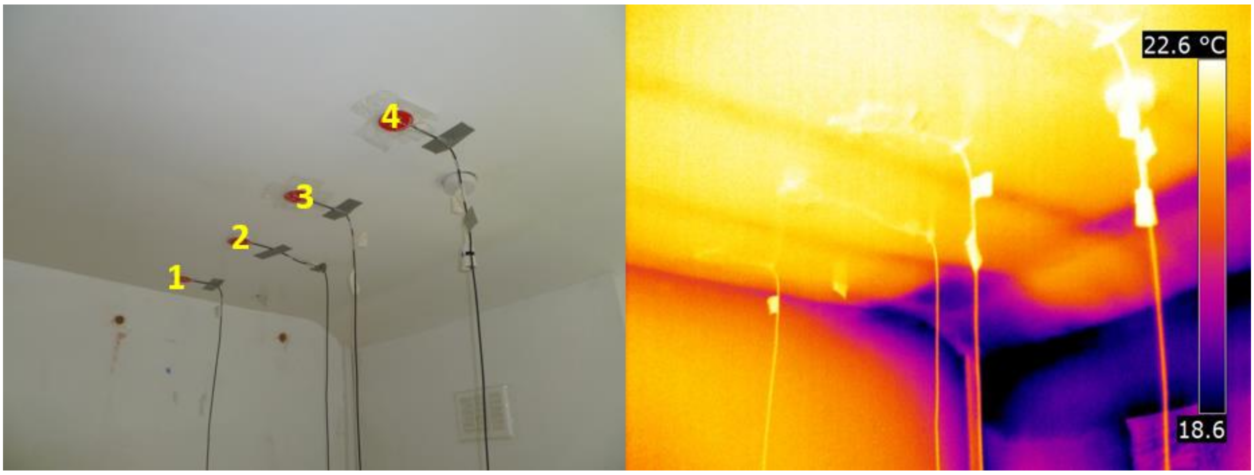


Figure A5: Image and thermogram of the ceiling in bedroom 3 post-retrofit. Numbers 1-4 are the roof HFP identifiers.

In situ U-value measurements

Eight HFPs were affixed to the first floor ceiling of the test house in bedroom 3 to measure the *in situ* U-value of the roof, the location and identifier of the HFPs are provided in Figure A2.

To eliminate the effects of solar gain the roof U-values were calculated from measurements obtained between 22:00-06:00 each day. This method is acceptable in ISO 9869 due to the lightweight nature of the roof construction.

Figure A6 illustrates the 8 hour *in situ* U-values measured pre- and post-retrofit for the test house roof.

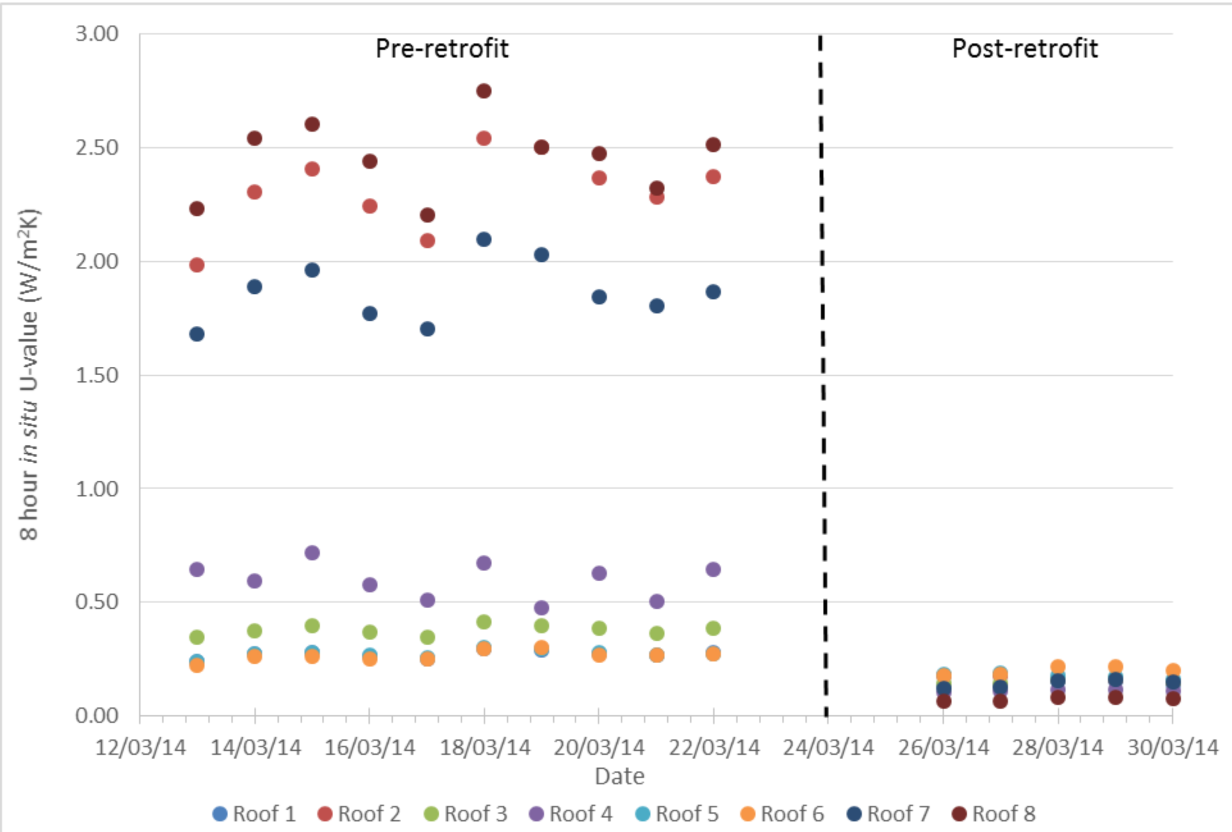


Figure A6: 8 hour *in situ* U-values measured pre- and post-retrofit for the test house roof

There are two distinct bands of pre-retrofit U-value measurements evident In Figure A6. The highest U-values measured correspond to the HFPs at the locations of greatest heat loss seen in Figure A2.

The improved thermal consistency seen in Figure A4 is reflected in the tight grouping of post-retrofit U-values seen in Figure A6.

Table A1 provides the per- and post-retrofit roof *in situ* U-value measurement at HFP.

Table A1: Pre- and post-retrofit U-values for the roof of the test house

Roof HFP location	*In situ* U-value (W/m²K)	
	Pre-retrofit	**Post-retrofit**
1	0.27	0.14
2	2.31	0.17
3	0.38	0.15
4	0.60	0.11
5	0.27	0.18
6	0.27	0.20
7	1.86	0.14
8	2.46	0.08
Mean	n/a	0.15

The HFP positioning on the pre-retrofit ceiling was not random in nature and the distribution of U-values measured pre-retrofit cannot be considered representative of the roof as a whole. The high level of thermal consistency observed on the first floor ceiling means that there can be some confidence that the mean post-retrofit roof U-value (excluding ceiling joists) 0.15 (± 0.01) W/m²K can be considered representative.

Heat loss coefficient

Coheating test result

Figure A7 illustrates the regression based HLC analysis for the pre- and post-retrofit coheating tests.

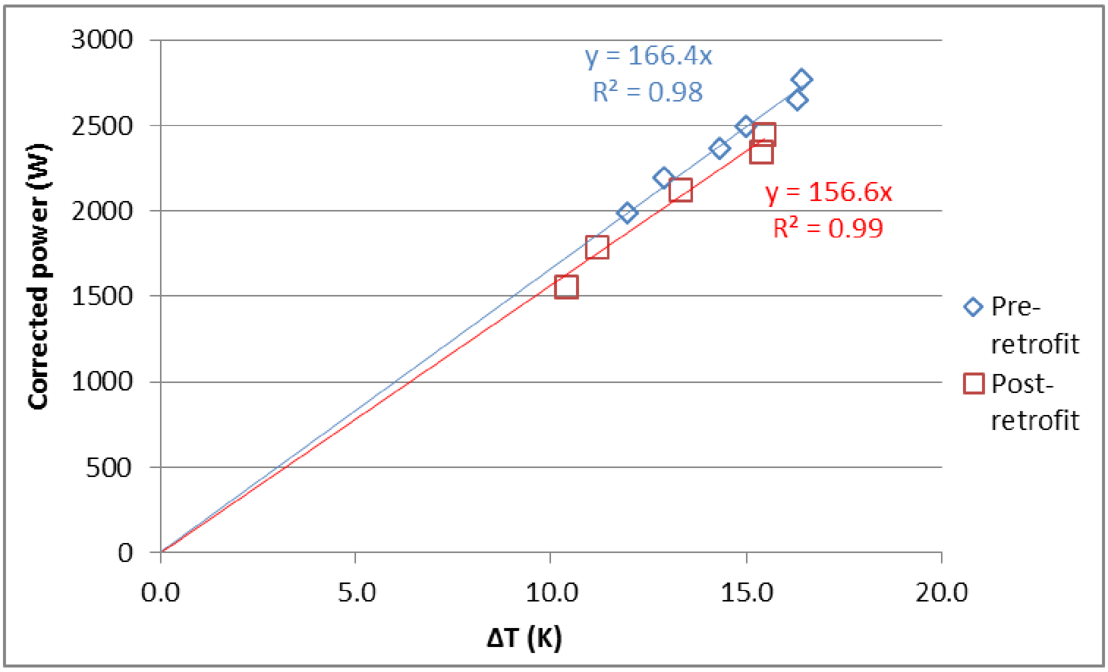


Figure A7: Linear regression HLC estimates for the test house pre- and post-retrofit of the roof

The post-retrofit coheating test measured a HLC of 156.6 (± 8.5) W/K[6]. The coheating test result must be treated with caution. Although there was a high R^2 correlation for regression neither the solar or wind

[6] The high level of HLC uncertainty is partially attributed to the short test duration.

coefficients were statistically significant. In addition, the 9.8 W/K HLC reduction is not statistically significant.

Background ventilation heat loss

The background ventilation rate derived from the post-retrofit fan pressurisation test (refer to Appendix A in the main report for details) was 0.59 ACH; this represents a 5% reduction on the pre-retrofit value.

Table A2 shows the disaggregation of the fabric and ventilation heat loss components of the HLC measured during the pre and post-retrofit of the roof.

Table A2: Disaggregation of the HLC measured in the pre- and post-retrofit test stages into fabric and ventilation heat loss

Roof condition	Heat loss coefficient (W/K)	Ventilation heat loss (W/K)	Fabric heat loss (W/K)
Pre-retrofit	166.4 ± 4.8	36.3	130.1
Post-retrofit	156.6 ± 8.5	34.6	122
Reduction on unfilled stage (W/K)	9.8	1.7	8.1
Reduction on pre-retrofit roof per m^2 (W/m^{2}K)			0.21

All values associated with the post-retrofit coheating test result in Table A2 must be treated with caution due to the high level of uncertainty associated with the test result.

Appendix B – Test house floor plans

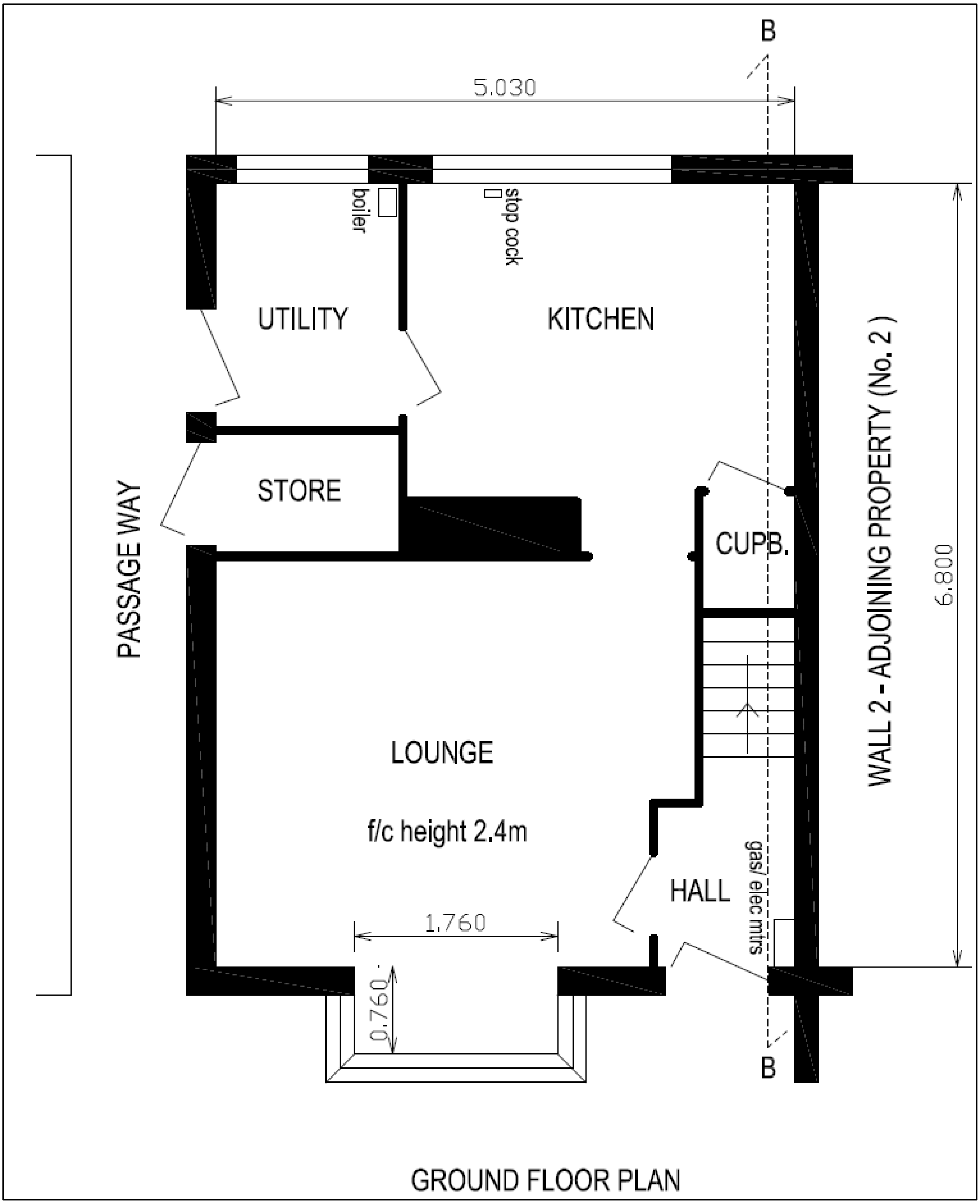


Figure B1: Ground floor plan of the test house

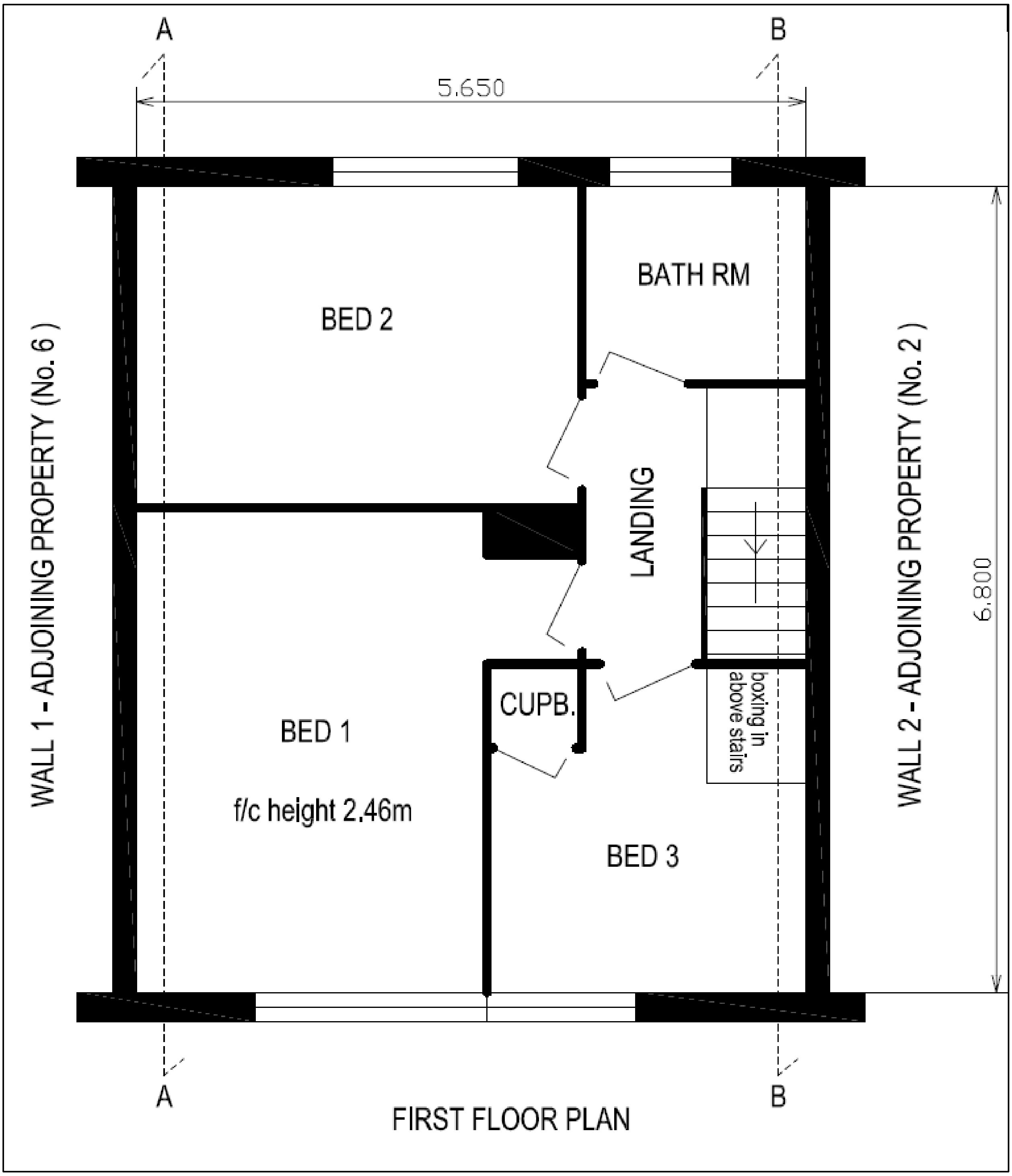


Figure B2: First floor plan of the test house

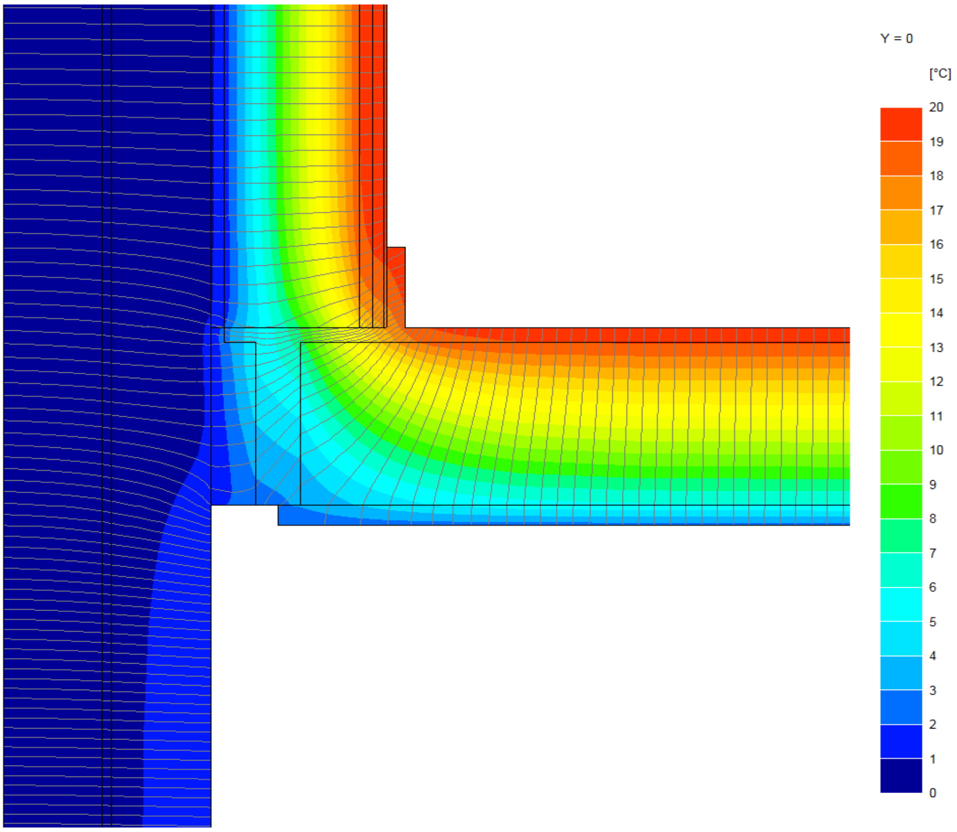
Appendix G. Thermal bridging calculations

Detail:	Ground Floor With Joist Parallel (50 mm) and 150 mm Wall Insulation						
Calc No:	TB/01	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	6.1507	ℓ_z:	1.000	U_w:	0.129	T_{si}:	18.34
T_i:	20.00	ℓ_w:	1.000	U_f:	0.162	L^{2D}:	0.3075
T_e:	0.00	ℓ_f:	1.000			**f_{min}:**	**0.917**
T_u:	2.38					**Ψ** (W/m·K):	**0.016**

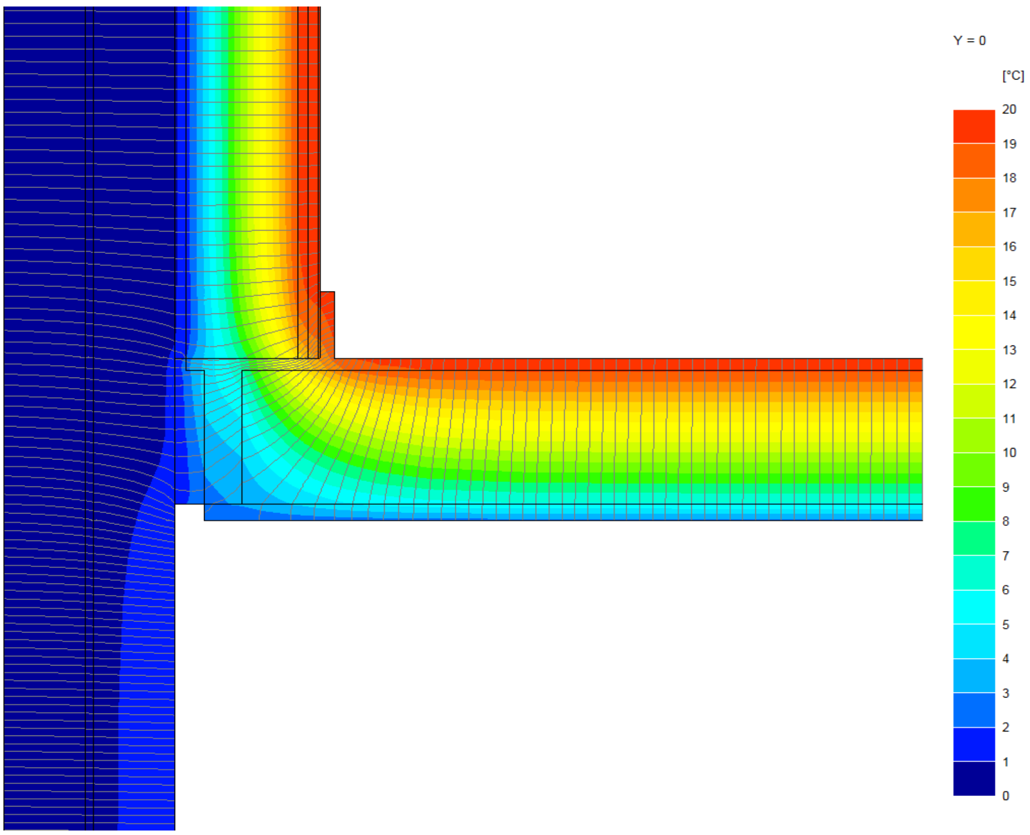
Notes:

Detail:	Ground Floor With Joist Parallel (40 mm) and 150 mm Wall Insulation						
Calc No:	TB/02	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	6.1413	ℓ_z:	1.000	U_w:	0.129	T_{si}:	18.36
T_i:	20.00	ℓ_w:	1.000	U_f:	0.162	L^{2D}:	0.3071
T_e:	0.00	ℓ_f:	1.000			**f_{min}:**	**0.918**
T_u:	2.38					**Ψ** (W/m·K):	**0.015**

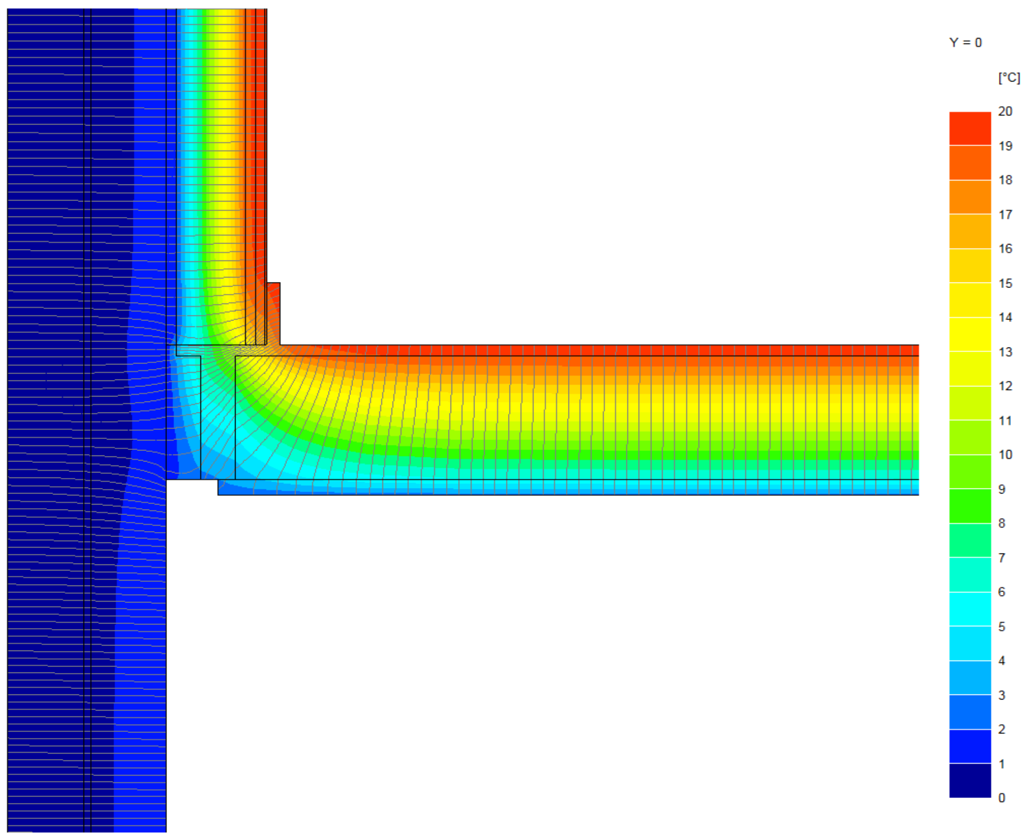
Notes:

Detail:	Ground Floor With Joist Parallel (50 mm) and 100 mm Wall Insulation						
Calc No:	TB/03	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	7.3467	ℓ_z:	1.000	U_w:	0.183	T_{si}:	18.02
T_i:	20.00	ℓ_w:	1.000	U_f:	0.162	L^{2D}:	0.3673
T_e:	0.00	ℓ_f:	1.000			**f_{min}:**	**0.901**
T_u:	2.38					**Ψ** (W/m·K):	**0.022**

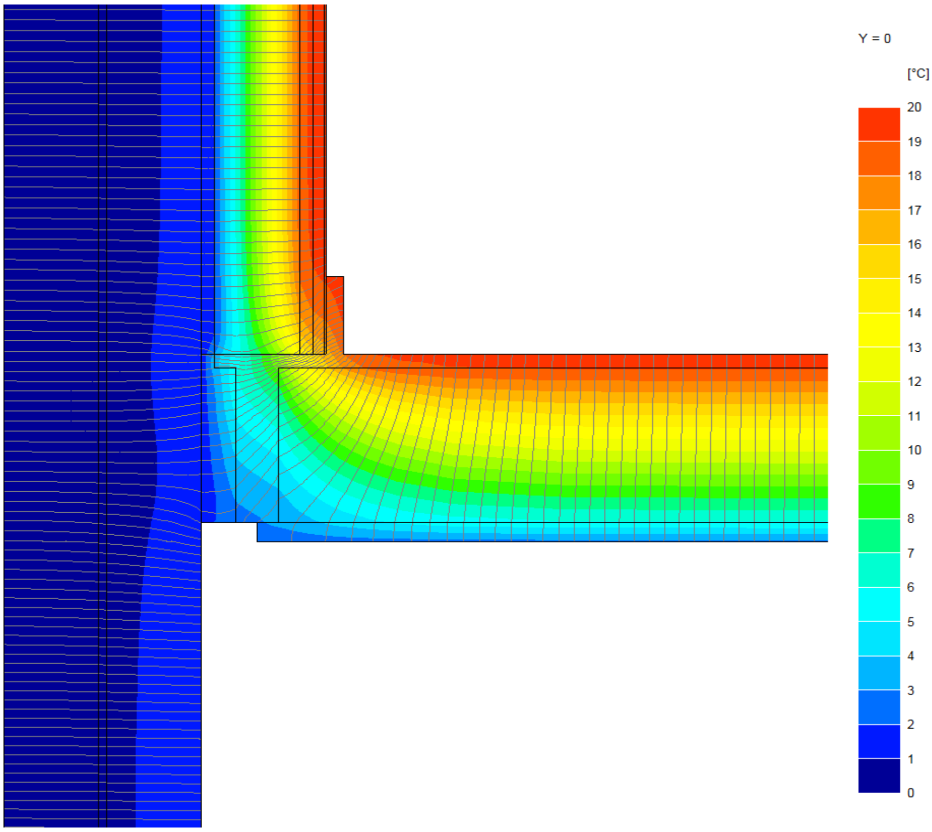
Notes:

Detail:	Ground Floor With Joist Parallel (40 mm) and 100 mm Wall Insulation						
Calc No:	TB/04	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	7.3351	ℓ_z:	1.000	U_w:	0.183	T_{si}:	18.04
T_i:	20.00	ℓ_w:	1.000	U_f:	0.162	L^{2D}:	0.3668
T_e:	0.00	ℓ_f:	1.000			**f_{min}:**	**0.902**
T_u:	2.38					**Ψ** (W/m·K):	**0.021**

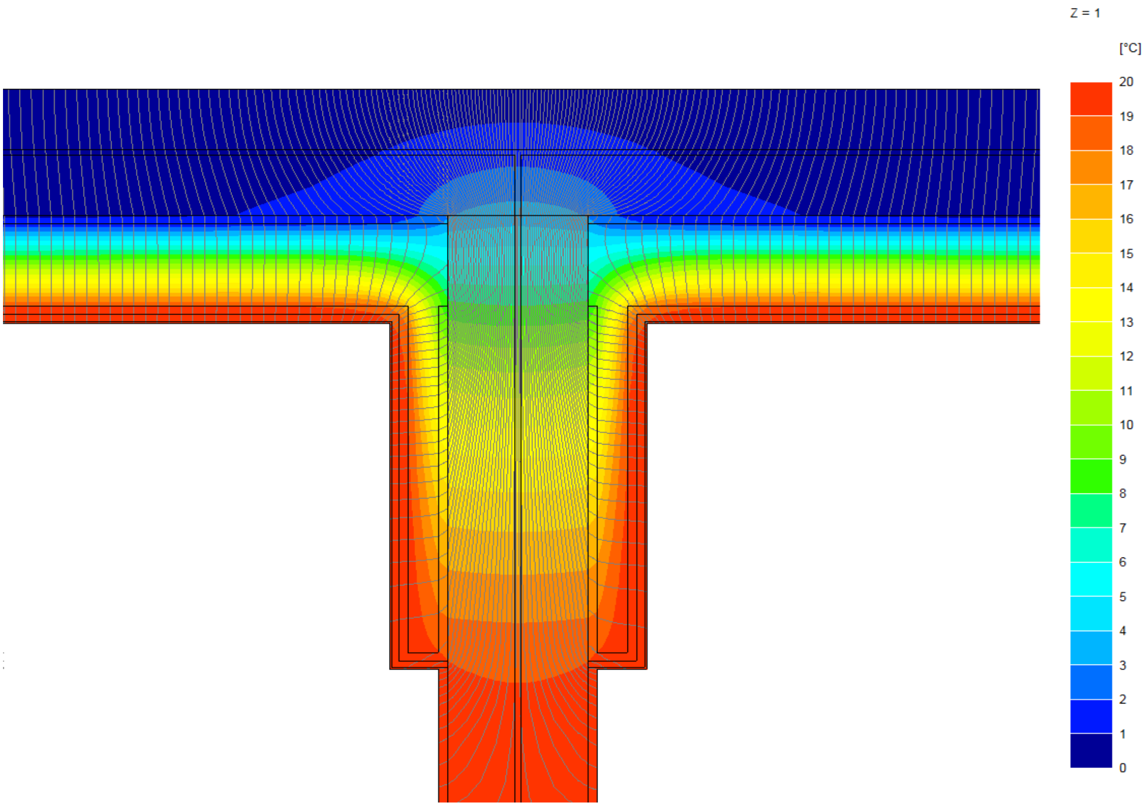
Notes:

Detail:	Party Wall 150 mm Insulation						
Calc No:	TB/05	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q:	9.4574	ℓ_z:	1.000	U_w:	0.129	T_{si}:	19.01
T_i:	20.00	ℓ_w:	1.000			L^{2D}:	0.4729
T_e:	0.00					**f_{min}:**	**0.951**
						Ψ (W/m·K):	**0.107**

Notes:

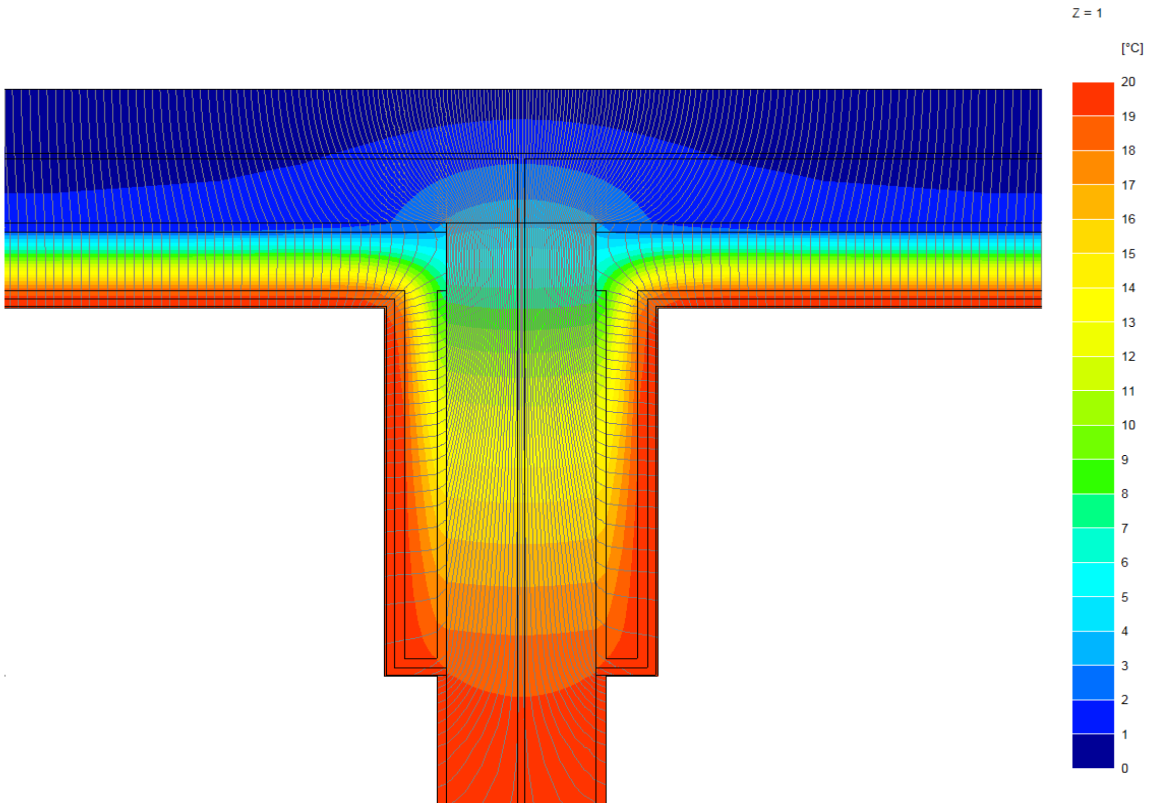
Ψ-value to be applied to each property.

Detail:	Party Wall 100 mm Insulation						
Calc No:	TB/06	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q:	11.9431	ℓ_z:	1.000	U_w:	0.183	T_{si}:	18.85
T_i:	20.00	ℓ_w:	1.000			L^{2D}:	0.5972
T_e:	0.00					f_{min}:	**0.943**
						Ψ (W/m·K):	**0.115**

Notes:

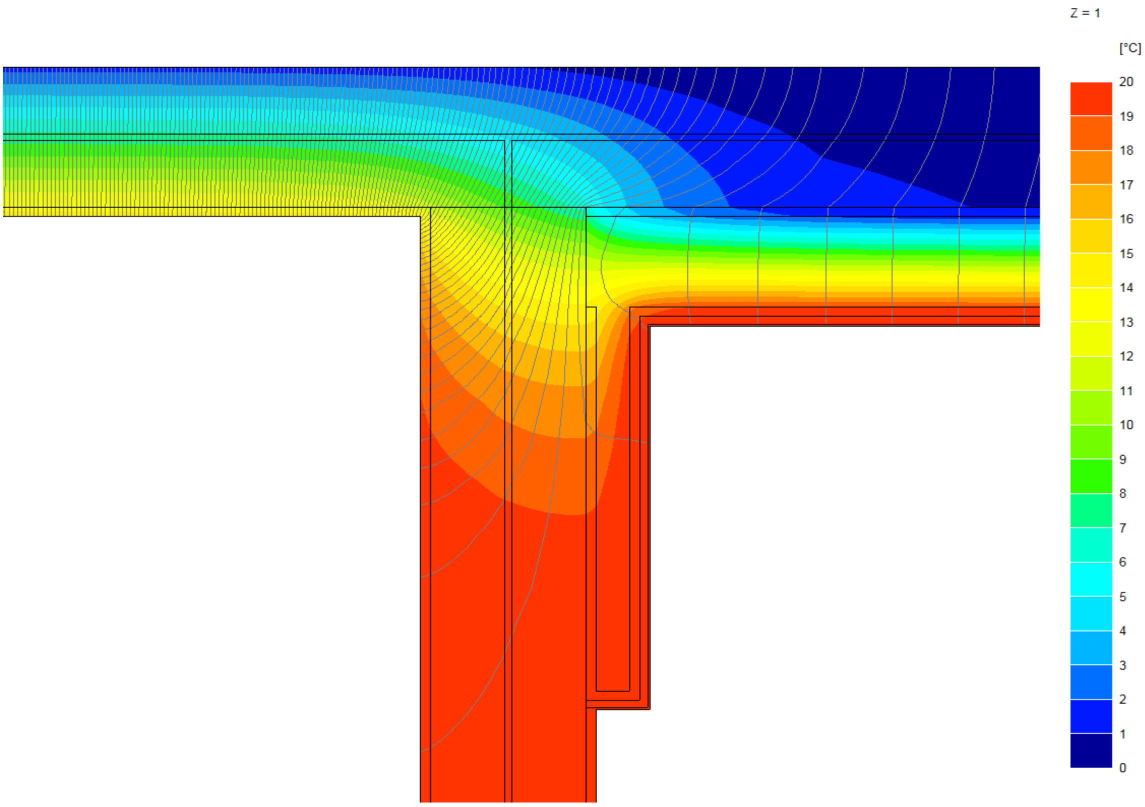
Ψ-value to be applied to each property.

Detail:	Party Wall 150 mm Insulation Single Side						
Calc No:	TB/07	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q_1:	3.1103	ℓ_z:	1.000	U_{w1}:	0.129	T_{si1}:	19.40
Q_2:	48.29	ℓ_{w1}:	1.000	U_{w2}:	2.004	T_{si2}:	13.40
T_i:	20.00	ℓ_{w2}:	1.000			L^{2D1}:	0.1555
T_e:	0.00					L^{2D2}:	2.4144
						f_{Rsi1}:	**0.970**
						f_{Rsi2}:	**0.670**
						Ψ_1 (W/m·K):	**0.026**
						Ψ_2 (W/m·K):	**0.410**

Notes:

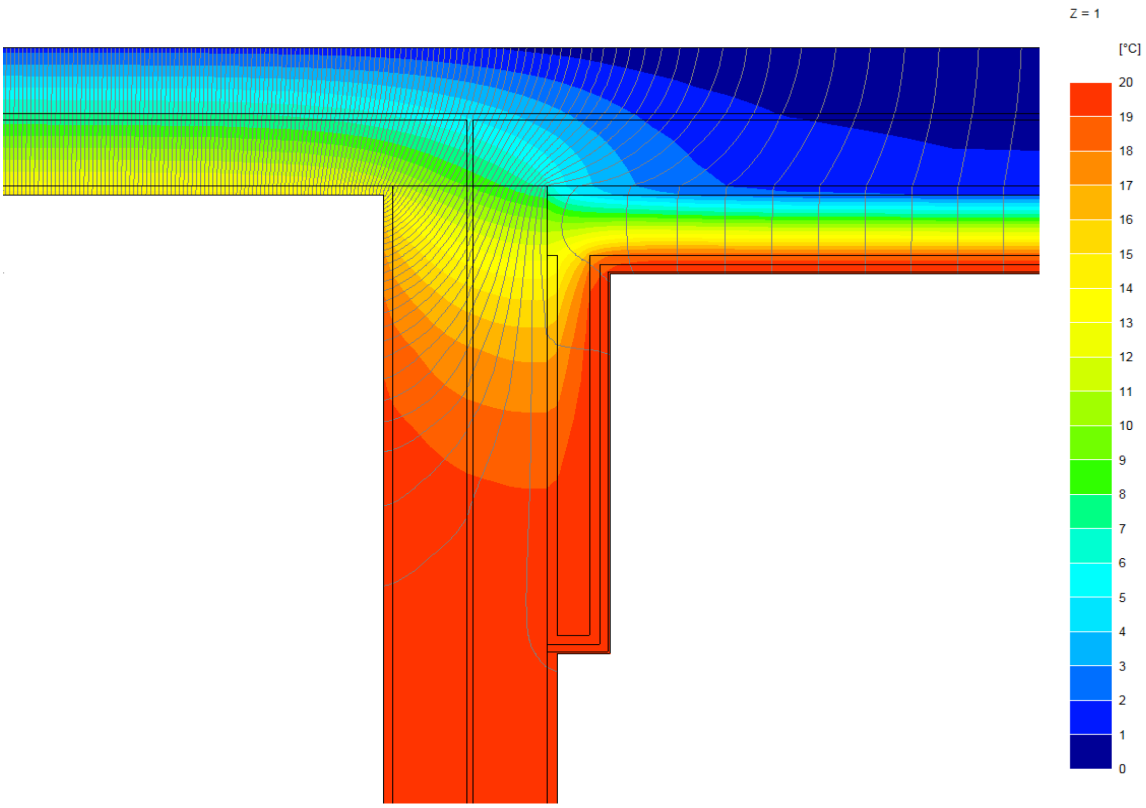
f_{Rsi} to neighbouring property < f_{CRsi} ∴ potential risk of surface condensation and mould growth

Detail:	Party Wall 100 mm Insulation Single Side						
Calc No:	TB/08	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q_1:	4.3287	ℓ_z:	1.000	U_w:	0.183	T_{si}:	19.20
Q_2:	48.1770	ℓ_w:	1.000	U_{w2}:	2.004	T_{si2}:	13.43
T_i:	20.00	ℓ_{w2}:	1.000			L^{2D1}:	0.2164
T_e:	0.00					L^{2D2}:	2.4089
						f_{Rsi1}:	**0.960**
						f_{Rsi2}:	**0.672**
						Ψ_1 (W/m·K):	**0.033**
						Ψ_2 (W/m·K):	**0.404**

Notes:

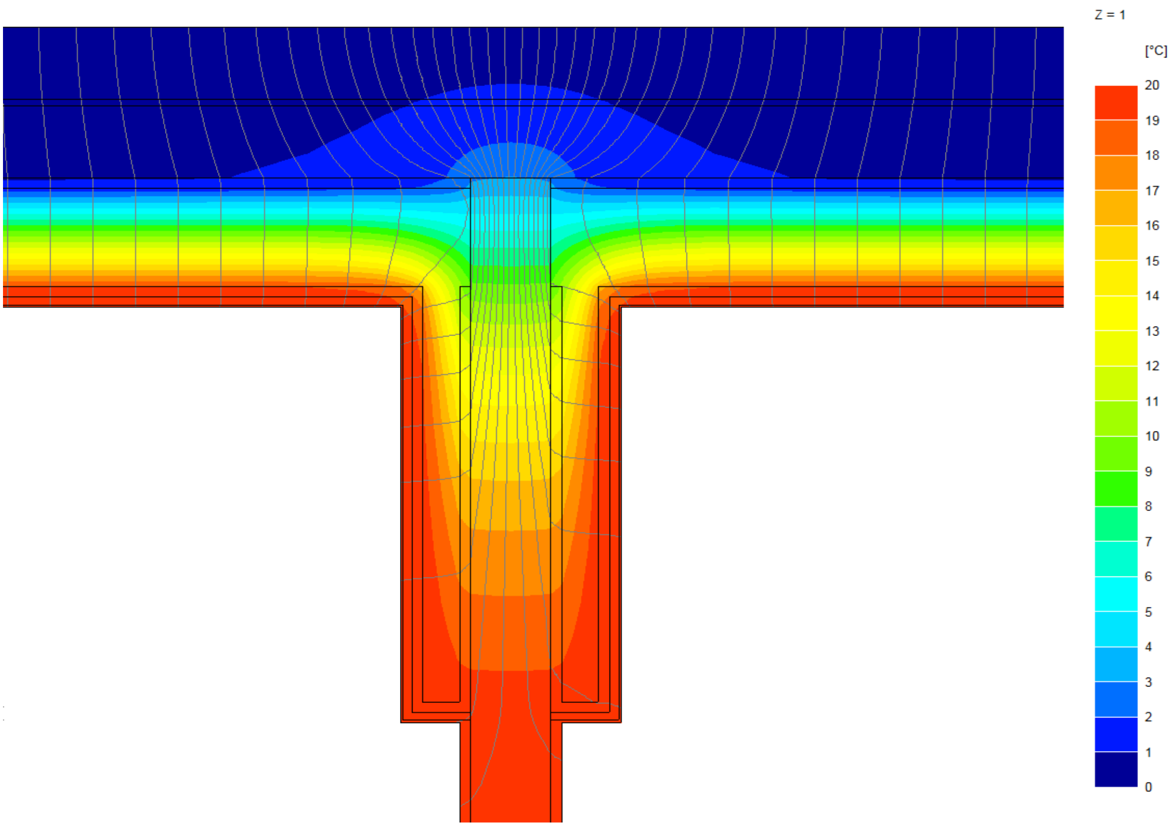
f_{min} to neighbouring property < f_{CRsi} ∴ potential risk of surface condensation and mould growth

Detail:	Partition 150 mm Insulation						
Calc No:	TB/09	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q:	7.8969	ℓ_z:	1.000	U_w:	0.129	T_{si}:	19.08
T_i:	20.00	ℓ_w:	2.301			L^{2D}:	0.3948
T_e:	0.00					f_{Rsi}:	**0.954**
						Ψ (W/m·K):	**0.097**

Notes:

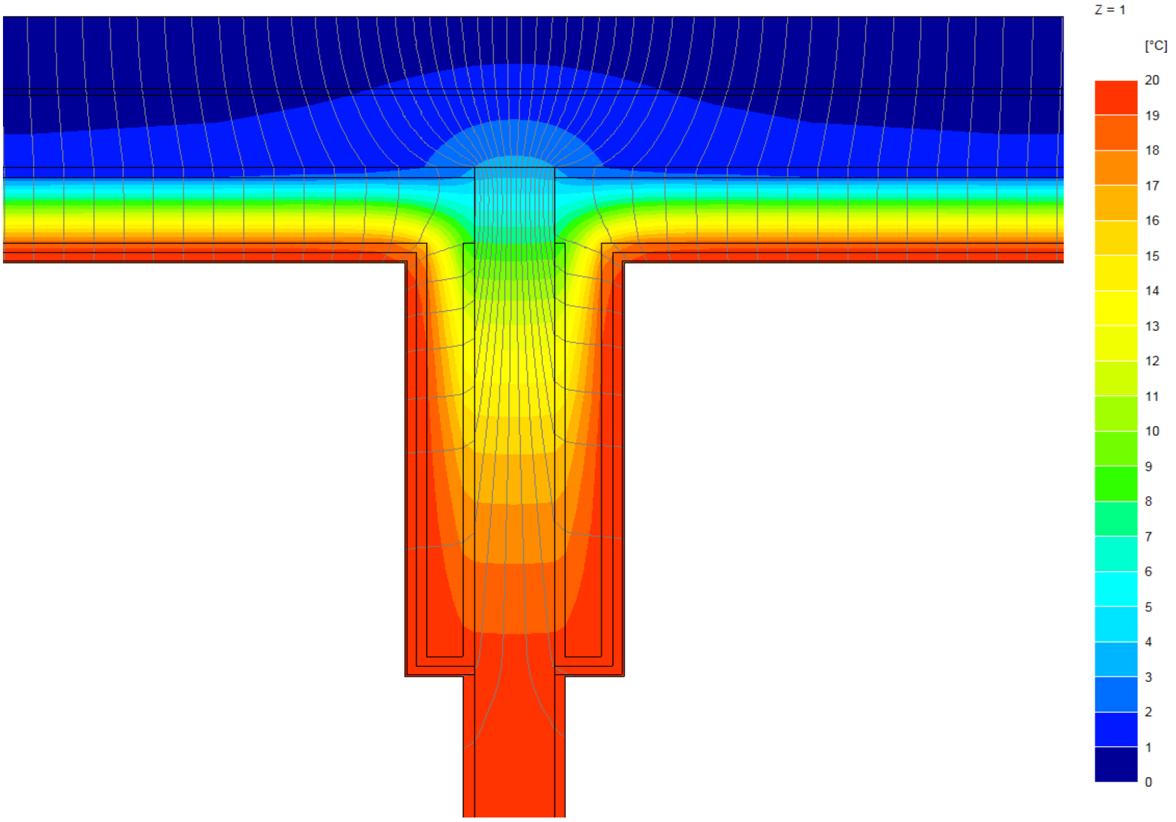
Ψ-value to be applied to each property.

Detail:	Partition 100 mm Insulation						
Calc No:	TB/10	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q:	10.3359	ℓ_z:	1.000	U_w:	0.183	T_{si}:	18.90
T_i:	20.00	ℓ_w:	2.301			L^{2D}:	0.5168
T_e:	0.00					f_{Rsi}:	**0.945**
						Ψ (W/m·K):	**0.095**

Notes:

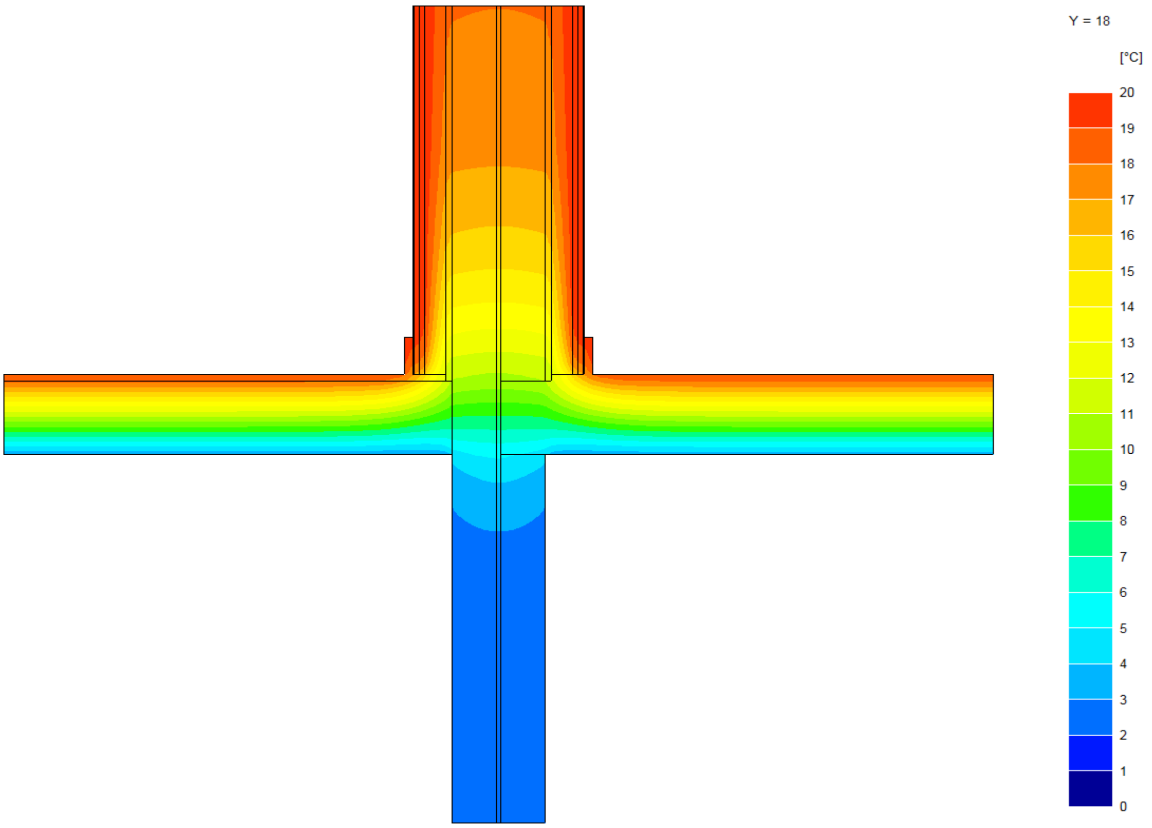
Ψ-value to be applied to each property.

Detail:	Party Wall/Ground Floor						
Calc No:	TB/11	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	2.2145	ℓ_z:	0.200			T_{si}:	18.25
T_i:	20.00			U_f:	0.186	L^{2D}:	0.1107
T_e:	0.00	ℓ_f:	1.000			f_{Rsi}:	**0.913**
T_u:	2.38					**Ψ** (W/m·K):	**0.091**

Notes:

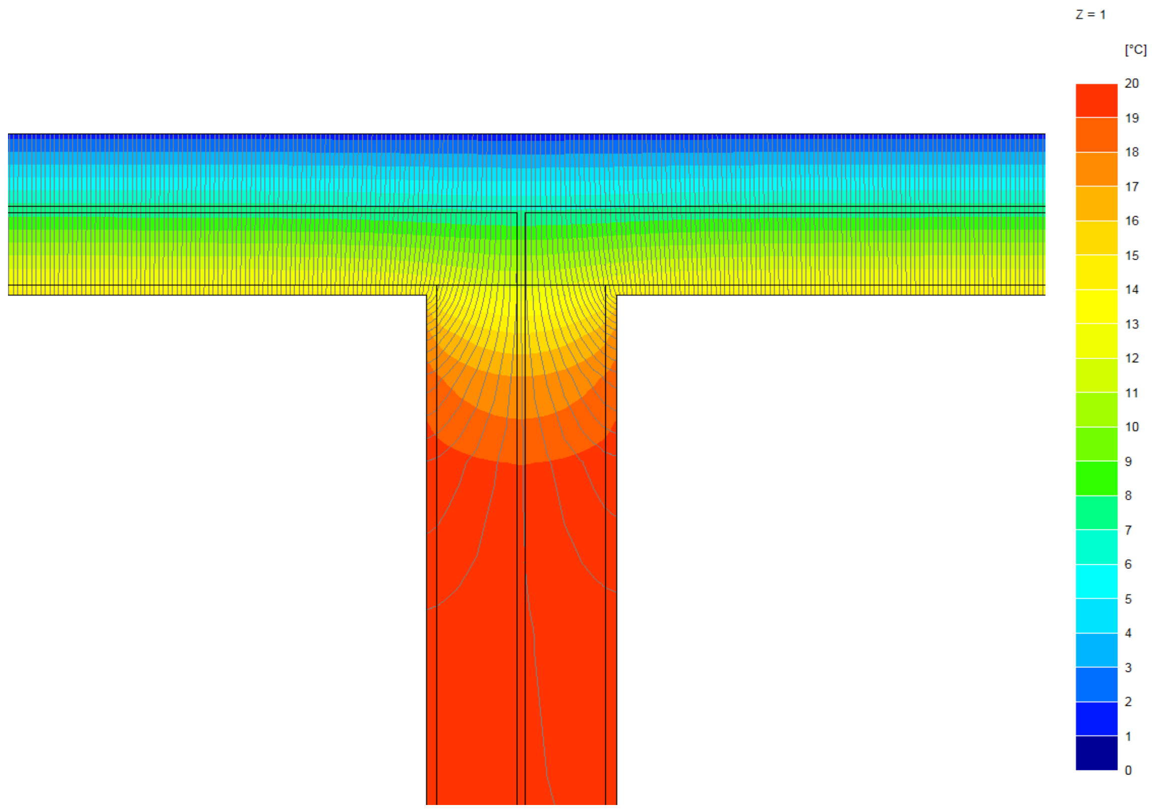
Ψ-value to be applied to each property.

Detail:	Party Wall Uninsulated						
Calc No:	TB/12	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524

Temperature Distribution:



Q:	89.4556	ℓ_z:	1.000	U_w:	2.004	T_{si}:	14.35
T_i:	20.00	ℓ_w:	1.000			T_{si2}:	14.35
T_e:	0.00					L^{2D}:	4.4728
						f_{Rsi}:	**0.718**
						Ψ (W/m·K):	**0.232**

Notes:

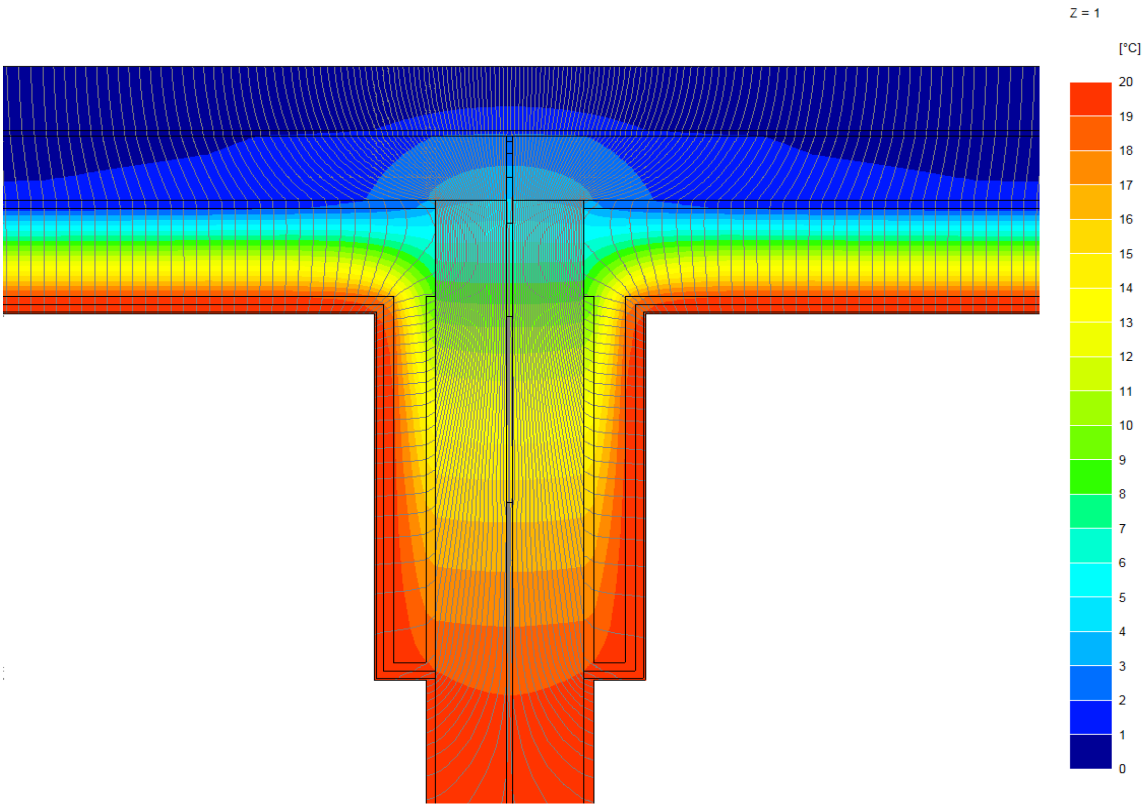
$f_{min} < f_{CRsi}$ ∴ potential risk of of surface condensation and mould growth. Ψ-value to be applied to each property.

Detail:	Party Wall 150 mm Insulation with Air Cavity						
Calc No:	TB/13	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Air Spaces	Varies	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q:	9.2539	ℓ_z:	1.000	U_w:	0.128	T_{si}:	19.05
T_i:	20.00	ℓ_w:	1.000			L^{2D}:	0.4627
T_e:	0.00					f_{Rsi}:	**0.953**
						Ψ (W/m·K):	**0.103**

Notes:

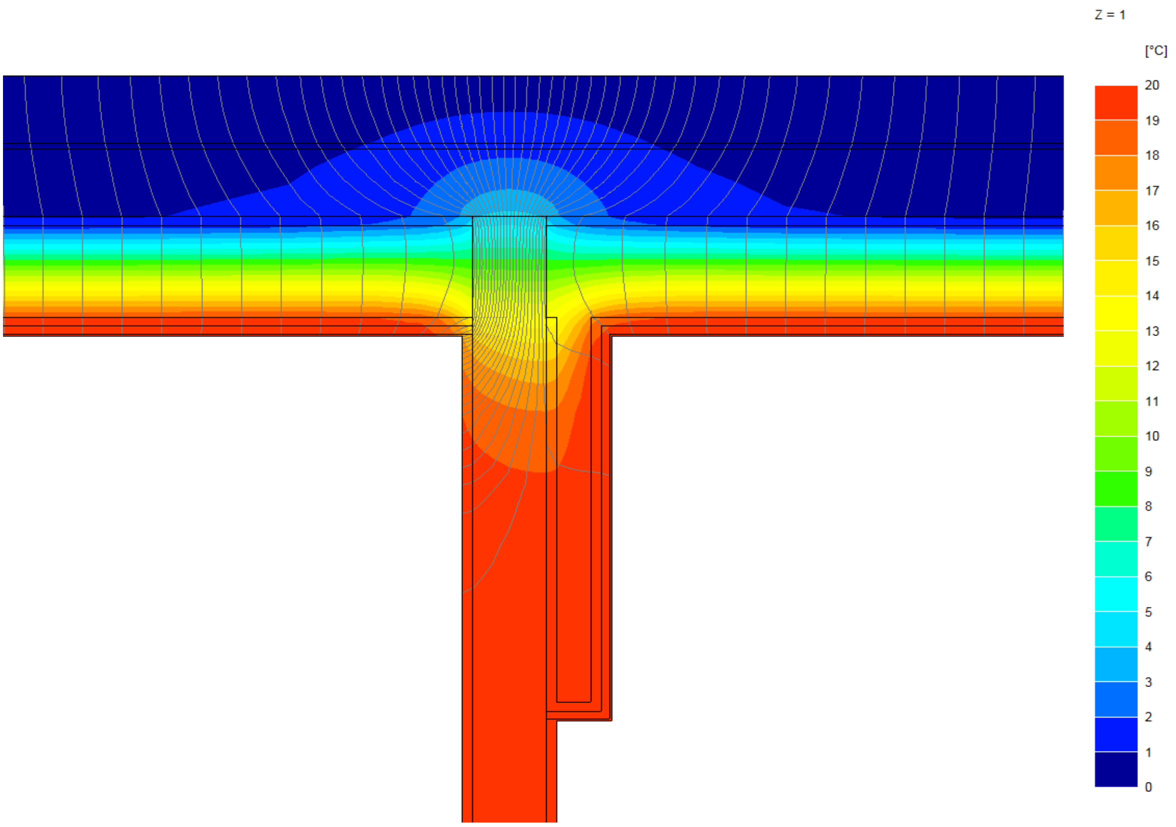
Ψ-value to be applied to each property.

Detail:	Partition 150 mm Insulation Single Sided Return						
Calc No:	TB/14	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



Q:	9.1138	ℓ_z:	1.000	U_w:	0.129	T_{si}:	19.33
T_i:	20.00	ℓ_w:	2.301			T_{si2}:	17.11
T_e:	0.00					L^{2D}:	0.4557
						f_{Rsi1}:	**0.967**
						f_{Rsi2}:	**0.856**
						Ψ (W/m·K):	**0.158**

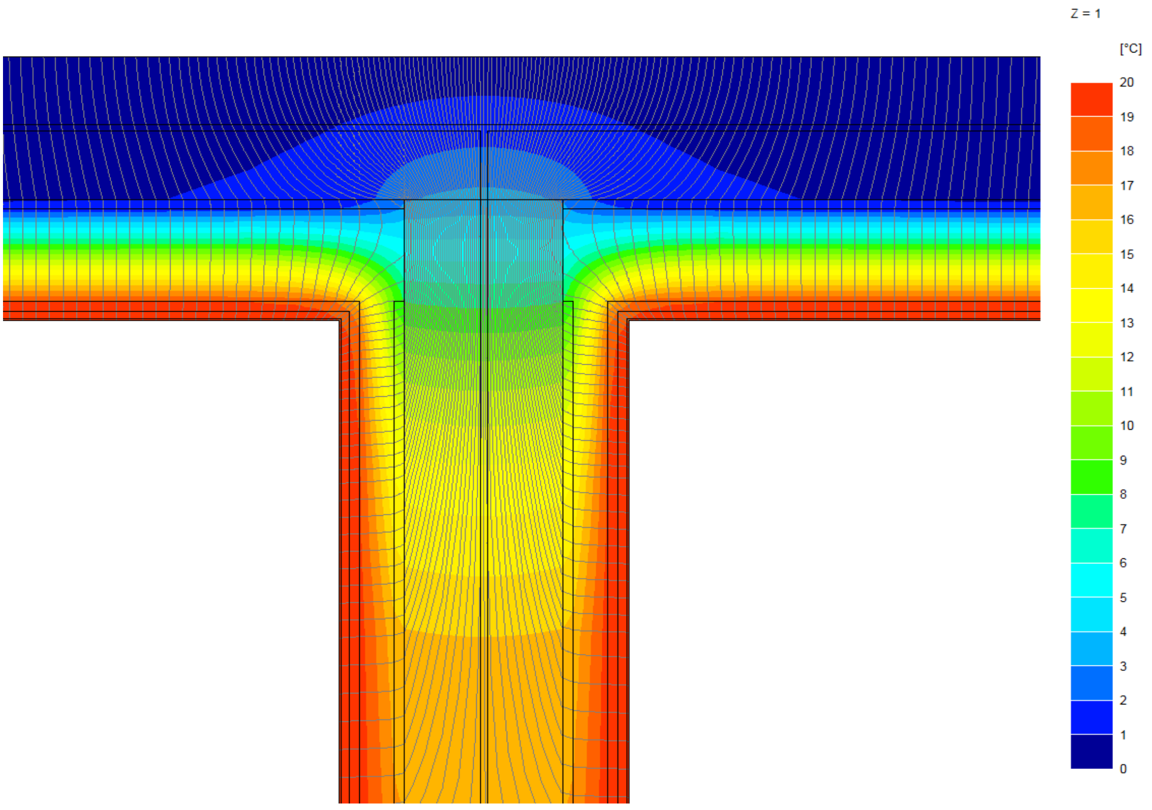
Notes:

Detail:	Party Wall 150 mm Insulation Full Return						
Calc No:	TB/15	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



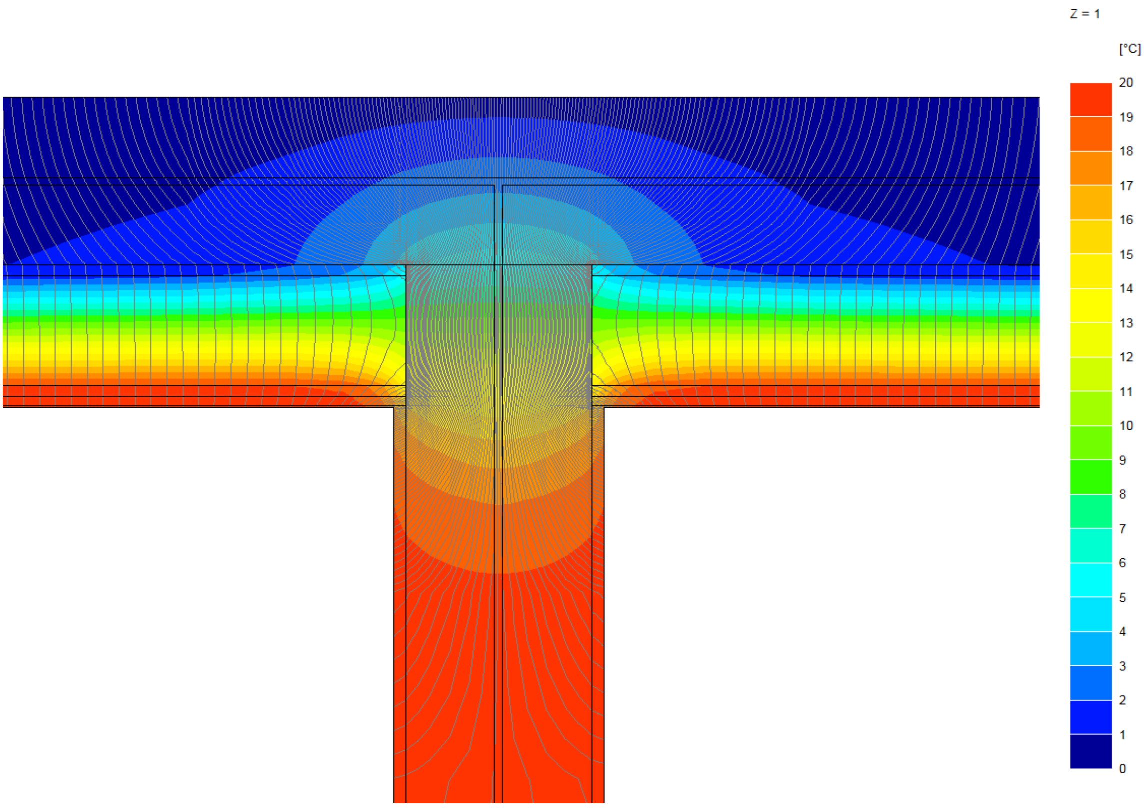
Q:	9.2848	ℓ_z:	1.000	U_w:	0.129	T_{si}:	18.99
T_i:	20.00	ℓ_w:	1.000			L^{2D}:	0.4642
T_e:	0.00					f_{Rsi}:	**0.950**
						Ψ (W/m·K):	**0.103**

Notes:

Ψ-value to be applied to each property.

Leeds Metropolitan University Centre for the Built Environment
Thermal Bridging Calculations

Detail:	Party Wall 150 mm Insulation No Return						
Calc No:	TB/16	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP
Materials and Thermal Conductivities:							
Material:					λ:	Source:	
Adhesive Dabs (20 % Expanding Foam, 80 % Air)					0.078	Calculated	
Bricks Inner Leaves					0.560	BR 443	
Bricks Outer Leaves					0.770	BR 443	
Expanding Foam					0.040	Manufacturer	
Insulation Walls					0.022	Manufacturer	
Mortar Exposed					0.940	BR 443	
Mortar Protected					0.880	BR 443	
Plaster					0.400	BS EN 12524	
Plasterboard					0.210	BR 443	
Temperature Distribution:							



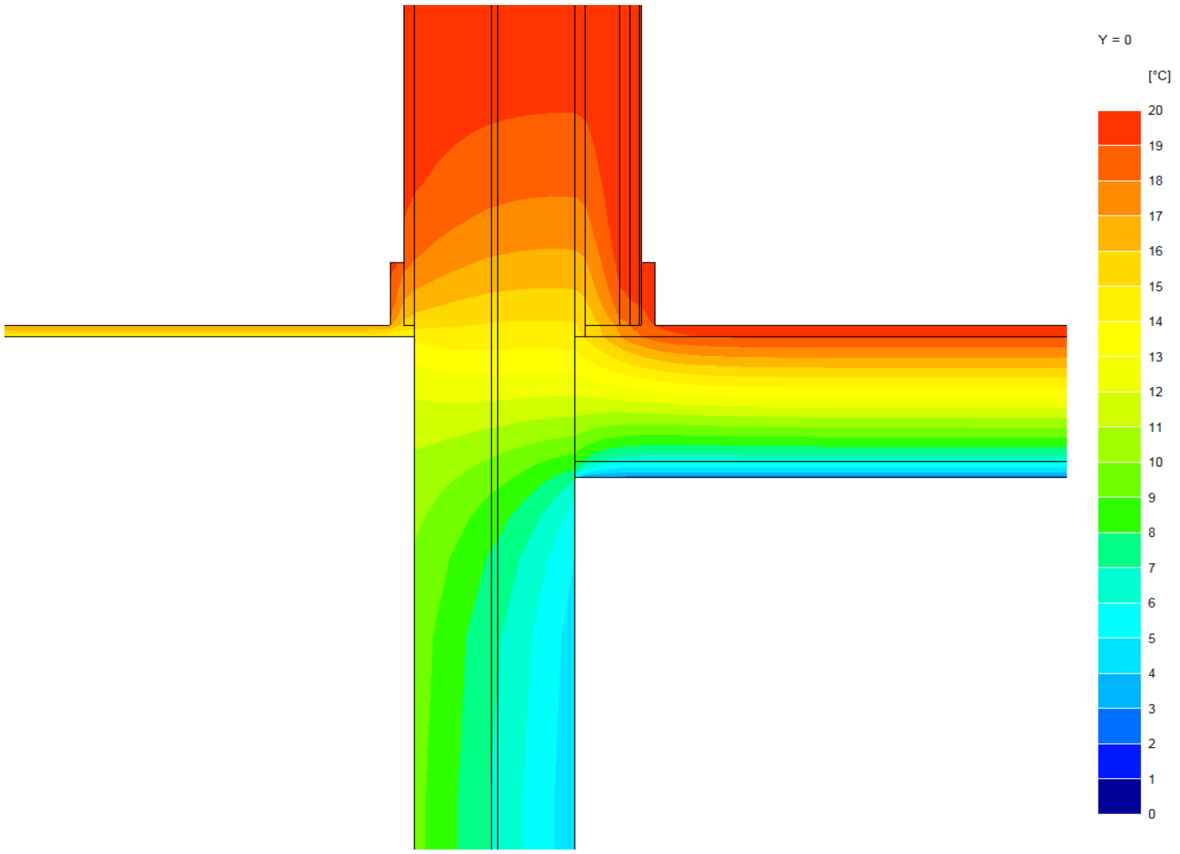
Q:	11.9294	ℓ_z:	1.000	U_w:	0.129	T_{si}:	17.20
T_i:	20.00	ℓ_w:	1.000			L^{2D}:	0.5965
T_e:	0.00					**f_{Rsi}:**	**0.860**
						Ψ (W/m·K)**:**	**0.169**
Notes:							
Ψ-value to be applied to each property.							

Detail:	Party Wall/Ground Floor Insulation Single Side						
Calc No:	TB/17	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q_1:	0.8824	ℓ_z:	0.200			T_{si1}:	18.68
Q_2:	4.0839	ℓ_{f1}:	1.000	U_{f1}:	0.186	T_{si2}:	16.69
T_i:	20.00	ℓ_{f2}:	1.000	U_{f2}:	2.073	L^{2D1}:	0.0441
T_e:	0.00					L^{2D2}:	0.2042
T_u:	2.15					f_{Rsi1}:	**0.934**
T_{u2}:	11.53					f_{Rsi2}:	**0.835**
						Ψ_1 (W/m·K):	**0.034**
						Ψ_2 (W/m·K):	**-1.052**

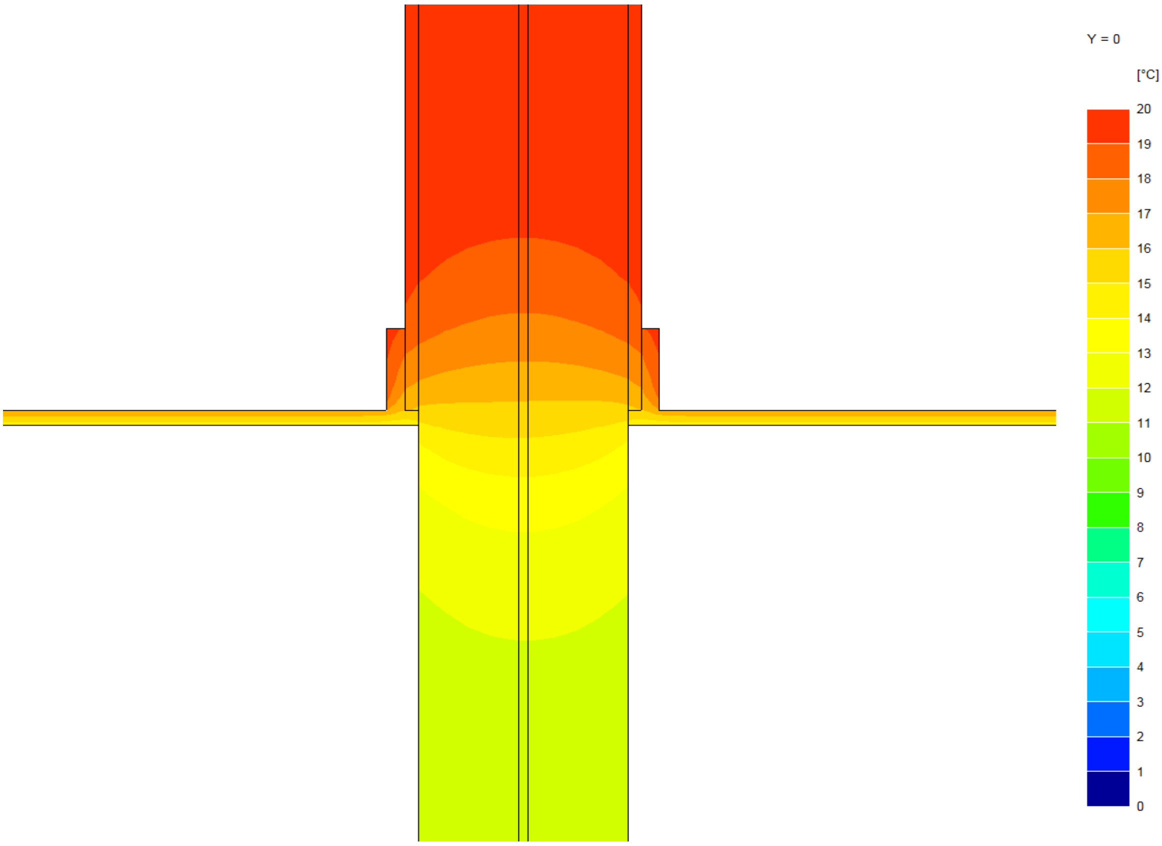
Notes:

Detail:	Party Wall/Ground Floor Uninsulated						
Calc No:	TB/18	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Bricks Inner Leaves	0.560	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Softwood	0.130	BR 443

Temperature Distribution:



Q:	7.7398	ℓ_z:	0.200			T_{si}:	16.82
T_i:	20.00			U_f:	2.073	L^{2D}:	0.3870
T_e:	0.00	ℓ_f:	1.000			**f_{Rsi}:**	**0.841**
T_u:	11.53					**Ψ** (W/m·K):	**-2.211**

Notes:

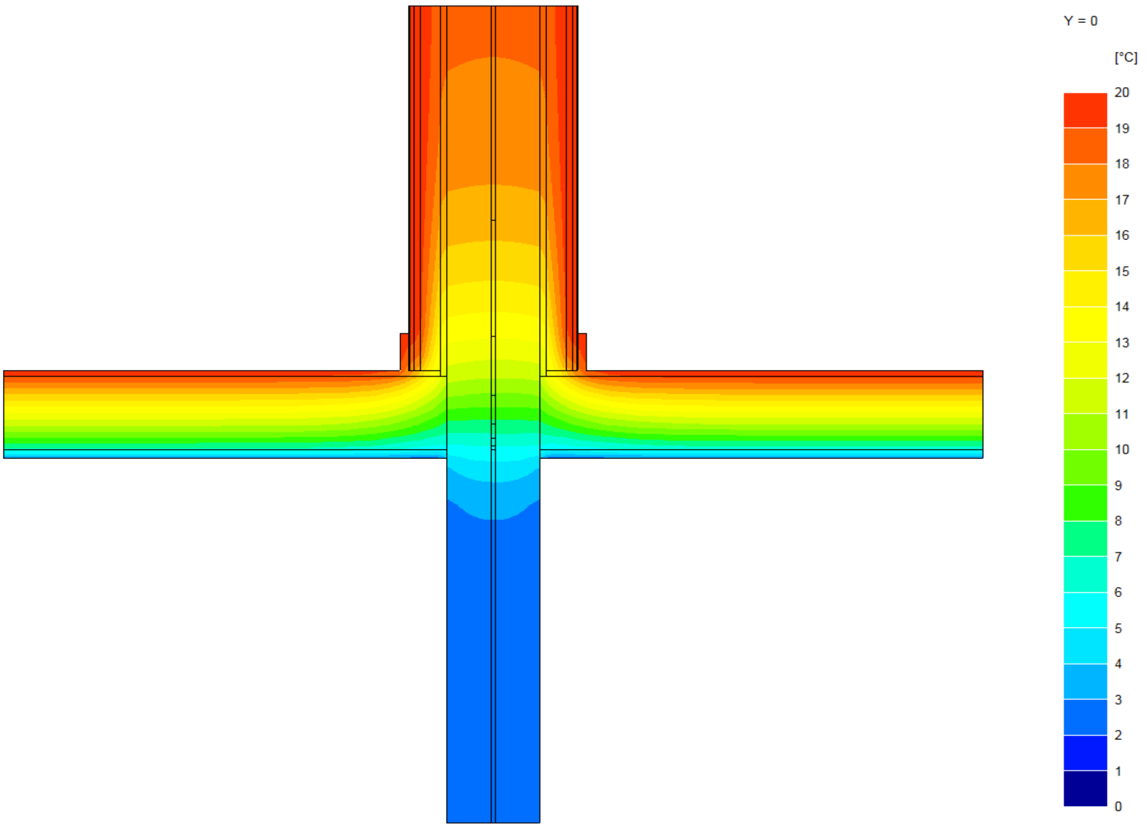
Ψ-value to be applied to each property.

Detail:	Party Wall/Ground Floor with Air Cavity						
Calc No:	TB/19	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Air Spaces	Varies	Calculated
Bricks Inner Leaves	0.560	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	2.1948	ℓ_z:	0.200			T_{si}:	18.26
T_i:	20.00			U_f:	0.186	L^{2D}:	0.1097
T_e:	0.00	ℓ_f:	1.000			f_{Rsi}:	**0.913**
T_u:	2.38					**Ψ** (W/m·K):	**0.088**

Notes:

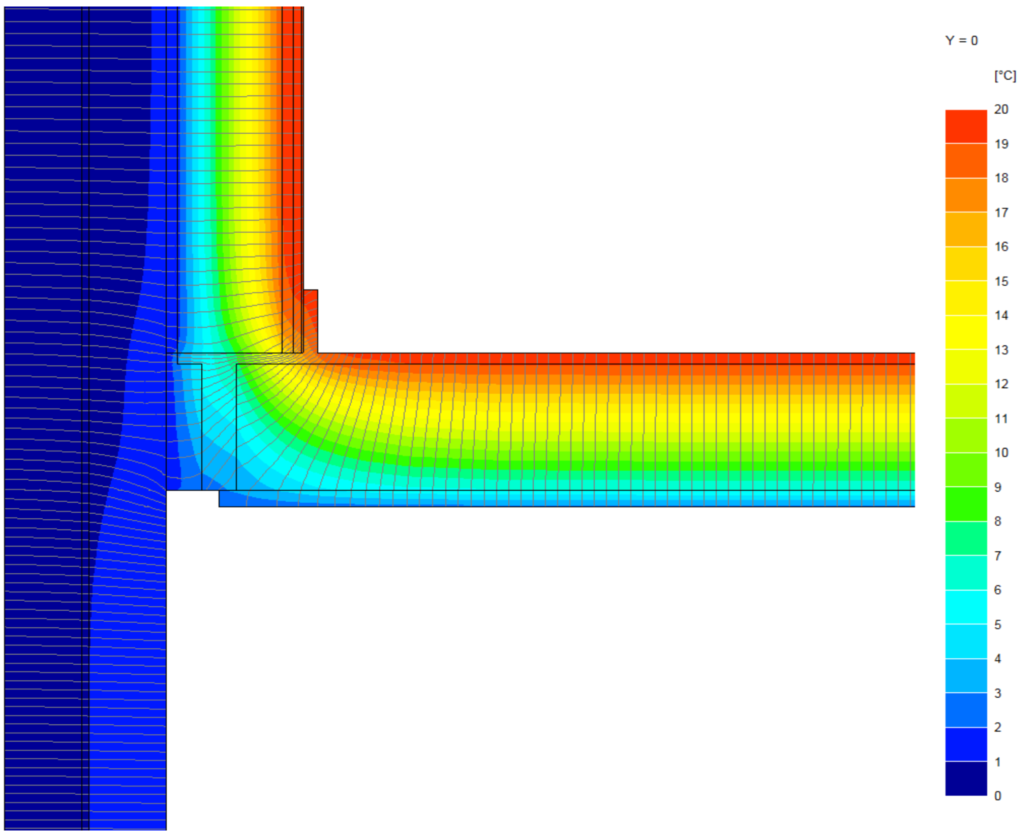
Ψ-value to be applied to each property.

Detail:	Ground Floor With Joist Parallel (50 mm) and 150 mm Insulation with Air Cavity						
Calc No:	TB/20	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Air Spaces	Varies	Calculated
Bricks Outer Leaves	0.770	BR 443
Expanding Foam	0.040	Manufacturer
Insulation Floor Between Joists	0.044	Manufacturer
Insulation Floor Under Joists	0.022	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	6.1177	ℓ_z:	1.000	U_w:	0.128	T_{si}:	18.35
T_i:	20.00	ℓ_w:	1.000	U_f:	0.162	L^{2D}:	0.3059
T_e:	0.00	ℓ_f:	1.000			**f_{Rsi}:**	**0.918**
T_u:	2.38					**Ψ** (W/m·K):	**0.016**

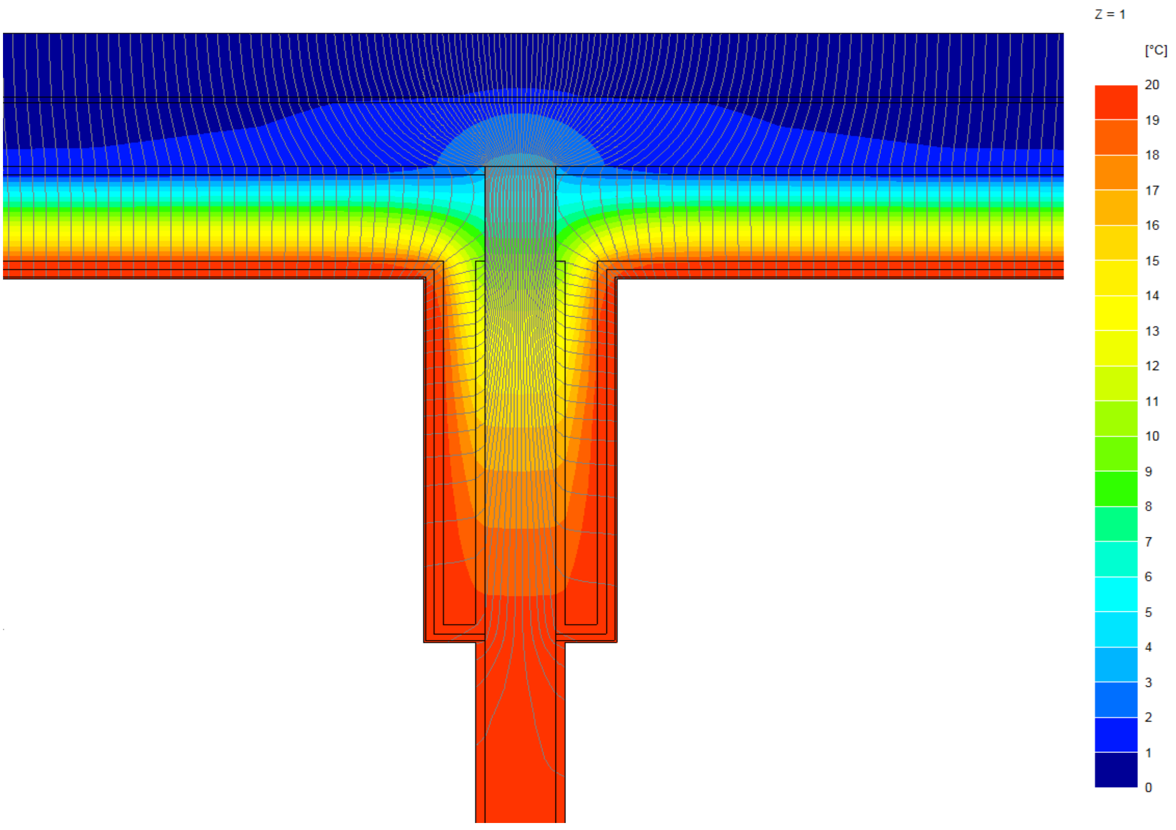
Notes:

Detail:	Partition 150 mm Insulation with Air Cavity								
Calc No:	TB/21	**Rev:**	A	**Date:**	Aug-13	**Calc By:**	MP		

Materials and Thermal Conductivities:

Material:	λ:	Source:
Adhesive Dabs (20 % Expanding Foam, 80 % Air)	0.078	Calculated
Bricks Inner Leaves	0.560	BR 443
Bricks Outer Leaves	0.770	BR 443
Cavity	0.105	Calculated
Expanding Foam	0.040	Manufacturer
Insulation Walls	0.022	Manufacturer
Mortar Exposed	0.940	BR 443
Mortar Protected	0.880	BR 443
Plaster	0.400	BS EN 12524
Plasterboard	0.210	BR 443

Temperature Distribution:



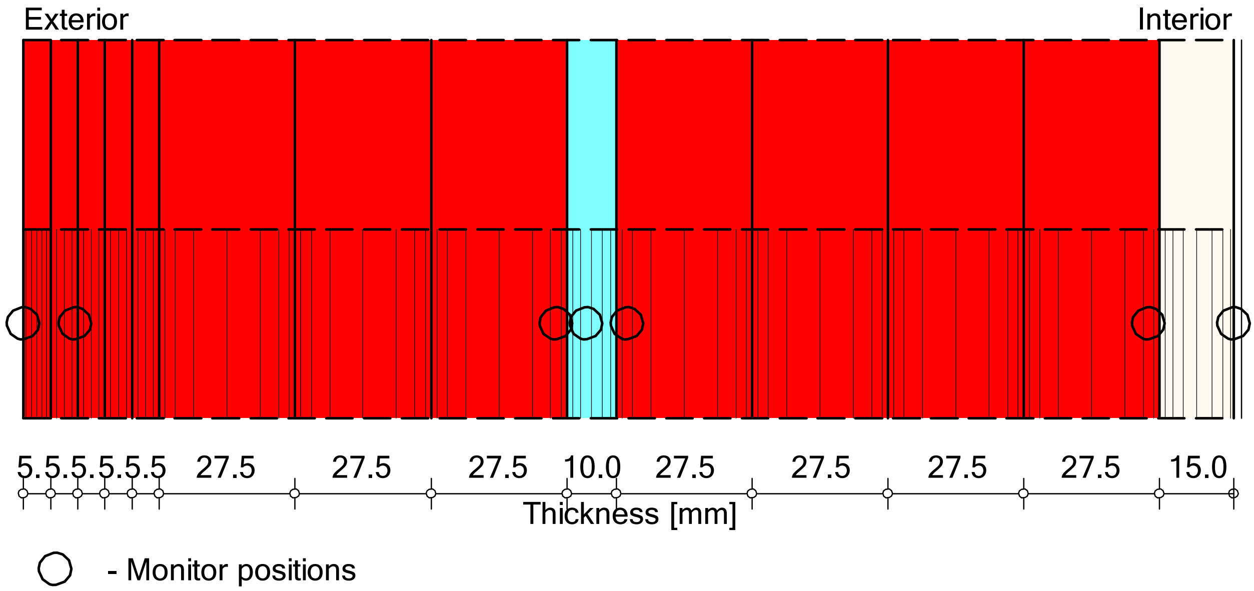
Q:	7.7656	ℓ_z:	1.000	U_w:	0.128	T_{si}:	19.10
T_i:	20.00	ℓ_w:	2.301			L^{2D}:	0.3883
T_e:	0.00					**f_{Rsi}:**	**0.955**
						Ψ (W/m·K):	**0.094**

Notes:

Appendix H. Hygrothermal simulation data

Component Assembly

Case: Base Case South West



Materials :

- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- Air Layer 10 mm; without additional moisture capacity
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Interior Plaster (Gypsum Plaster)

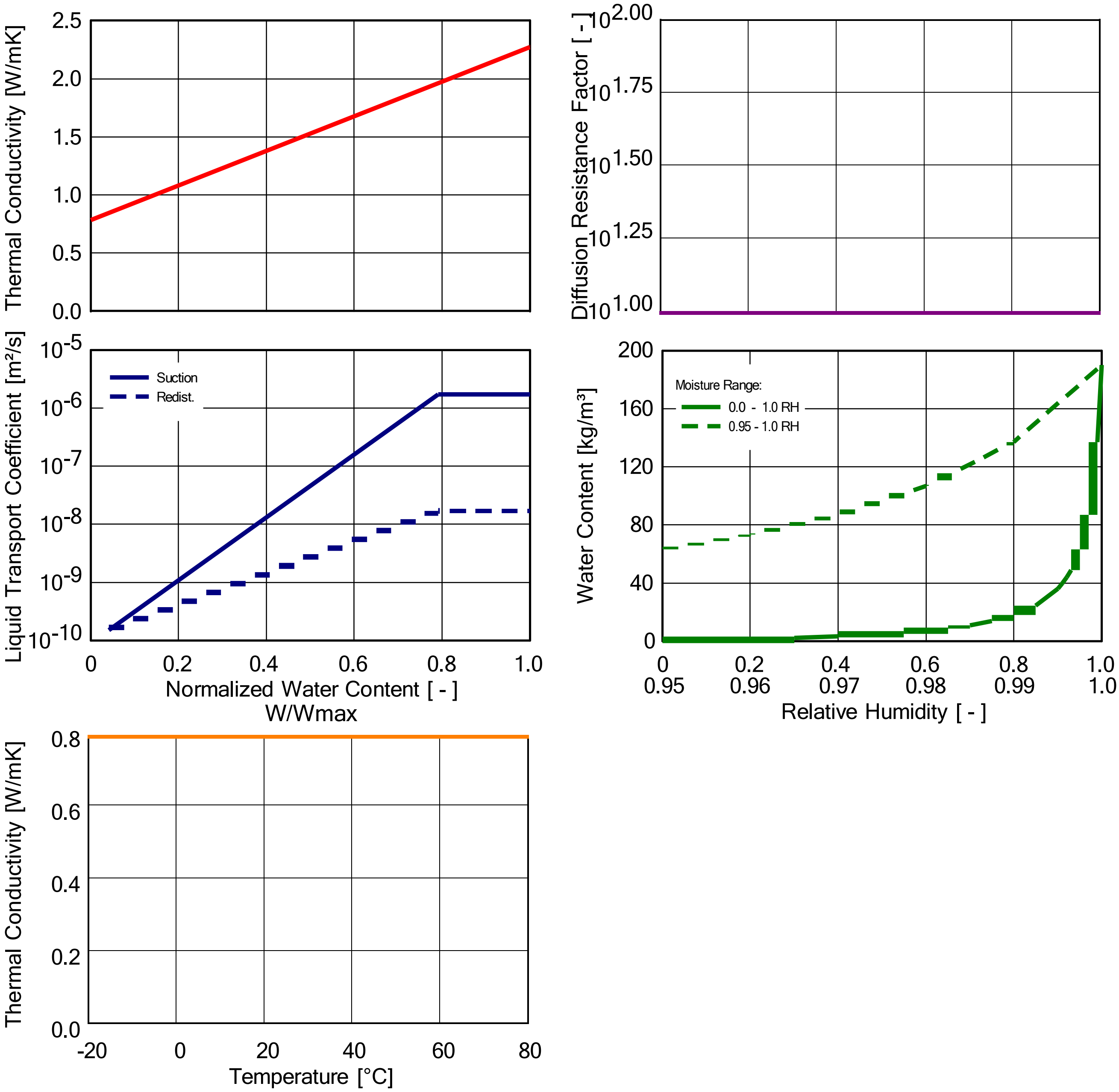
Sd-Value Int. [m]: 0.1

Total Thickness: 0.25 m
R-Value: 0.42 m²K/W
U-Value: 1.651 W/m²K

Material : *Solid Brick Masonry

Checking Input Data

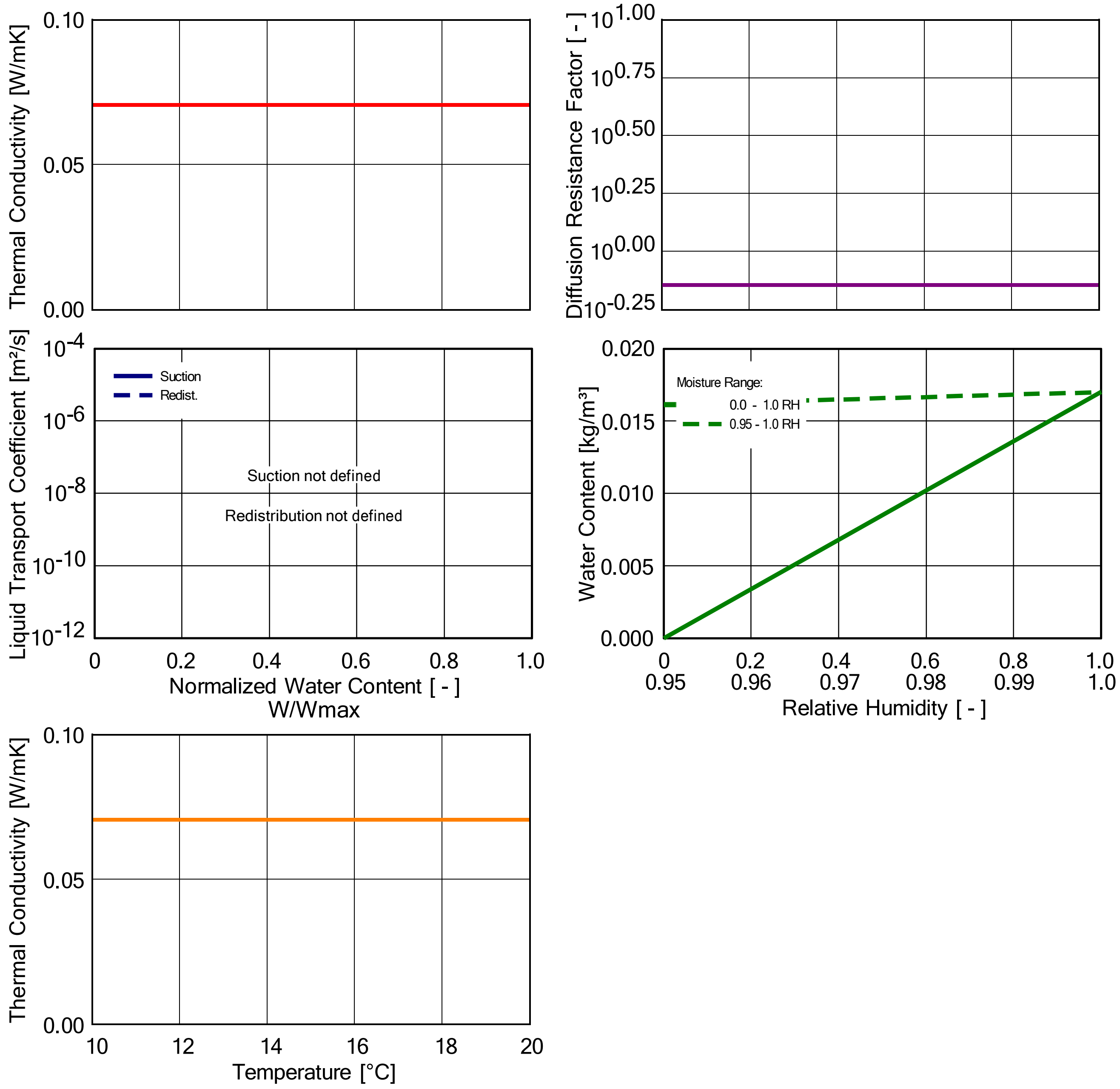
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002



Material : Air Layer 10 mm; without additional moisture capacity

Checking Input Data

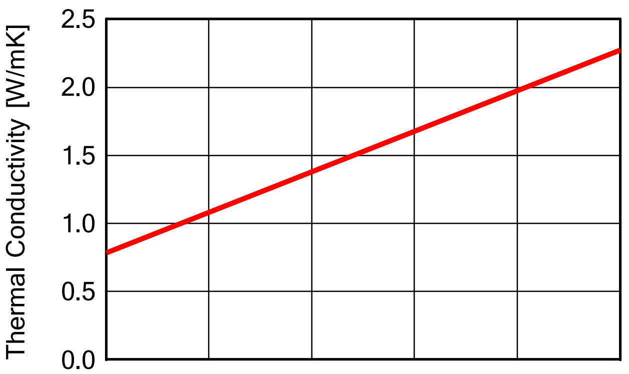
Property	Unit	Value
Bulk density	[kg/m³]	1.3
Porosity	[m³/m³]	0.999
Specific Heat Capacity, Dry	[J/kgK]	1000.0
Thermal Conductivity, Dry ,10°C	[W/mK]	0.071
Water Vapour Diffusion Resistance Factor	[-]	0.73

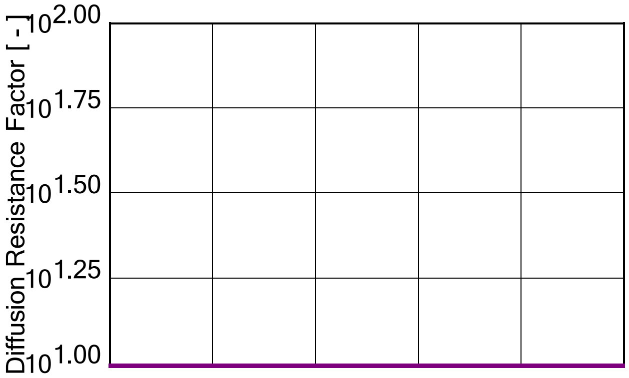


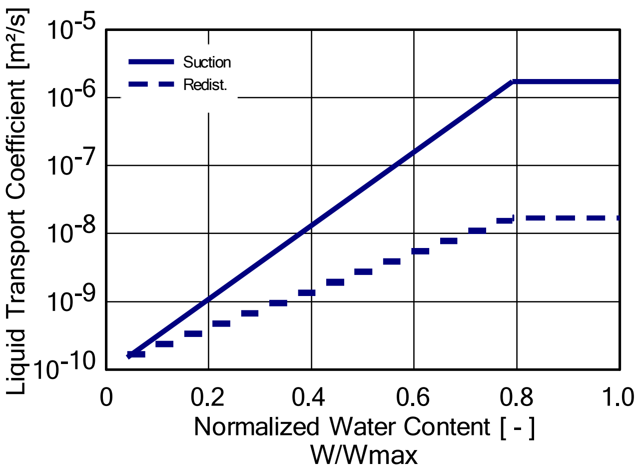
Material : *Solid Brick Masonry

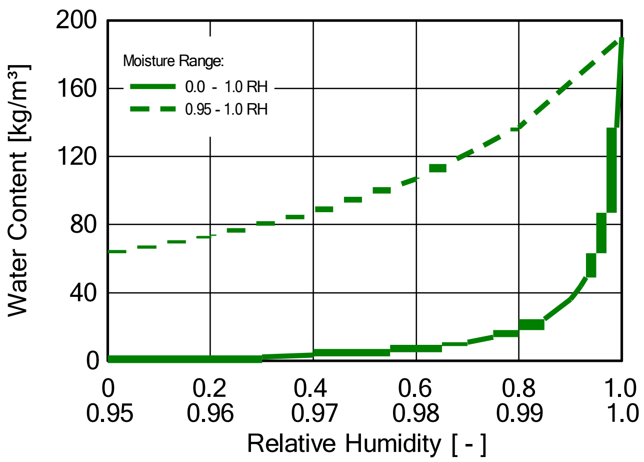
Checking Input Data

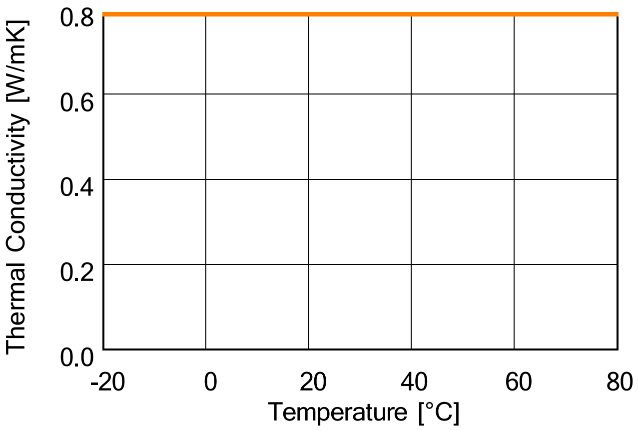
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







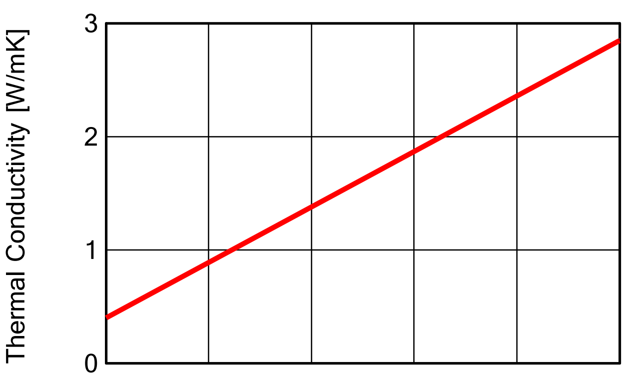


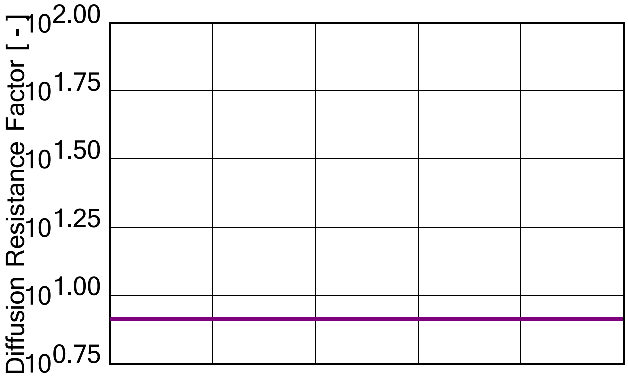


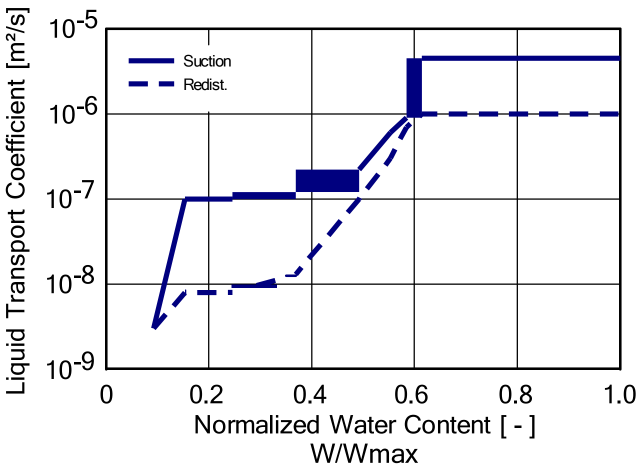
Material : *Interior Plaster (Gypsum Plaster)

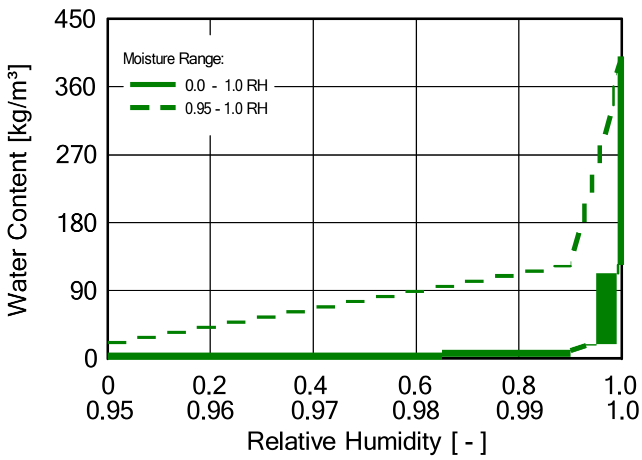
Checking Input Data

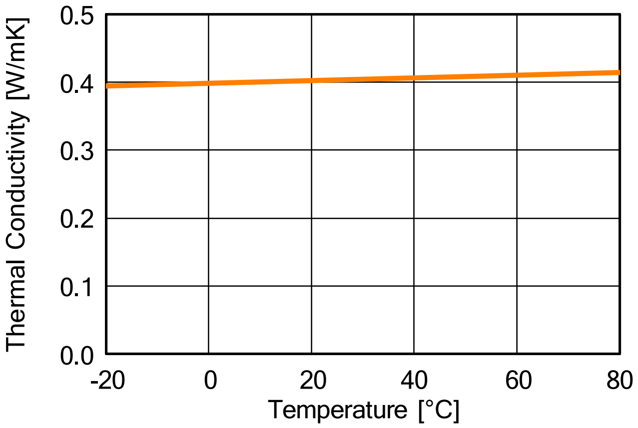
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,4
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002











Boundary Conditions

Exterior (Left Side)

Location: Leeds_UK-hour.wac
Orientation / Inclination: South-West / 90 °

Interior (Right Side)

Indoor Climate: EN 15026
Normal Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	External Wall	[m²K/W]	0.0588 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Brick, red	[-]	0.68
Long-Wave Radiation Emissivity	Brick, red	[-]	0.9
Adhering Fraction of Rain	According to inclination an	[-]	0,7
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	External Wall	[m²K/W]	0.125
Sd-Value	Gypsum plaster	[m]	0.1

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	22/07/2014 12:03:20
Computing Time	1 min,4 sec.
Begin / End of calculation	01/10/2013 / 01/10/2016
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	75.04 -74.64
Integral of fluxes, right side (kr,dr)	[kg/m²]	5.7E-7 2.04
Balance 1	[kg/m²]	-1.63
Balance 2	[kg/m²]	-1.63

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	4.05	2.42	2.02	8.04

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
*Solid Brick Masonry	18.00	16.27	1.52	158.37
*Solid Brick Masonry	18.00	28.61	2.90	146.15
*Solid Brick Masonry	18.00	27.17	4.54	136.16
*Solid Brick Masonry	18.00	18.84	6.11	127.31
*Solid Brick Masonry	18.00	13.76	7.42	119.09
*Solid Brick Masonry	18.00	10.63	9.24	68.95
*Solid Brick Masonry	18.00	10.76	10.59	43.52
*Solid Brick Masonry	18.00	11.24	10.51	41.02
Air Layer 10 mm; without additional m	0.01	0.01	0.01	0.01
*Solid Brick Masonry	18.00	8.69	7.36	18.00
*Solid Brick Masonry	18.00	8.33	7.53	18.00
*Solid Brick Masonry	18.00	7.76	7.07	18.00
*Solid Brick Masonry	18.00	7.20	6.47	18.00
*Interior Plaster (Gypsum Plaster)	6.30	4.46	3.83	6.30

Time Integral of fluxes

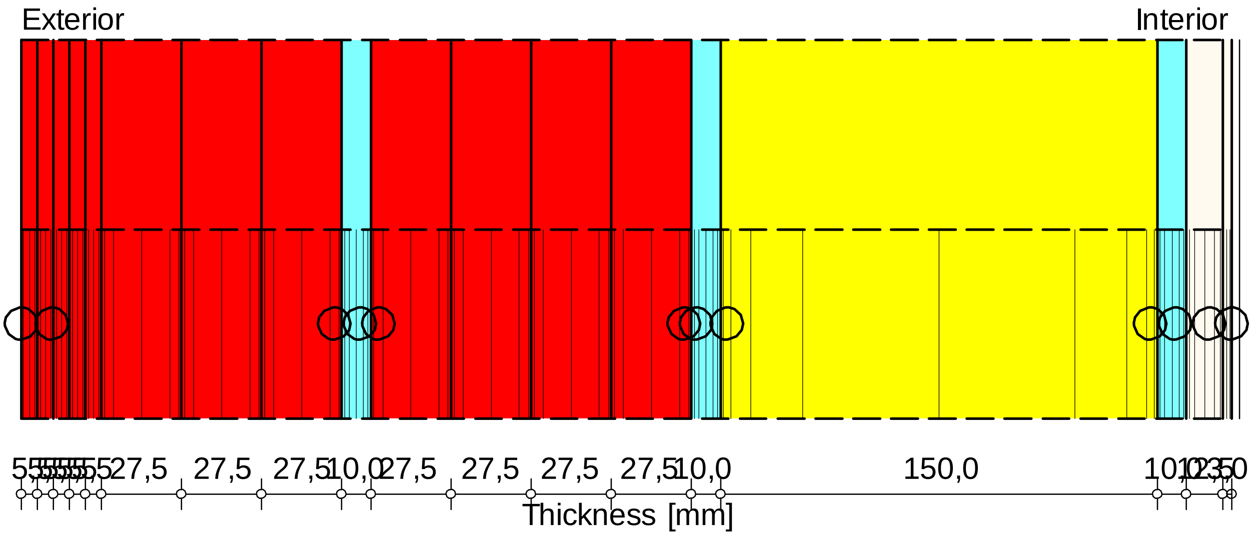
Heat Flux, left side	[MJ/m²]	-1487.82
Heat Flux, right side	[MJ/m²]	-1489.08
Moisture Fluxes, left side	[kg/m²]	0.4
Moisture Fluxes, right side	[kg/m²]	2.04

Hygrothermal Sources

Heat Sources	[MJ/m²]	0.0
Moisture Sources	[kg/m²]	0.0
Unreleased Moisture Sources (due to cut-off)	[kg/m²]	0.0

Component Assembly

Case: 150 Cavity South West



- Monitor positions

Materials :

- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- Air Layer 10 mm; without additional moisture capacity
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Air Layer 10 mm; without additional moisture capacity
- *PIR
- *Air Layer 10 mm; without additional moisture capacity
- *Gypsum Board
- *Interior Plaster (Gypsum Plaster)

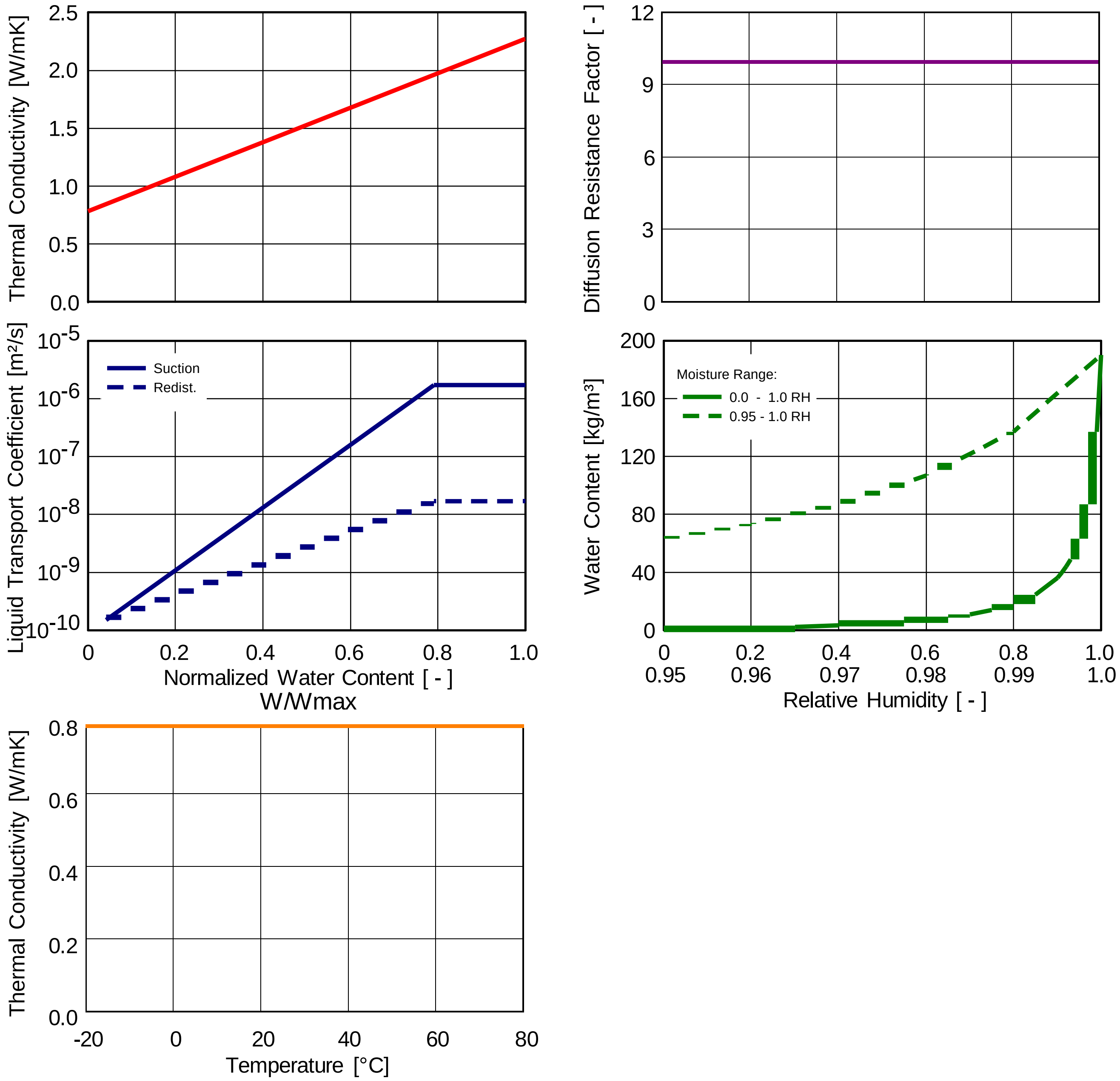
Sd-Value Int. [m]: 0.1

Total Thickness: 0,42 m
R-Value: 7,34 m²K/W
U-Value: 0,133 W/m²K

Material : *Solid Brick Masonry

Checking Input Data

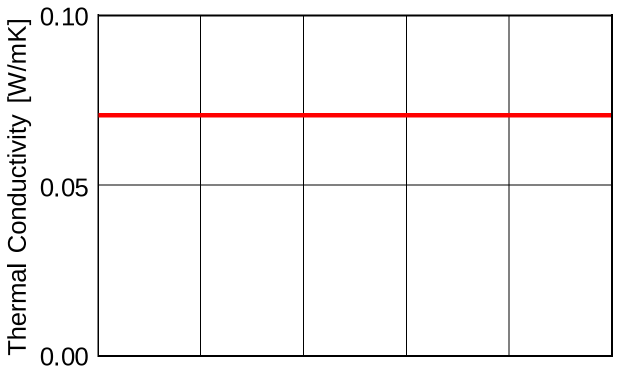
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002

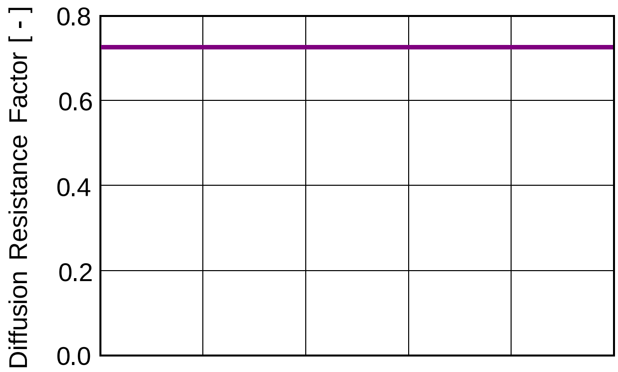


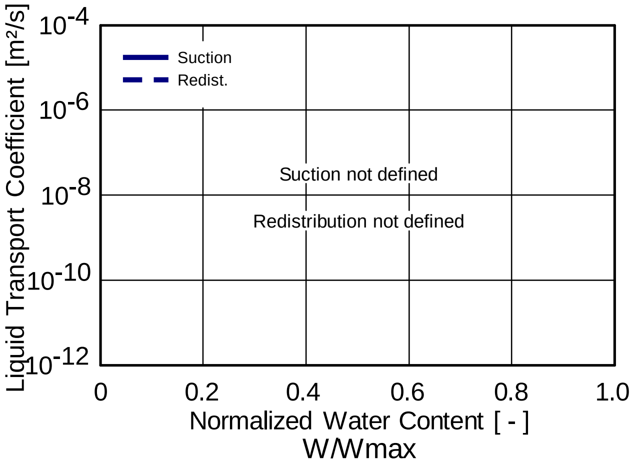
Material : Air Layer 10 mm; without additional moisture capacity

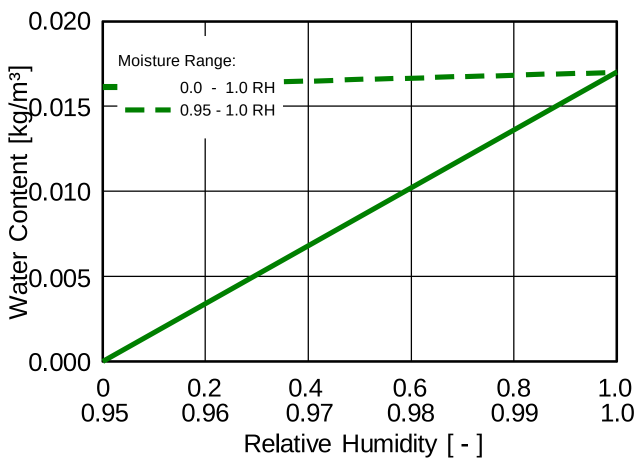
Checking Input Data

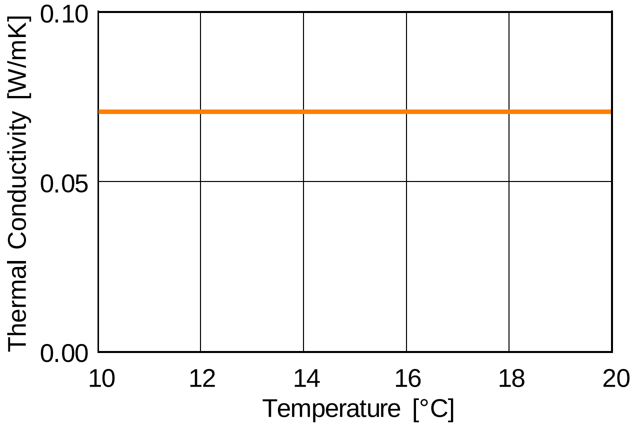
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73







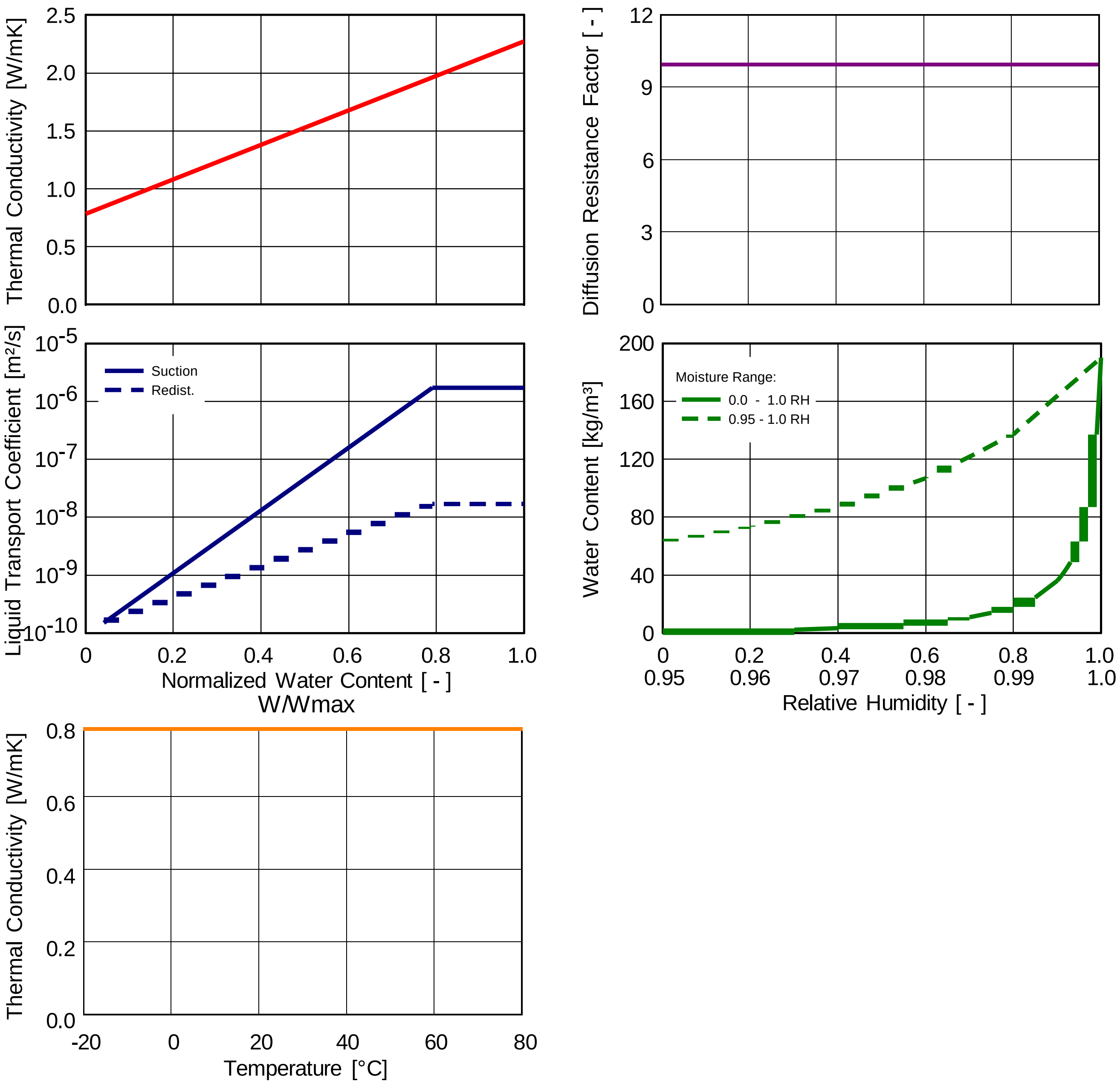




Material : *Solid Brick Masonry

Checking Input Data

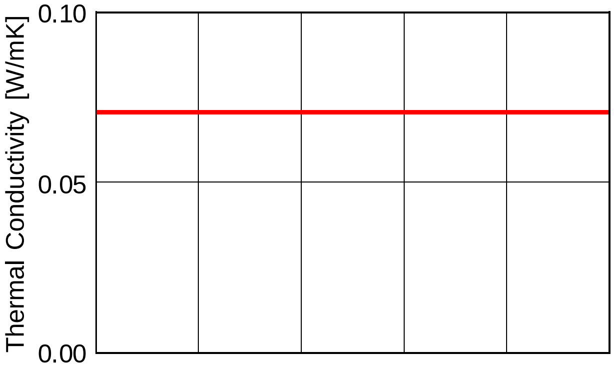
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002

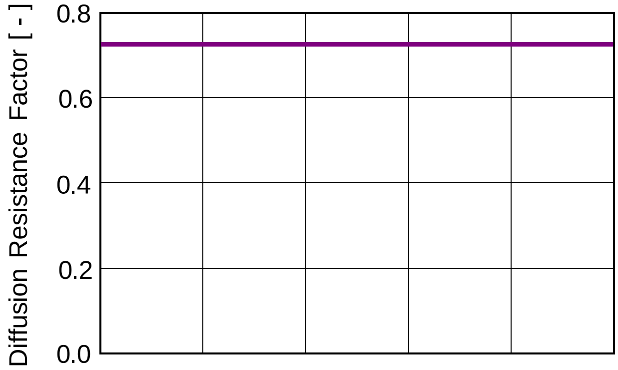


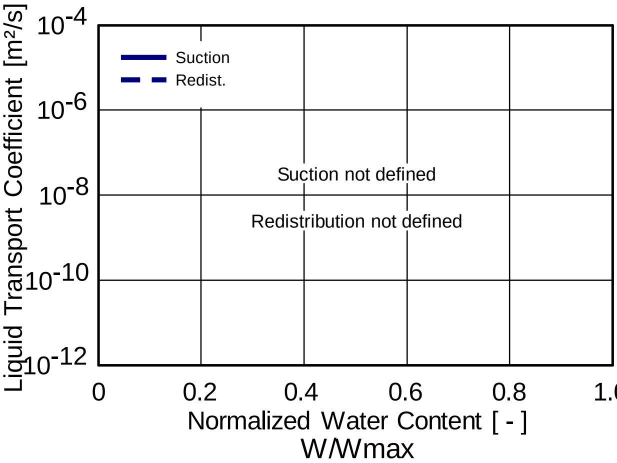
Material : *Air Layer 10 mm; without additional moisture capacity

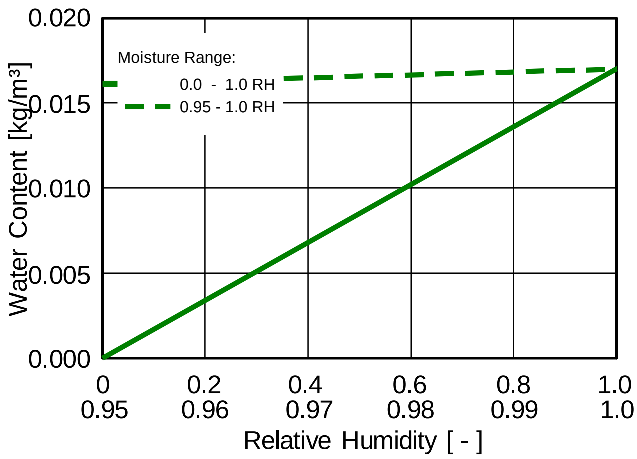
Checking Input Data

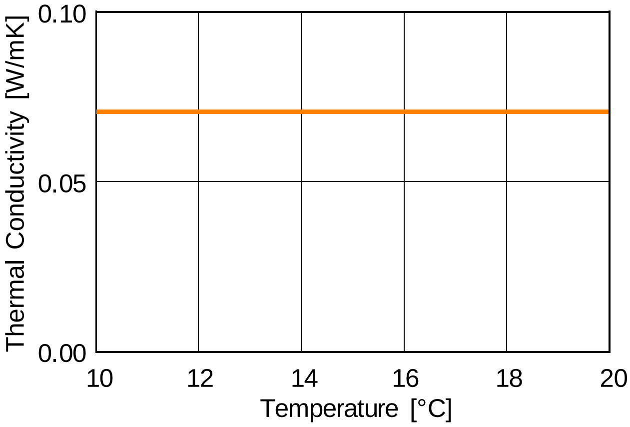
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73







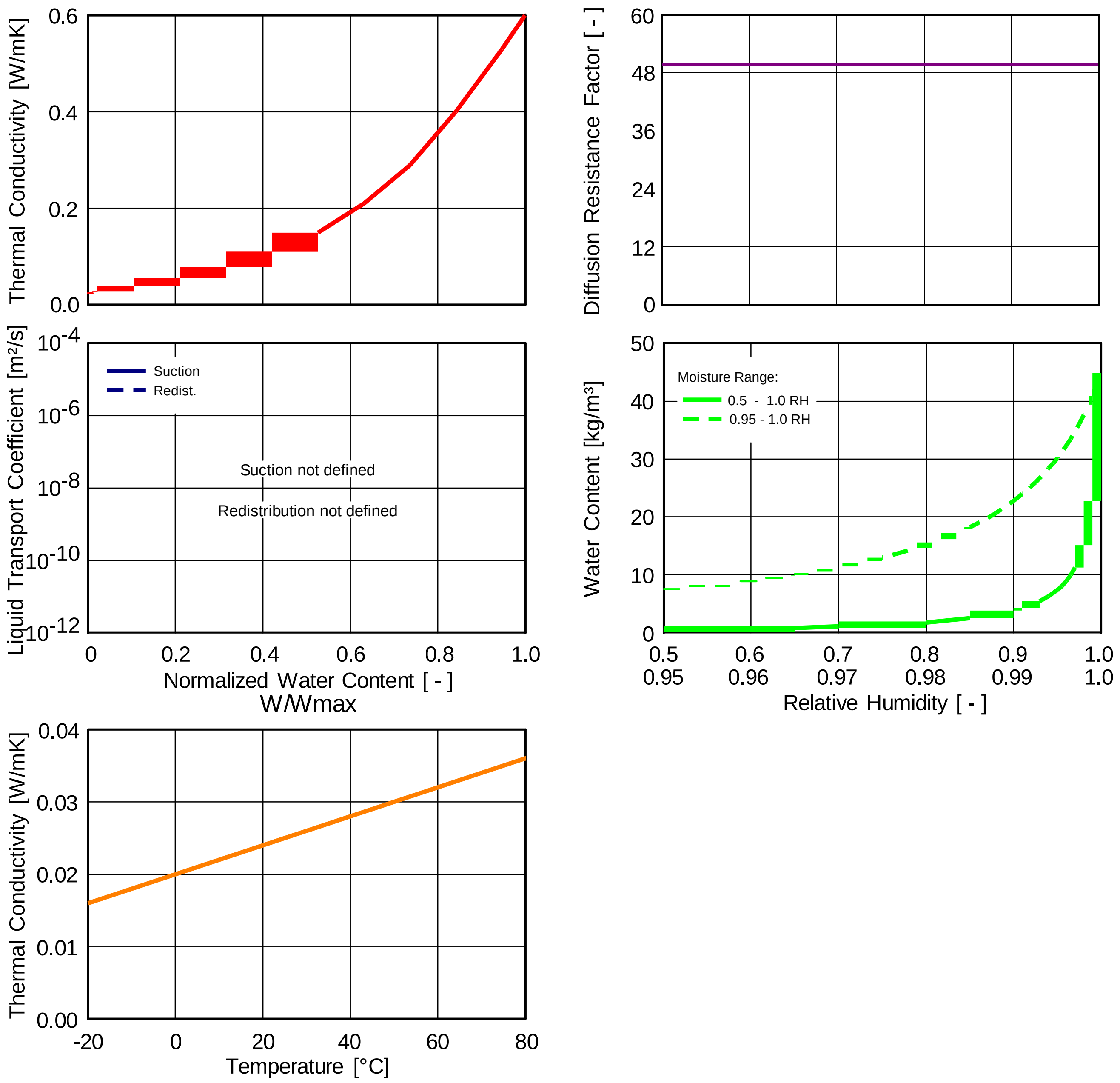




Material : *PIR

Checking Input Data

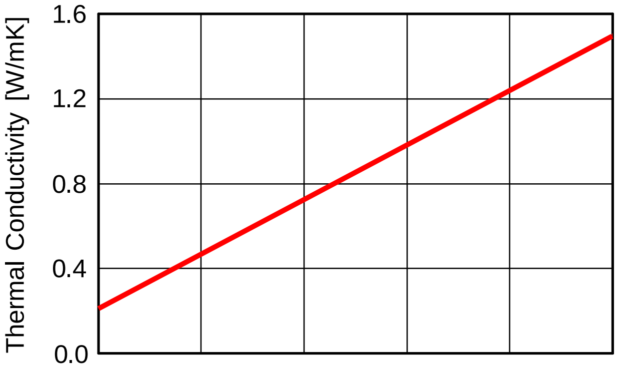
Property	Unit	Value
Bulk density	[kg/m³]	40,0
Porosity	[m³/m³]	0,95
Specific Heat Capacity, Dry	[J/kgK]	1500,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,022
Water Vapour Diffusion Resistance Factor	[-]	50,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002

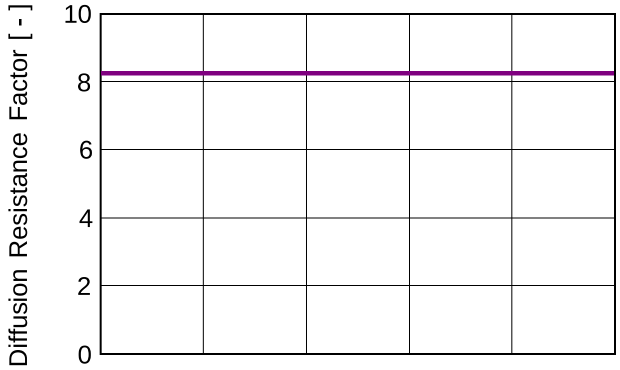


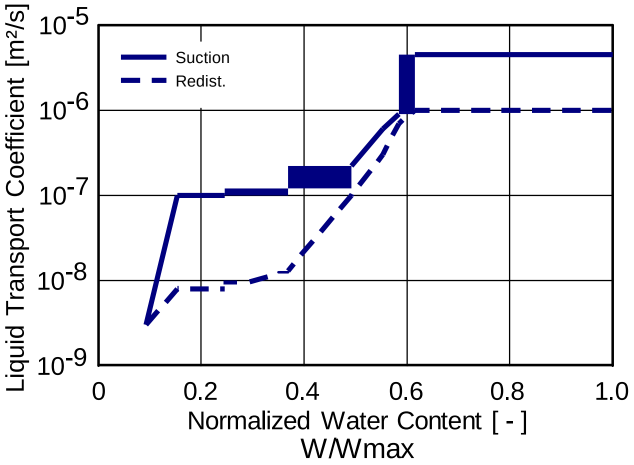
Material : *Gypsum Board

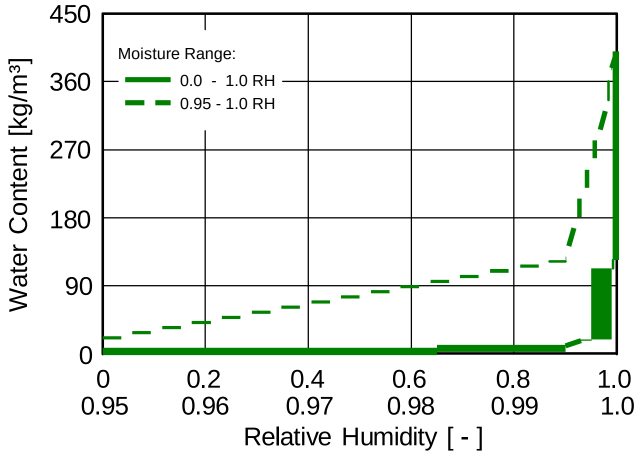
Checking Input Data

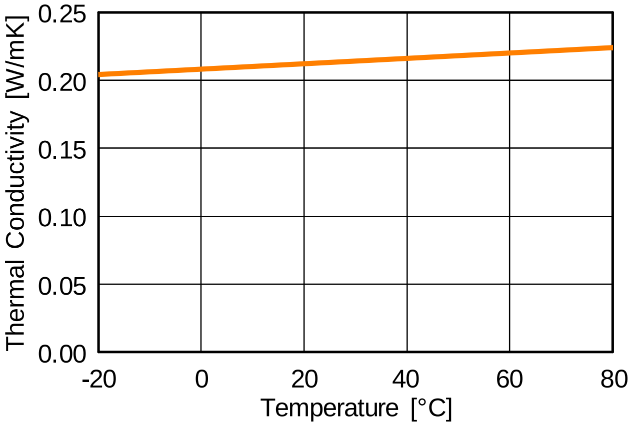
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,21
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







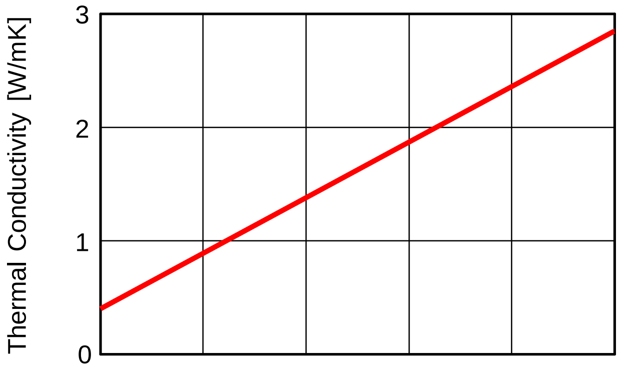


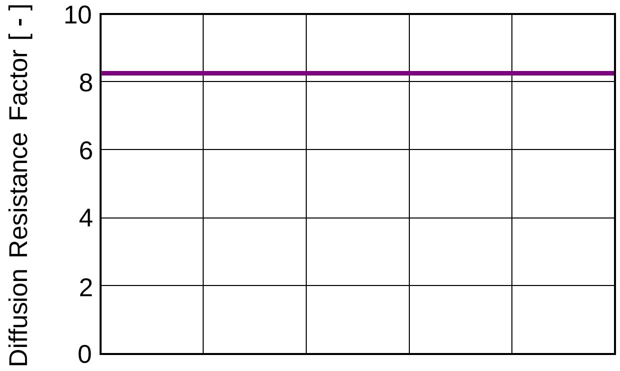


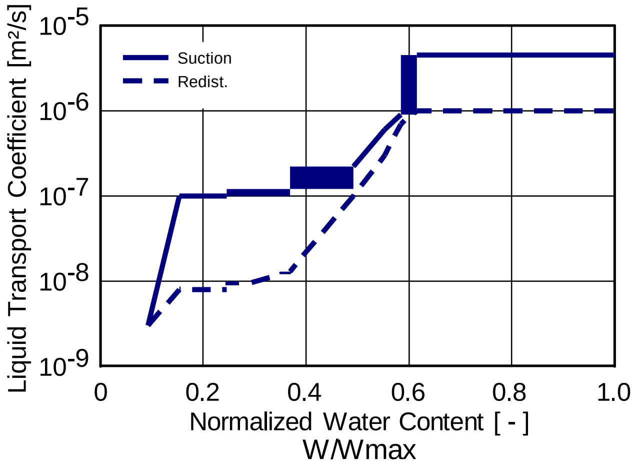
Material : *Interior Plaster (Gypsum Plaster)

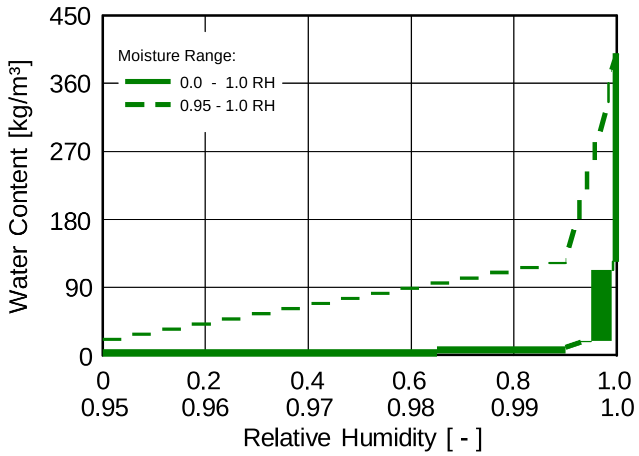
Checking Input Data

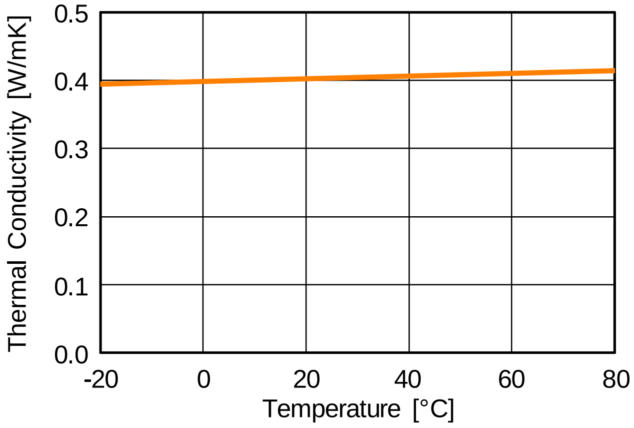
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,4
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002











Boundary Conditions

Exterior (Left Side)

Location: Leeds_UK-hour.wac
Orientation / Inclination: South-West / 90 °

Interior (Right Side)

Indoor Climate: EN 15026
Normal Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	External Wall	[m²K/W]	0.0588 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Brick, red	[-]	0.68
Long-Wave Radiation Emissivity	Brick, red	[-]	0.9
Adhering Fraction of Rain	According to inclination an	[-]	0,7
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	External Wall	[m²K/W]	0.125
Sd-Value	Gypsum plaster	[m]	0.1

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	16/06/2014 11:38:23
Computing Time	0 min,55 sec.
Begin / End of calculation	01/10/2013 / 01/10/2016
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	74,48 -71,89
Integral of fluxes, right side (kr,dr)	[kg/m²]	3.7E-8 0,2
Balance 1	[kg/m²]	2,4
Balance 2	[kg/m²]	2,4

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	4,33	6,73	4,07	12,06

Water Content [kg/m³]

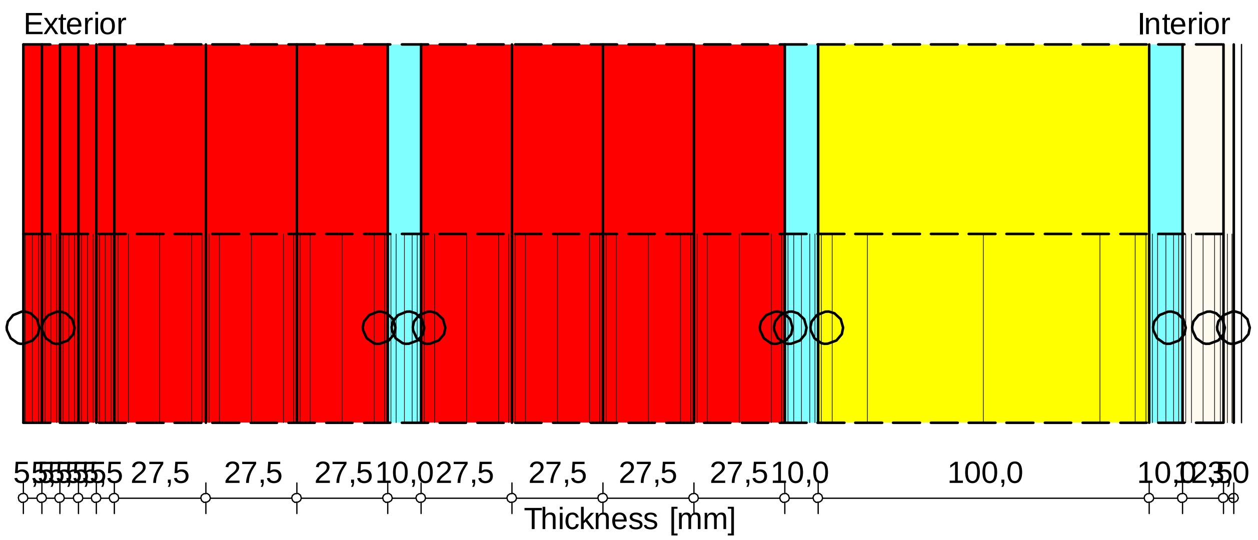
Layer/Material	Start	End	Min.	Max.
*Solid Brick Masonry	18,00	19,64	1,73	162,23
*Solid Brick Masonry	18,00	35,10	3,64	151,64
*Solid Brick Masonry	18,00	33,45	6,21	145,07
*Solid Brick Masonry	18,00	23,81	8,84	138,40
*Solid Brick Masonry	18,00	18,30	10,54	131,12
*Solid Brick Masonry	18,00	18,06	15,12	86,70
*Solid Brick Masonry	18,00	23,97	17,91	63,64
*Solid Brick Masonry	18,00	29,14	17,01	58,30
Air Layer 10 mm; without additional m	0,01	0,01	0,01	0,02
*Solid Brick Masonry	18,00	32,20	16,63	46,67
*Solid Brick Masonry	18,00	34,39	17,87	40,47
*Solid Brick Masonry	18,00	35,43	17,97	38,57
*Solid Brick Masonry	18,00	35,73	18,00	37,49
*Air Layer 10 mm; without additional	0,01	0,02	0,01	0,02
*PIR	1,79	1,34	0,79	1,79
*Air Layer 10 mm; without additional	0,01	0,01	0,01	0,01
*Gypsum Board	6,30	4,00	2,84	6,30
*Interior Plaster (Gypsum Plaster)	6,30	3,96	2,81	6,30

Time Integral of fluxes

Heat Flux, left side	[MJ/m²]	-123,59
Heat Flux, right side	[MJ/m²]	-124,32
Heat Sources	[MJ/m²]	0,0
Moisture Fluxes, left side	[kg/m²]	2,59
Moisture Fluxes, right side	[kg/m²]	0,2
Moisture Sources	[kg/m²]	0,0
Clipped Moisture Sources	[kg/m²]	0,0

Component Assembly

Case: 100 Cavity South West



- Monitor positions

Materials :

- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Air Layer 10 mm; without additional moisture capacity
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Air Layer 10 mm; without additional moisture capacity
- *PIR
- *Air Layer 10 mm; without additional moisture capacity
- *Gypsum Board
- *Interior Plaster (Gypsum Plaster)

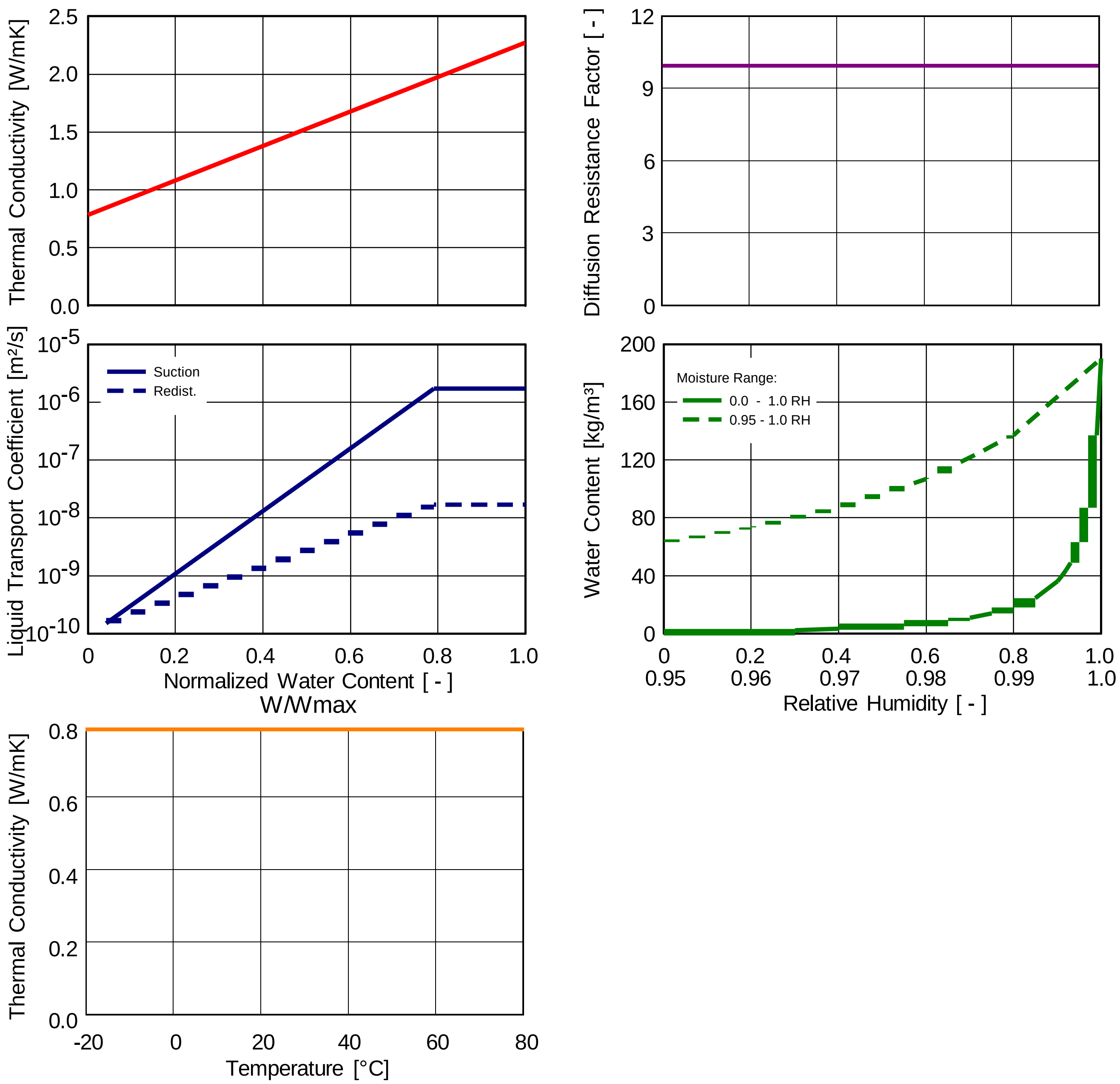
Sd-Value Int. [m]: 0.1

Total Thickness: 0,37 m
R-Value: 5,13 m²K/W
U-Value: 0,188 W/m²K

Material : *Solid Brick Masonry

Checking Input Data

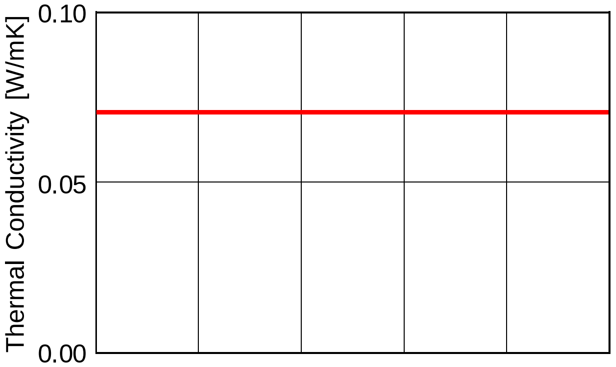
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002

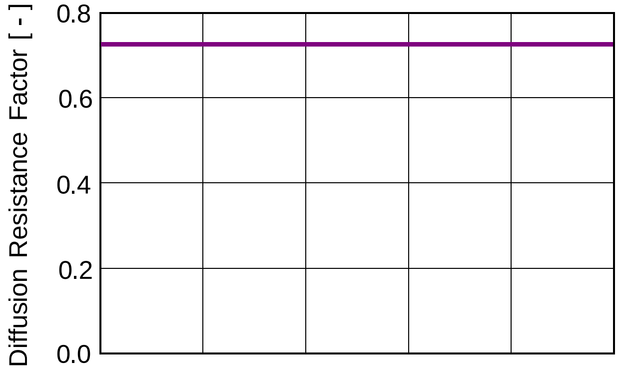


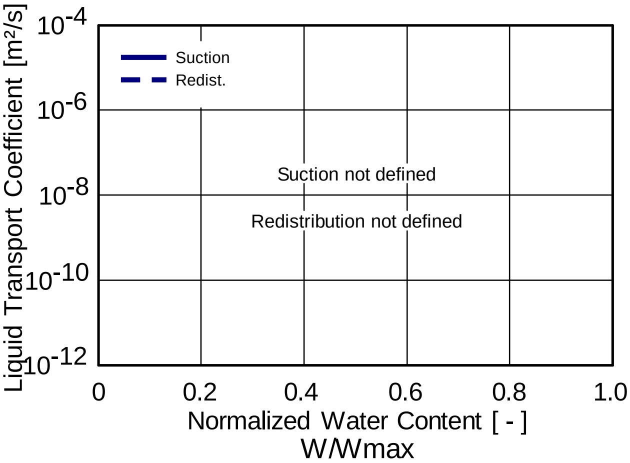
Material : *Air Layer 10 mm; without additional moisture capacity

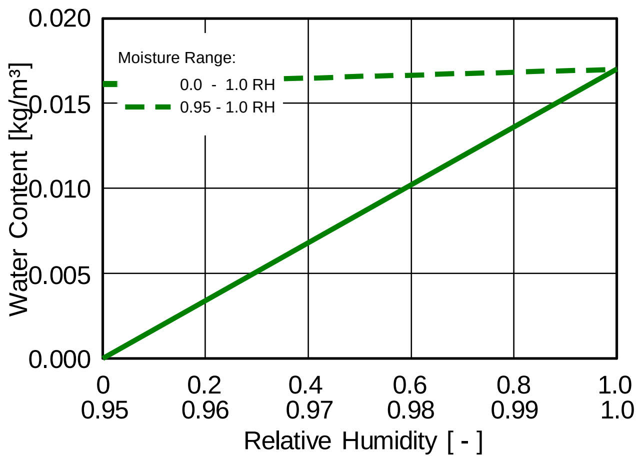
Checking Input Data

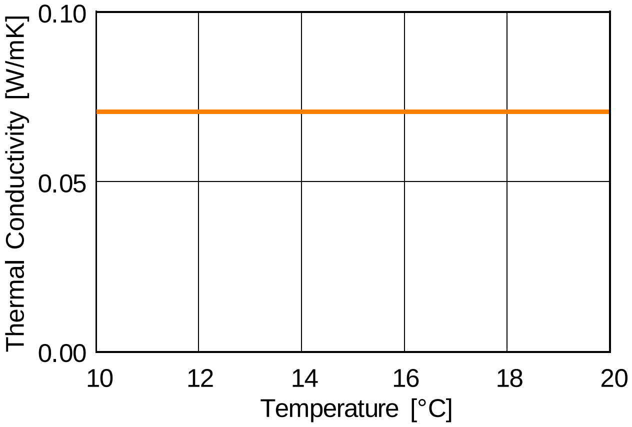
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73







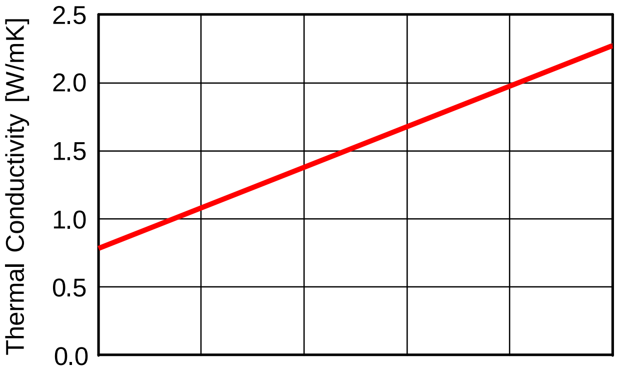


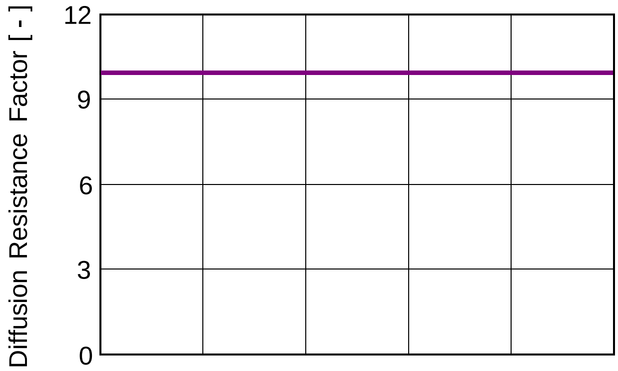


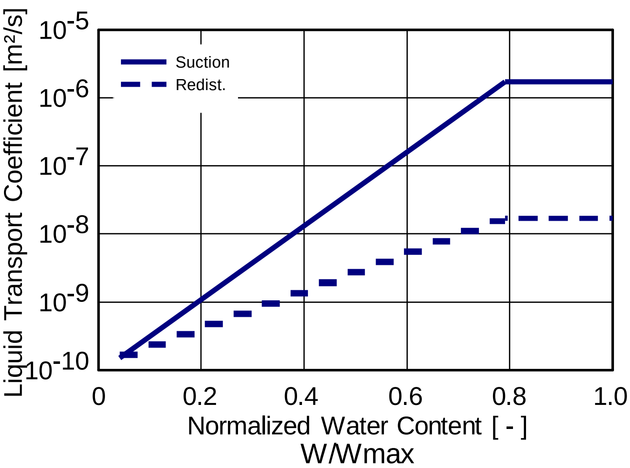
Material : *Solid Brick Masonry

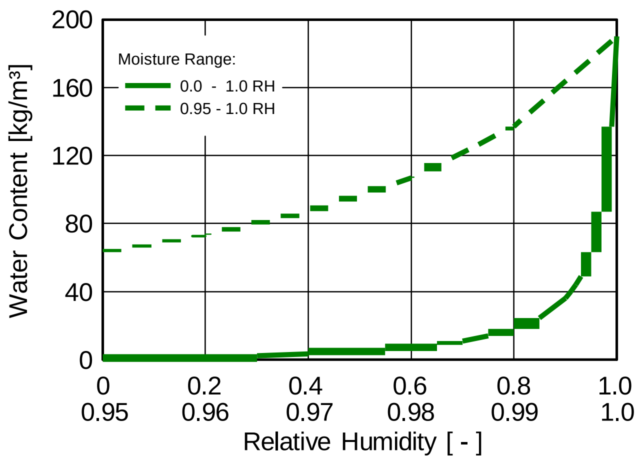
Checking Input Data

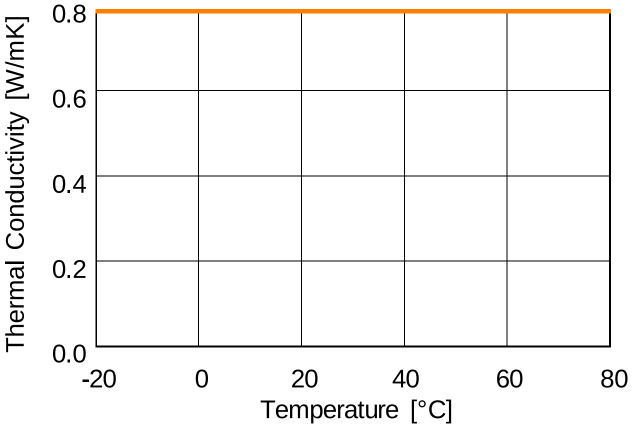
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







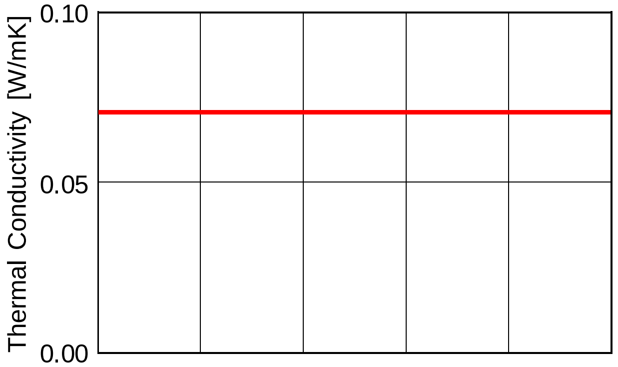


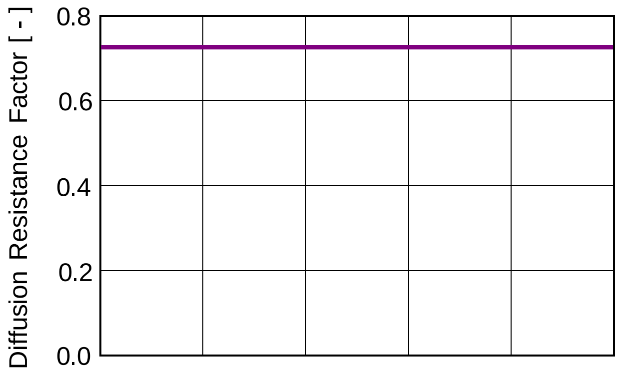


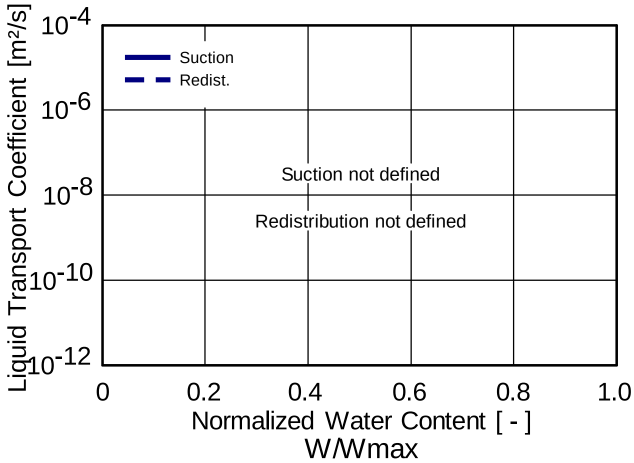
Material : *Air Layer 10 mm; without additional moisture capacity

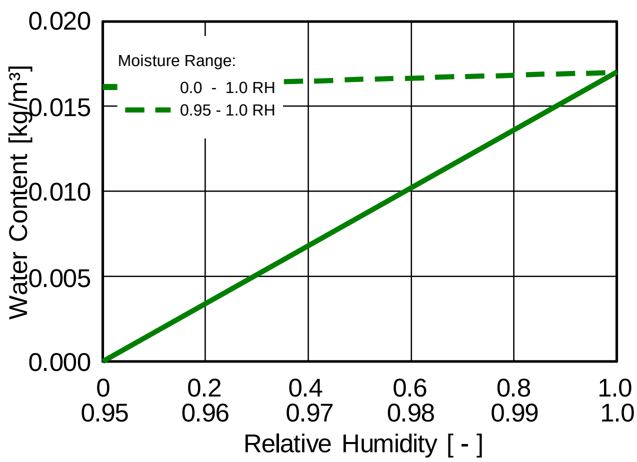
Checking Input Data

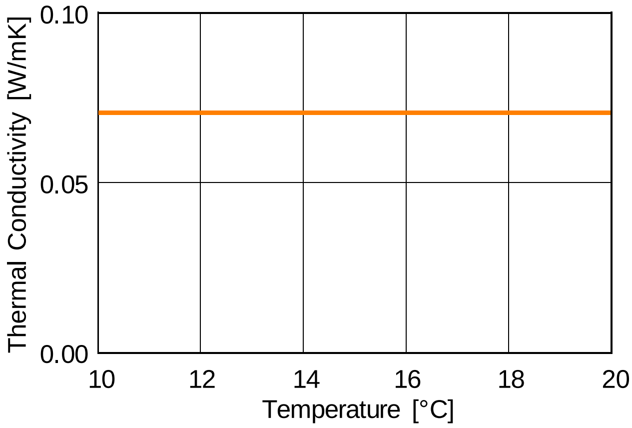
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73







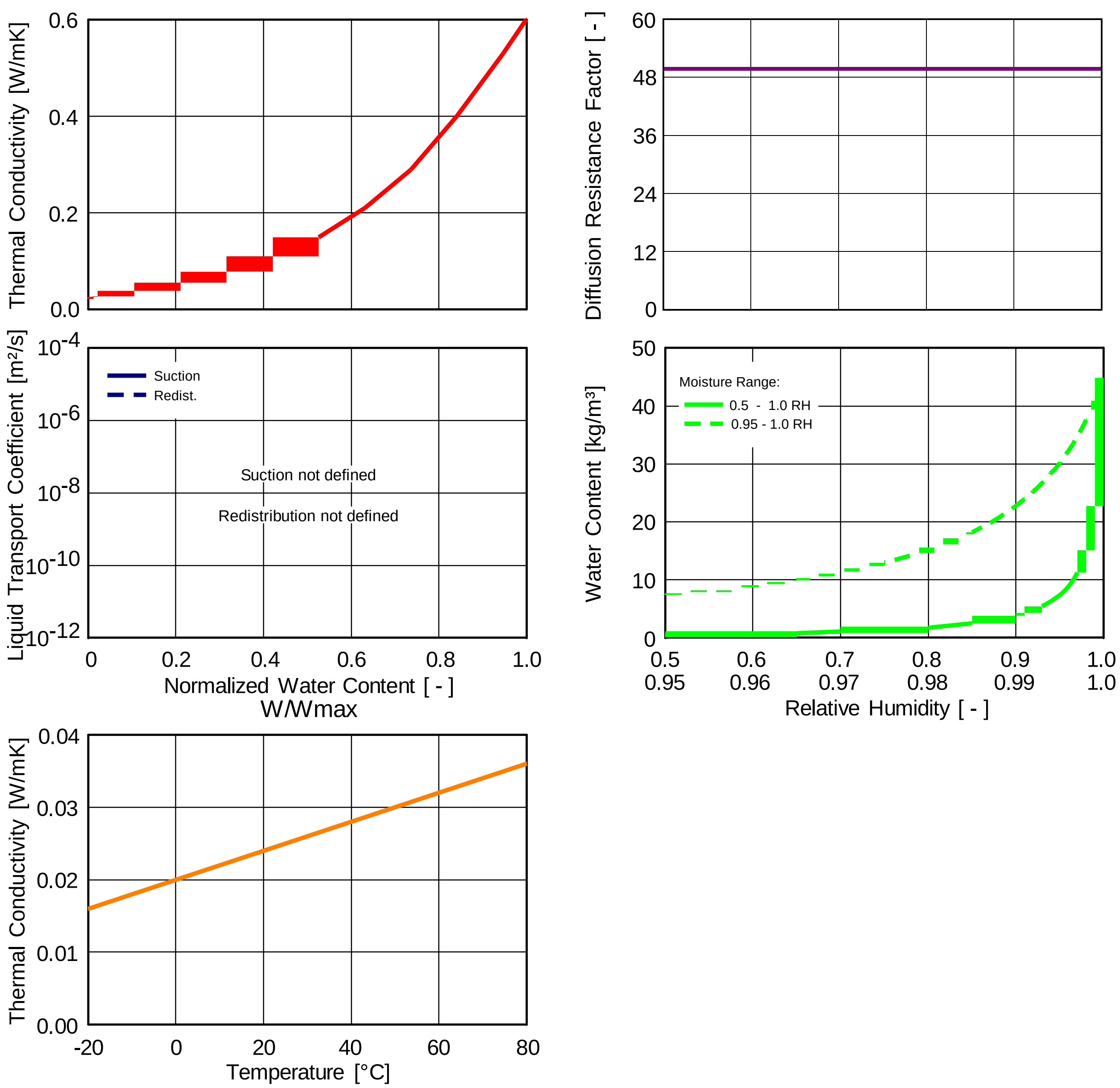




Material : *PIR

Checking Input Data

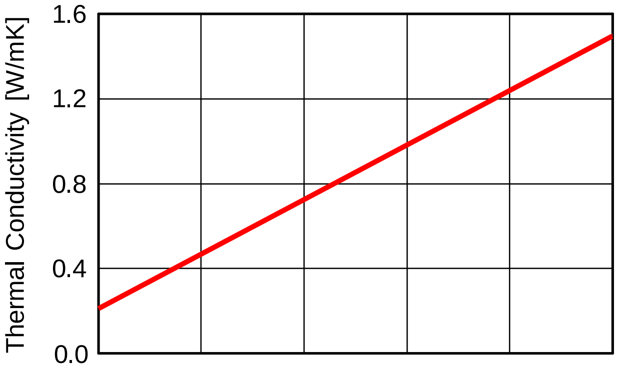
Property	Unit	Value
Bulk density	[kg/m³]	40,0
Porosity	[m³/m³]	0,95
Specific Heat Capacity, Dry	[J/kgK]	1500,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,022
Water Vapour Diffusion Resistance Factor	[-]	50,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002

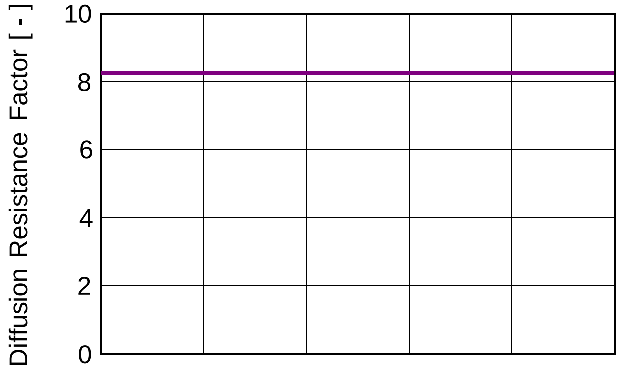


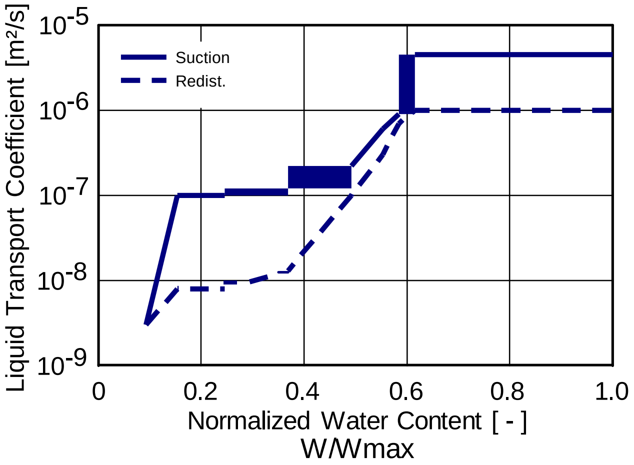
Material : *Gypsum Board

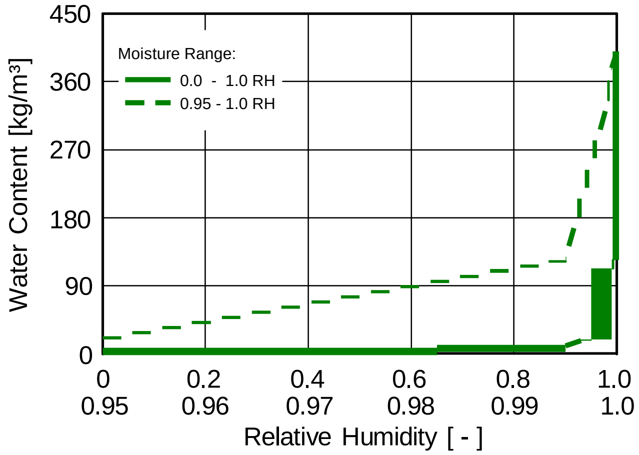
Checking Input Data

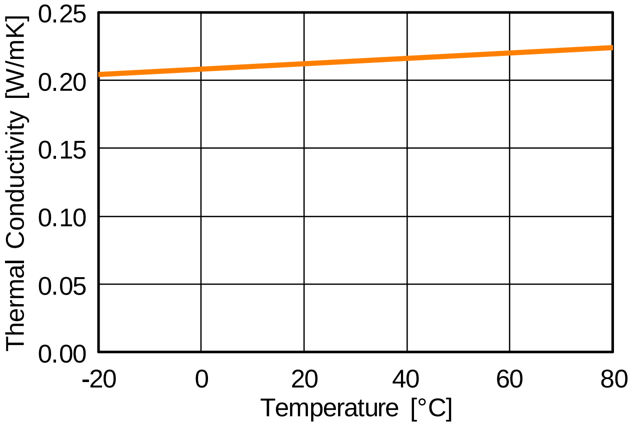
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,21
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







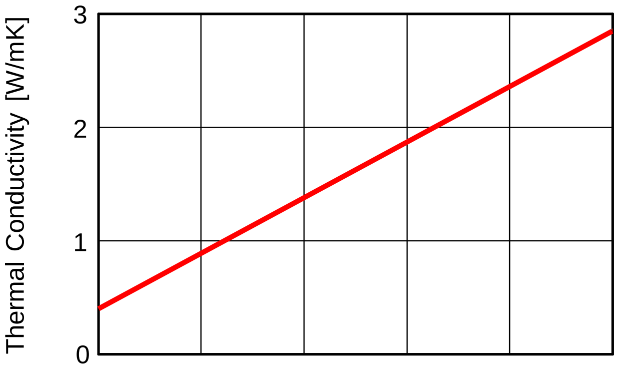


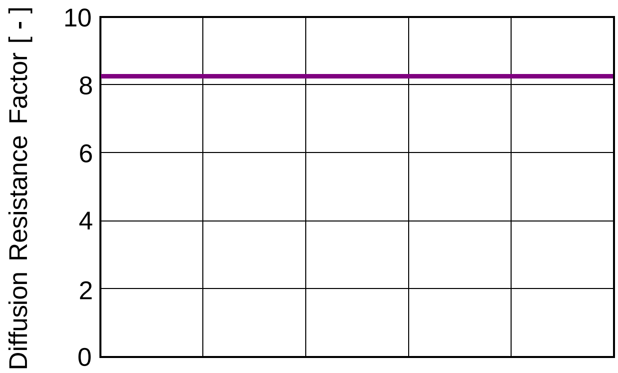


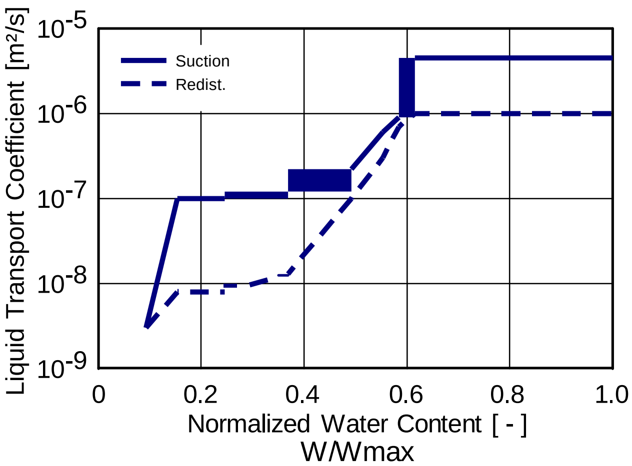
Material : *Interior Plaster (Gypsum Plaster)

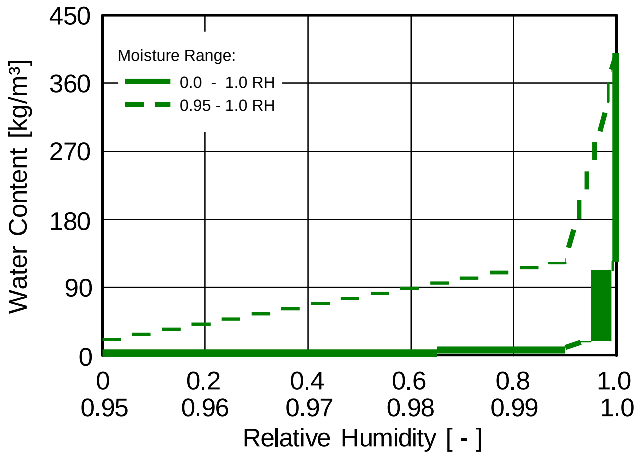
Checking Input Data

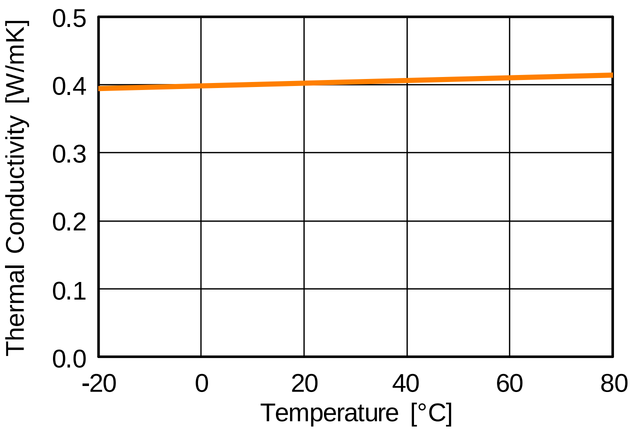
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,4
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002











Boundary Conditions

Exterior (Left Side)

Location: Leeds_UK-hour.wac
Orientation / Inclination: South-West / 90 °

Interior (Right Side)

Indoor Climate: EN 15026
Normal Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	External Wall	[m²K/W]	0.0588 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Brick, red	[-]	0.68
Long-Wave Radiation Emissivity	Brick, red	[-]	0.9
Adhering Fraction of Rain	According to inclination an	[-]	0,7
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	External Wall	[m²K/W]	0.125
Sd-Value	Gypsum plaster	[m]	0.1

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	16/06/2014 15:34:47
Computing Time	0 min,55 sec.
Begin / End of calculation	01/10/2013 / 01/10/2016
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	74,28 -71,92
Integral of fluxes, right side (kr,dr)	[kg/m²]	5.2E-8 0,25
Balance 1	[kg/m²]	2,11
Balance 2	[kg/m²]	2,11

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	4,24	6,34	3,98	11,64

Water Content [kg/m³]

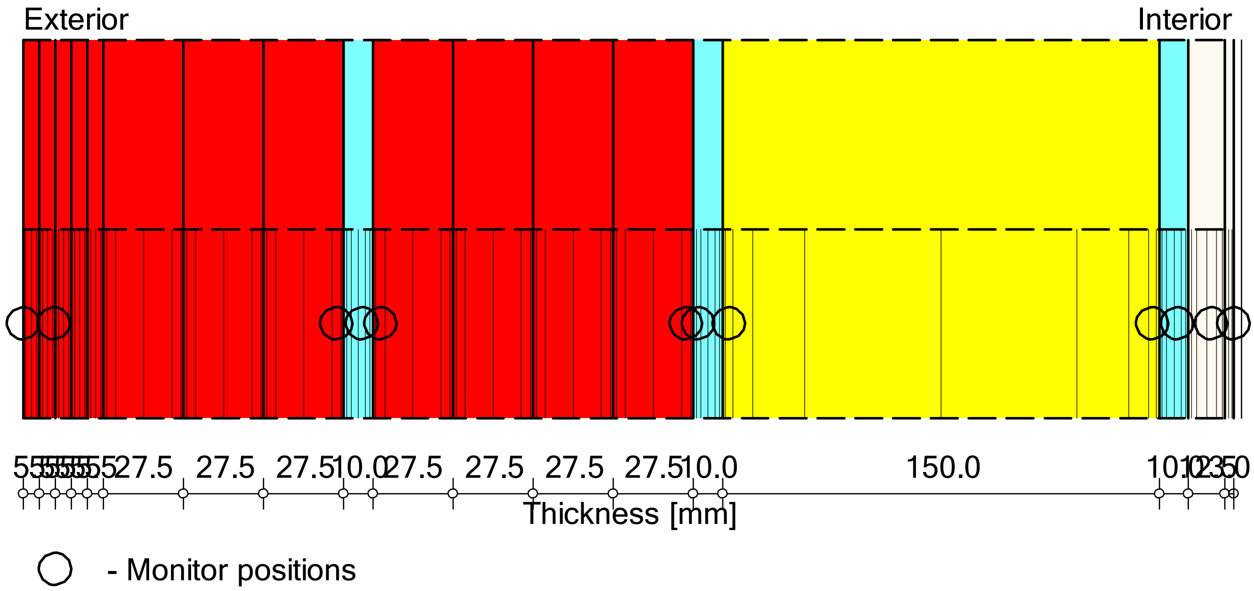
Layer/Material	Start	End	Min.	Max.
*Solid Brick Masonry	18,00	19,49	1,73	162,08
*Solid Brick Masonry	18,00	34,87	3,62	151,41
*Solid Brick Masonry	18,00	33,20	6,15	144,73
*Solid Brick Masonry	18,00	23,57	8,78	138,01
*Solid Brick Masonry	18,00	18,07	10,47	130,72
*Solid Brick Masonry	18,00	17,63	14,98	85,73
*Solid Brick Masonry	18,00	23,20	17,92	62,49
*Solid Brick Masonry	18,00	28,06	17,11	57,40
*Air Layer 10 mm; without additional	0,01	0,01	0,01	0,02
*Solid Brick Masonry	18,00	30,38	16,62	44,25
*Solid Brick Masonry	18,00	32,37	17,85	38,24
*Solid Brick Masonry	18,00	33,18	17,97	36,26
*Solid Brick Masonry	18,00	33,20	18,00	35,10
*Air Layer 10 mm; without additional	0,01	0,01	0,01	0,02
*PIR	1,79	1,26	0,76	1,79
*Air Layer 10 mm; without additional	0,01	0,01	0,01	0,01
*Gypsum Board	6,30	4,03	2,85	6,30
*Interior Plaster (Gypsum Plaster)	6,30	3,98	2,82	6,30

Time Integral of fluxes

Heat Flux, left side	[MJ/m²]	-174,87
Heat Flux, right side	[MJ/m²]	-175,64
Heat Sources	[MJ/m²]	0,0
Moisture Fluxes, left side	[kg/m²]	2,35
Moisture Fluxes, right side	[kg/m²]	0,25
Moisture Sources	[kg/m²]	0,0
Clipped Moisture Sources	[kg/m²]	0,0

Component Assembly

Case: 150 Cavity South West 10 Year



Materials :

- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- Air Layer 10 mm; without additional moisture capacity
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Air Layer 10 mm; without additional moisture capacity
- *PIR
- *Air Layer 10 mm; without additional moisture capacity
- *Gypsum Board
- *Interior Plaster (Gypsum Plaster)

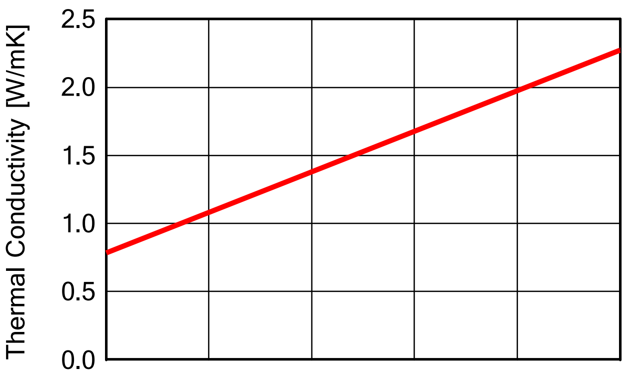
Sd-Value Int. [m]: 0.1

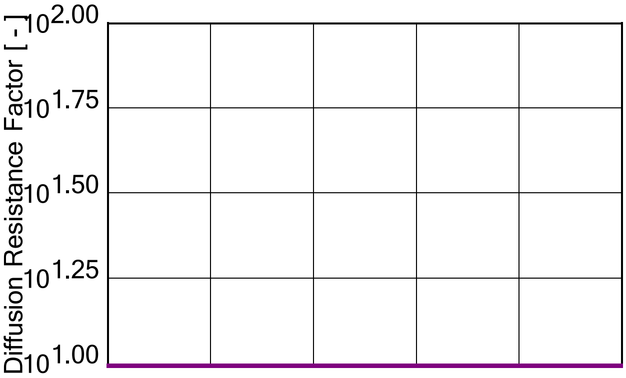
Total Thickness: 0.42 m
R-Value: 7.34 m²K/W
U-Value: 0.133 W/m²K

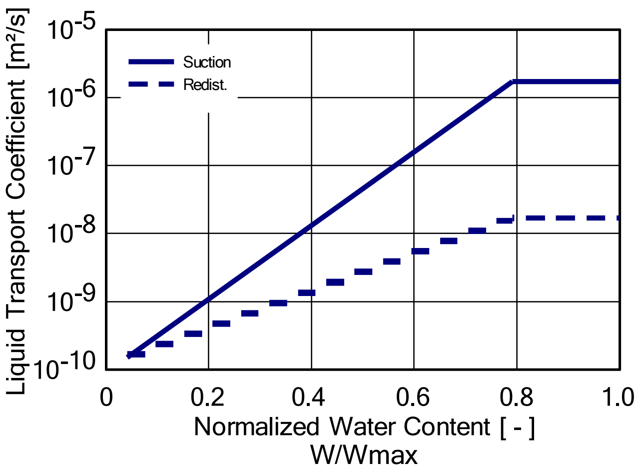
Material : *Solid Brick Masonry

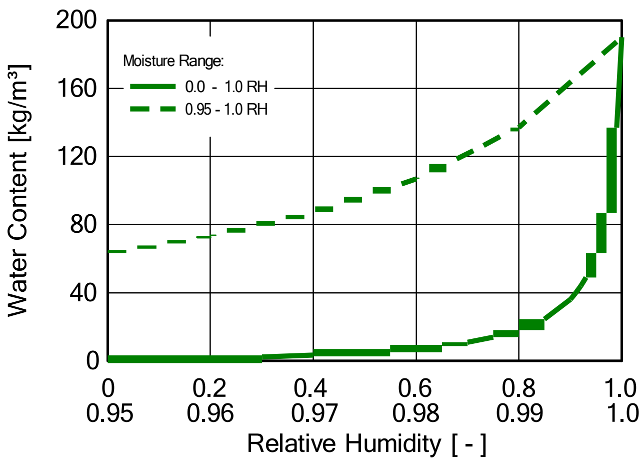
Checking Input Data

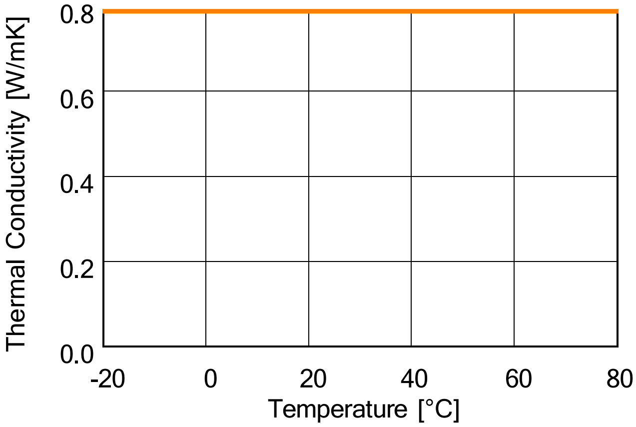
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







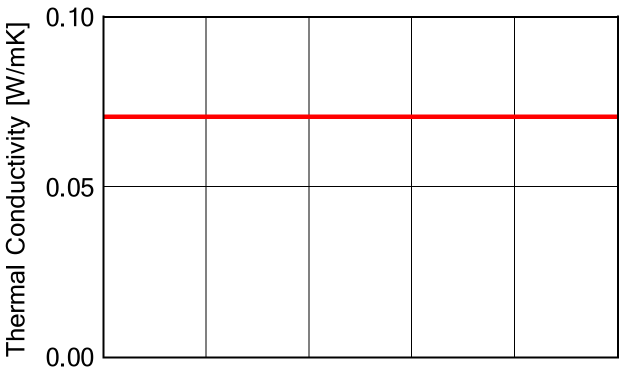


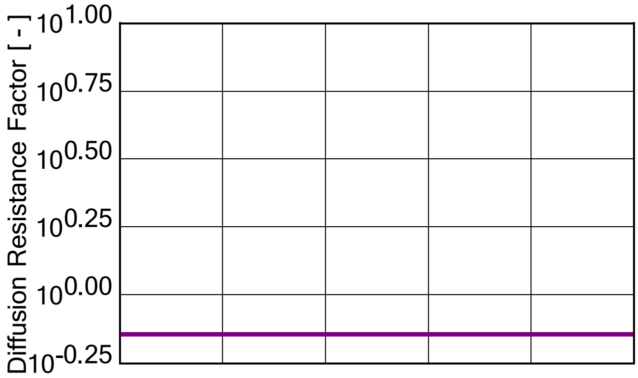


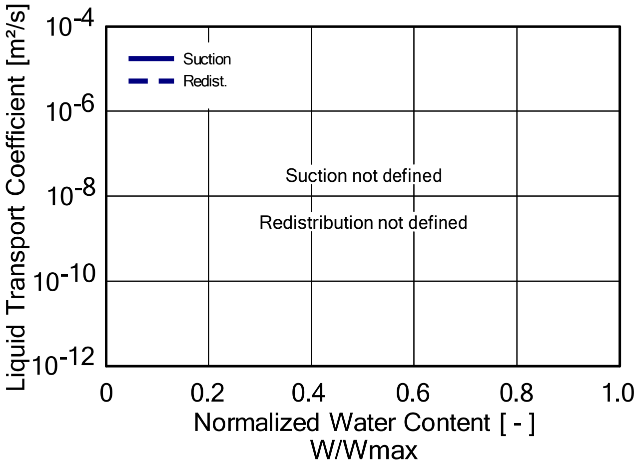
Material : Air Layer 10 mm; without additional moisture capacity

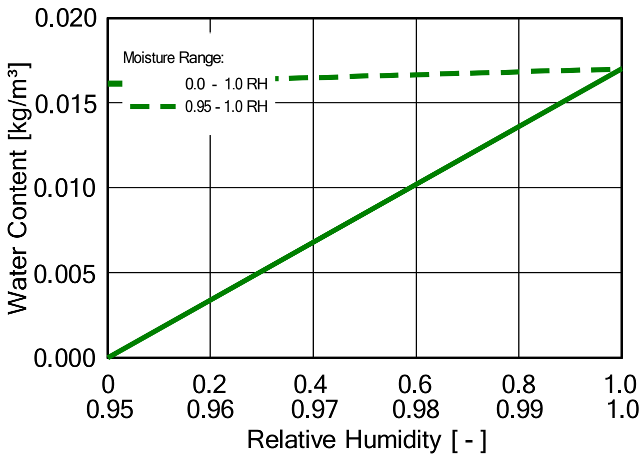
Checking Input Data

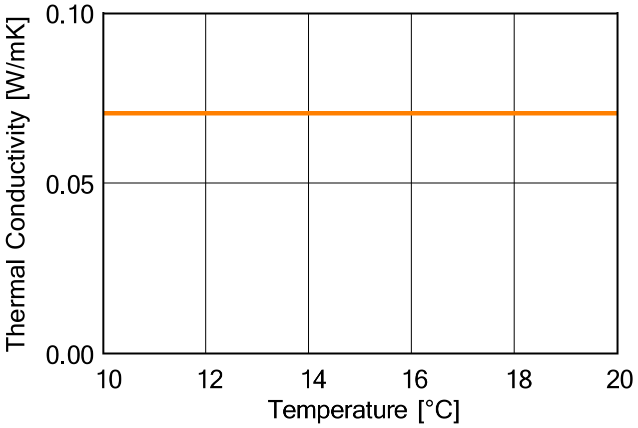
Property	Unit	Value
Bulk density	[kg/m³]	1.3
Porosity	[m³/m³]	0.999
Specific Heat Capacity, Dry	[J/kgK]	1000.0
Thermal Conductivity, Dry ,10°C	[W/mK]	0.071
Water Vapour Diffusion Resistance Factor	[-]	0.73







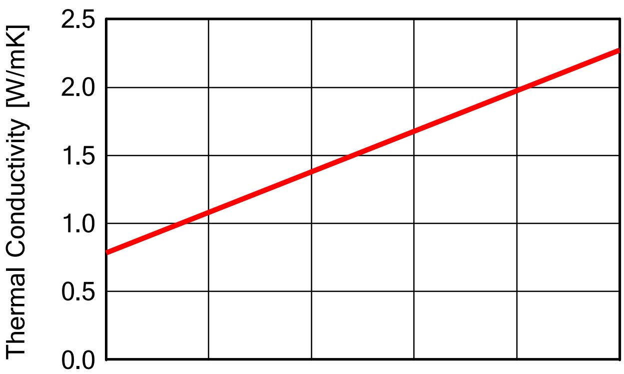


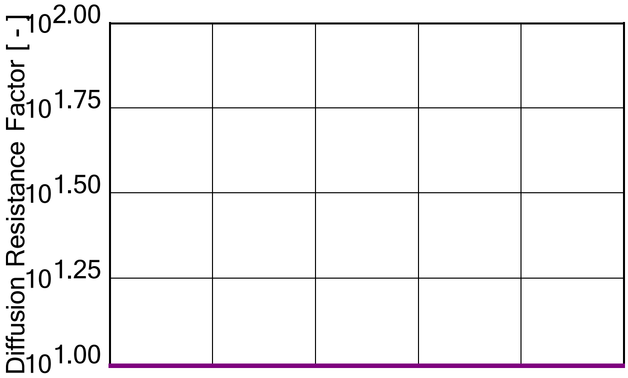


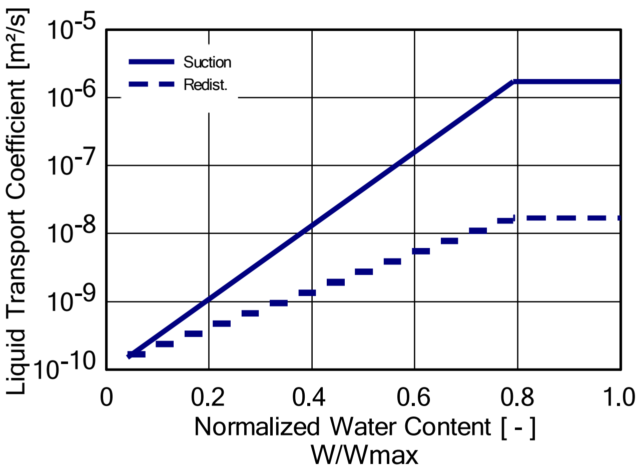
Material : *Solid Brick Masonry

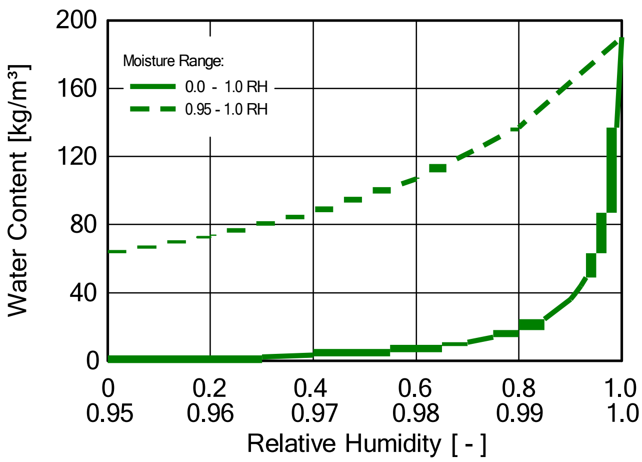
Checking Input Data

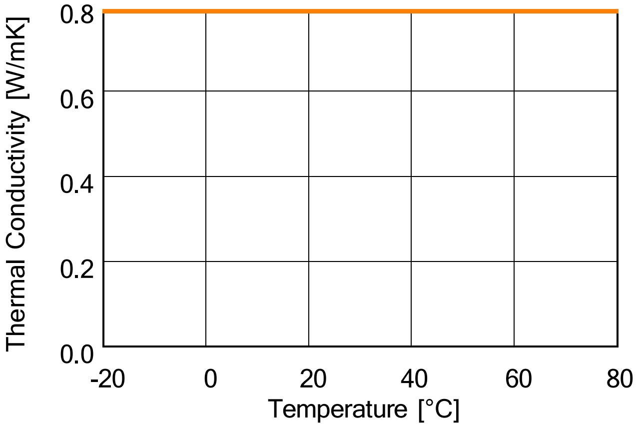
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







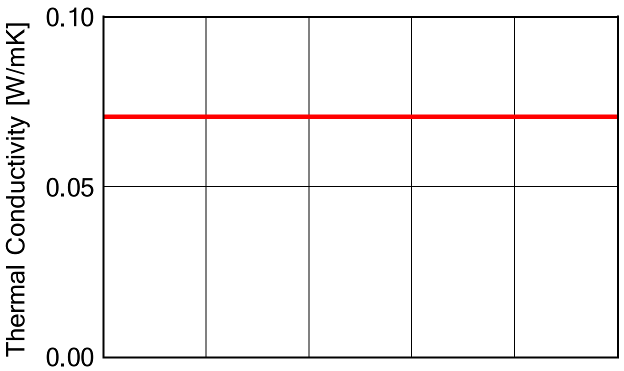


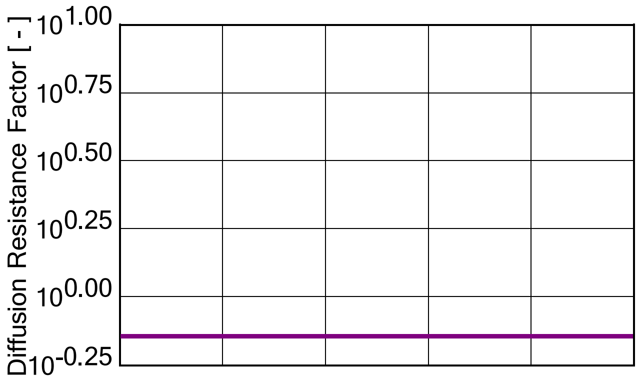


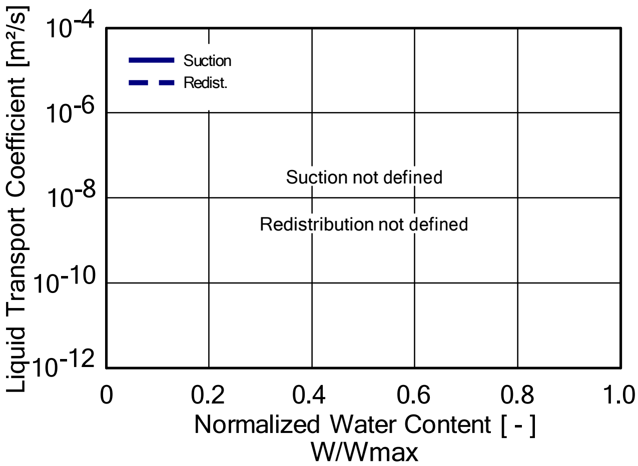
Material : *Air Layer 10 mm; without additional moisture capacity

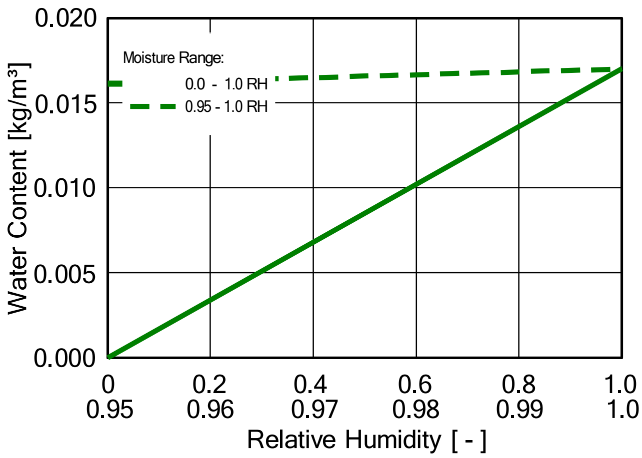
Checking Input Data

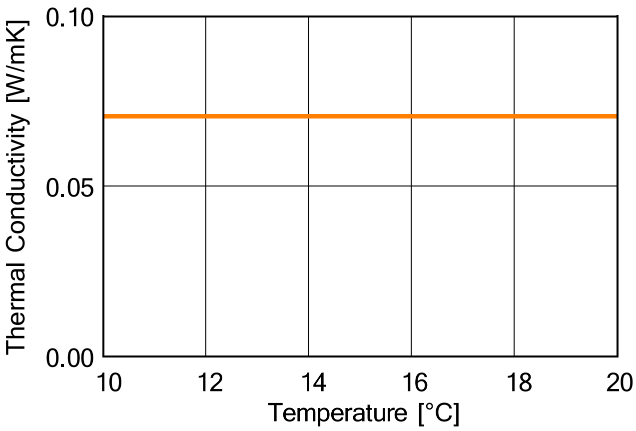
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73







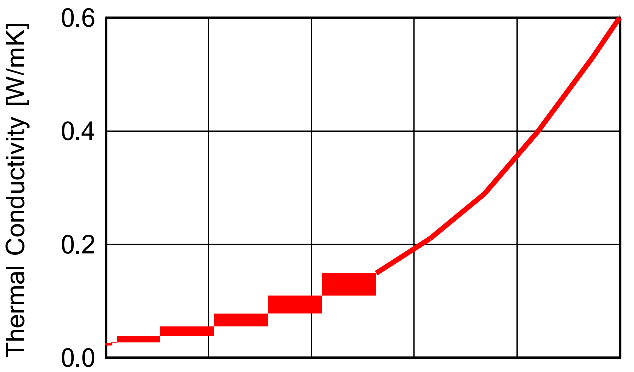


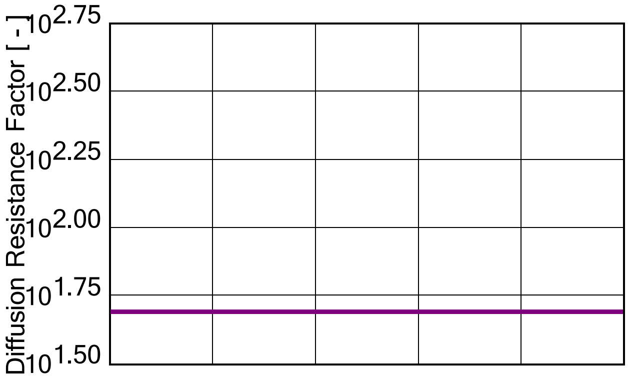


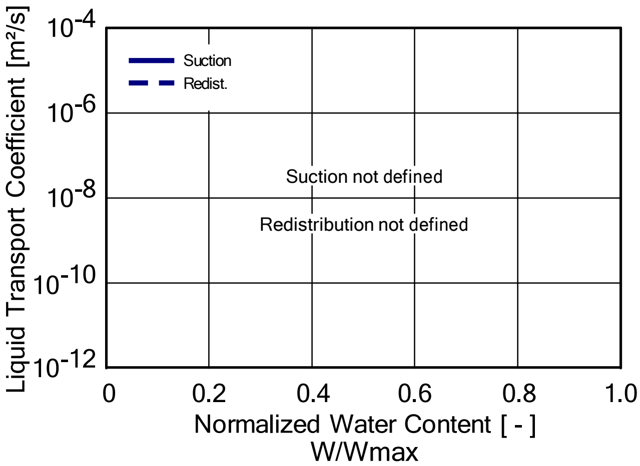
Material : *PIR

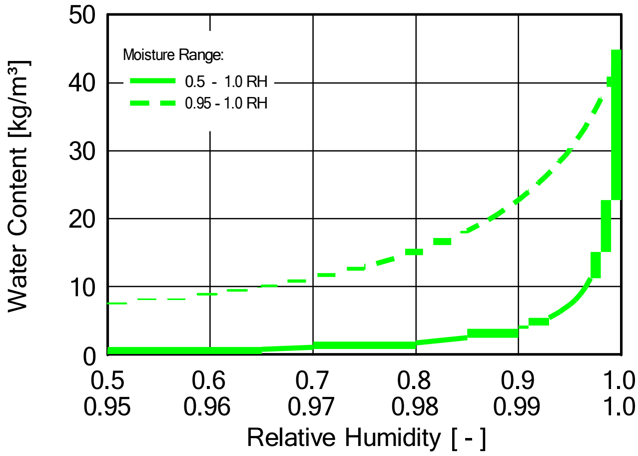
Checking Input Data

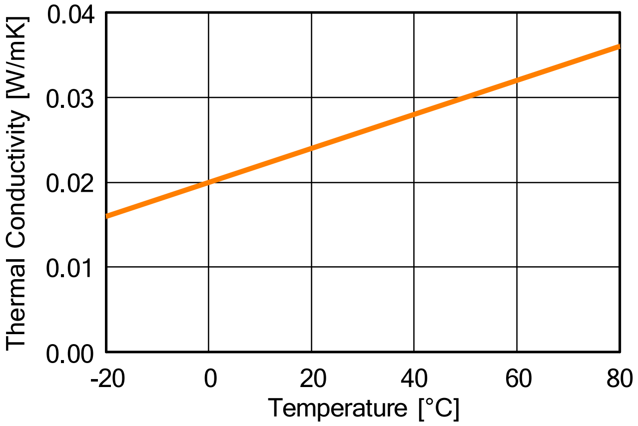
Property	Unit	Value
Bulk density	[kg/m³]	40,0
Porosity	[m³/m³]	0,95
Specific Heat Capacity, Dry	[J/kgK]	1500,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,022
Water Vapour Diffusion Resistance Factor	[-]	50,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







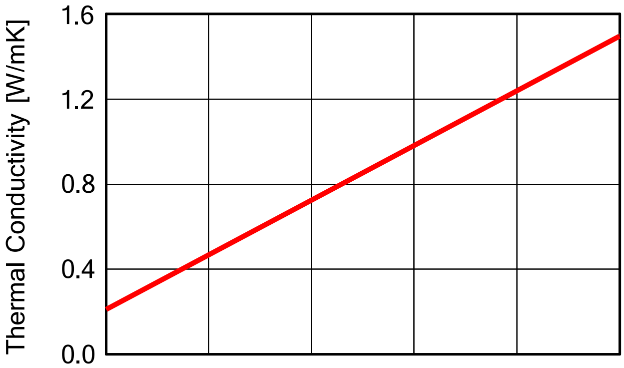


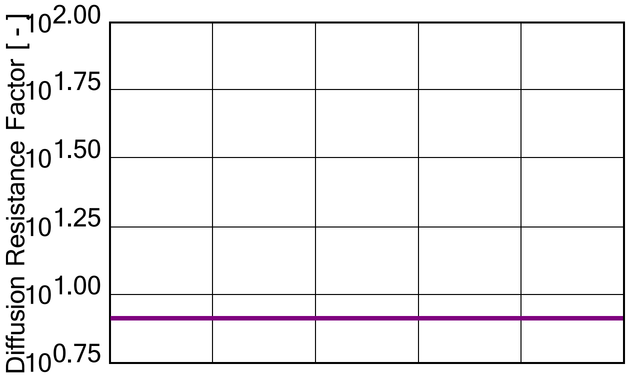


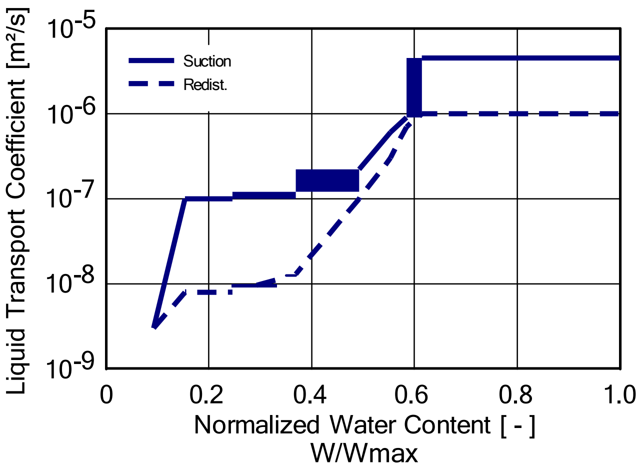
Material : *Gypsum Board

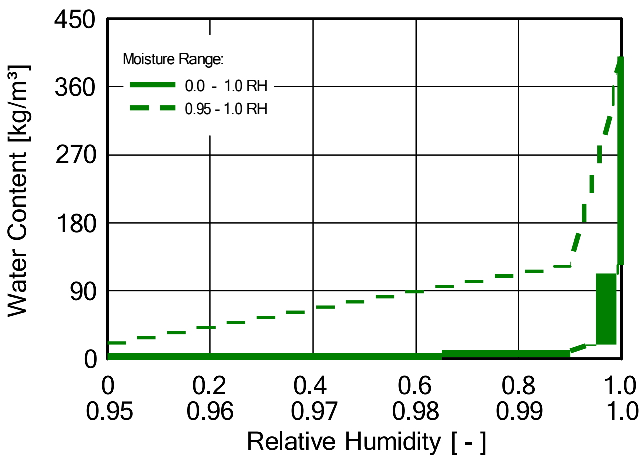
Checking Input Data

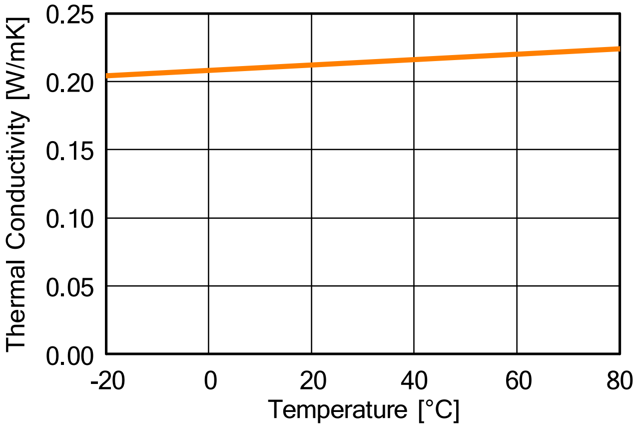
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,21
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







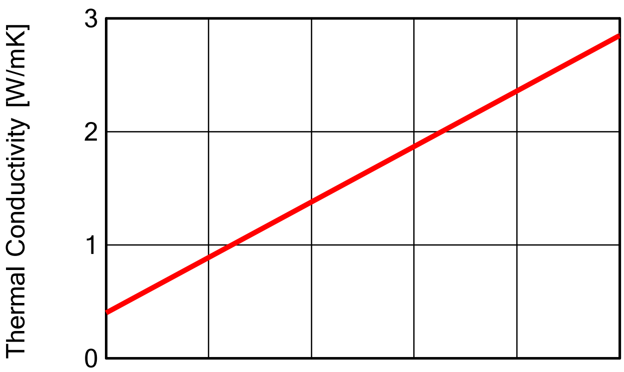


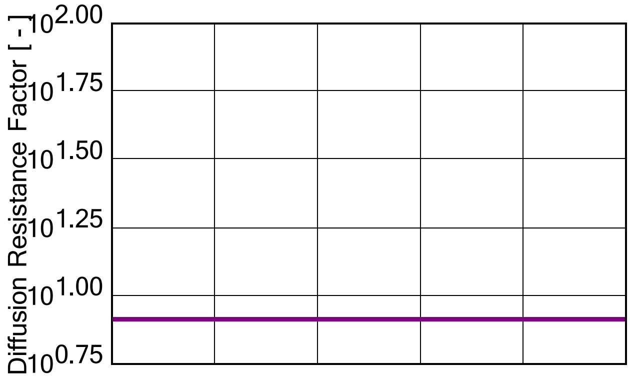


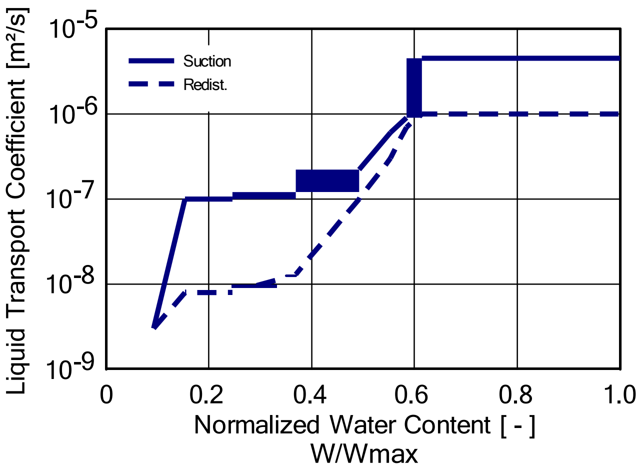
Material : *Interior Plaster (Gypsum Plaster)

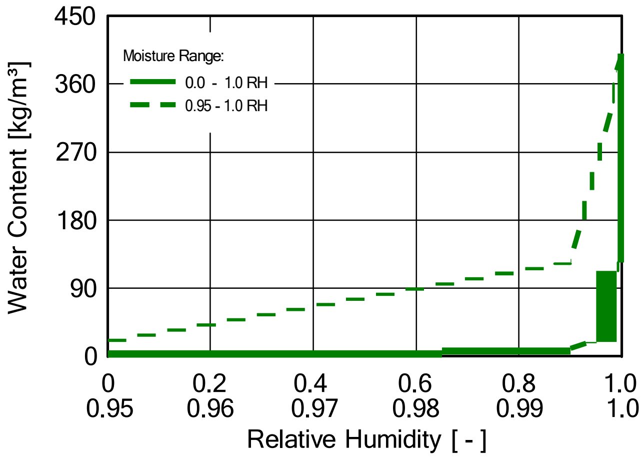
Checking Input Data

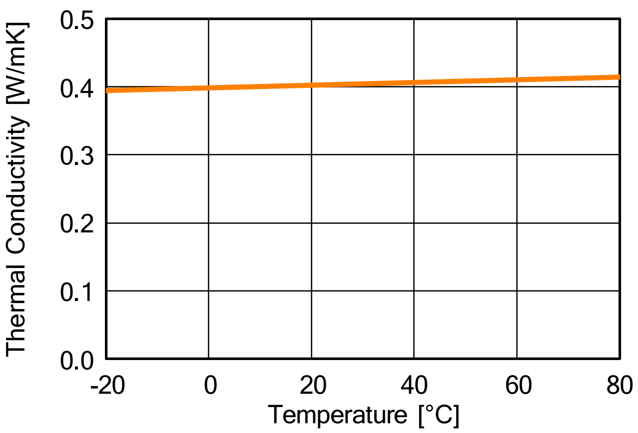
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,4
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002











Boundary Conditions

Exterior (Left Side)

Location: Leeds_UK-hour.wac

Orientation / Inclination: South-West / 90 °

Interior (Right Side)

Indoor Climate: EN 15026

Normal Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	External Wall	[m²K/W]	0.0588 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Brick, red	[-]	0.68
Long-Wave Radiation Emissivity	Brick, red	[-]	0.9
Adhering Fraction of Rain	According to inclination an	[-]	0,7
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	External Wall	[m²K/W]	0.125
Sd-Value	Gypsum plaster	[m]	0.1

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	22/07/2014 11:50:06
Computing Time	3 min,39 sec.
Begin / End of calculation	01/10/2013 / 01/10/2023
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	2 45.7 -242.1 6
Integral of fluxes, right side (kr,dr)	[kg/m²]	1.2E-7 0.7
Balance 1	[kg/m²]	2.84
Balance 2	[kg/m²]	2.84

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	4.33	7.17	4.07	12.77

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
*Solid Brick Masonry	18.00	19.67	1.73	162.28
*Solid Brick Masonry	18.00	35.22	3.64	151.72
*Solid Brick Masonry	18.00	33.66	6.21	145.22
*Solid Brick Masonry	18.00	24.11	8.84	138.61
*Solid Brick Masonry	18.00	18.66	10.54	131.38
*Solid Brick Masonry	18.00	18.80	15.12	88.14
*Solid Brick Masonry	18.00	25.44	17.91	65.84
*Solid Brick Masonry	18.00	31.14	17.01	61.92
Air Layer 10 mm; without additional m	0.01	0.02	0.01	0.02
*Solid Brick Masonry	18.00	34.57	16.63	50.08
*Solid Brick Masonry	18.00	37.13	17.87	44.02
*Solid Brick Masonry	18.00	38.48	17.97	42.26
*Solid Brick Masonry	18.00	38.87	18.00	41.13
*Air Layer 10 mm; without additional n	0.01	0.02	0.01	0.02
*PIR	1.79	1.40	0.79	1.79
*Air Layer 10 mm; without additional n	0.01	0.01	0.01	0.01
*Gypsum Board	6.30	4.00	2.84	6.30
*Interior Plaster (Gypsum Plaster)	6.30	3.96	2.81	6.30

Time Integral of fluxes

Heat Flux, left side	[MJ/m²]	-407.87
Heat Flux, right side	[MJ/m²]	-415.12

Time Integral of fluxes (Continue)

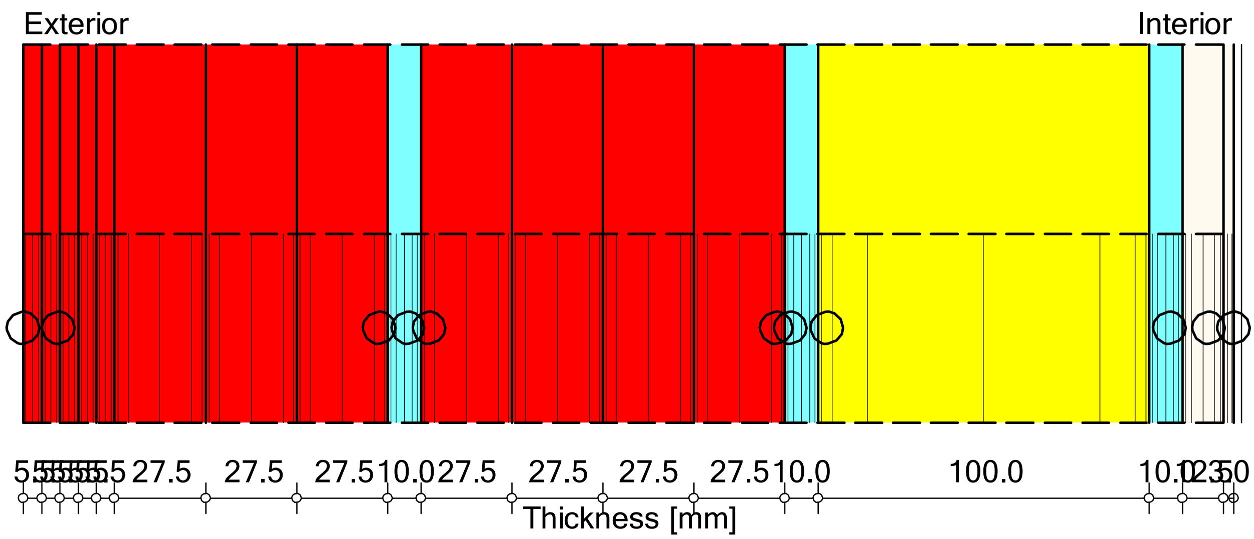
Moisture Fluxes, left side	[kg/m²]	3.53
Moisture Fluxes, right side	[kg/m²]	0.7

Hygrothermal Sources

Heat Sources	[MJ/m²]	0.0
Moisture Sources	[kg/m²]	0.0
Unreleased Moisture Sources (due to cut-off)	[kg/m²]	0.0

Component Assembly

Case: 100 Cavity South West



- Monitor positions

Materials :

- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Air Layer 10 mm; without additional moisture capacity
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Solid Brick Masonry
- *Air Layer 10 mm; without additional moisture capacity
- *PIR
- *Air Layer 10 mm; without additional moisture capacity
- *Gypsum Board
- *Interior Plaster (Gypsum Plaster)

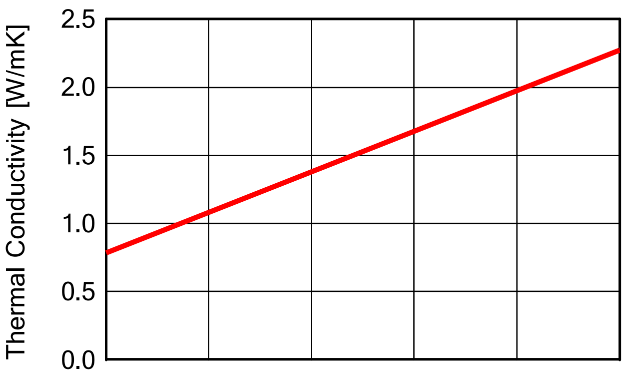
Sd-Value Int. [m]: 0.1

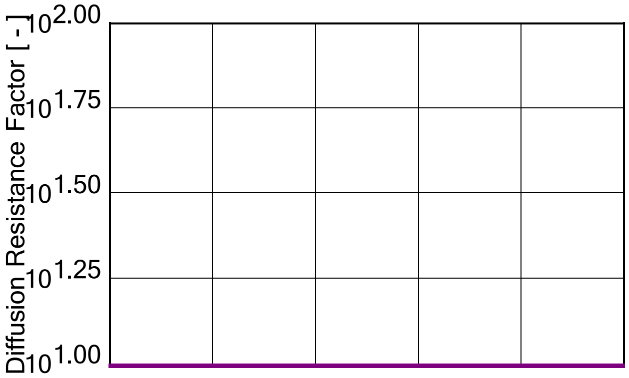
Total Thickness: 0.37 m
R-Value: 5.13 m²K/W
U-Value: 0.188 W/m²K

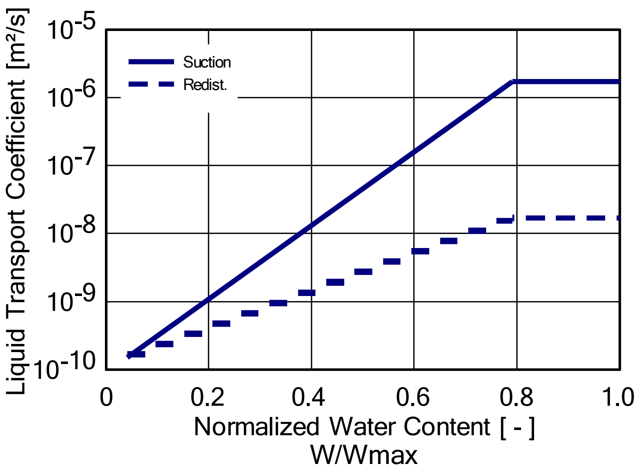
Material : *Solid Brick Masonry

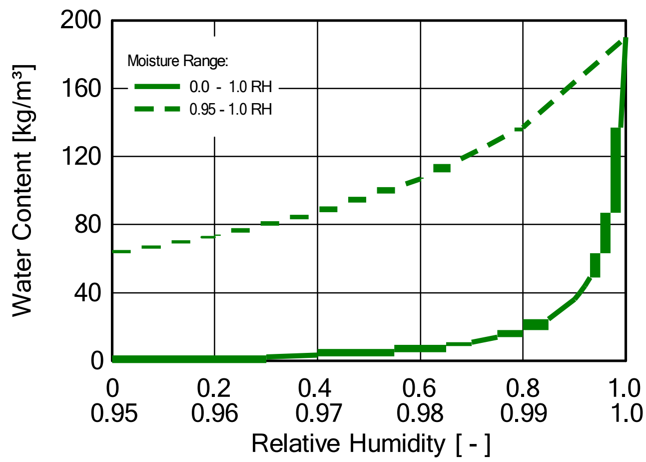
Checking Input Data

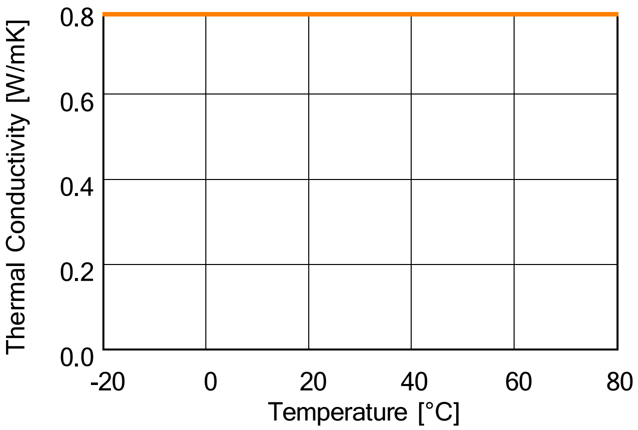
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







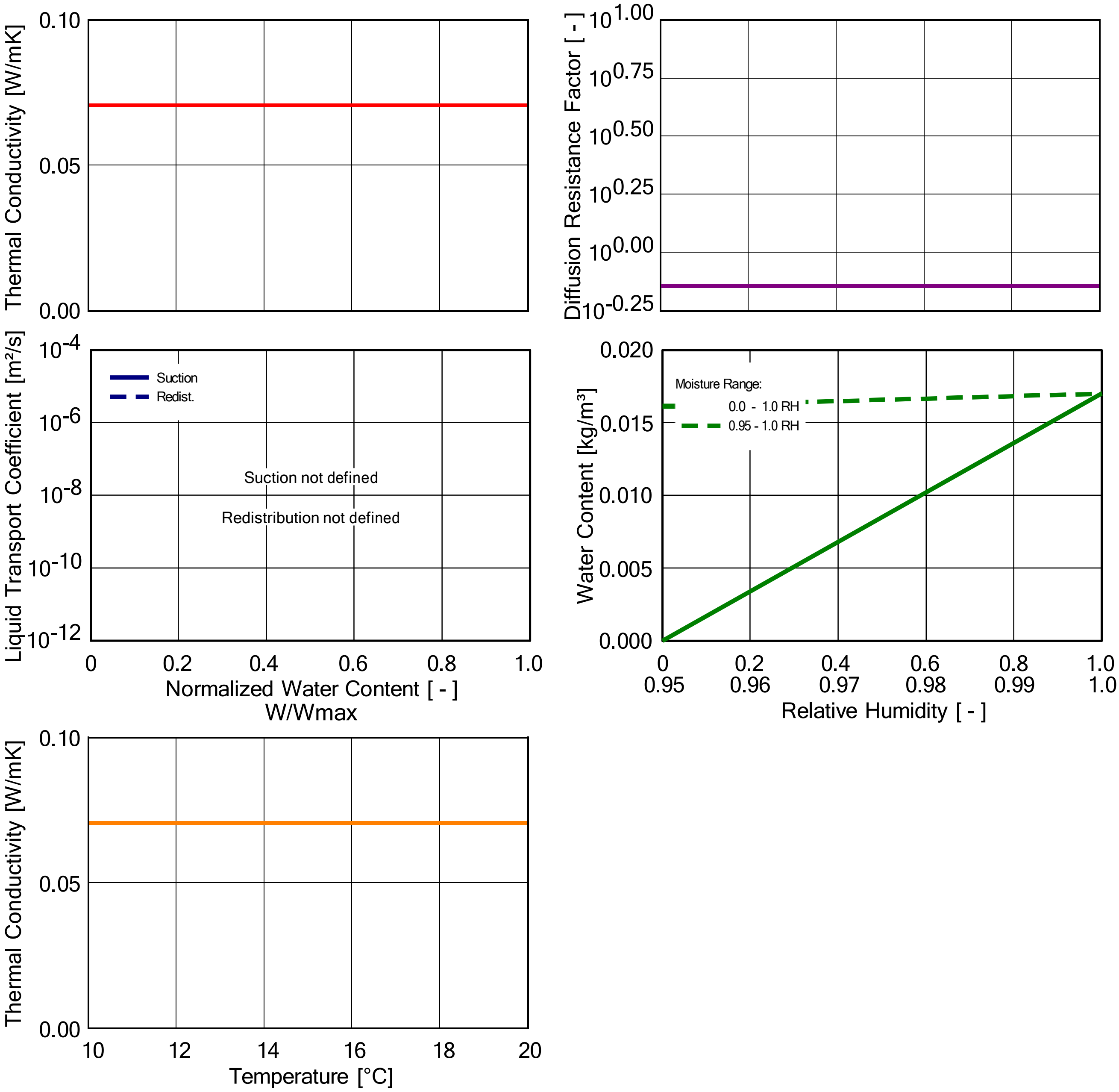




Material : *Air Layer 10 mm; without additional moisture capacity

Checking Input Data

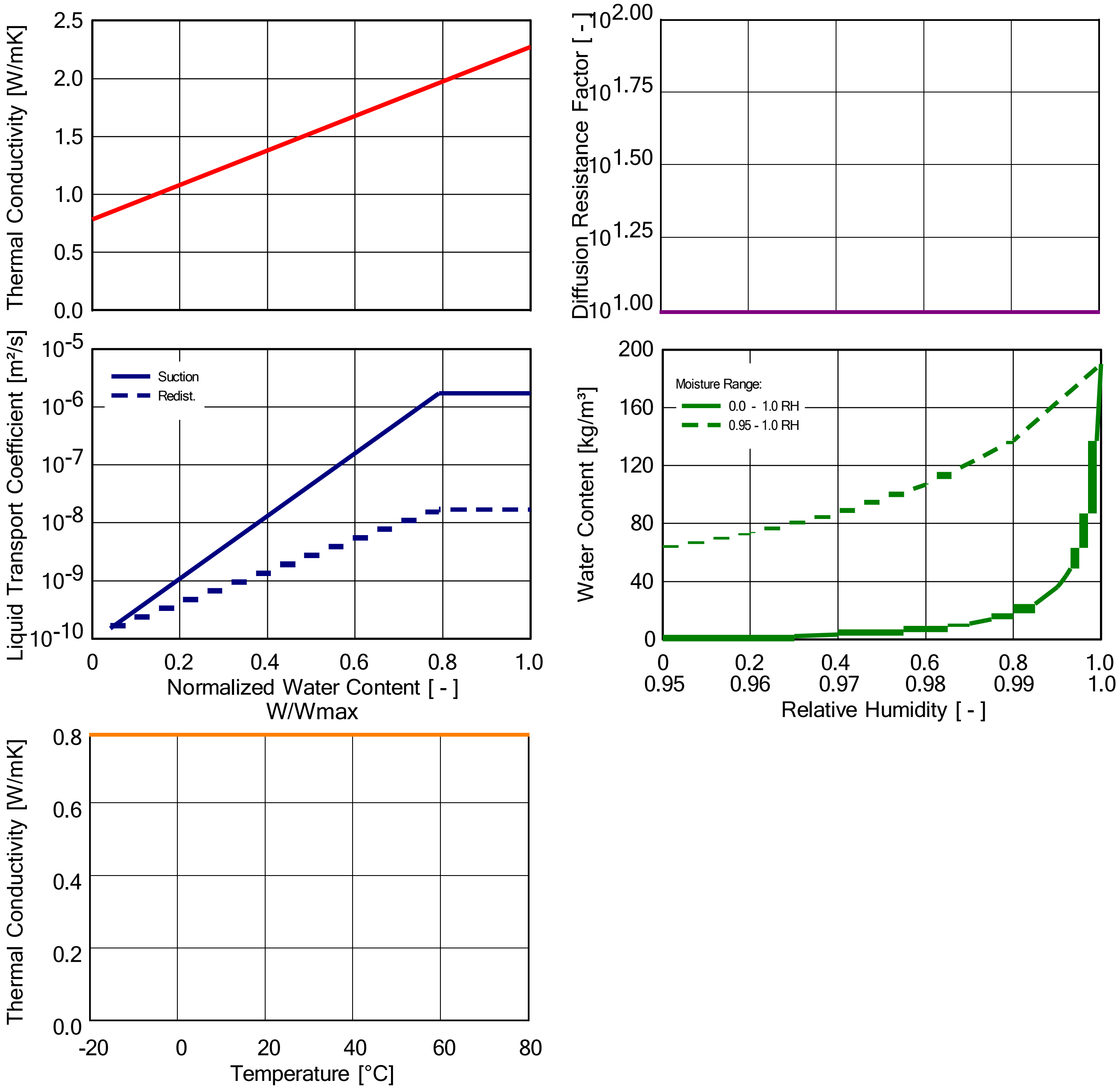
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73



Material : *Solid Brick Masonry

Checking Input Data

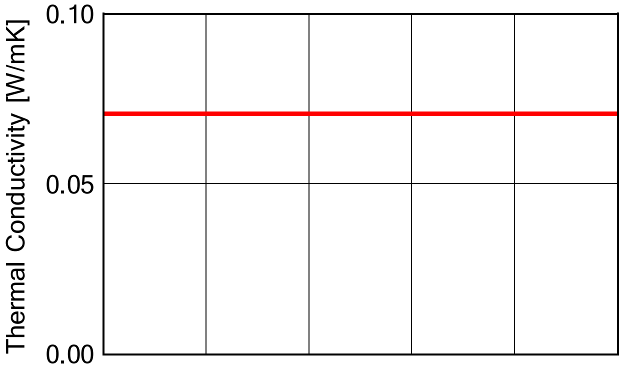
Property	Unit	Value
Bulk density	[kg/m³]	1900,0
Porosity	[m³/m³]	0,24
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,784
Water Vapour Diffusion Resistance Factor	[-]	10,0
Reference Water Content	[kg/m³]	18,0
Free Water Saturation	[kg/m³]	190,0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	15,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002

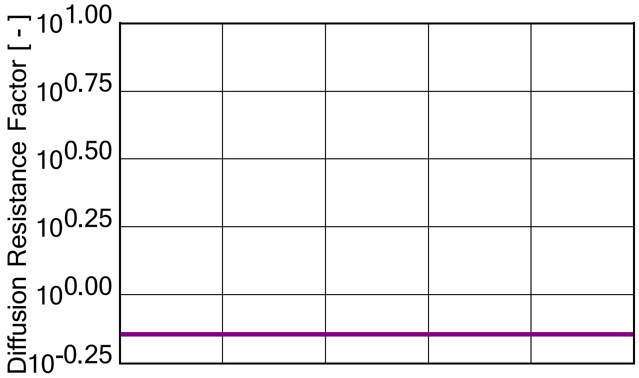


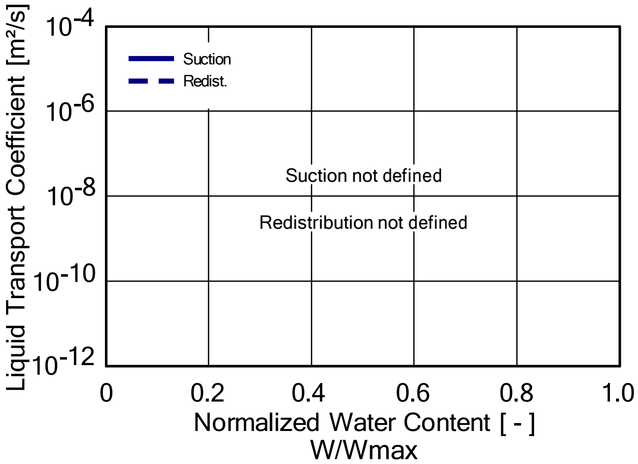
Material : *Air Layer 10 mm; without additional moisture capacity

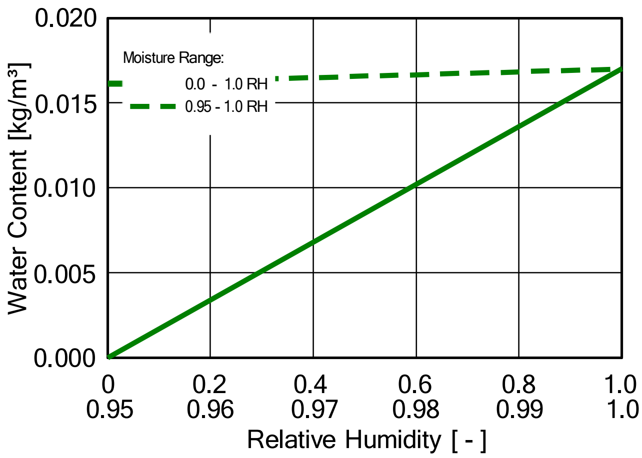
Checking Input Data

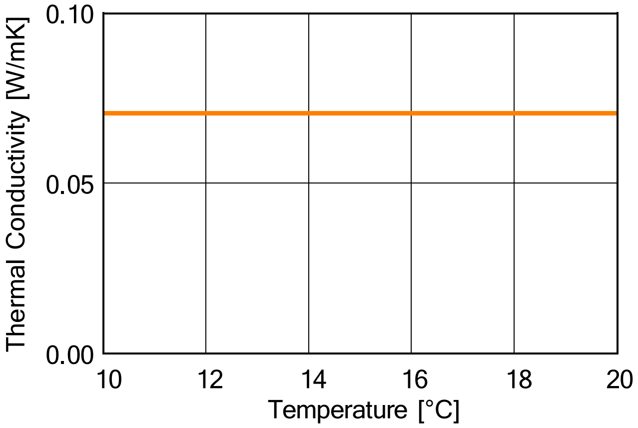
Property	Unit	Value
Bulk density	[kg/m³]	1,3
Porosity	[m³/m³]	0,999
Specific Heat Capacity, Dry	[J/kgK]	1000,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,071
Water Vapour Diffusion Resistance Factor	[-]	0,73







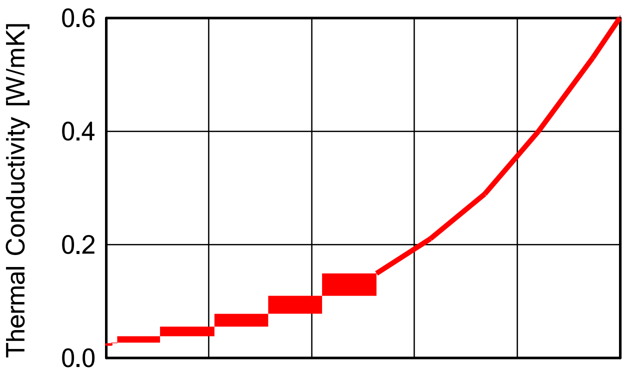


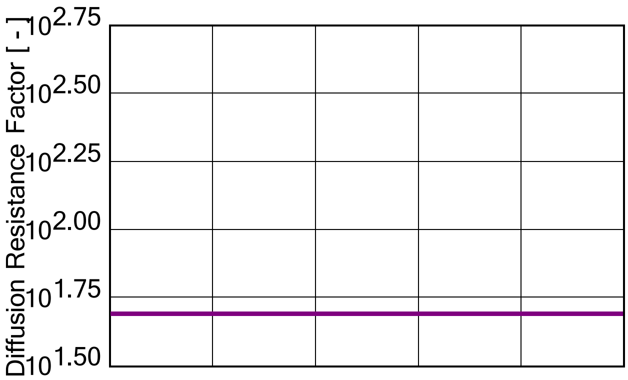


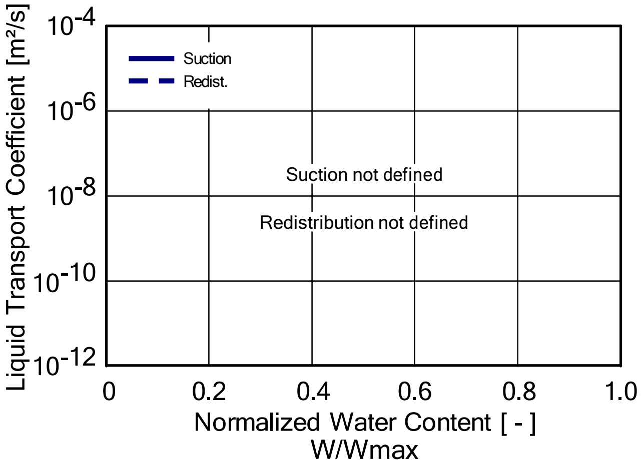
Material : *PIR

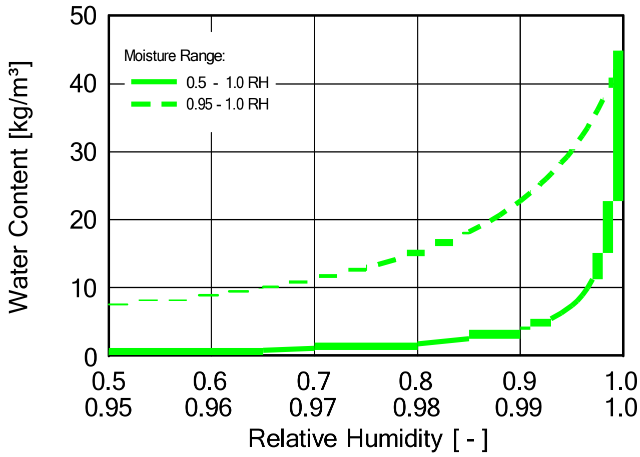
Checking Input Data

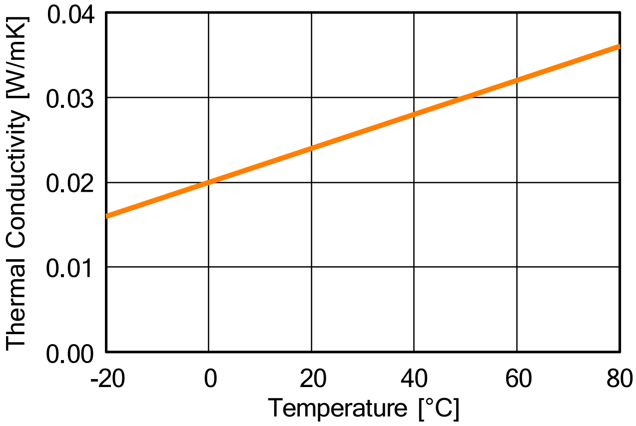
Property	Unit	Value
Bulk density	[kg/m³]	40,0
Porosity	[m³/m³]	0,95
Specific Heat Capacity, Dry	[J/kgK]	1500,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,022
Water Vapour Diffusion Resistance Factor	[-]	50,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







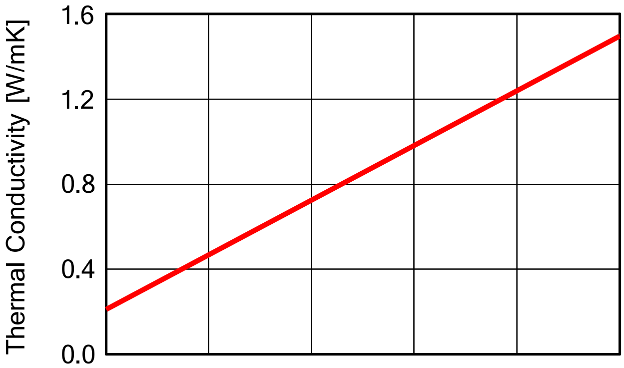


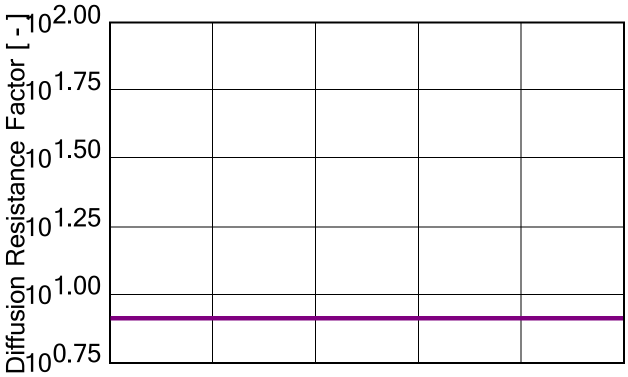


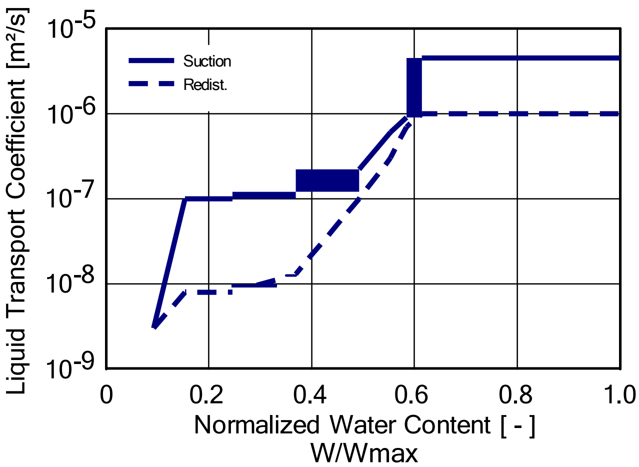
Material : *Gypsum Board

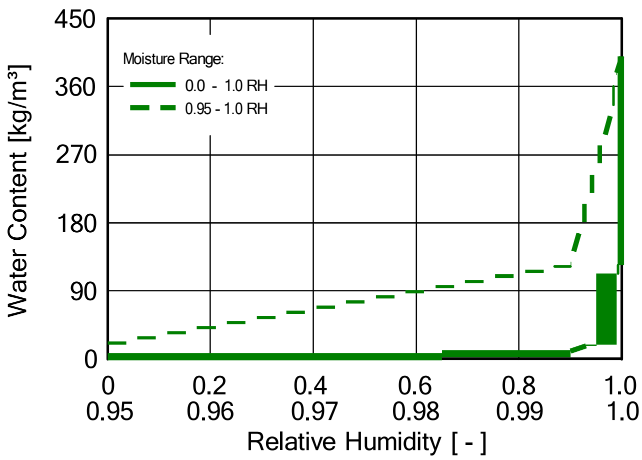
Checking Input Data

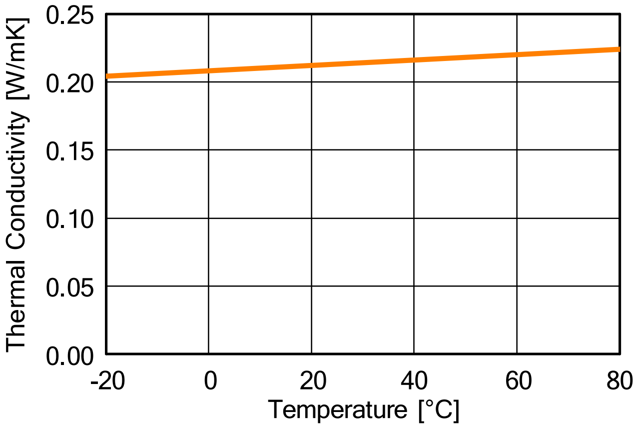
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,21
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002







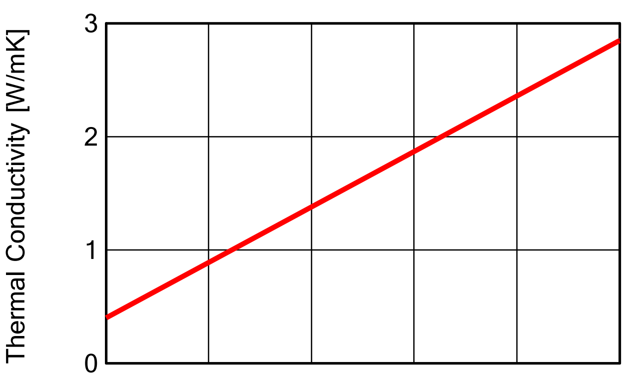


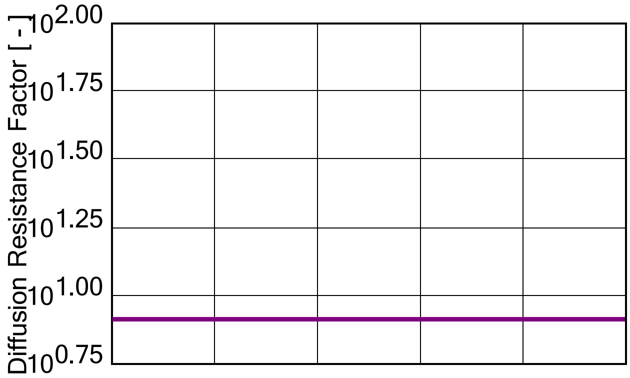


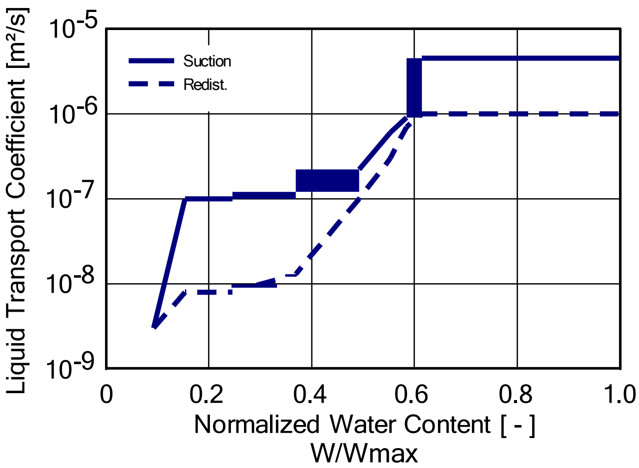
Material : *Interior Plaster (Gypsum Plaster)

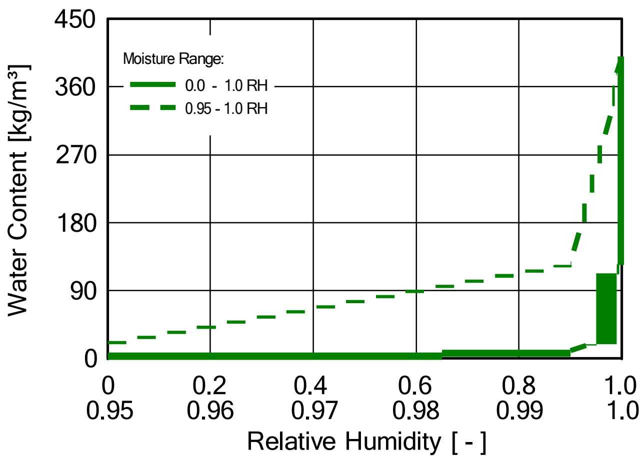
Checking Input Data

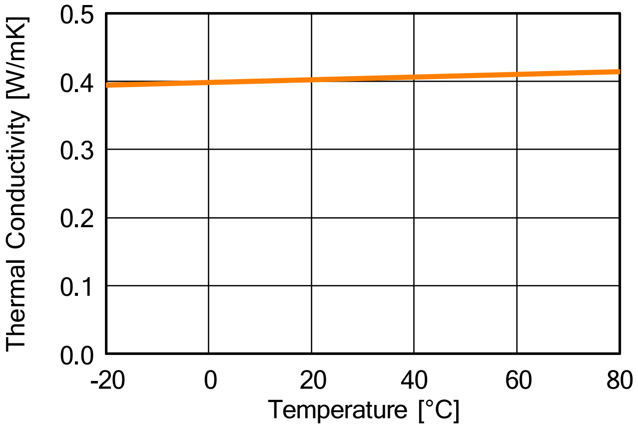
Property	Unit	Value
Bulk density	[kg/m³]	850,0
Porosity	[m³/m³]	0,65
Specific Heat Capacity, Dry	[J/kgK]	850,0
Thermal Conductivity, Dry ,10°C	[W/mK]	0,4
Water Vapour Diffusion Resistance Factor	[-]	8,3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8,0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0,0002











Boundary Conditions

Exterior (Left Side)

Location: Leeds_UK-hour.wac

Orientation / Inclination: South-West / 90 °

Interior (Right Side)

Indoor Climate: EN 15026

Normal Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	External Wall	[m²K/W]	0.0588 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Brick, red	[-]	0.68
Long-Wave Radiation Emissivity	Brick, red	[-]	0.9
Adhering Fraction of Rain	According to inclination an	[-]	0,7
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	External Wall	[m²K/W]	0.125
Sd-Value	Gypsum plaster	[m]	0.1

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	25/07/2014 15:17:39
Computing Time	3 min,49 sec.
Begin / End of calculation	01/10/2013 / 01/10/2023
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	245.41 -241.97
Integral of fluxes, right side (kr,dr)	[kg/m²]	1.8E-7 1.01
Balance 1	[kg/m²]	2.43
Balance 2	[kg/m²]	2.43

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	4.24	6.67	3.98	12.19

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
*Solid Brick Masonry	18.00	19.52	1.73	162.11
*Solid Brick Masonry	18.00	34.95	3.62	151.47
*Solid Brick Masonry	18.00	33.36	6.15	144.86
*Solid Brick Masonry	18.00	23.79	8.78	138.18
*Solid Brick Masonry	18.00	18.34	10.47	130.93
*Solid Brick Masonry	18.00	18.20	14.98	86.87
*Solid Brick Masonry	18.00	24.30	17.92	64.30
*Solid Brick Masonry	18.00	29.62	17.11	60.39
*Air Layer 10 mm; without additional n	0.01	0.01	0.01	0.02
*Solid Brick Masonry	18.00	32.21	16.62	46.84
*Solid Brick Masonry	18.00	34.39	17.85	40.91
*Solid Brick Masonry	18.00	35.33	17.97	38.99
*Solid Brick Masonry	18.00	35.41	18.00	37.64
*Air Layer 10 mm; without additional n	0.01	0.02	0.01	0.02
*PIR	1.79	1.30	0.76	1.79
*Air Layer 10 mm; without additional n	0.01	0.01	0.01	0.01
*Gypsum Board	6.30	4.03	2.85	6.30
*Interior Plaster (Gypsum Plaster)	6.30	3.98	2.82	6.30

Time Integral of fluxes

Heat Flux, left side	[MJ/m²]	-579.12
Heat Flux, right side	[MJ/m²]	-586.39

Time Integral of fluxes (Continue)

Moisture Fluxes, left side	[kg/m²]	3.43
Moisture Fluxes, right side	[kg/m²]	1.01

Hygrothermal Sources

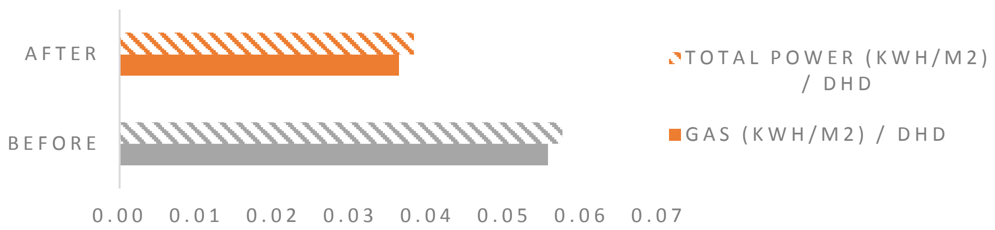
Heat Sources	[MJ/m²]	0.0
Moisture Sources	[kg/m²]	0.0
Unreleased Moisture Sources (due to cut-off)	[kg/m²]	0.0

Appendix I. Retrofit performance summary sheets

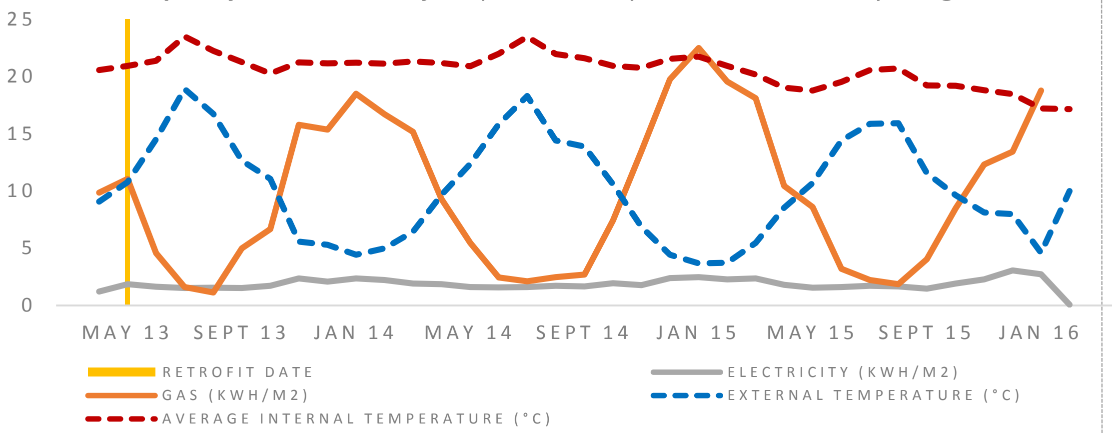
DECC, Leeds Go Early Energy Monitoring Project

Mid-terrace, Concrete, EWI

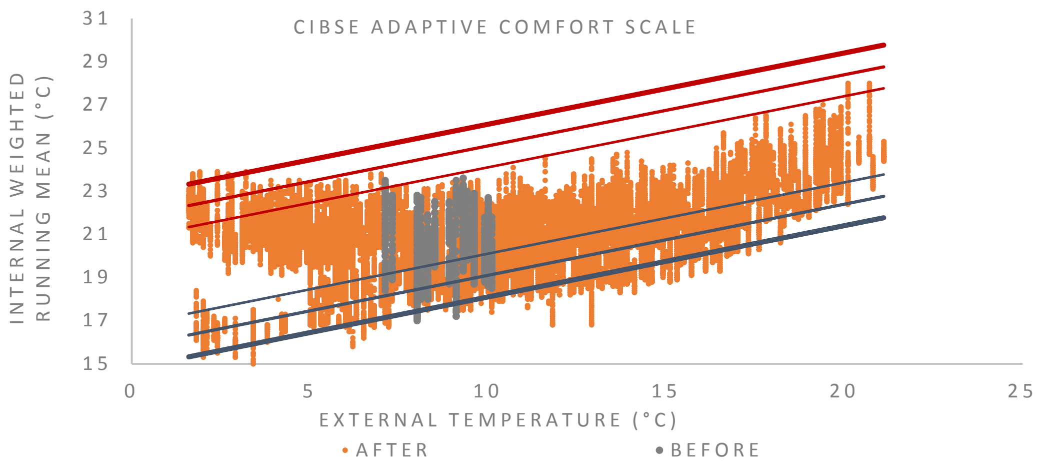
1. **Summary**; Data suggests a 37% energy reduction and £140 annual heating bill saving



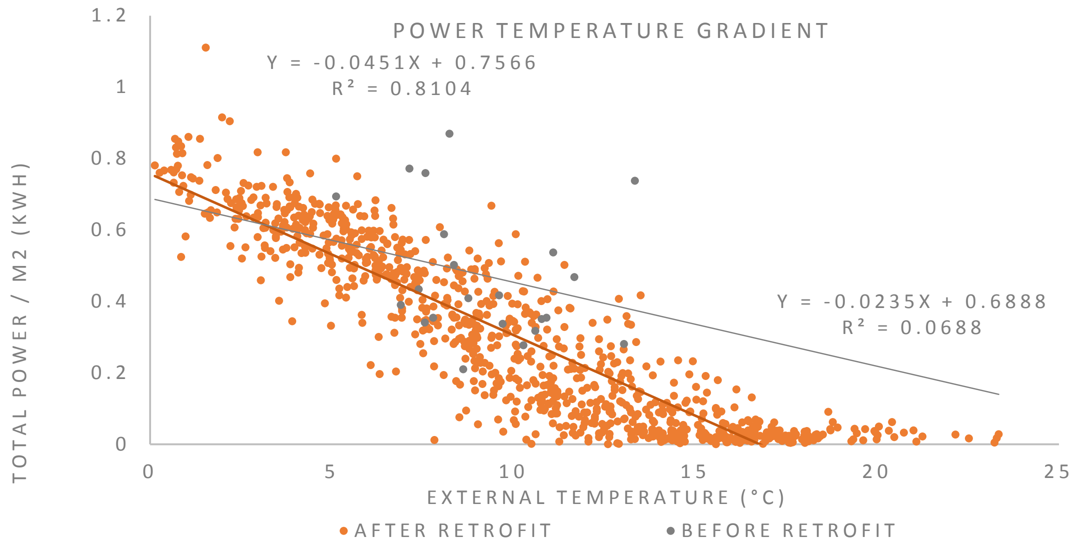
2. **Data quality**; OK, but the *before* period is very small so uncertainty is high



3. ***Comfort***; Dwelling appears comfortable, before data is not substantial



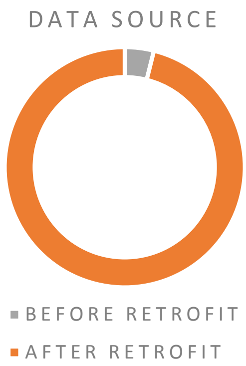
4. ***Retrofit performance;*** *More energy is used when it is cold outside*

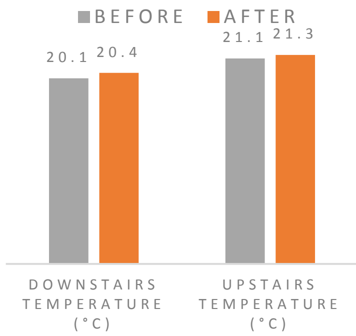


Property E1

Survey observations:

- thermal bridging at front eaves and ground floor
- insufficient roof insulation
- insulation cut-outs made for services and drains





- Energy use is lower *after* retrofit
- Few *before* data points
- Relatively normal heating behaviour
- External temperature explains 81% of energy use

Leeds Beckett University
Leeds Sustainability Institute

Contact: Dr David Glew
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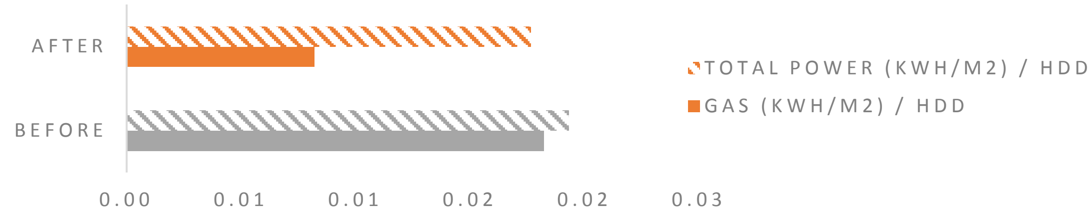
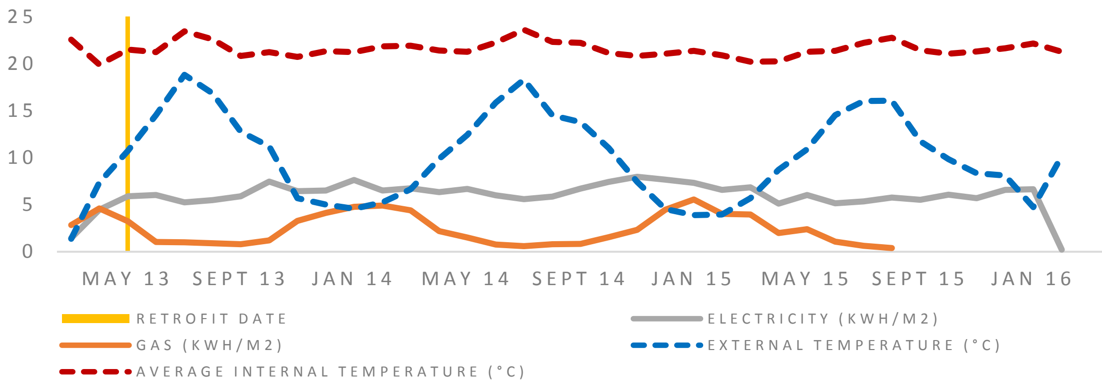
DECC, Leeds Go Early Energy Monitoring Project

End-terrace, Concrete, EWI

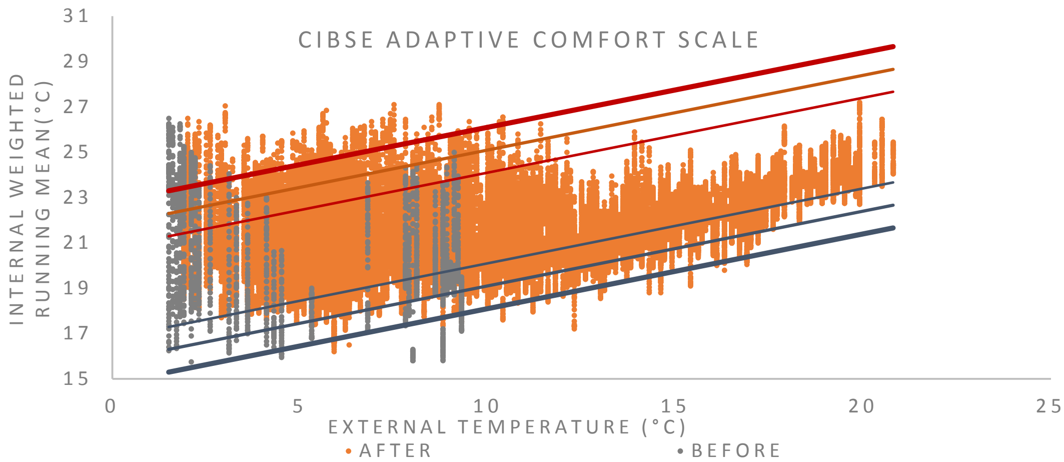
1. **Summary**; Data suggests a 55% heating energy reduction and £69 annual saving



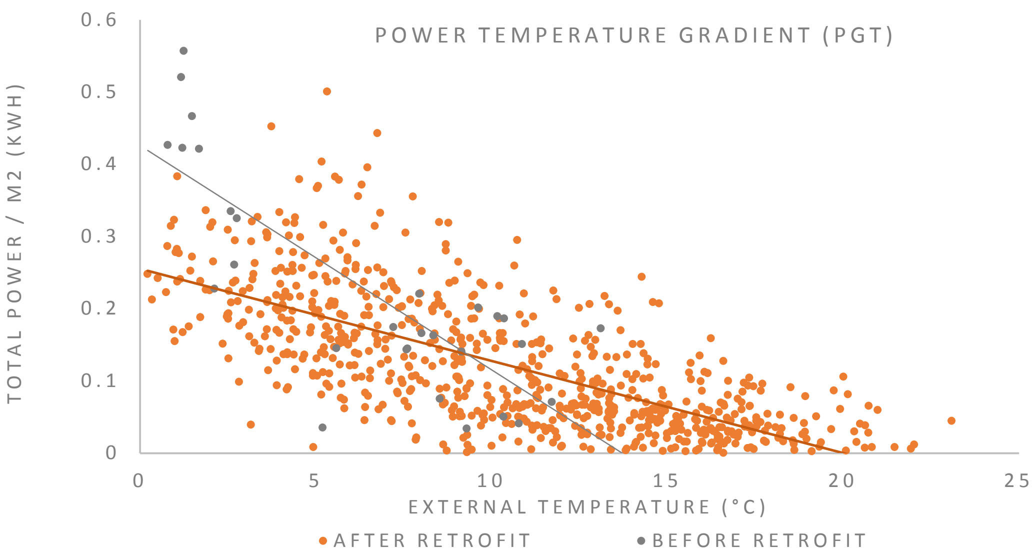
2. **Data quality**; Gas drops out and limited *before* data, leading to high uncertainty



3. ***Comfort***; Possible overheating when cold outside, but generally comfortable



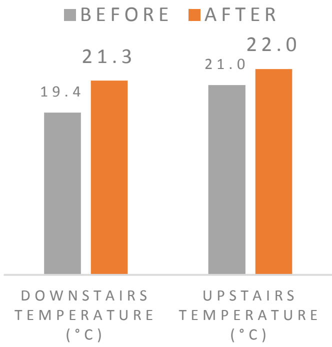
4. ***Retrofit performance;*** Only slight connection between outside temp and energy use



Property E2

Survey observations:

- thermal bridging at front eaves and ground floor
- insufficient roof insulation
- insulation cut-outs for services and drains



- Energy use may be lower *after* retrofit
- Uncertainty is very high
- External temperature explains only 48% of energy use

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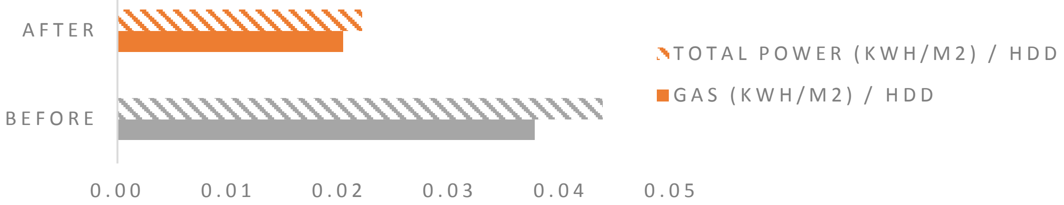
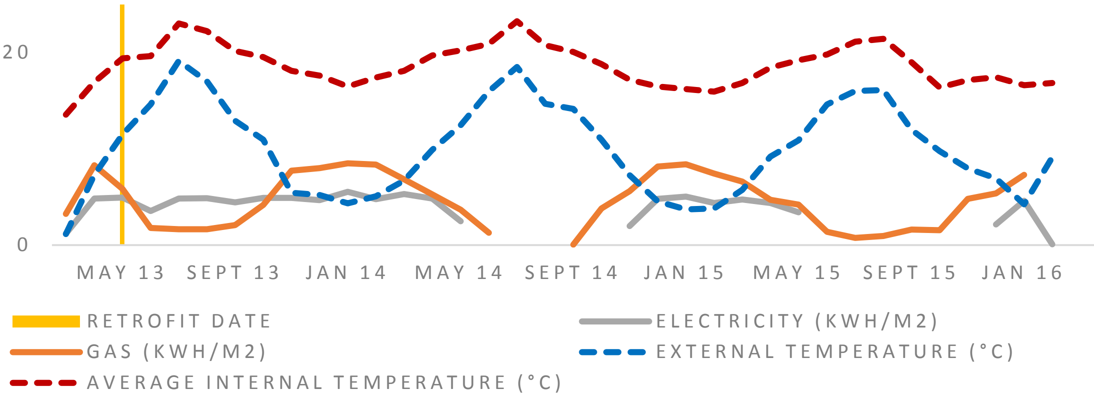
DECC, Leeds Go Early Energy Monitoring Project

End-terrace, Concrete, EWI

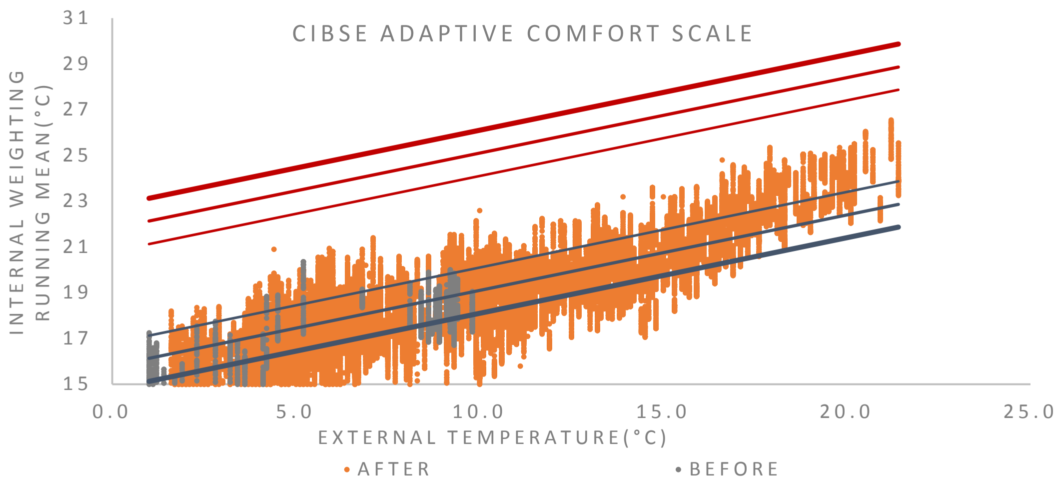
1. **Summary**; Data suggests a 46% heating energy reduction and £119 annual bill saving



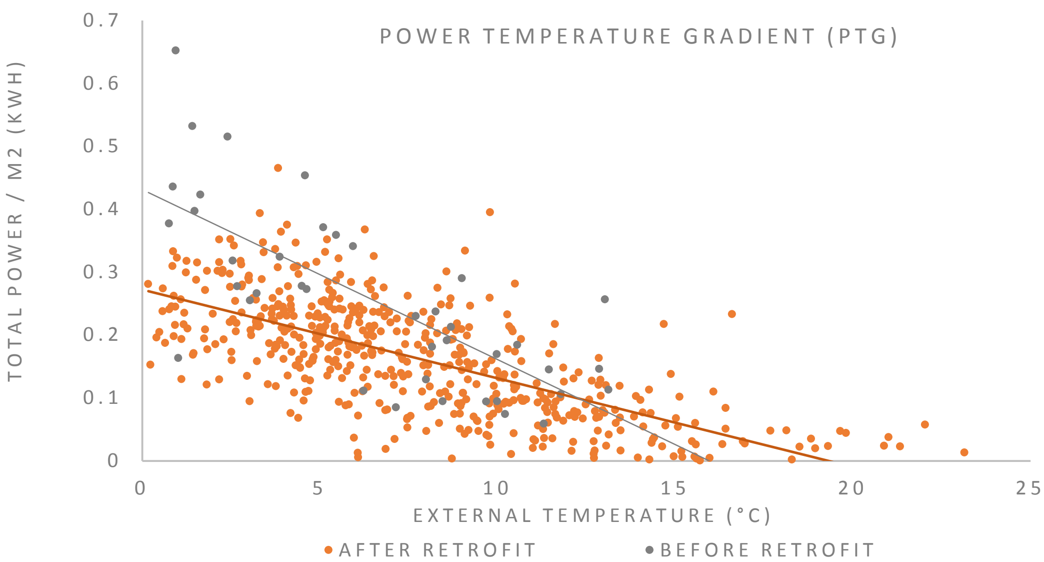
2. **Data quality**; Large gaps where data is missing and before period is very small



3. ***Comfort***; Dwelling is under heated, downstairs temperatures may not be realistic



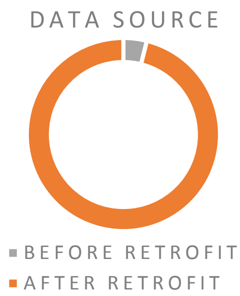
4. ***Retrofit performance;*** Less energy is used when it is cold outside after retrofit

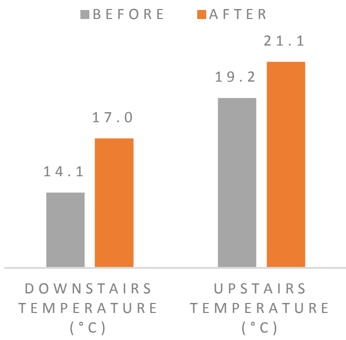


Property E3

Survey observations:

- uninsulated store door used as wall to internal room
- thermal bridging at front eaves and ground floor
- insufficient roof insulation
- insulation cut-outs for services and drains





- Energy use may be lower *after* retrofit
- Few *before* data points and periods of missing data so high uncertainty
- External temperature only explains 54% of energy use

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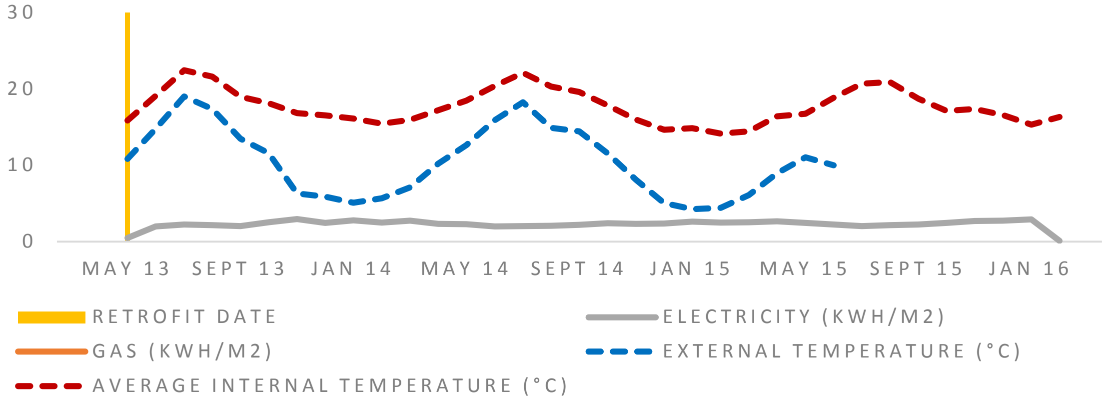
DECC, Leeds Go Early Energy Monitoring Project

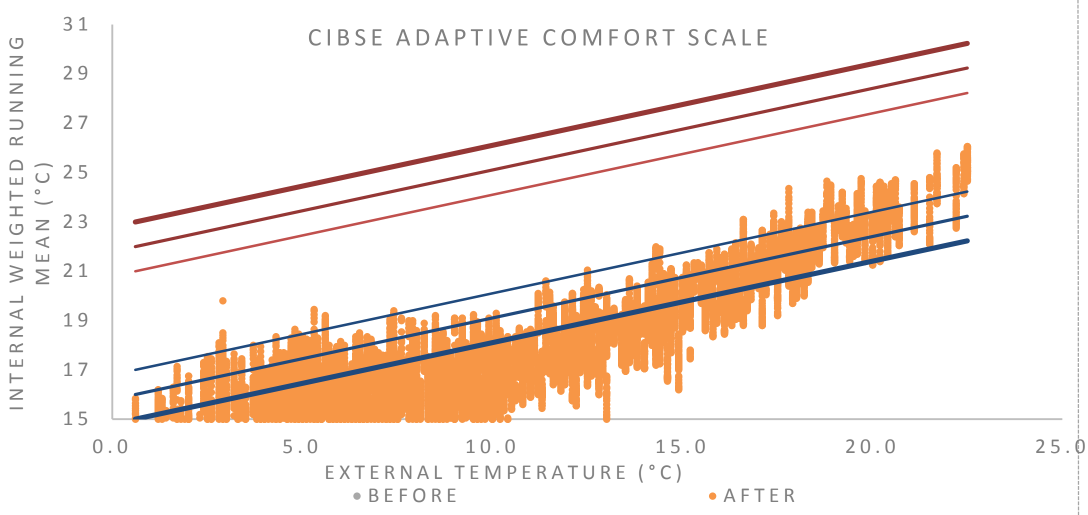
Through terrace, Solid brick, EWI

1. **Summary**; No before data to infer energy efficiency gains of improvement

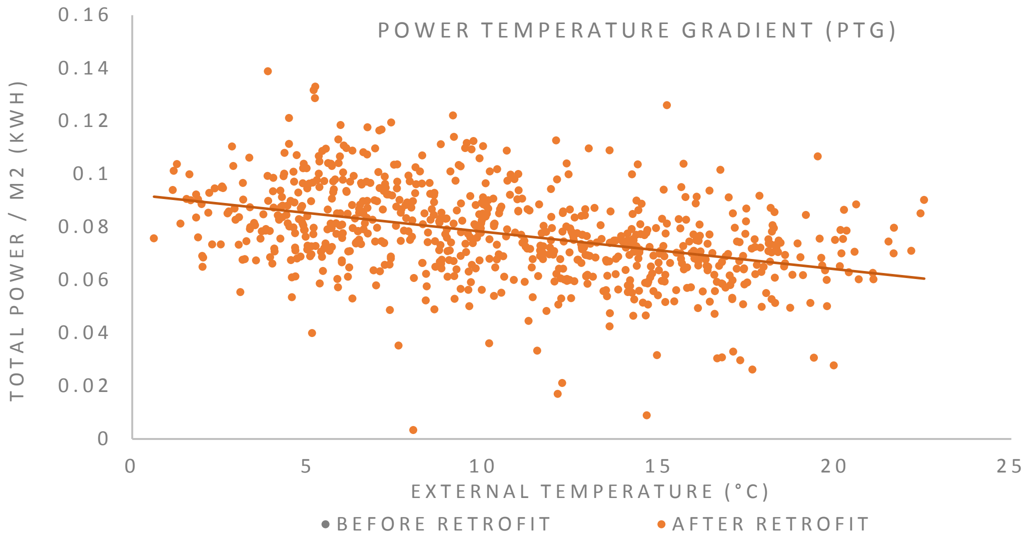
2. **Data quality**; Only temperature and electricity data available



3. ***Comfort***; Dwelling appears stable and broadly under heated after retrofit



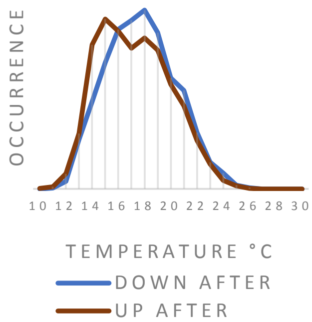
4. ***Retrofit performance;*** No space heating data available



Property E4

Survey observations:

- No insulation at stairs between basement & upper floors
- no insulation at junction of intermediate floor:wall
- party wall returns not insulated



- Upstairs and downstairs are similar temperatures
- Gas data not available
- External temperature only explains 16% of electricity use
- Electricity is very stable

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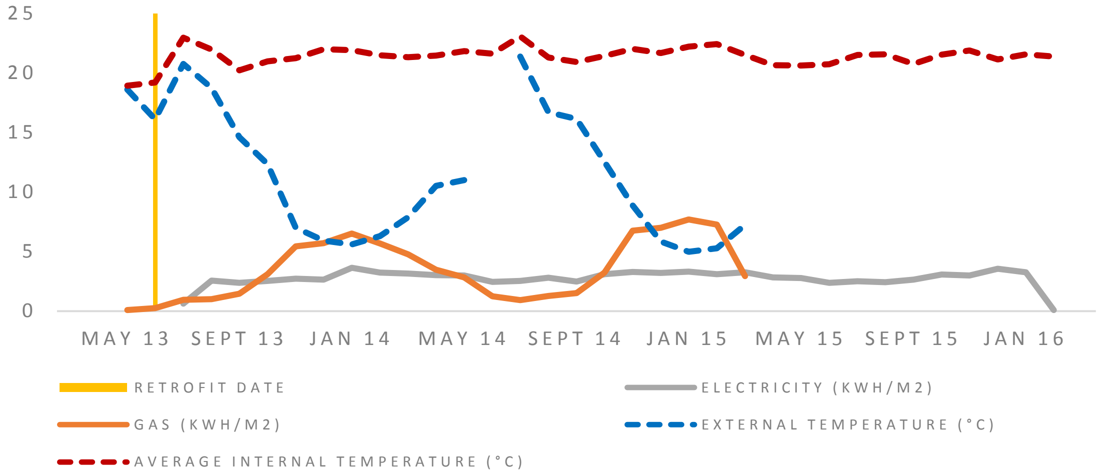
DECC, Leeds Go Early Energy Monitoring Project

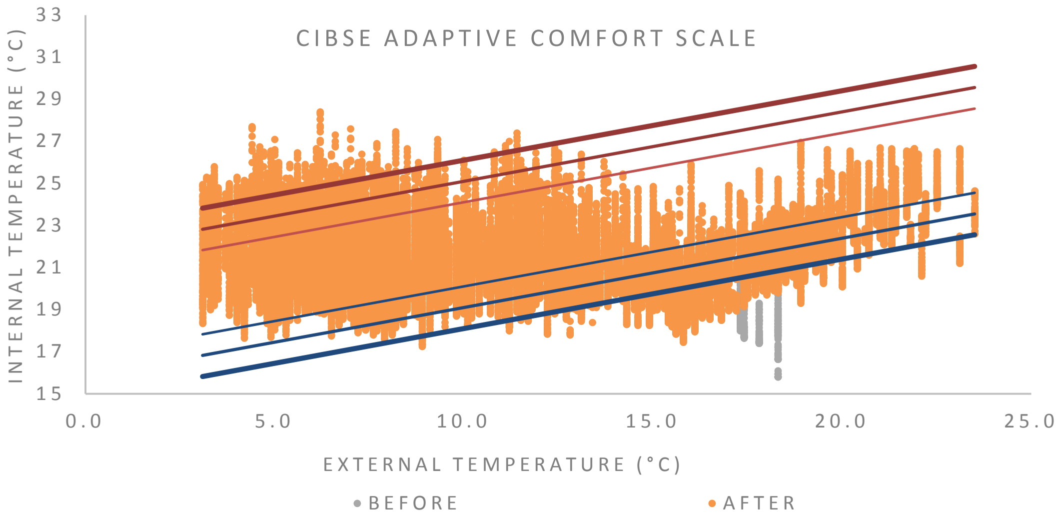
Terrace, Back to back, Solid brick, EWI

1. ***Summary;*** Insufficient before data to calculate savings

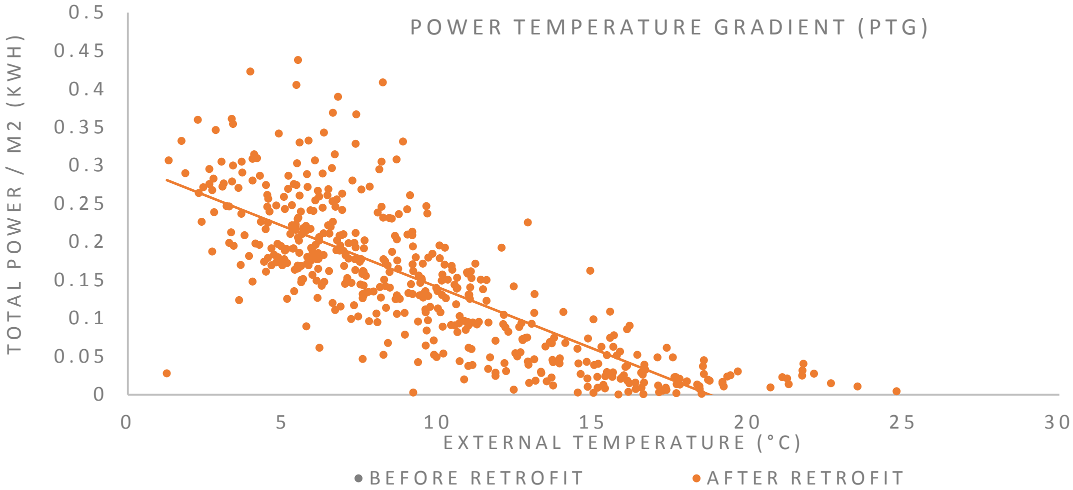
2. ***Data quality;*** *Before* period is small and large drop outs in external and gas data



3. ***Comfort***; Dwelling may be warmer after retrofit but not very well controlled



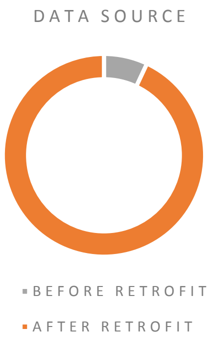
4. ***Retrofit performance;*** Relatively normal heating behaviour

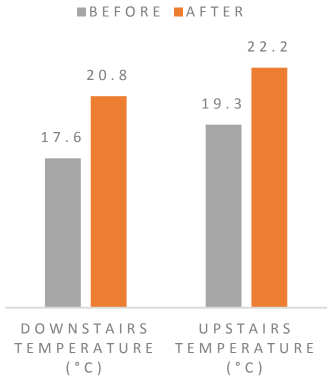


Property E5

Survey observations:

- front wall only insulated
- mineral wool to attic room not airtight
- thinner insulation at openings





- No *before* energy data points
- External temperature explains 63% of energy use

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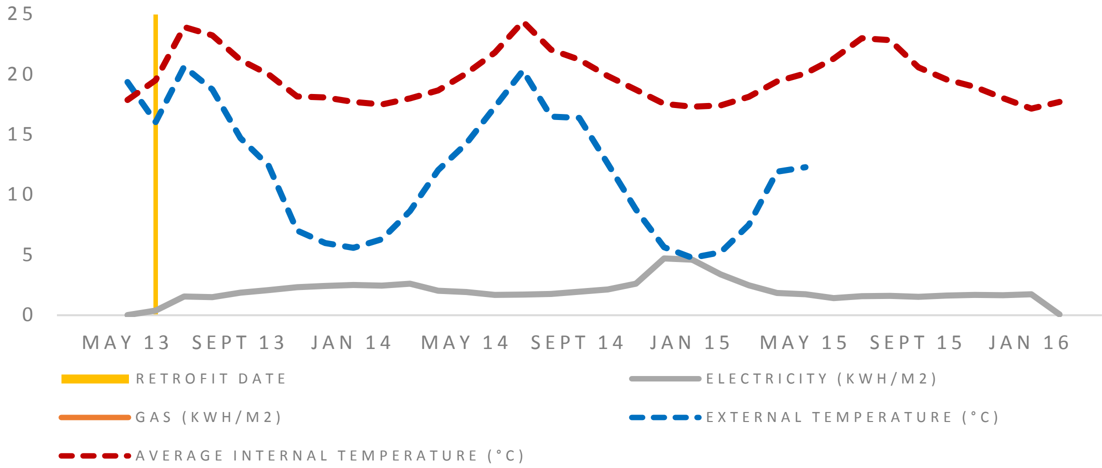
DECC, Leeds Go Early Energy Monitoring Project

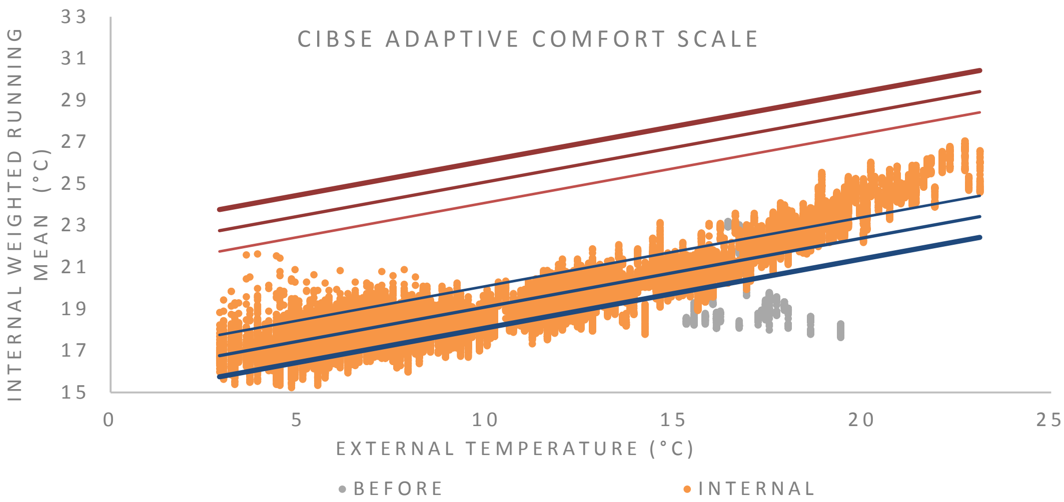
Through terrace, Solid brick, EWI

1. ***Summary***; No gas data to calculate heating energy savings

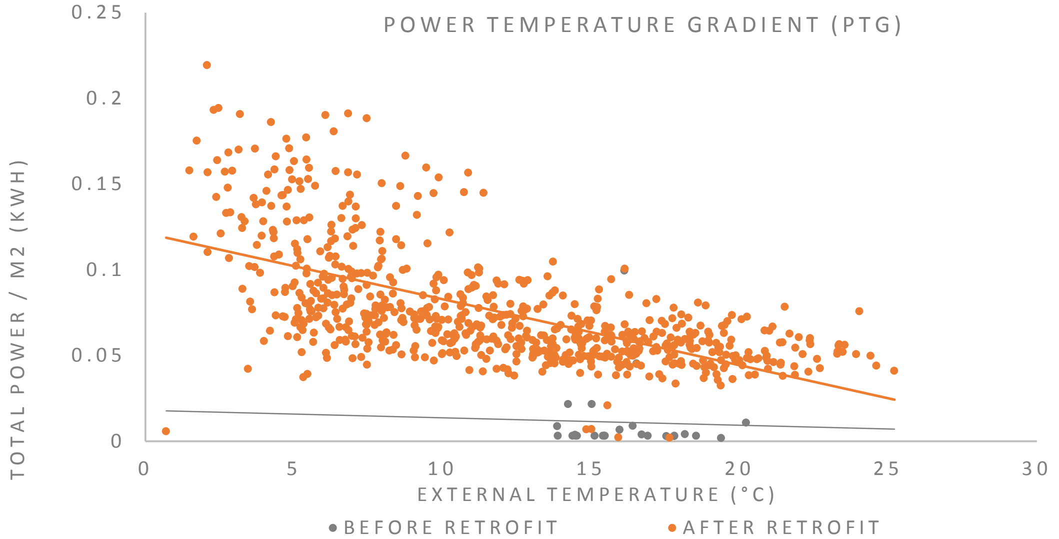
2. ***Data quality***; *Before* period is very small external temperature is lost in final year



3. ***Comfort***; Dwelling is warmer after and has stable conditions but it is under heated



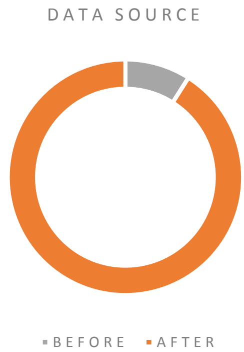
4. ***Retrofit performance;*** Unusual *before* use, potential evidence of secondary heating

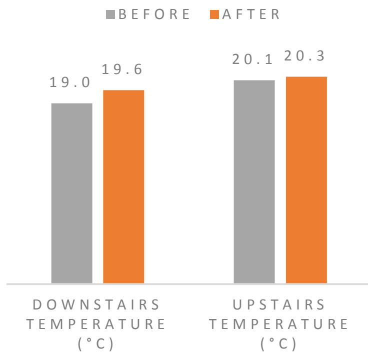


Property E6

Survey observations:

- no insulation at junction of intermediate floor:wall
- party wall returns not insulated
- uninsulated stores in attic





- Stable electricity use.
- Few *before* data points, high uncertainty.
- External temperature explains 38% of electricity use.

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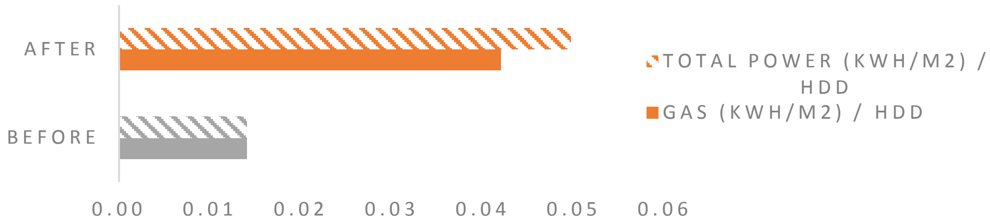
DECC, Leeds Go Early Energy Monitoring Project

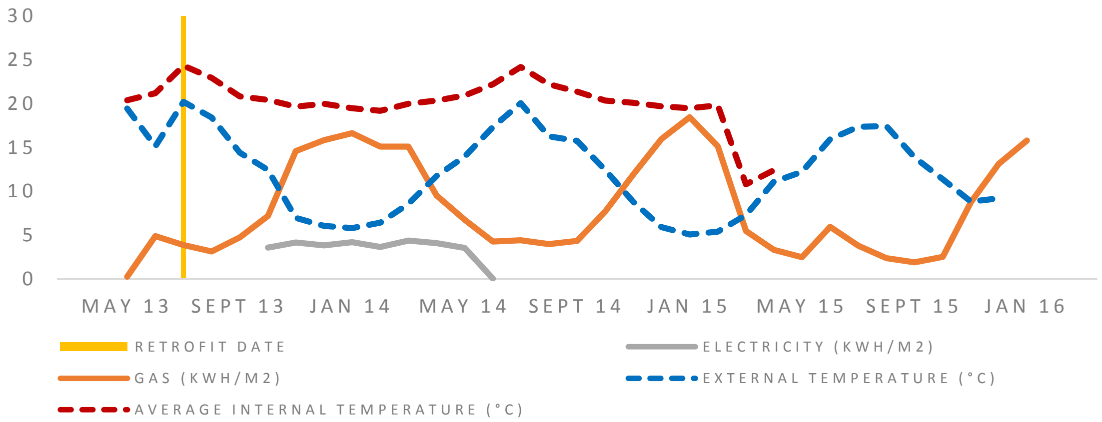
Property E7

1960s, Mid-terrace, Concrete, EWI

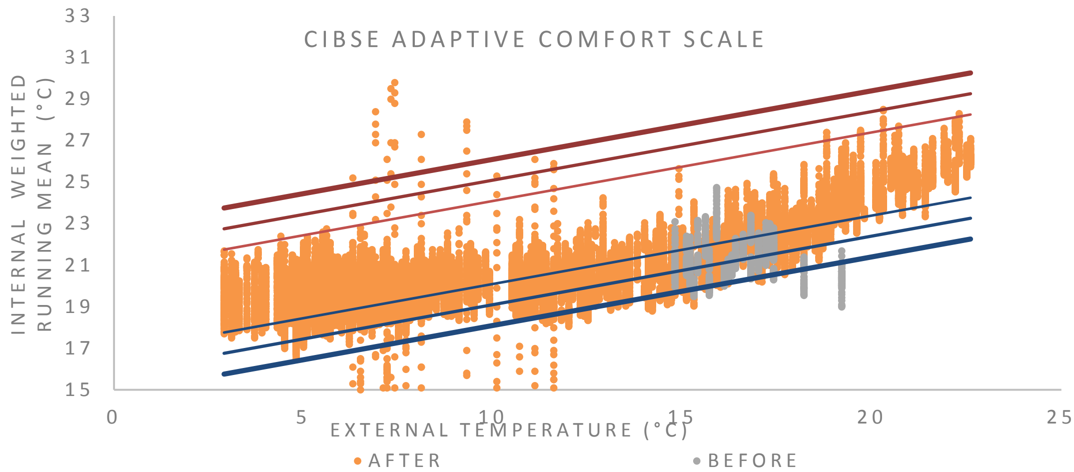
1. ***Summary***; A potential increase in space heating bills but before data are limited



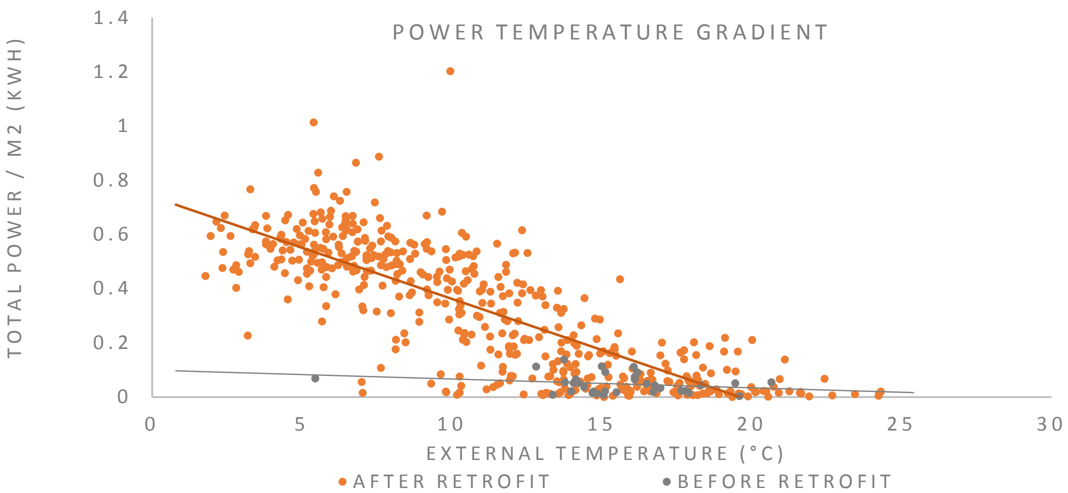
2. ***Data quality***; limited *before* data, electricity and internal temperature data failure



3. ***Comfort***; Dwelling is comfortable and controlled but potential sensor failure

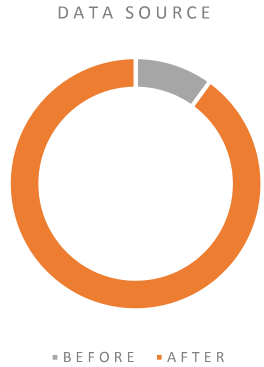


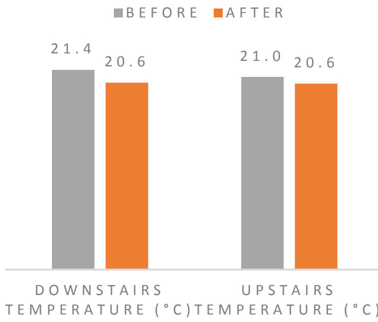
4. ***Retrofit performance;*** Relatively normal heating behaviour, insufficient *before* data



Survey observations:

- thermal bridging at front eaves and ground floor
- insufficient roof insulation
- insulation cut-outs for meter-box
- new tenant (May 2015) has condensation





- Few *before* data points, high uncertainty.
- External temperature explains 65% of energy use.
- Before period during non-heating season.

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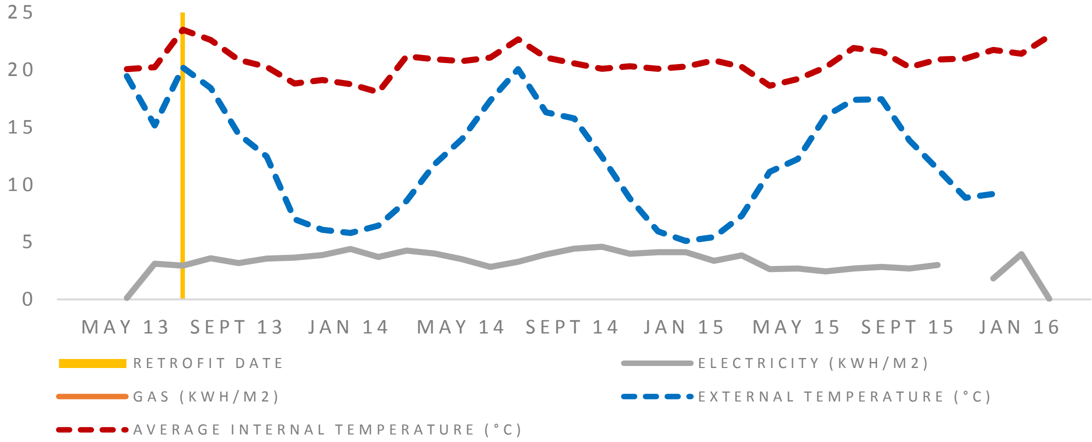
DECC, Leeds Go Early Energy Monitoring Project

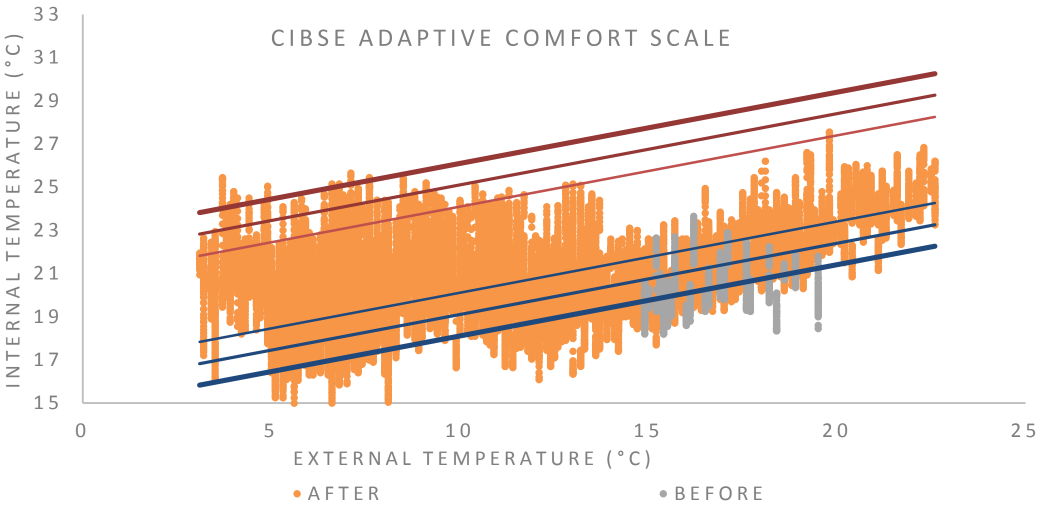
1960s, Mid-terrace, Concrete, EWI

1. ***Summary***; No gas data to predict annual heating bill saving

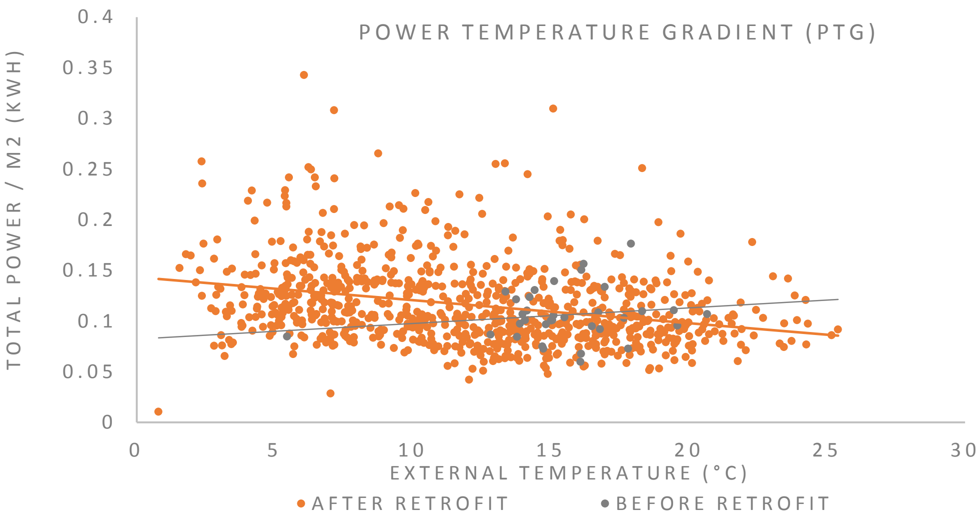
2. ***Data quality***; very limited *Before* data and no gas data



3. ***Comfort***; Dwelling is not very well controlled when it is cold outside



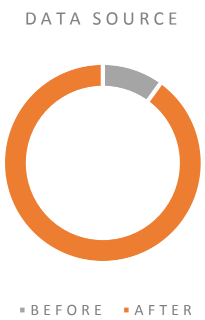
4. ***Retrofit performance;*** Electricity use is stable, unlikely to have secondary heating

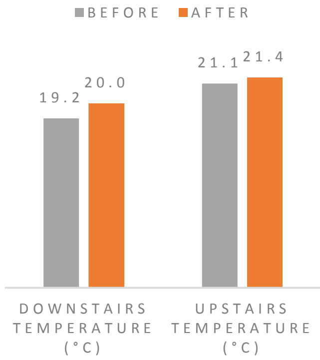


Property E8

Survey observations:

- thermal bridging at front eaves and ground floor
- insulation taken around garden wall abutment
- insufficient roof insulation
- insulation cut-outs for meter box
- occupant keeps windows open





- Dwelling appears comfortable but difficult to control after retrofit.
- External temperature has little effect on electricity use.

Contact: Dr David Glew
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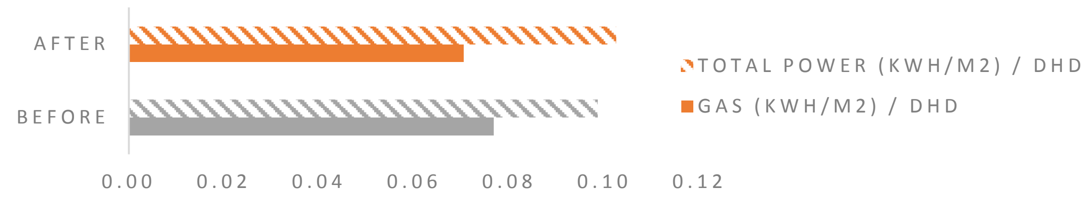
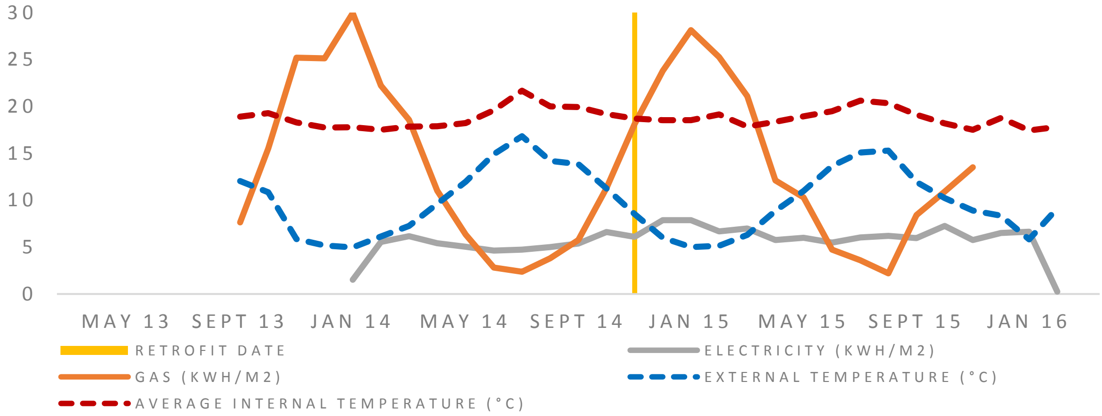
DECC, Leeds Go Early Energy Monitoring Project

1950s, Semi, Concrete, EWI

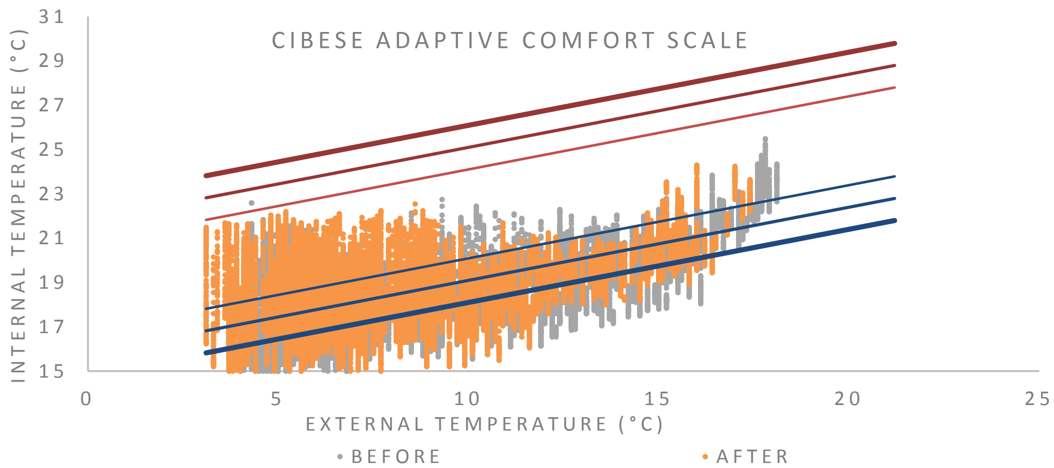
1. ***Summary***; Data suggests a 8% heating energy reduction and £52 annual bill saving



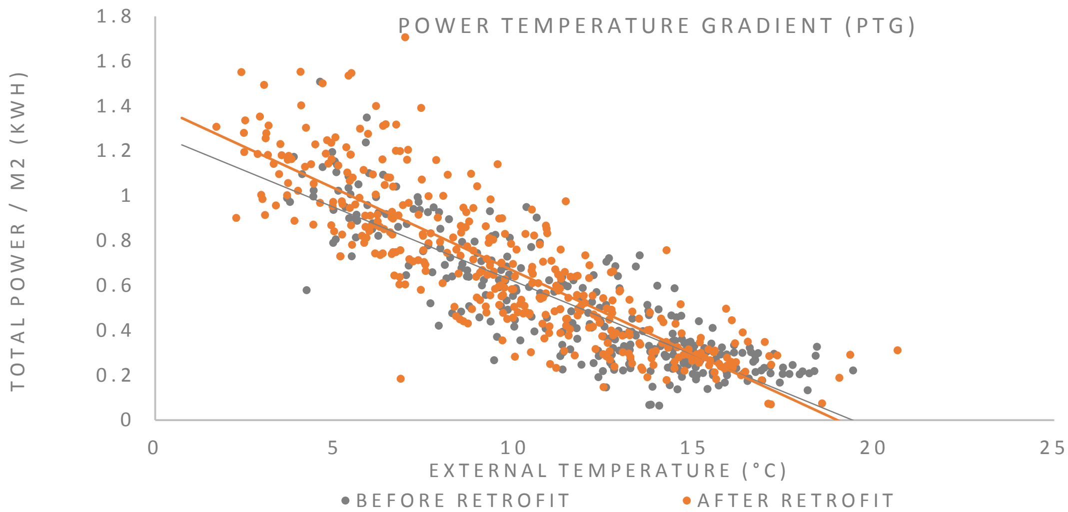
2. ***Data quality***; good before and after data



3. ***Comfort***; Similar *before* and *after* comfort range and pattern.



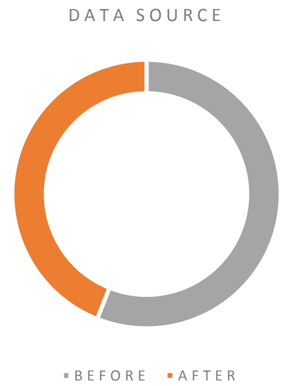
4. ***Retrofit performance;*** Slight reduction in fuel use after retrofit

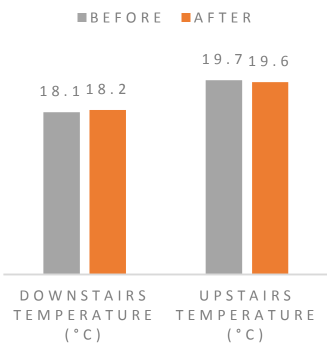


Property E9

Survey observations:

- thermal bridging at eaves and ground floor
- insufficient roof insulation
- no EWI to 2 recent extensions
- thermal bridge shows at junction between EWI treated wall/extension





- Good data before and after
- Relatively normal heating behaviour
- External temperature explains 72% of energy use

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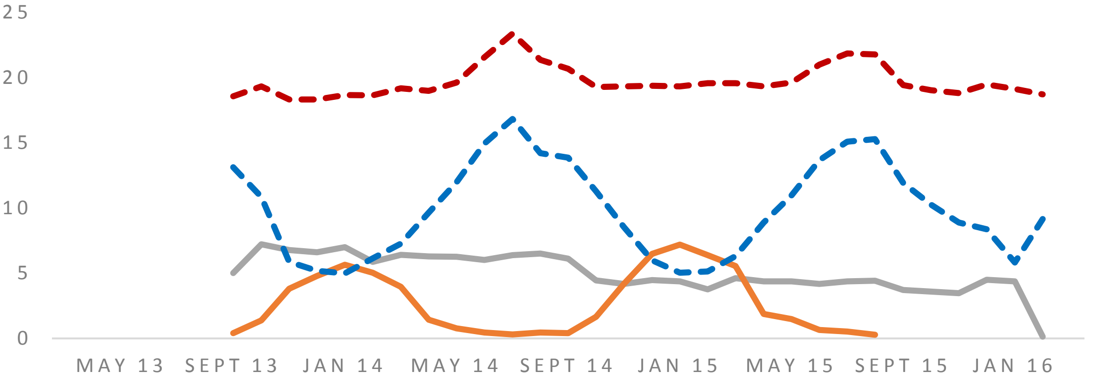
DECC, Leeds Go Early Energy Monitoring Project

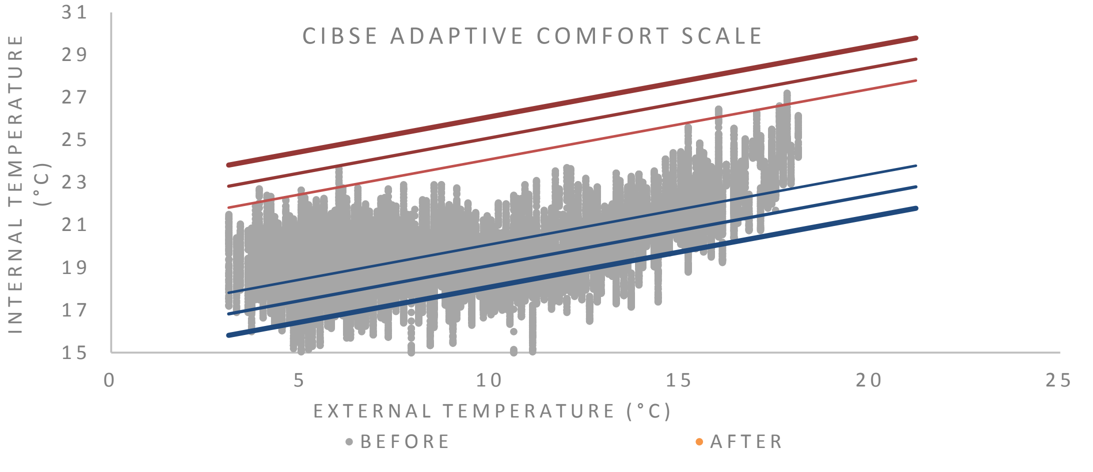
1950s, End-terrace, Concrete panel, EWI

1. ***Summary***; Retrofit did not take place

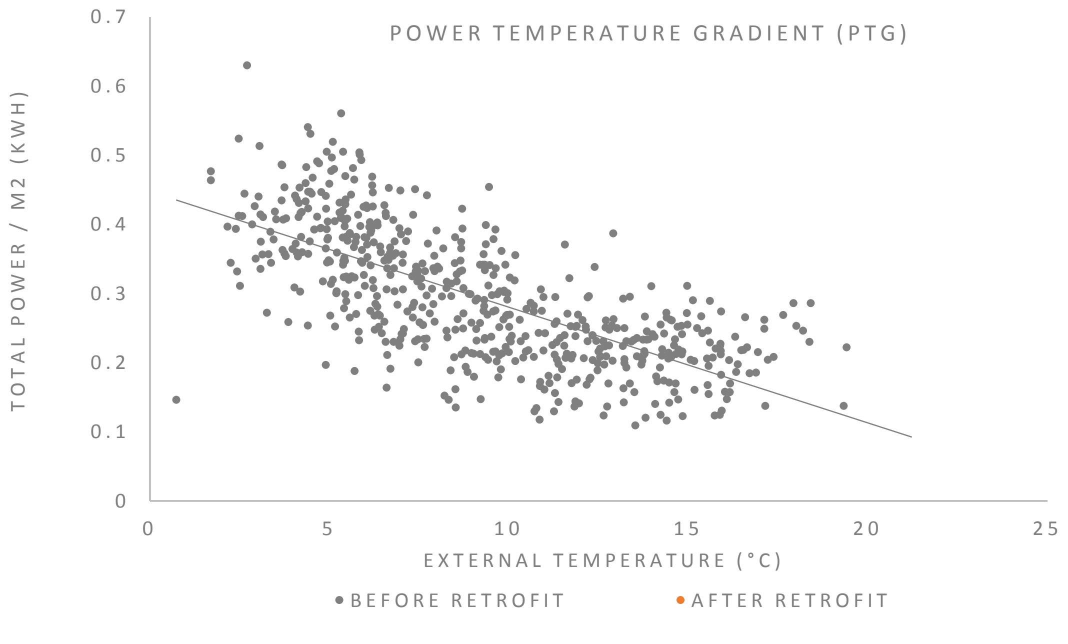
2. ***Data quality***; gas dropped out at end of monitoring and no retrofit took place



3. ***Comfort***; Dwelling appears comfortable, but tends to be under heated.



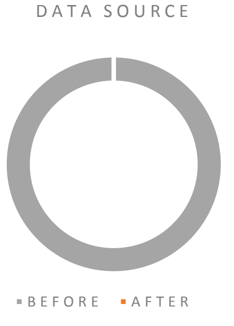
4. ***Retrofit performance;*** Energy use is weakly linked to outside conditions

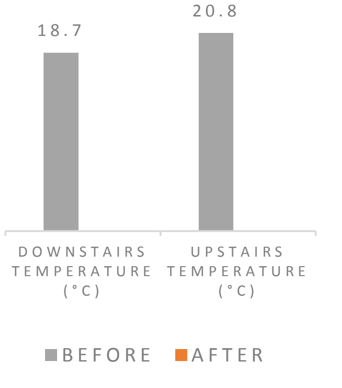


Property E10

Survey observations:

- panel construction needs special insulation design to avoid complete thermal bridging
- additionally EWI would require additional roof works and below DPC insulation to avoid thermal bridging at eaves and ground floor





- Upstairs is warmer than downstairs
- External temperature explains 49% of energy use

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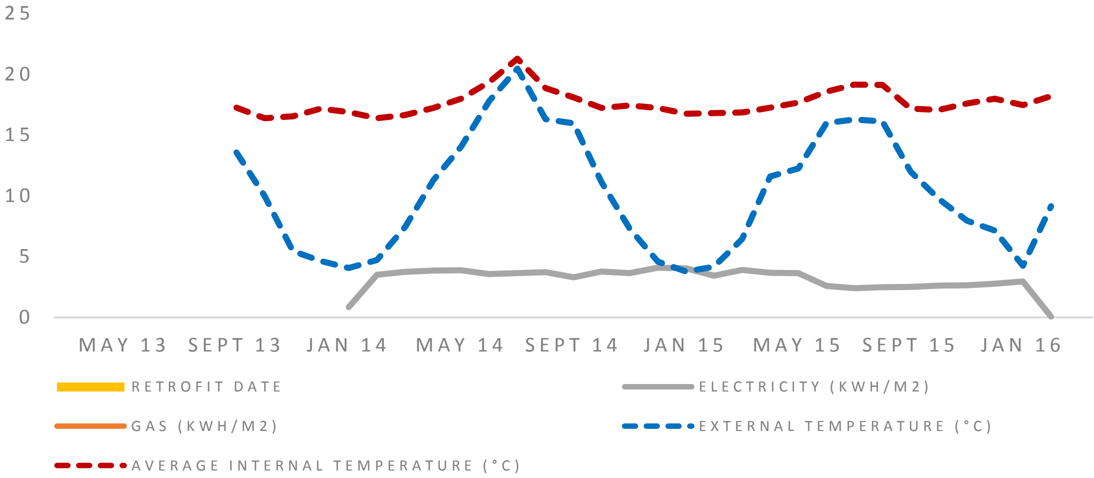
DECC, Leeds Go Early Energy Monitoring Project

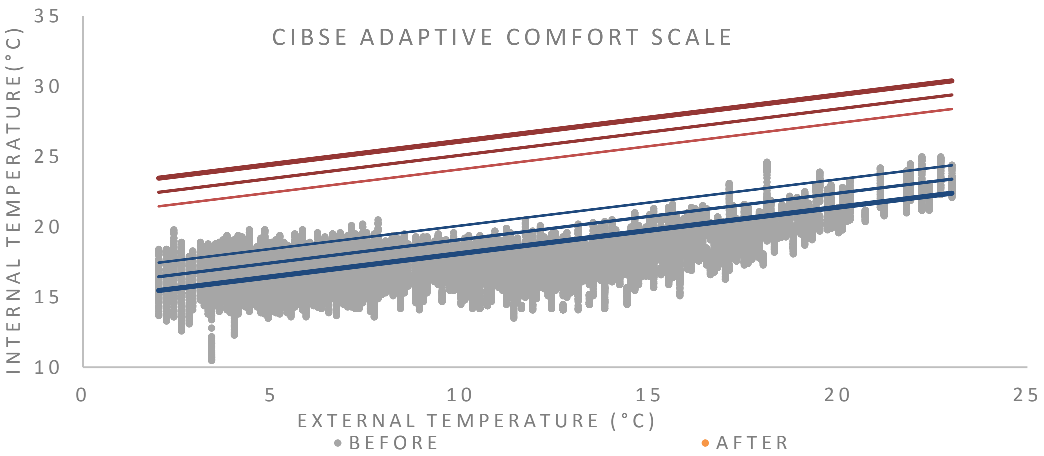
1950s, Semi-detached bungalow, Concrete

1. ***Summary***; Retrofit did not take place

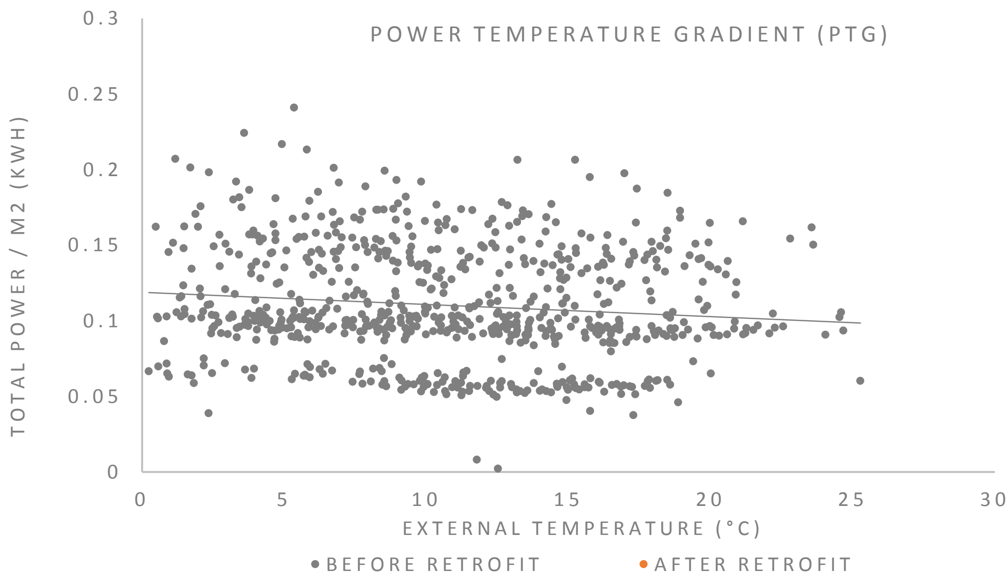
2. ***Data quality***; No gas data since a smart meter was installed



3. ***Comfort***; Dwelling appears cold and under heated, but only one sensor working



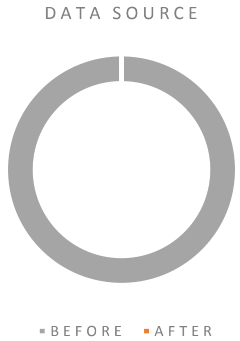
4. ***Retrofit performance;*** Unusual energy use profile.

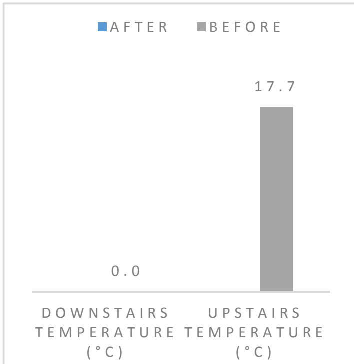


Property E11

Survey observations:

- EWI would require additional roof works and below DPC insulation to avoid thermal bridging at eaves and floor
- additional works would be required at windows as minimal cills
- additional works for rear flat roofed extension





- No gas consumption data available
- Dwelling appears uncomfortably cold
- External temperature explains almost none of the electricity use

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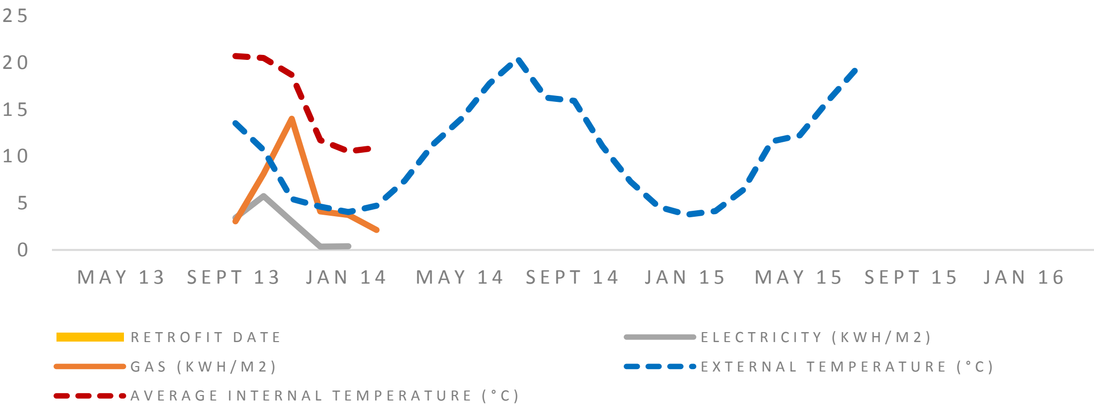
DECC, Leeds Go Early Energy Monitoring Project

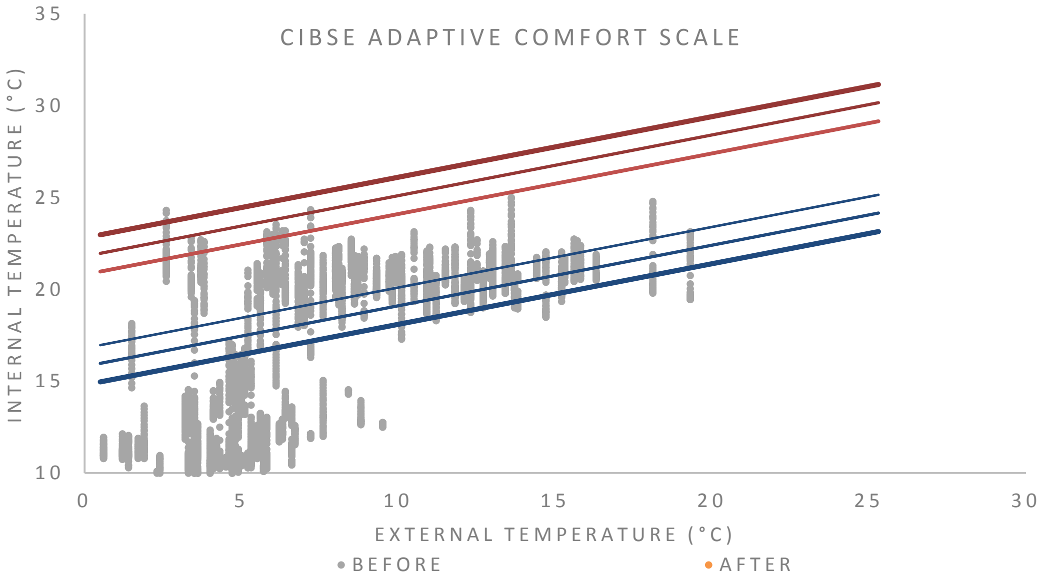
1950s, Mid-terrace, Concrete

1. ***Summary***; Retrofit did not go ahead

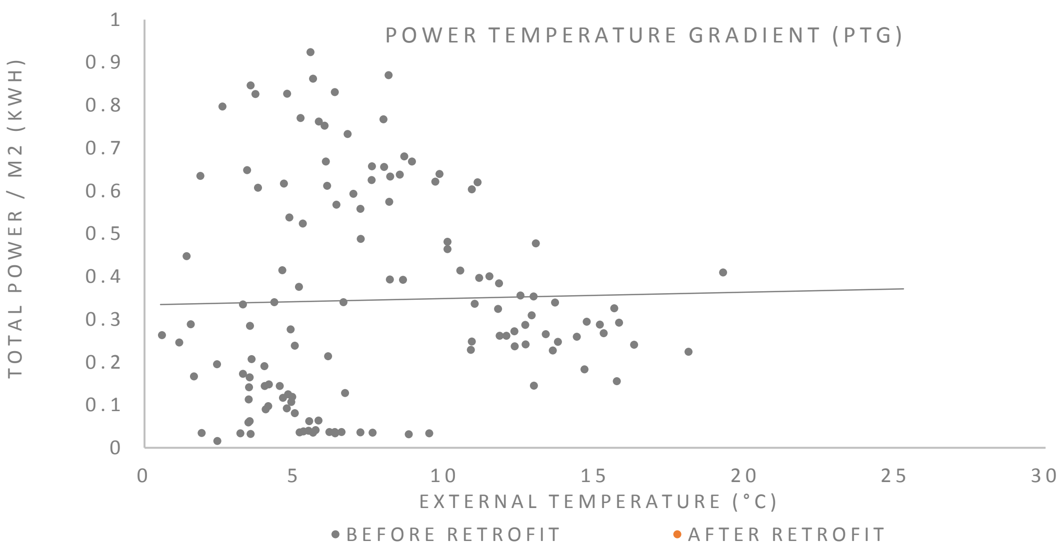
2. ***Data quality***; Sensor failure for gas, electricity and internal temperature



3. ***Comfort***; Dwelling appears comfortable at times, though relatively uncontrollable



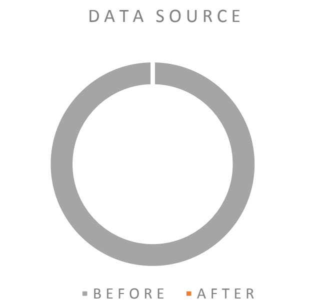
4. ***Retrofit performance;*** Very unusual energy use pattern

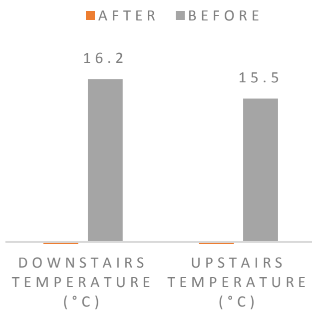


Property E12

Survey observations:

- EWI requires additional roof works and below DPC insulation to avoid thermal bridging
- additional works required at windows as returns
- 50mm only loft insulation





- External temperature explains none of the energy use
- Sensor failure compromises analysis

LEEDS BECKETT UNIVERSITY
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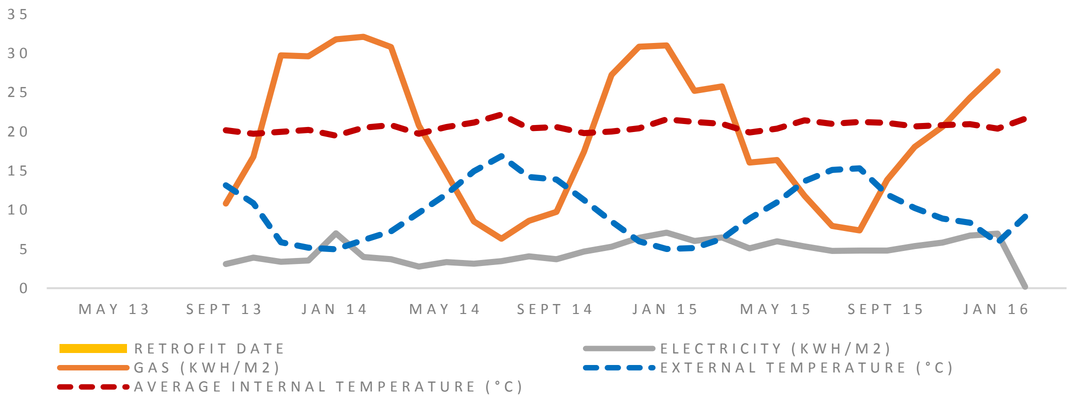
DECC, Leeds Go Early Energy Monitoring Project

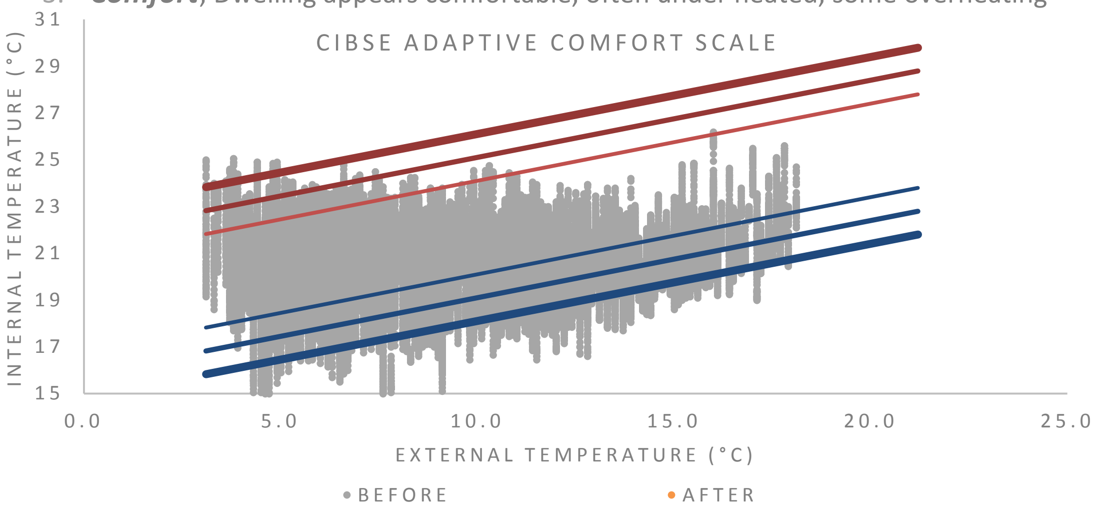
End-terrace, Concrete, EWI

1. ***Summary***; No retrofit undertaken. No improvement in thermal performance.

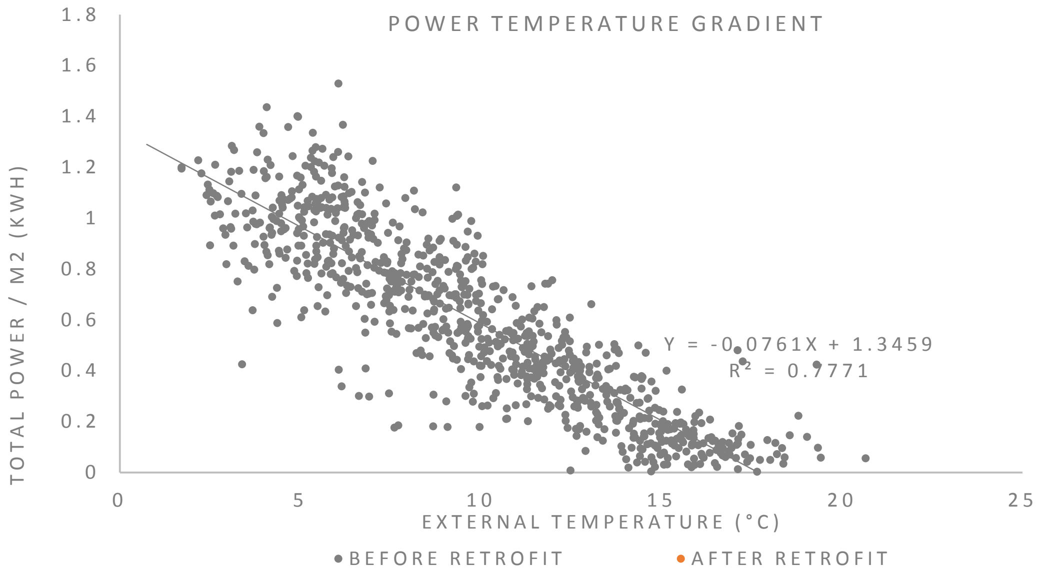
2. ***Data quality***; reliable data, but no retrofit undertaken



3. ***Comfort***; Dwelling appears comfortable, often under heated, some overheating



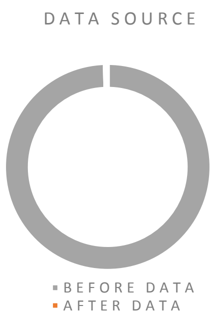
4. ***Retrofit performance; Energy use correlates to external temperature***

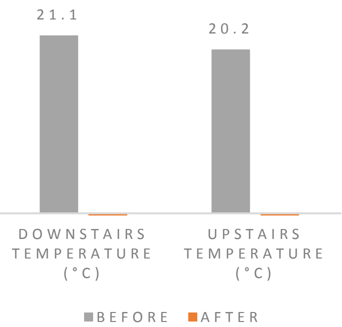


Property E13

Survey observations:

- panel construction needs poses problems of thermal bridging
- EWI requires additional roof works and below DPC insulation to avoid thermal bridging.
- Uninsulated solid ground floor.





- No Retrofit.
- Relatively normal heating behaviour.
- External temperature appears to explain 77% of energy use.

Contact: Dr David Glew
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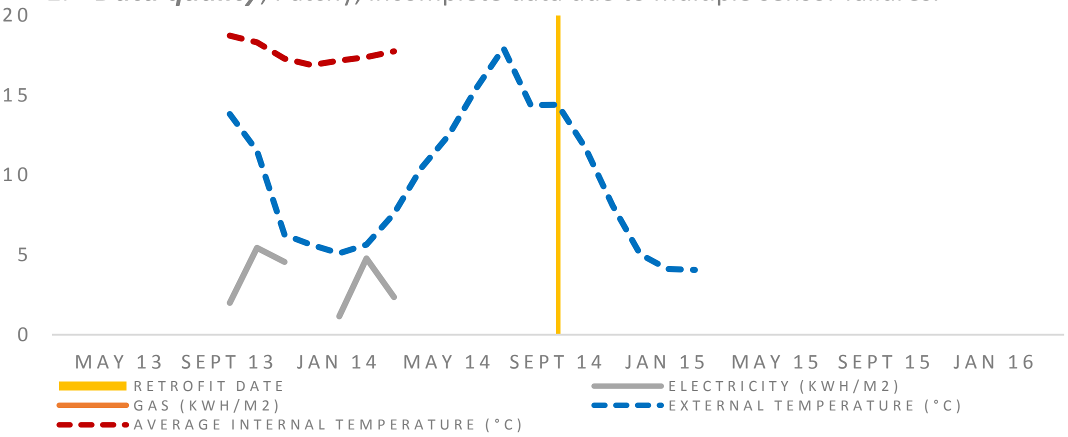
DECC, Leeds Go Early Energy Monitoring Project

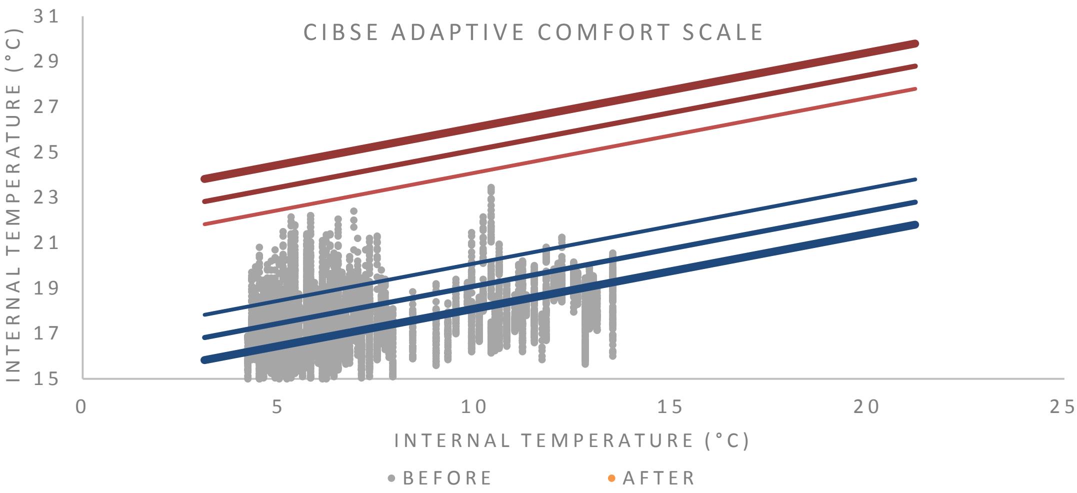
Semi-Detached, Concrete, EWI

1. ***Summary***; No gas data collected.

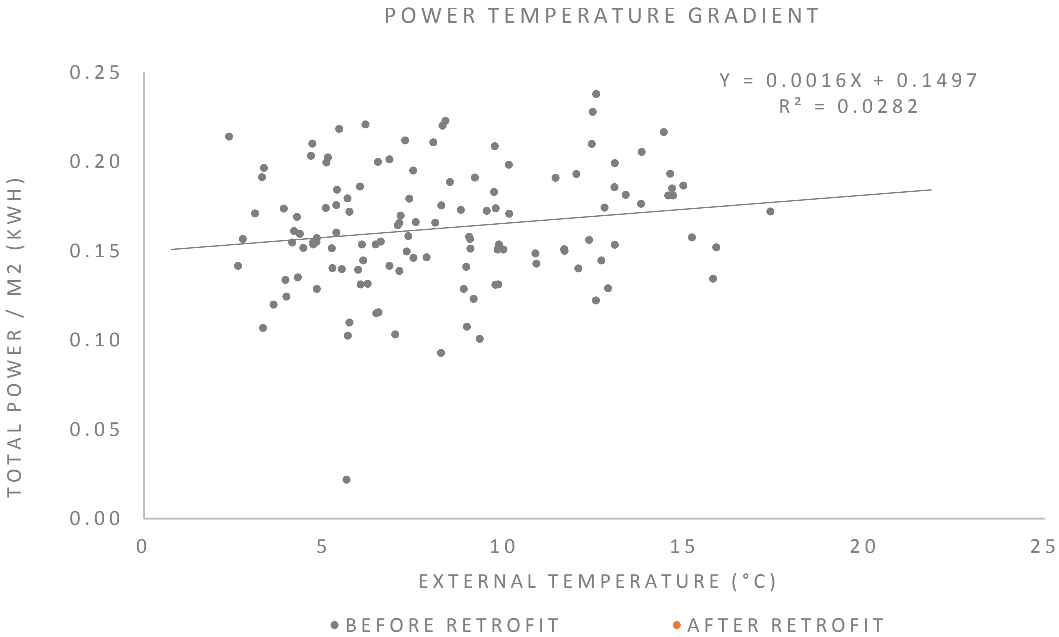
2. ***Data quality***; Patchy, incomplete data due to multiple sensor failures.



3. ***Comfort***; Very limited data, dwelling appears to be under heated



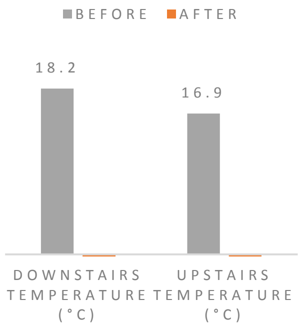
4. ***Retrofit performance;*** *No clear correlation with external temperature (electricity only)*



Property E14

Survey observations:

- EWI requires additional roof works and below DPC insulation to avoid thermal bridging.
- additional required at windows as minimal returns & cills
- uninsulated solid ground floor



- Very limited data makes drawing conclusions impossible
- Sensor failure before retrofit

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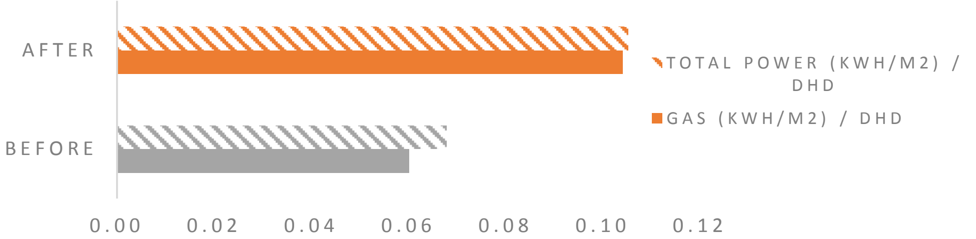
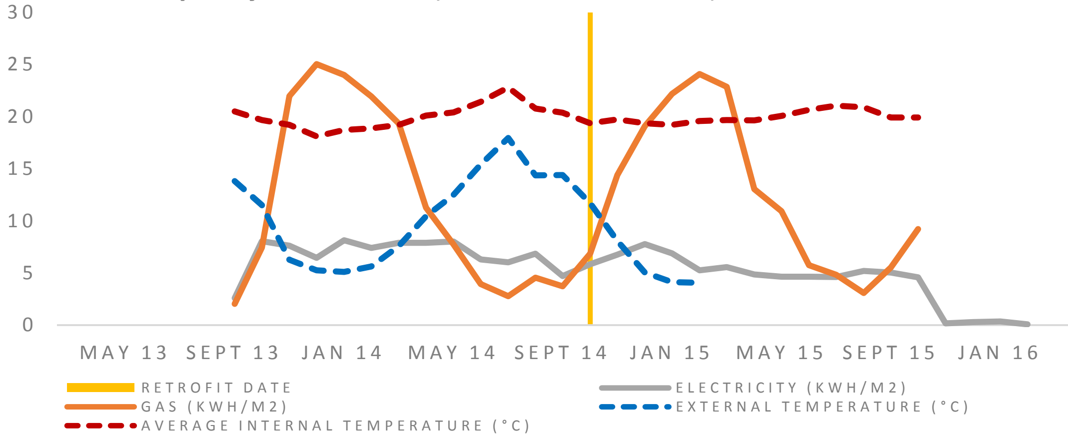
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Concrete, EWI

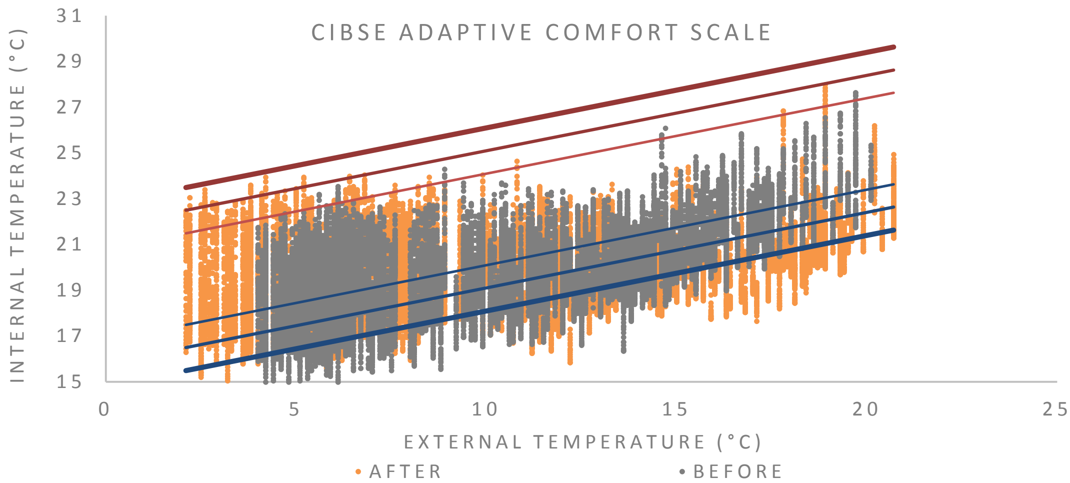
1. ***Summary***; Data Indicates a significant rise in energy consumption after retrofit



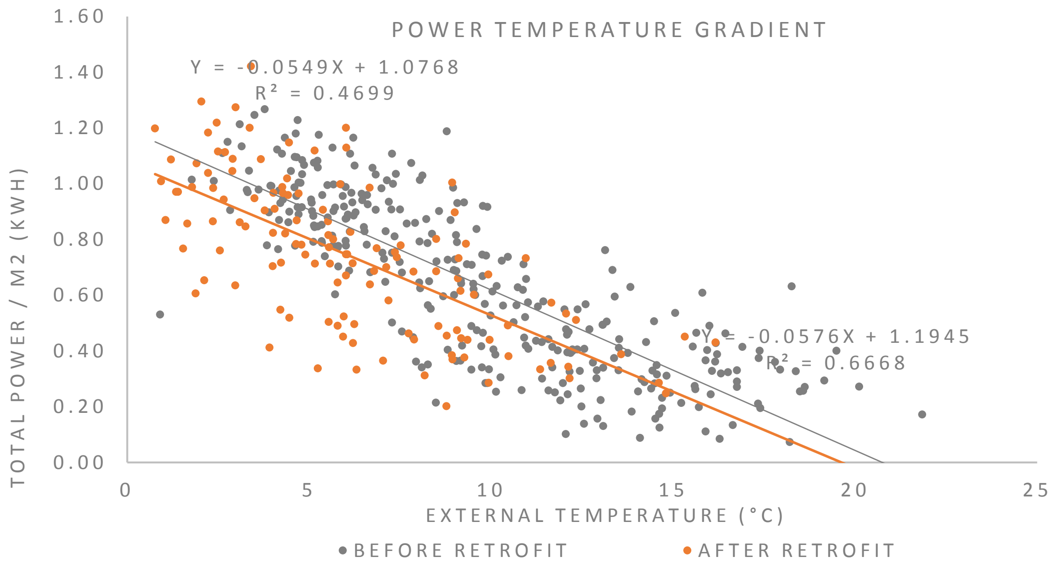
2. ***Data quality***; Data is mostly reliable, external temperature is lost later on.



3. ***Comfort***; Dwelling is often under heated, conditions appear difficult to control



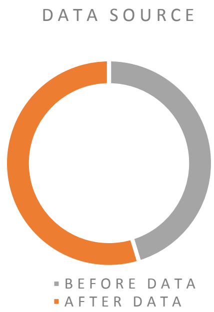
4. ***Retrofit performance; Energy use due to external temperature lower after retrofit***

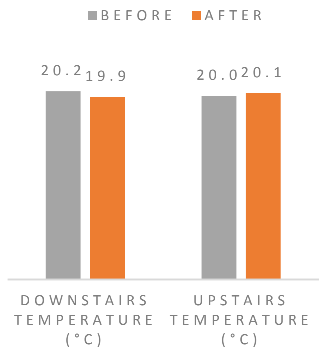


Property E15

Survey observations:

- EWI requires additional roof works and below DPC insulation to avoid thermal bridging
- additional works be required at windows as minimal returns & cills
- uninsulated solid ground floor





- Internal temperature appears difficult to control, and is often under heated.
- Energy consumption appears to be lower due to external temperature.
- Energy use per heating demand appears to increase

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Contact: Dr David Glew
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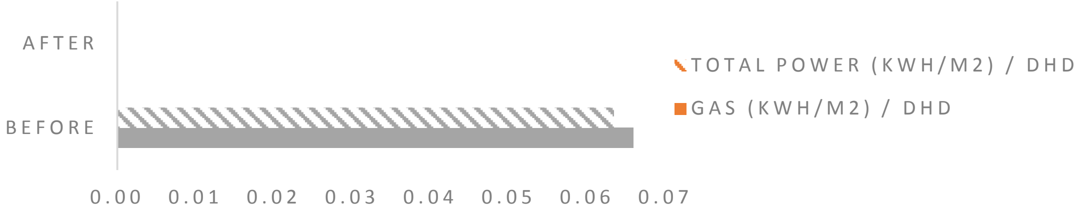
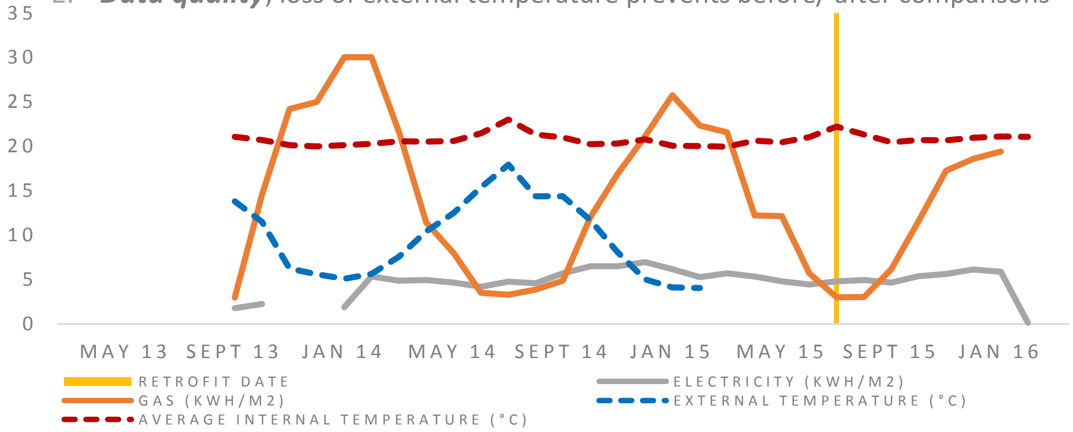
DECC, Leeds Go Early Energy Monitoring Project

End-terrace flat, Concrete, EWI

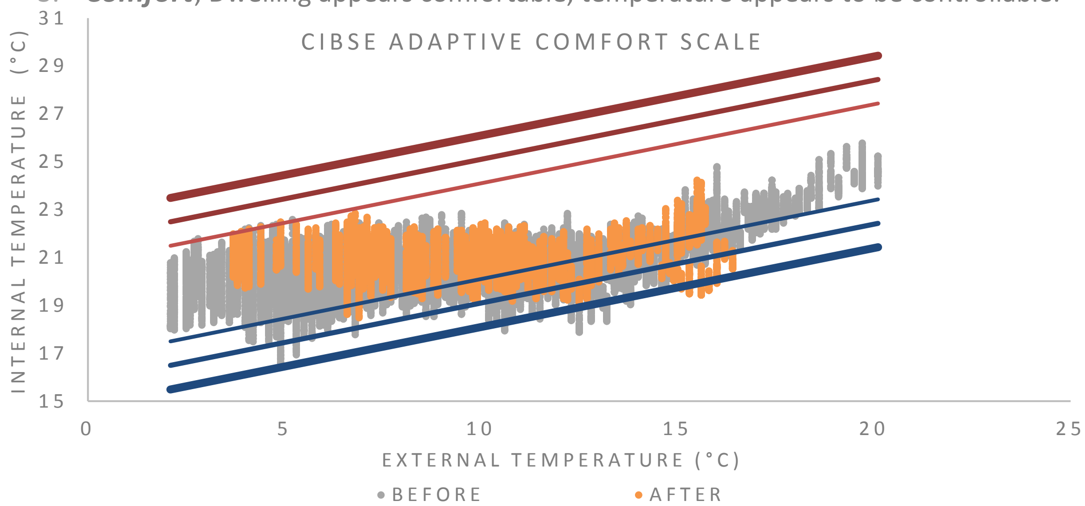
1. ***Summary***; External sensor failure prevented before after comparison



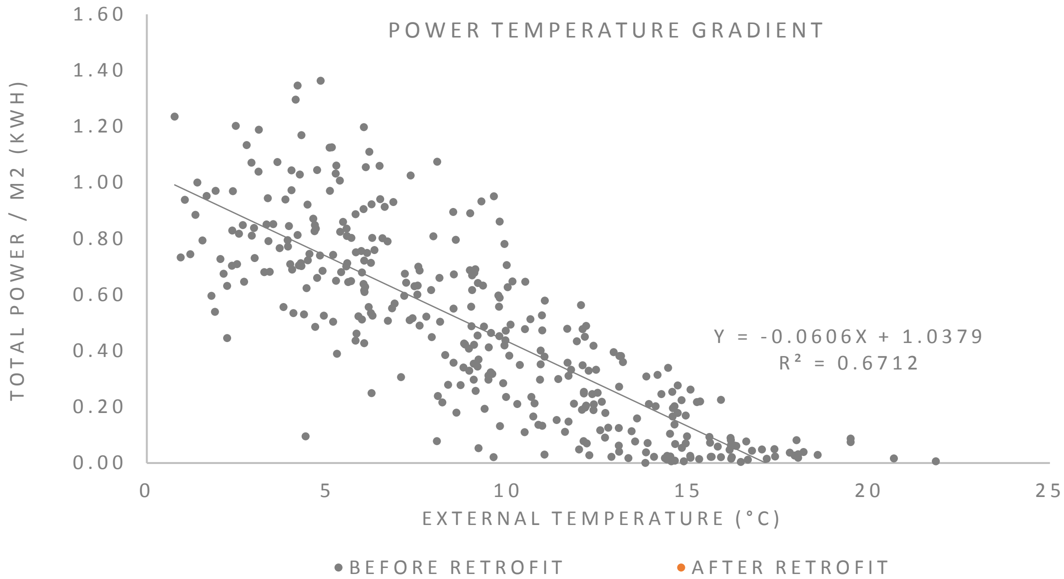
2. ***Data quality***; loss of external temperature prevents before/ after comparisons



3. ***Comfort***; Dwelling appears comfortable, temperature appears to be controllable.



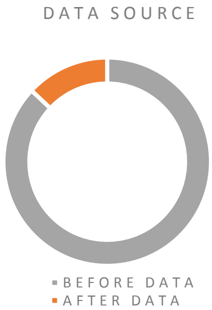
4. ***Retrofit performance;*** *More energy is used when it is cold outside.*

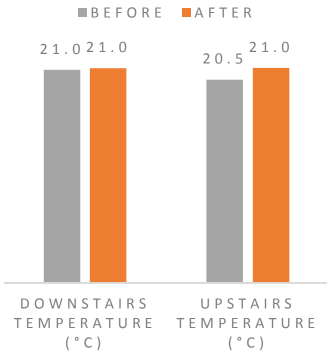


Property E16

Survey observations:

- EWI requires additional roof works and below DPC insulation to avoid thermal bridging
- additional works required at windows as minimal returns & cills
- uninsulated solid ground floor





- Lack of external temperature after retrofit makes comparison impossible
- Internal temperatures after retrofit appear more controllable.

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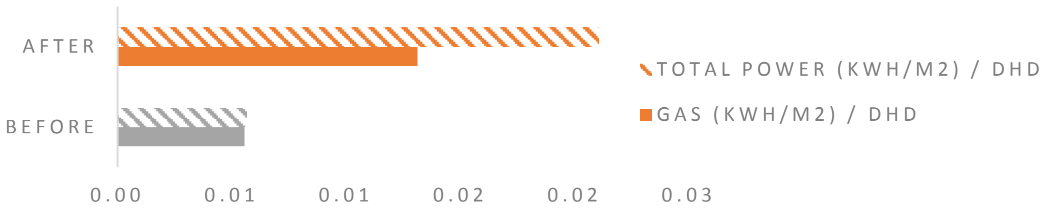
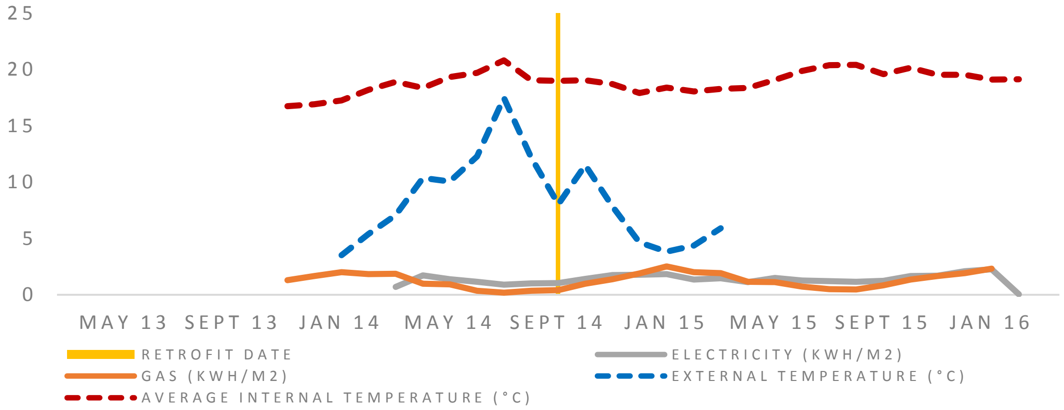
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Stone, loft insulation and improvements to heating system

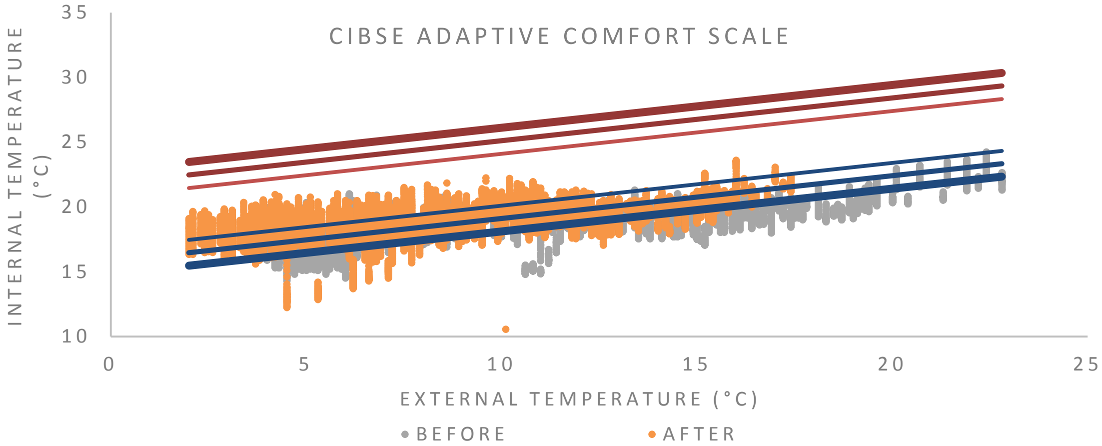
1. ***Summary***; Data suggests an increase in energy use to heat the dwelling



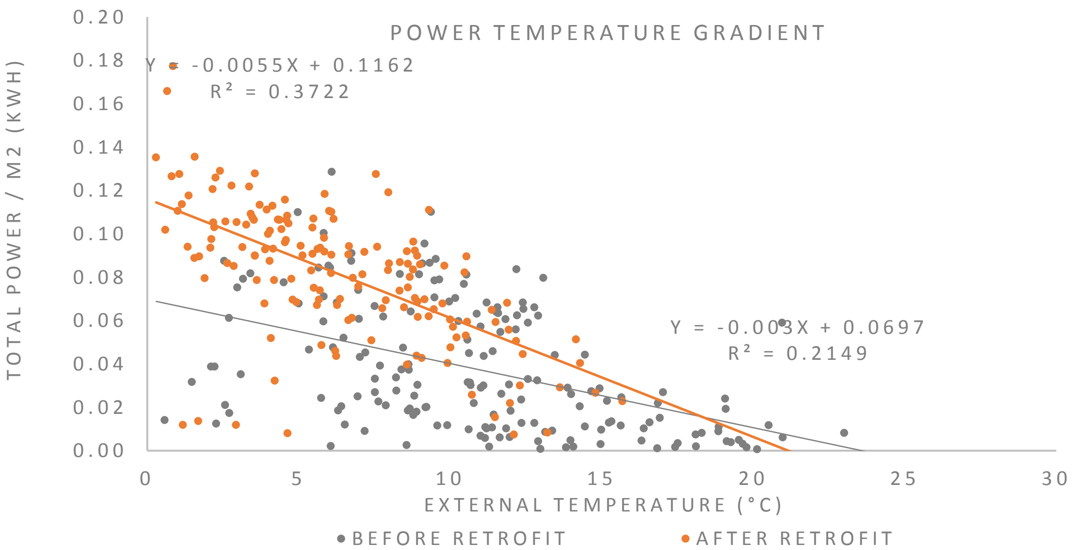
2. ***Data quality***; external sensor failure reduces increases uncertainty of analysis



3. ***Comfort***; Dwelling is under heated much of the time, appears controllable



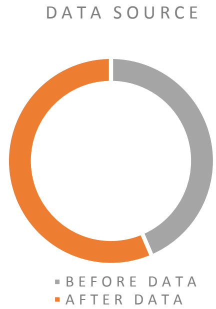
4. ***Retrofit performance; More energy appears to be used in cold weather after retrofit***

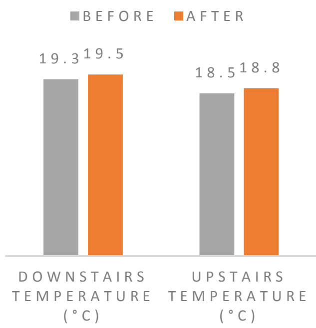


Property E17

Survey observations:

- no wall insulation due to listed status
- ventrolla system to windows
- damp ingress & gaps between loft insulating slabs increasing thermal loss in attic rooms





- Limited external temperature after retrofit increases uncertainty
- Dwelling appears to use more energy for heating after retrofit

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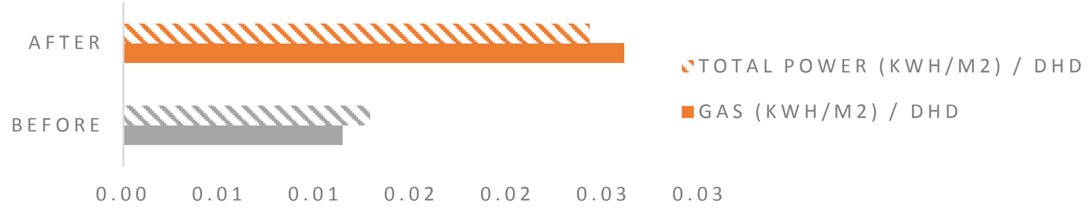
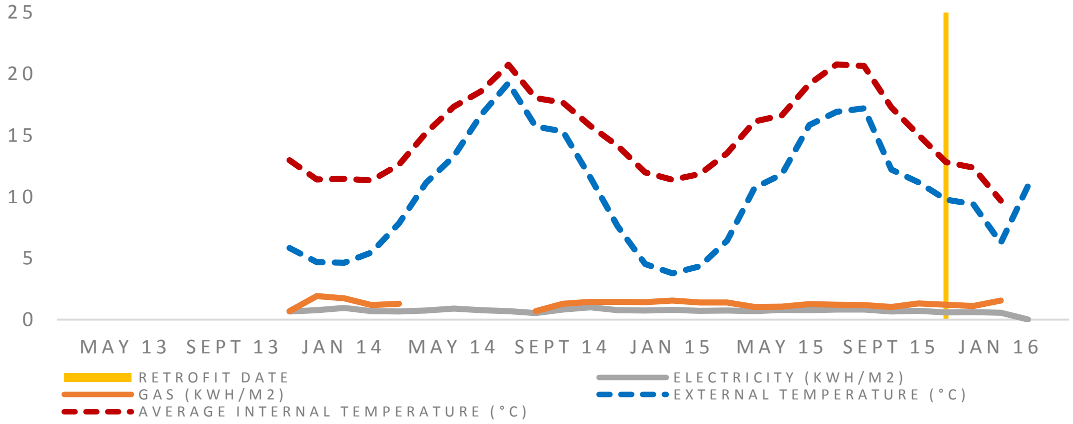
DECC, Leeds Go Early Energy Monitoring Project

Mid-terrace, Solid brick, EWI

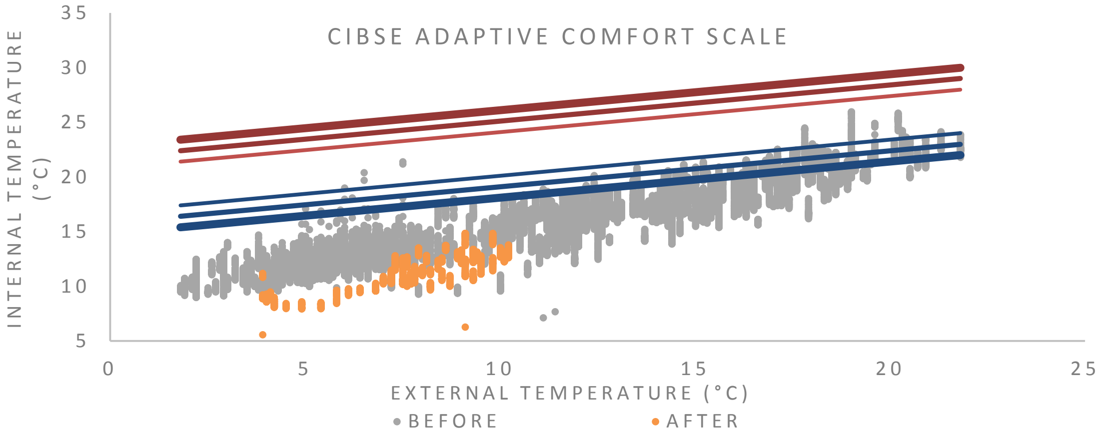
1. ***Summary***; Small increase in energy use in absolute terms



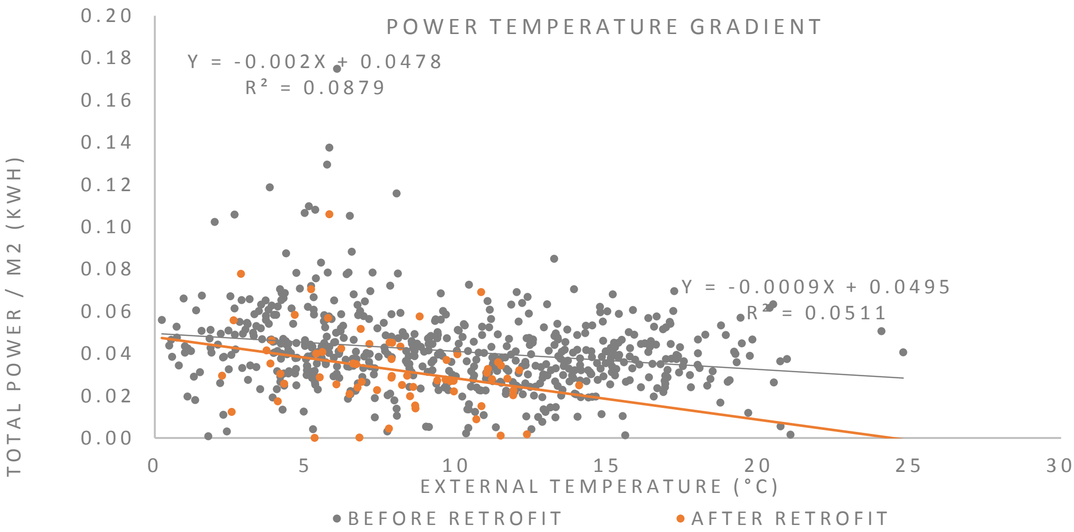
2. ***Data quality***; some gas drop outs, overall quality is good. Limited after data



3. ***Comfort***; Dwelling is consistently under heated, little change after retrofit



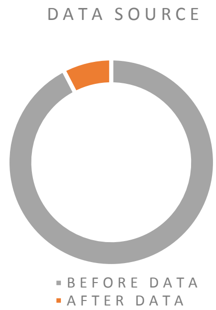
4. ***Retrofit performance; There is no change in energy use with external temperature***

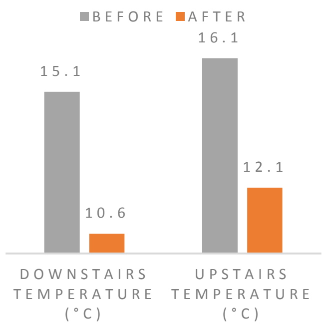


Property E18

Survey observations:

- no heating
- damp ingress behind EWI on rear wall
- thermal bridging at eaves and ground floor
- thermal bridging at party wall junctions with (uninsulated) adjacent properties





- Survey and data indicate that no space heating is used in dwelling, limiting the benefits of retrofit.
- Limited after data adds to uncertainty

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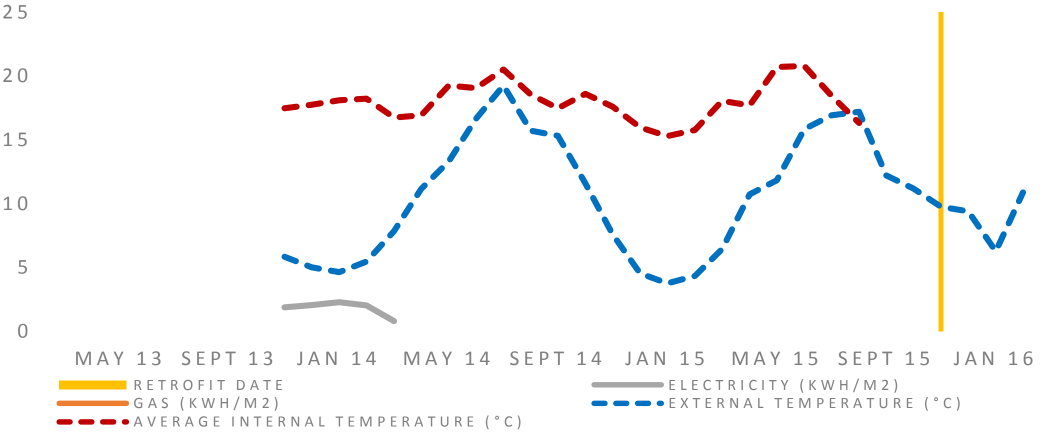
DECC, Leeds Go Early Energy Monitoring Project

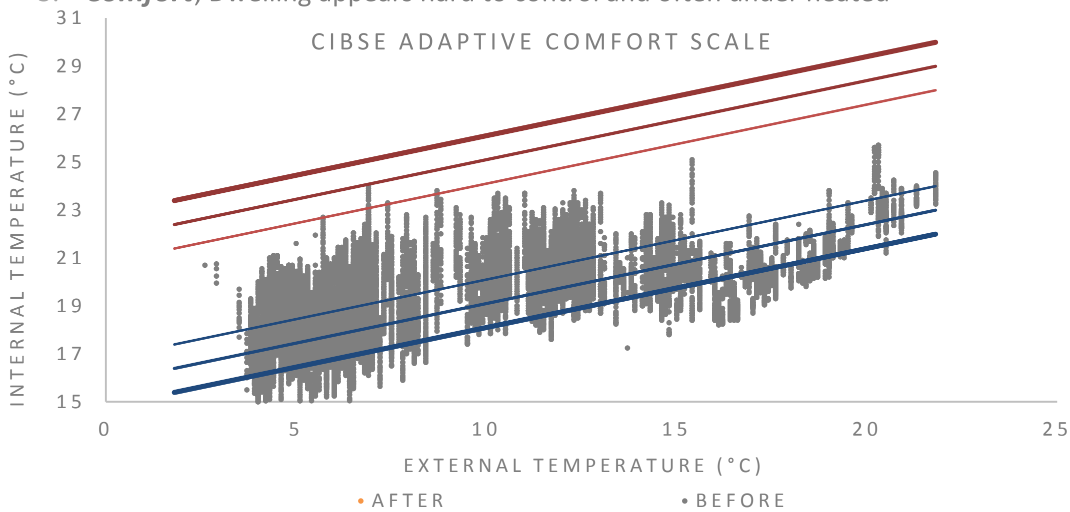
Mid-terrace, Solid brick, EWI

1. ***Summary***; No gas data, unable to compare heating performance

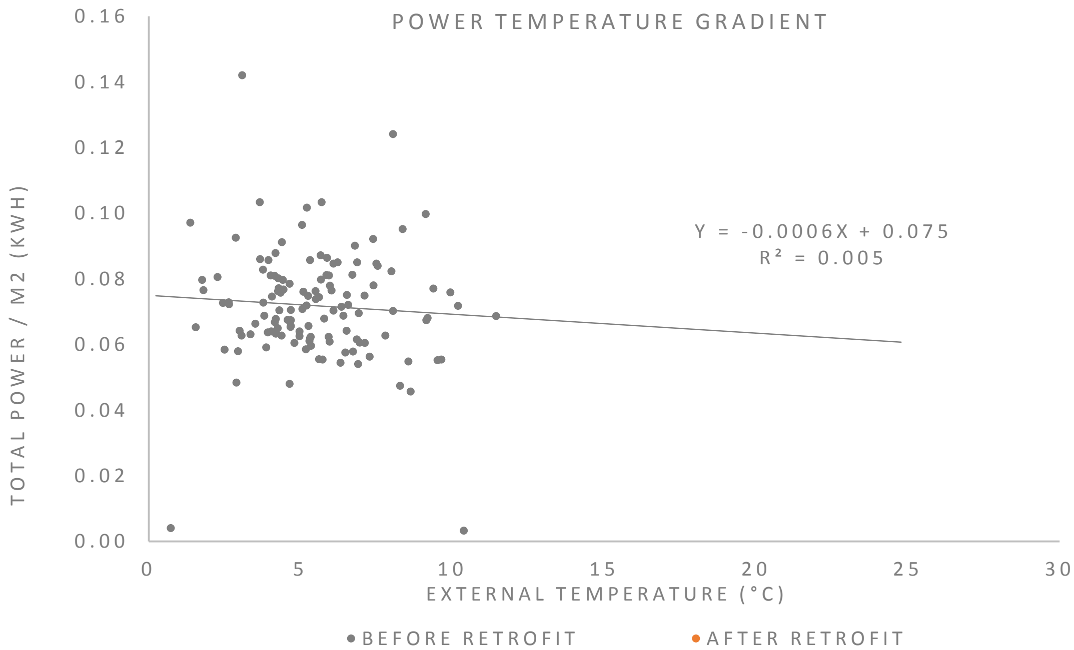
2. ***Data quality***; No gas and electricity sensor failure. Lacking significant elements



3. ***Comfort***; Dwelling appears hard to control and often under heated



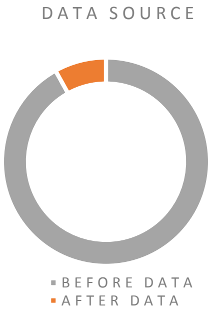
4. ***Retrofit performance; Low energy use data limits possible analysis***

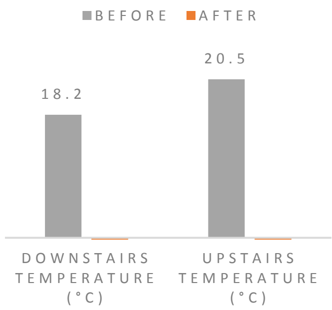


Property E19

Survey observations:

- thermal bridging at eaves and ground floor
- large insulation cut-outs at rear for external plumbing, gate, store, service pipe





- Sensor failure makes before after comparisons impossible
- Very little after data
- Dwelling heating is not easily controllable

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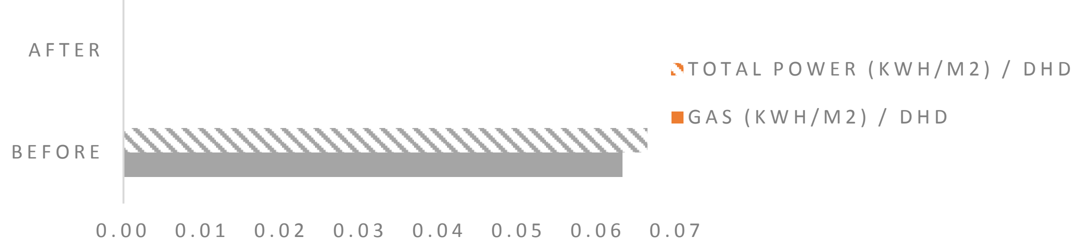
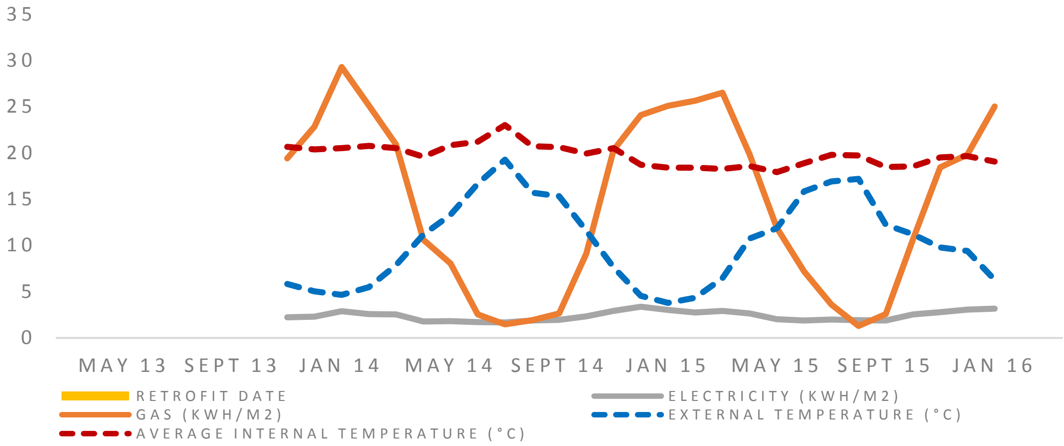
Mid-terrace, Solid brick, retrofit not undertaken

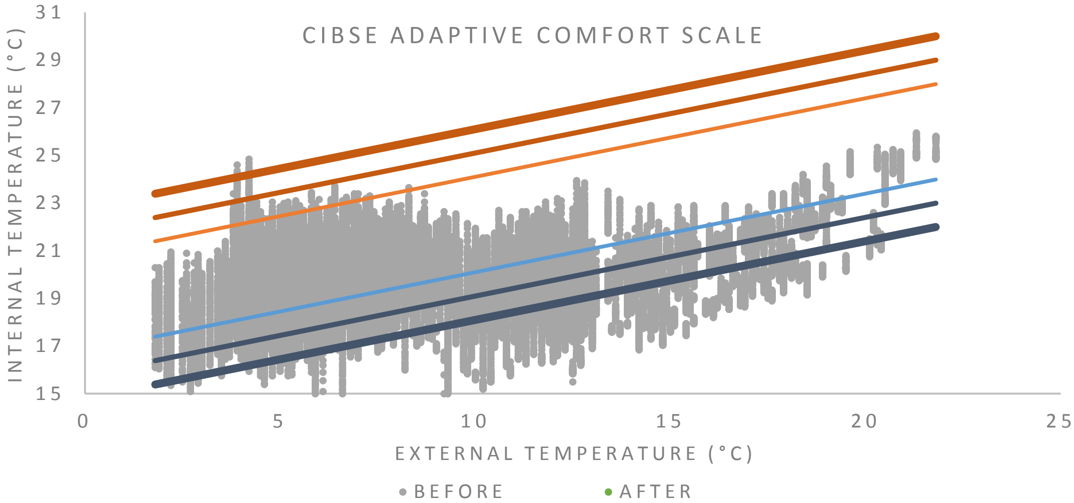
1. ***Summary***; No after data, retrofit was not carried out.



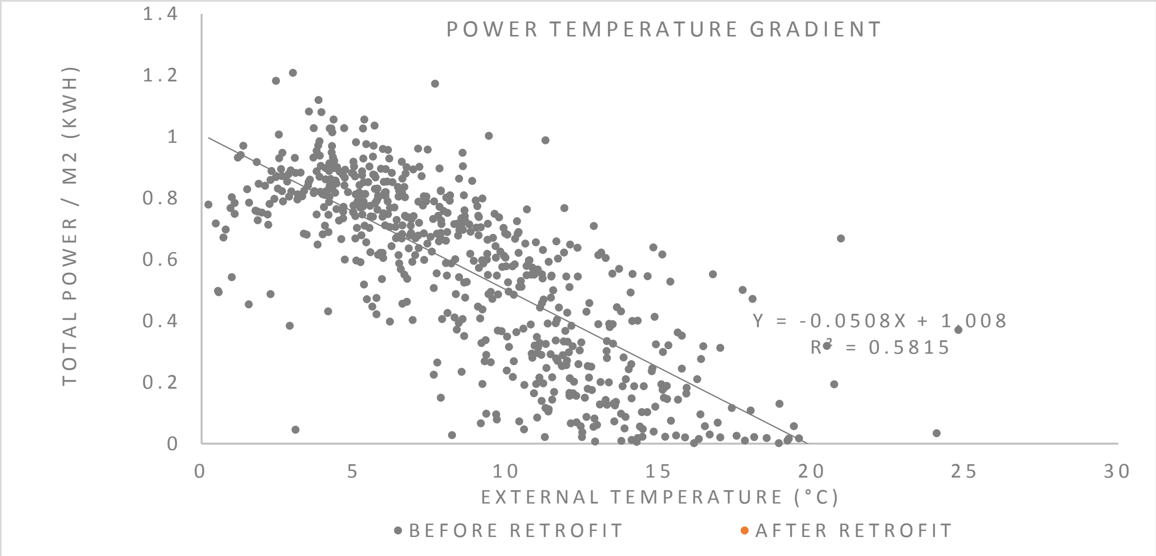
2. ***Data quality***; reliable data, however no retrofit was undertaken



3. ***Comfort***; dwelling is hard to control, often under heated.



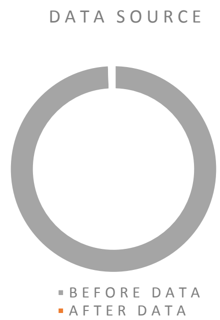
4. ***Retrofit performance;*** *More energy is used when it is cold outside.*

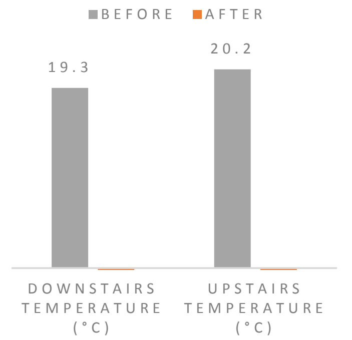


Property E20

Survey observations:

- no wall insulation, walls in poor condition
- dormer rooms retrofitted with insulation





- No retrofit undertaken
- Energy use increases when external temperature is low
- Internal conditions are not easily controlled, and are often under heated.

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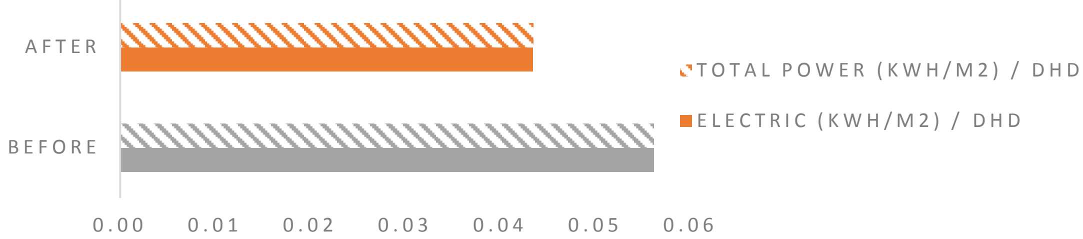
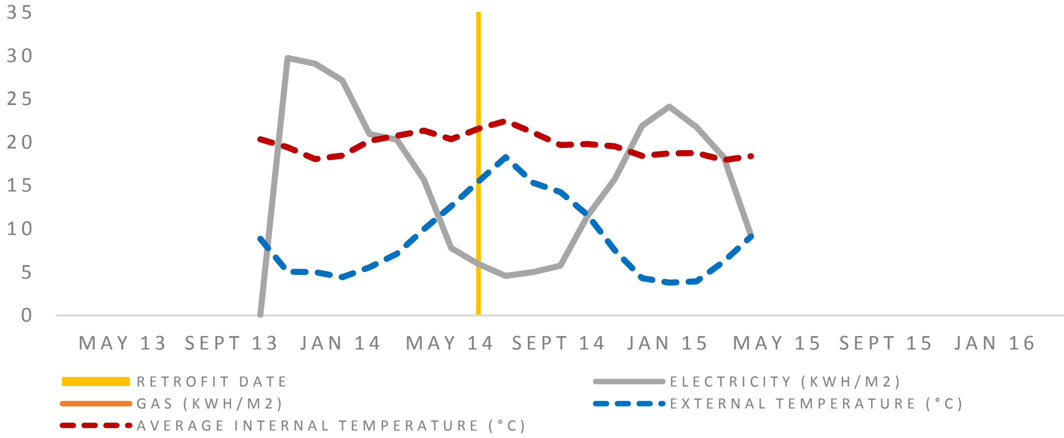
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Solid brick, EWI

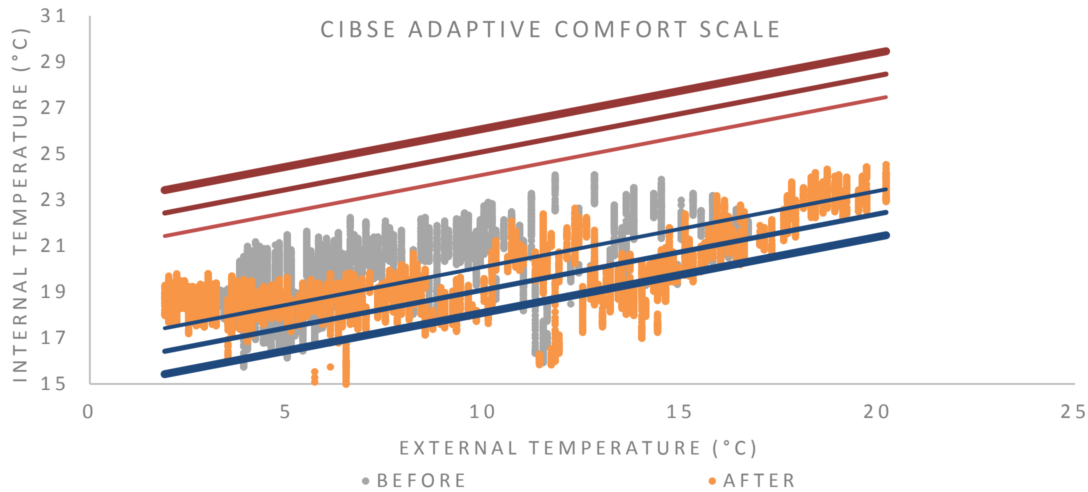
1. ***Summary***; Electric only house, Data suggests a 23% energy use reduction.



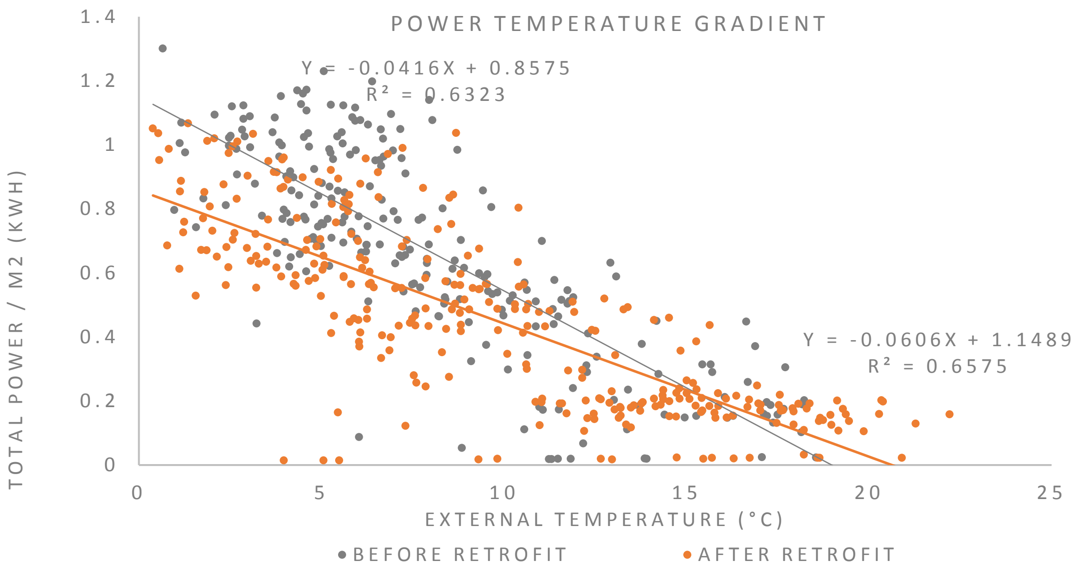
2. ***Data quality***; reliable data, adequate before and after data.



3. ***Comfort***; Dwelling is often under heated, appears to be controllable



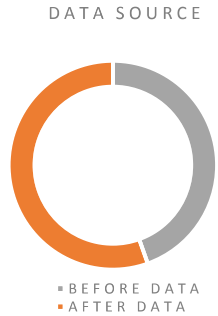
4. ***Retrofit performance; Energy use in cold weather reduced post retrofit***

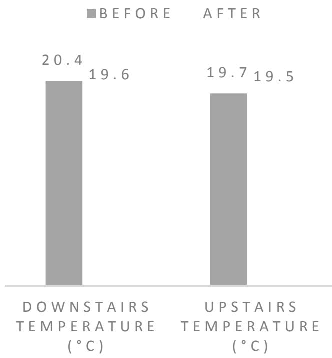


Property E21

Survey observations:

- thermal bridging at eaves and ground floor
- excessive condensation each day to windows
- thermal bridging at sloping eaves soffits





- Energy use is lower *after* retrofit
- Electric only house
- retrofit appears to make house more controllable

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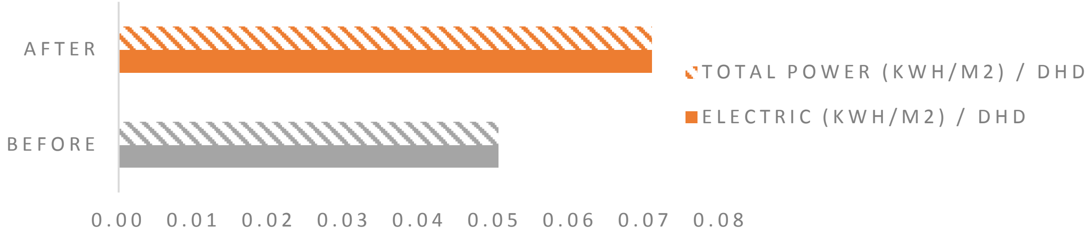
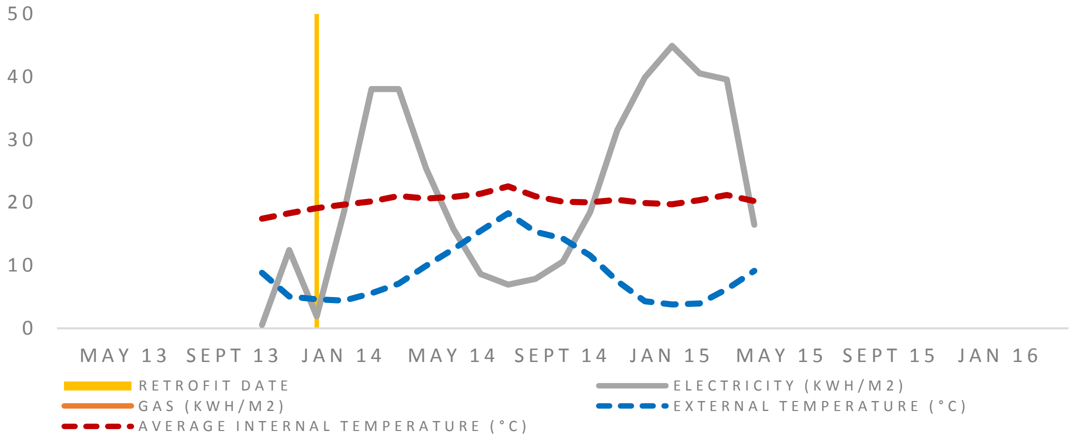
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Solid brick, EWI

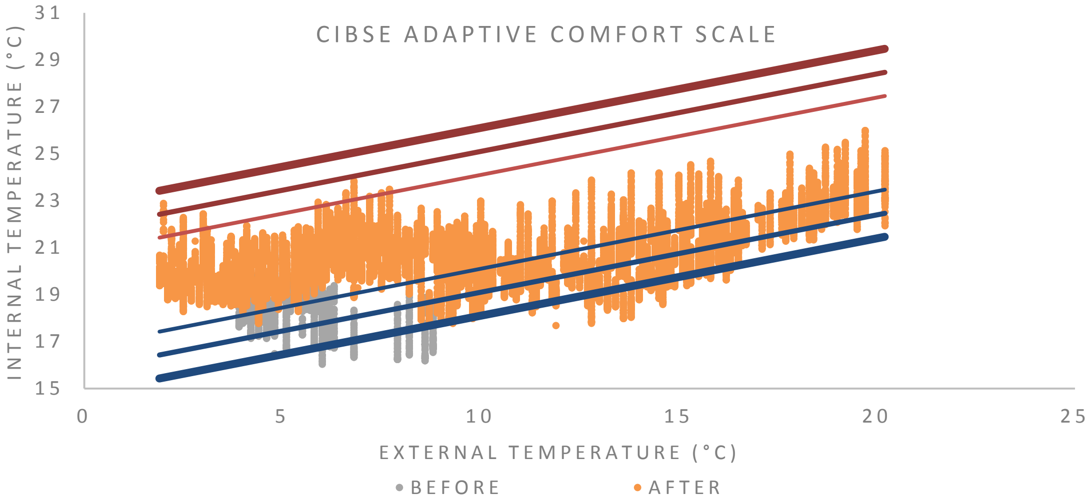
1. ***Summary***; Data suggests a 40% increase in energy use after retrofit



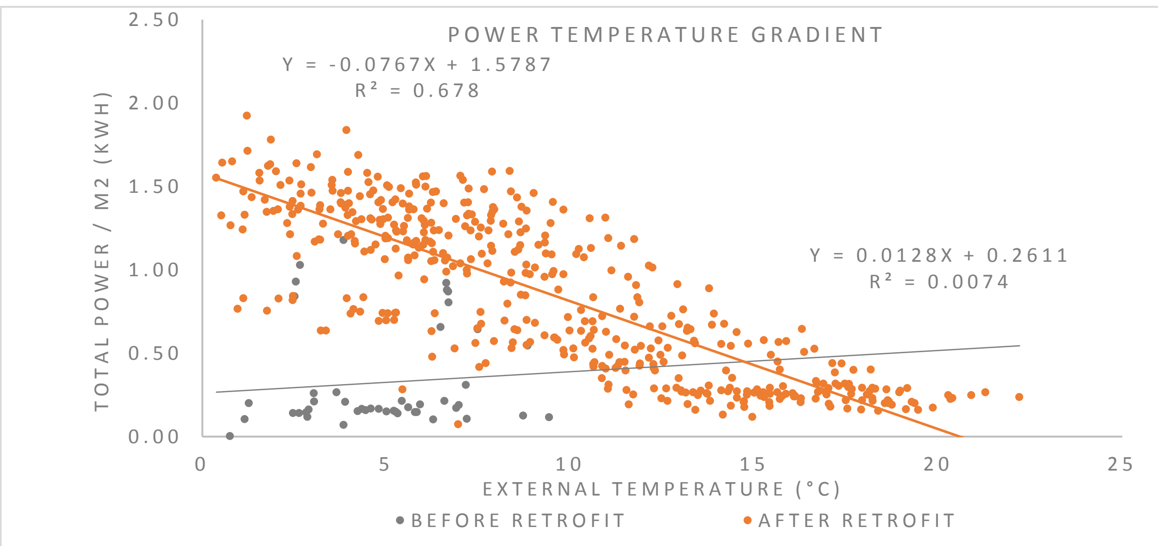
2. ***Data quality***; Data is reliable, however limited before data increases uncertainty.



3. ***Comfort***; Dwelling shows an improvement in comfort after retrofit



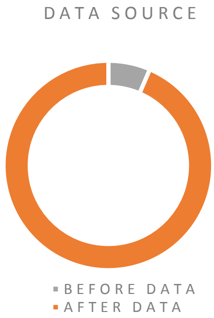
4. ***Retrofit performance; 67% of energy used after retrofit is weather dependant***

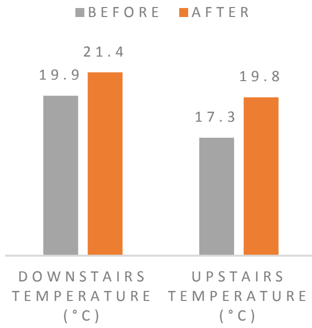


Property E22

Survey observations:

- thermal bridging at sloping soffits
- thermal bridging at eaves and ground floor
- EWI close to ground level possibly covering DPC
- cut-outs at services





- Limited before data increases uncertainty
- Before after comparison limited
- Retrofit appears to improve controllability of internal conditions

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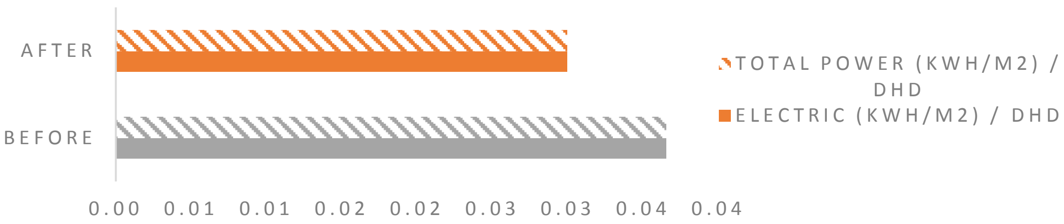
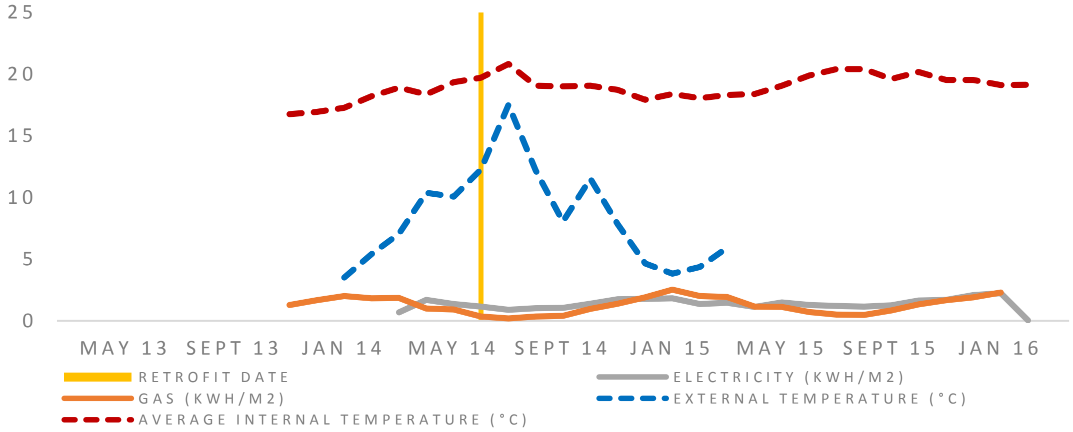
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Solid brick, EWI

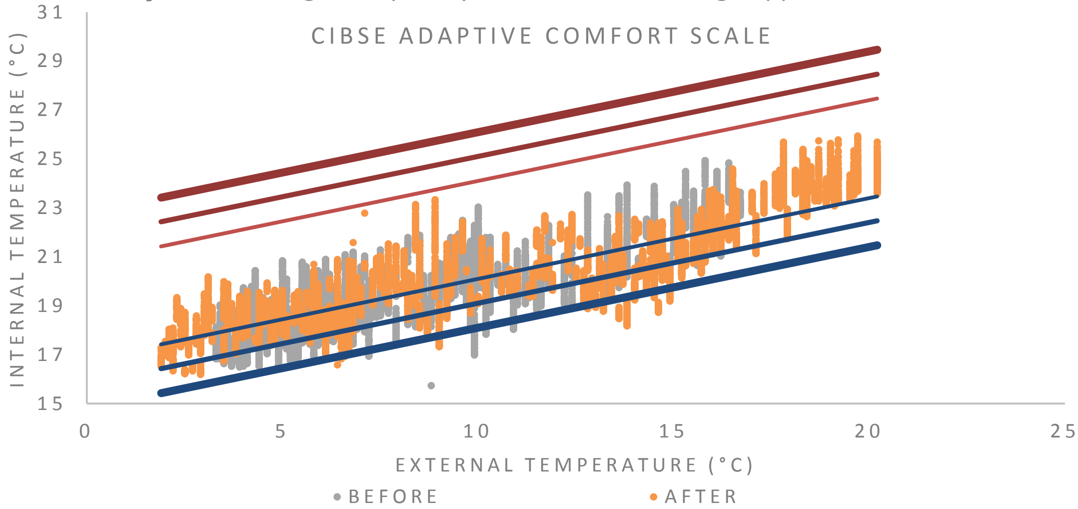
1. ***Summary***; Data suggests an 18% reduction in heating energy use



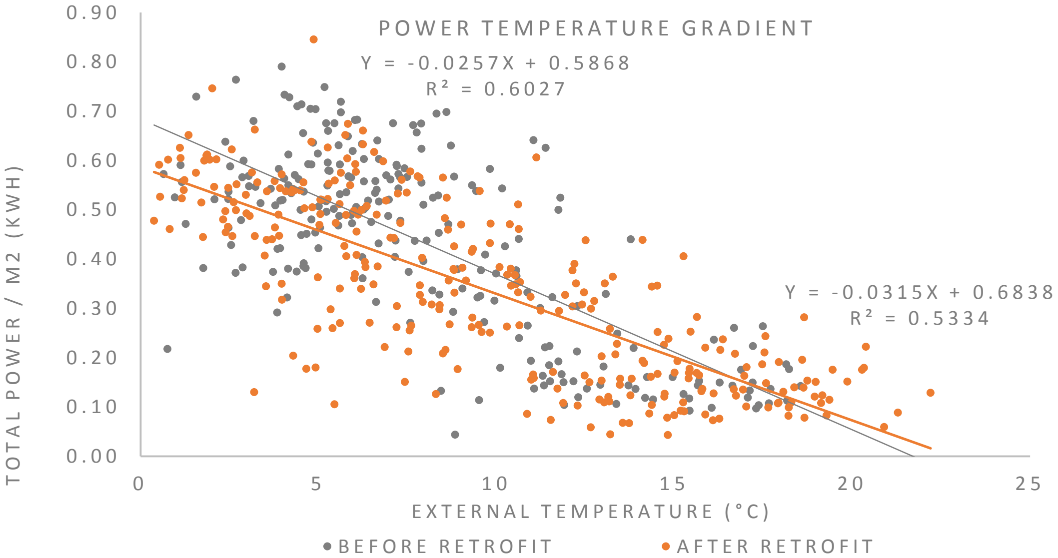
2. ***Data quality***; acceptable data quality, external temperature lost part way.



3. ***Comfort***; Dwelling is frequently under heated. Though appears controllable.



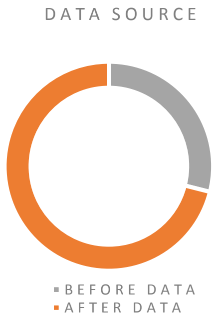
4. ***Retrofit performance; weather dependant energy use reduces after retrofit***

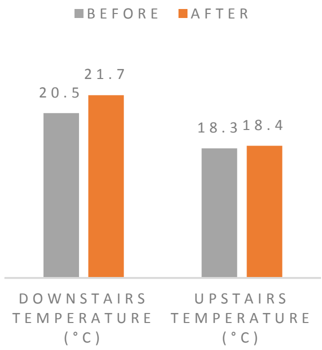


Property E23

Survey observations:

- thermal bridging at sloping soffits
- thermal bridging at eaves and ground floor
- cut-outs at services





- Energy use is lower *after* retrofit
- Fewer before data than after, though an acceptable quantity
- Relatively normal heating behaviour

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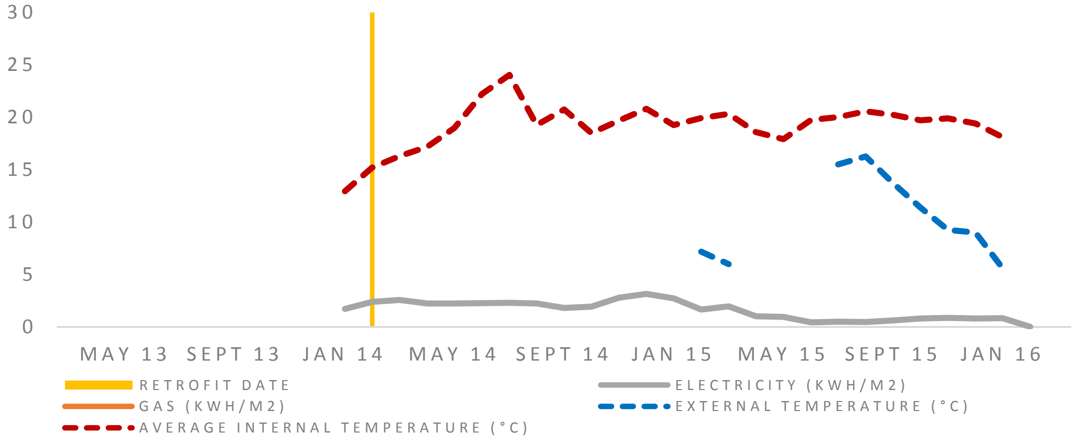
DECC, Leeds Go Early Energy Monitoring Project

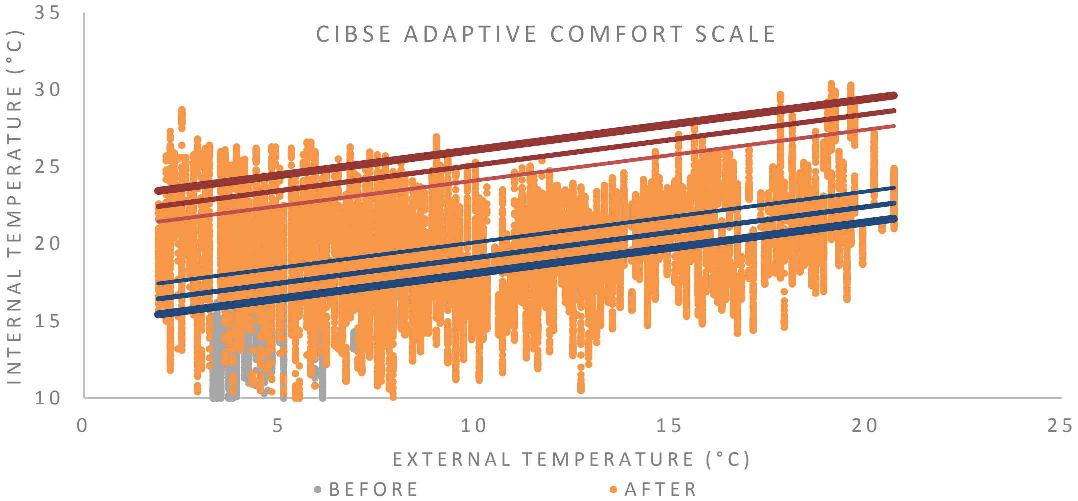
Flat, Solid stone, IWI

1. ***Summary***; No gas data, preventing analysis of heating performance

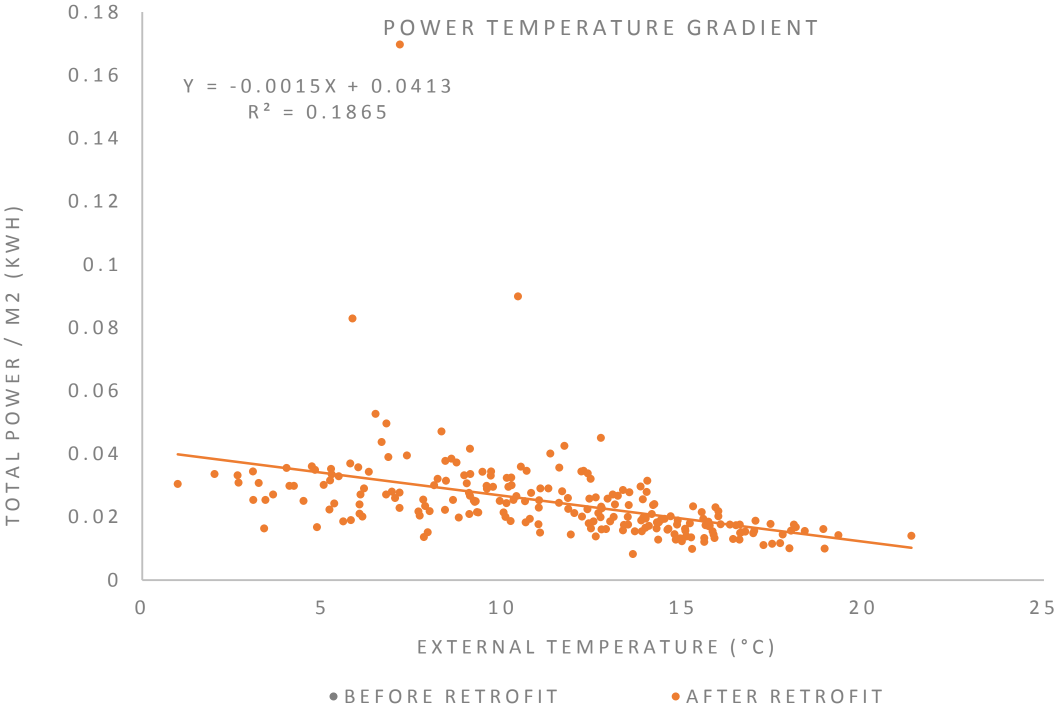
2. ***Data quality***; lack of external data limits possible analysis, limited before data



3. ***Comfort***; dwelling experiences over heating and under heating, difficult to control



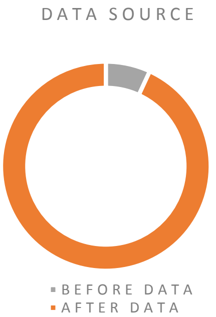
4. ***Retrofit performance;*** *Energy use is not greatly affected by external conditions*

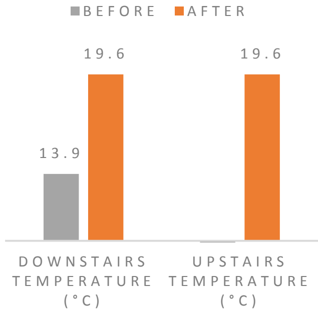


Property E24

Survey observations:

- Grade II listed, EWI not permitted, IWI permit limited
- thermal bridging with IWI
- lacking in roof void insulation
- sash windows listed





- No gas data, little before data. High uncertainty
- Internal conditions are difficult to control
- Missing external temperature data

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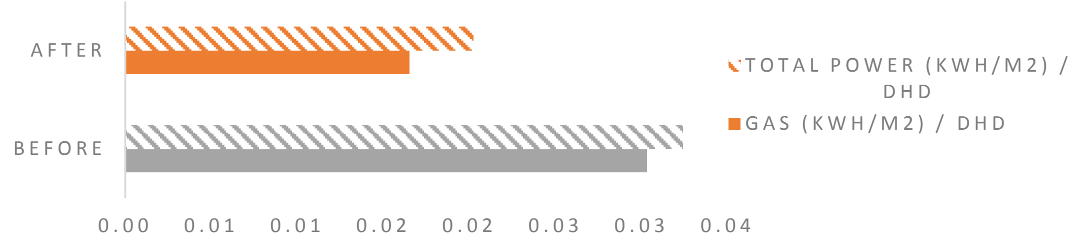
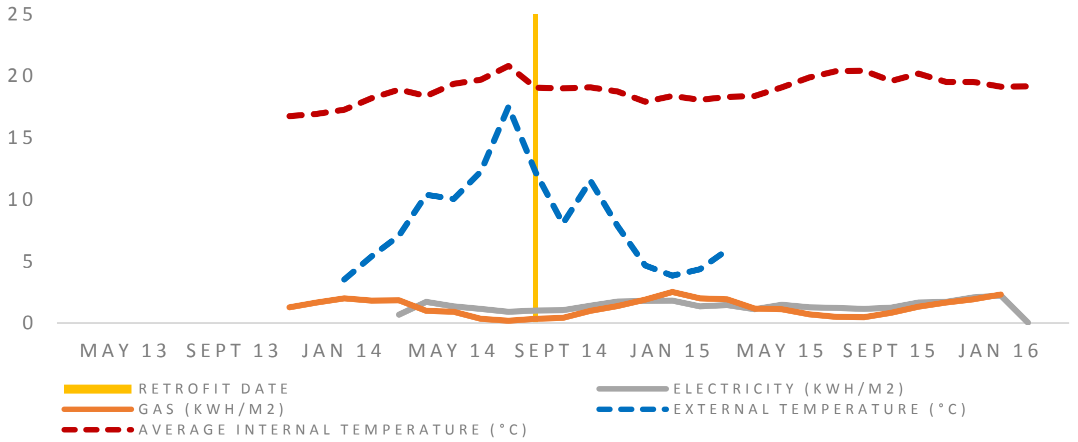
Mid-terrace, No-fines concrete, EWI

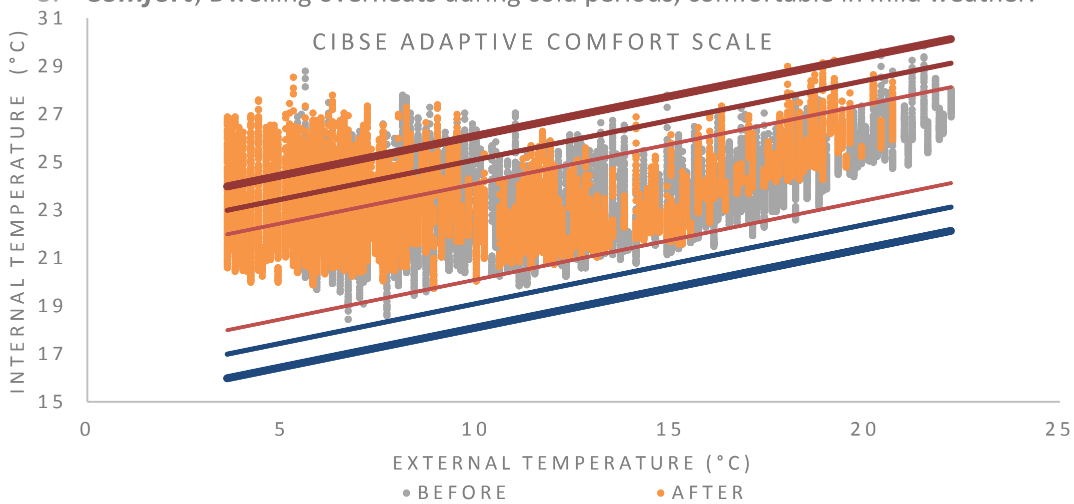
1. ***Summary***; Data suggests a 38% reduction in heating energy demand.



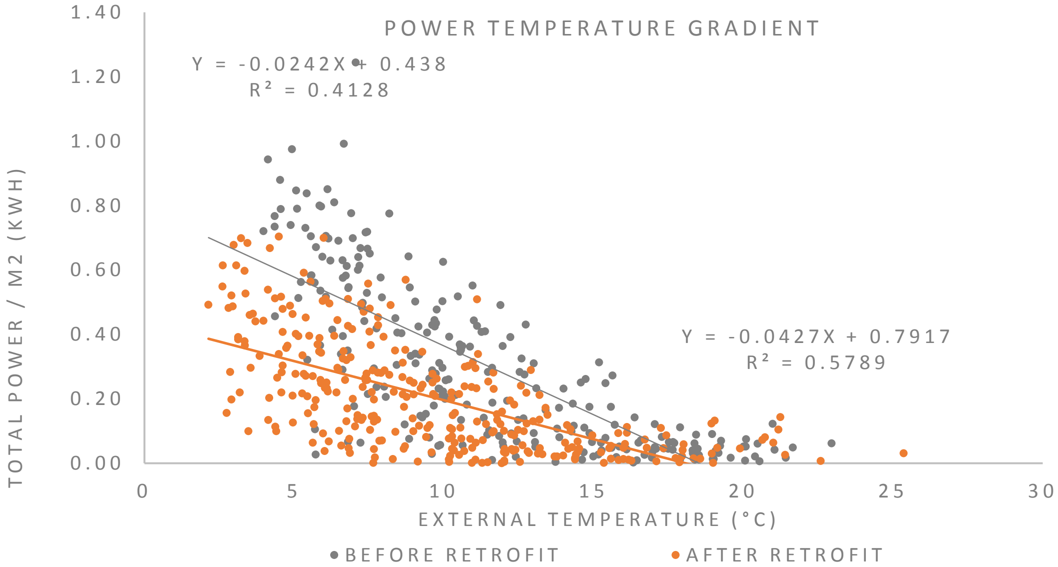
2. ***Data quality***; Acceptable before and after data, external temperature lost part way.



3. ***Comfort***; Dwelling overheats during cold periods, comfortable in mild weather.



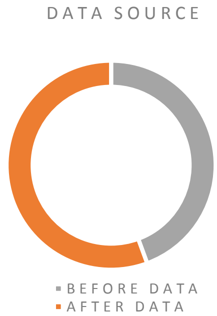
4. ***Retrofit performance; Energy use in cold weather reduced after retrofit***

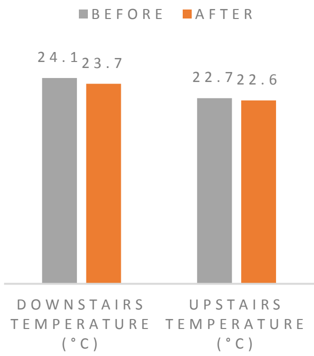


Property E25

Survey observations:

- thermal bridging at eaves and ground floor
- large insulation cut-outs at first floor level for porch roof





- Retrofit reduced heating energy use
- Internal temperatures tend to be high
- Retrofit appears to reduce weather dependant energy use

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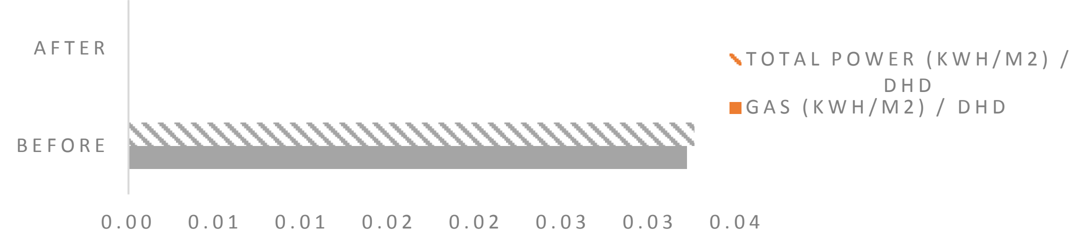
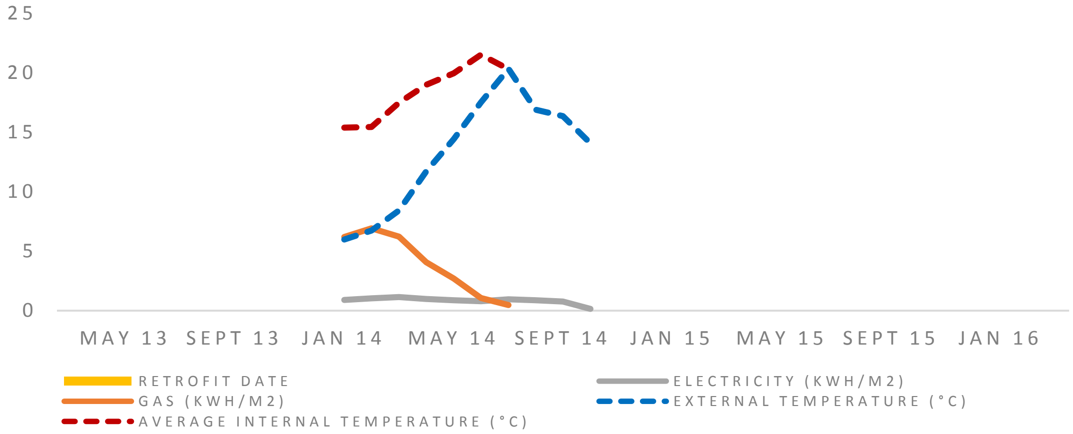
DECC, Leeds Go Early Energy Monitoring Project

Mid-terrace, Solid brick, No retrofit

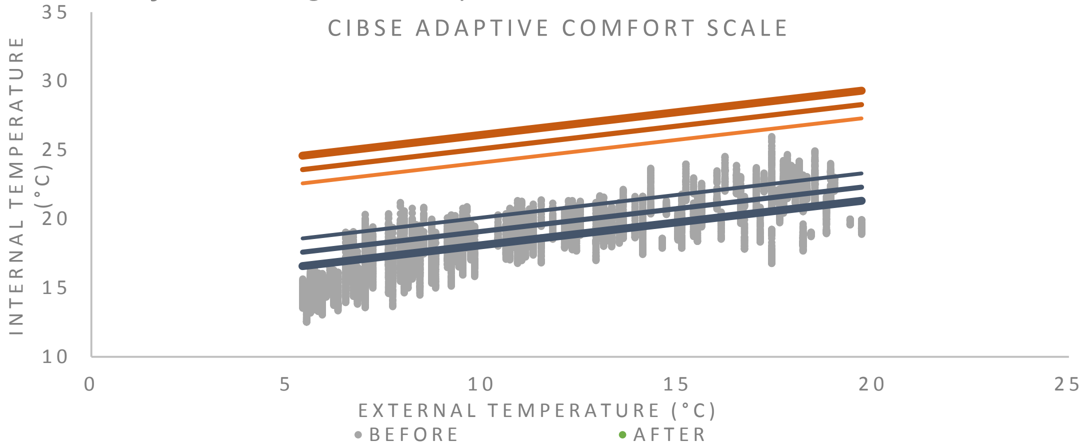
1. ***Summary***; No retrofit undertaken.



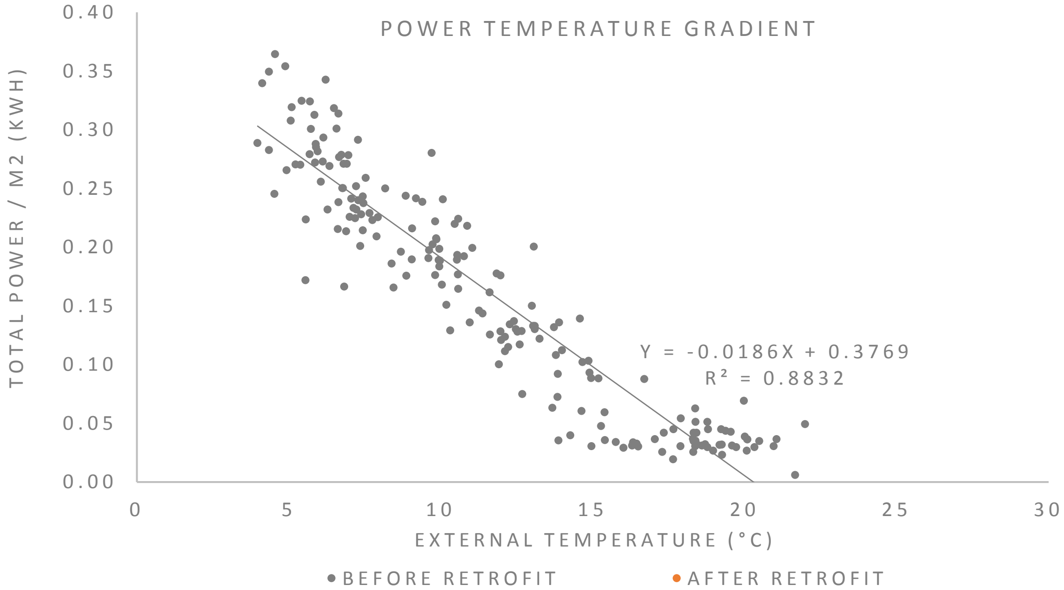
2. ***Data quality***; No after data, monitoring ceased.



3. ***Comfort***; Dwelling consistently under heated



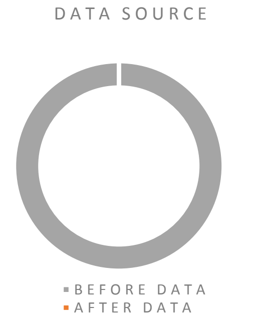
4. ***Retrofit performance; energy use increases significantly in cold weather***

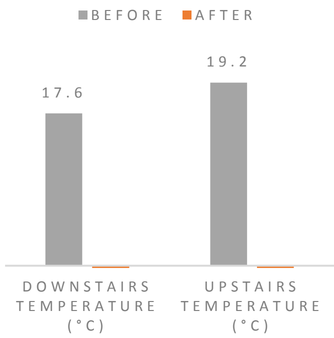


Property E26

Survey observations:

- pre-survey only
- EWI would require additional roof works and below DPC insulation to avoid thermal bridging at eaves and ground floor





- No Retrofit carried out
- Short monitoring period increases uncertainty
- Highly weather dependant heating energy use.

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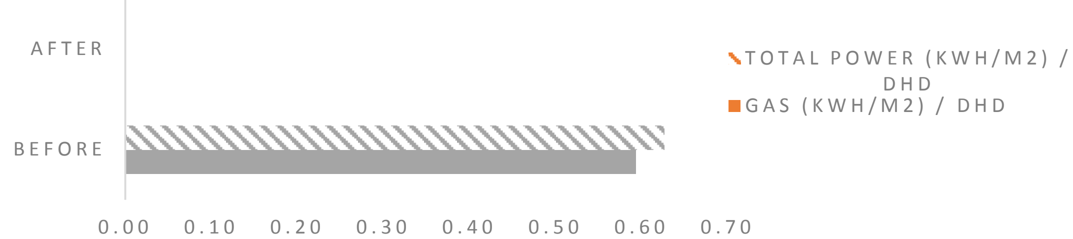
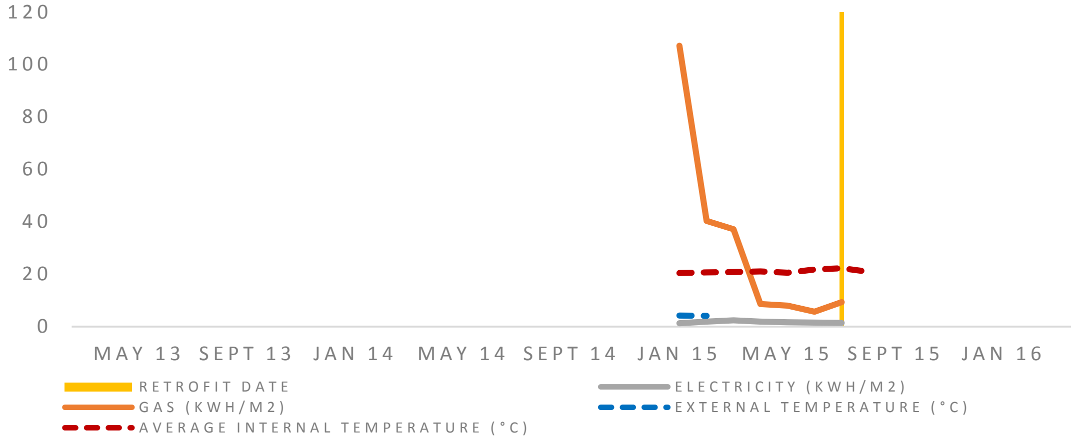
Mid-terrace, Solid brick, IWI

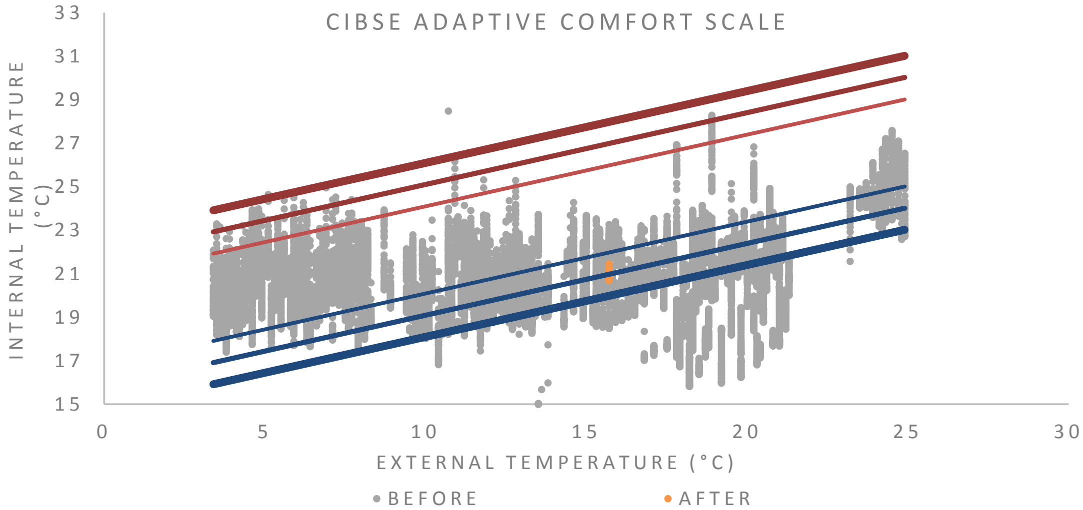
1. ***Summary***; No after retrofit data



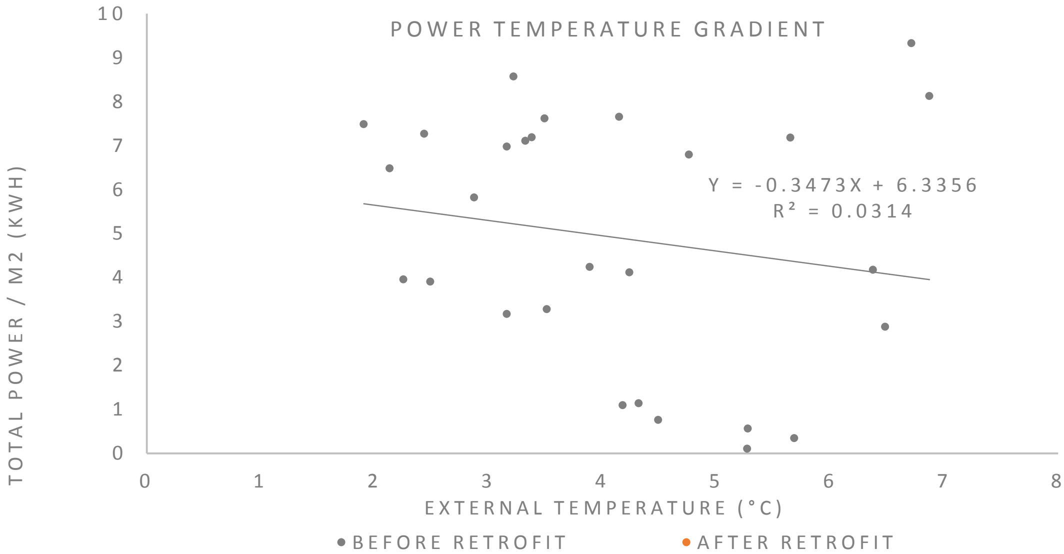
2. ***Data quality***; Data loss after retrofit, little external temperature data.



3. ***Comfort***; Dwelling appears difficult to control, under heated



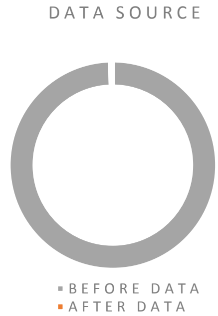
4. ***Retrofit performance;*** *limited post retrofit data.*

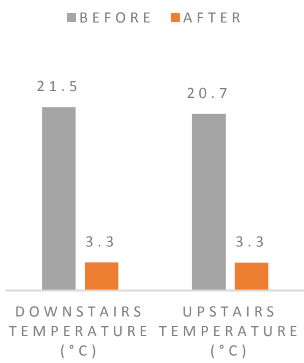


Property E27

Survey observations:

- thermal bridging at eaves
- cut-outs for services at rear





- Data loss after retrofit
- House is difficult to control before retrofit
- Limited external temperature limits analysis

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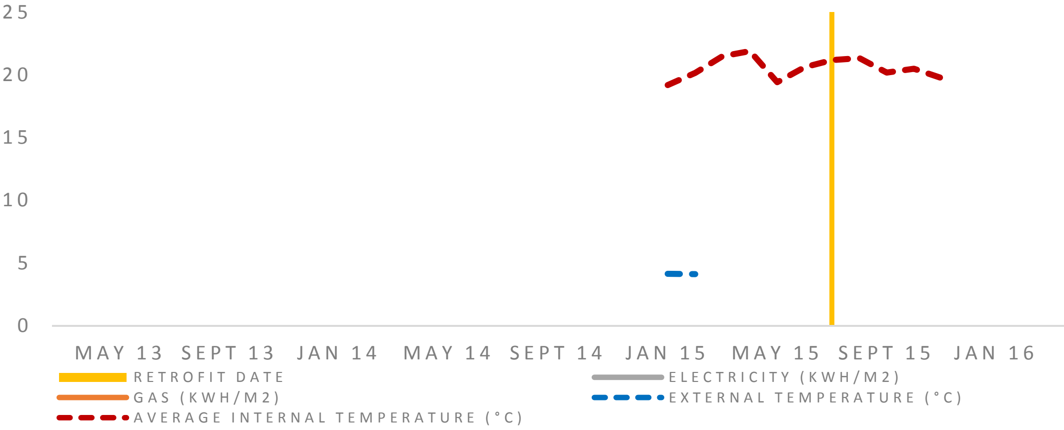
DECC, Leeds Go Early Energy Monitoring Project

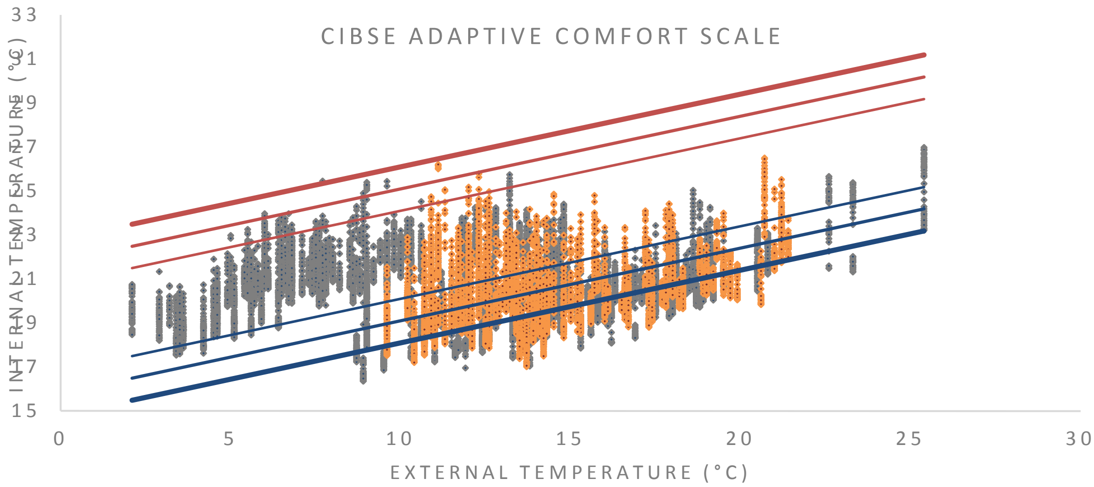
Mid-terrace, Solid brick, IWI

1. ***Summary***; No gas or electricity data

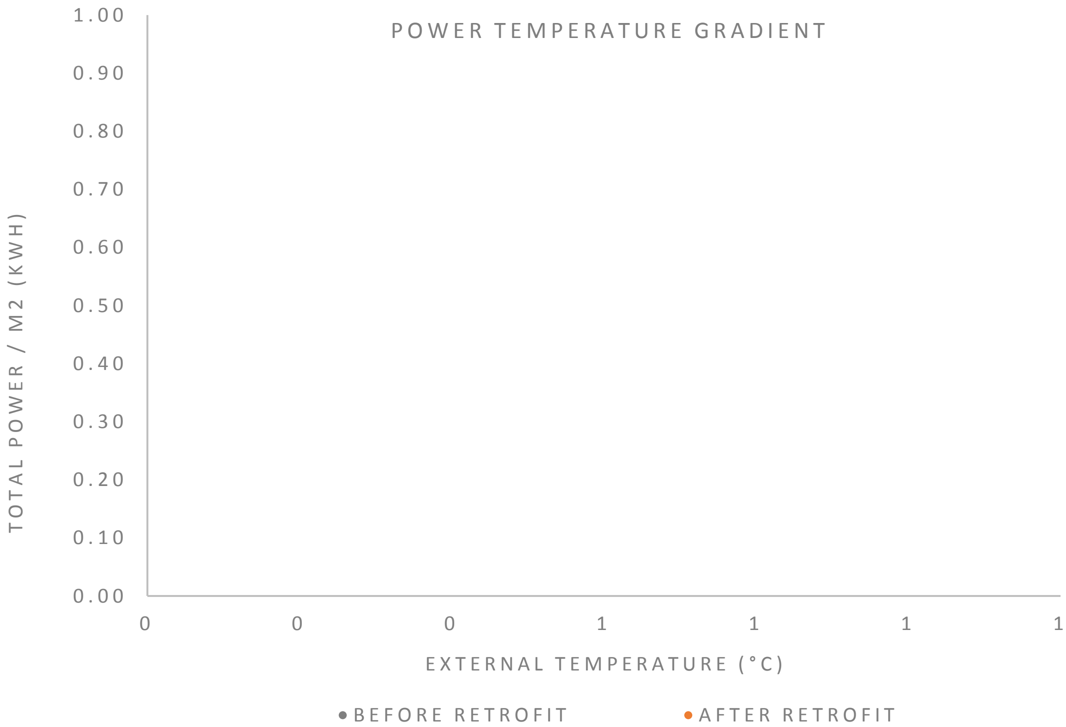
2. ***Data quality***; Very limited data, prototype monitoring equipment failure



3. ***Comfort***; Dwelling appears difficult to control, often under heated.



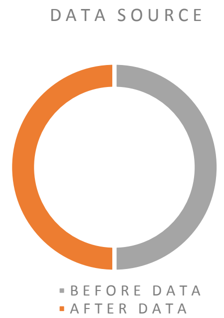
4. ***Retrofit performance; insufficient data.***

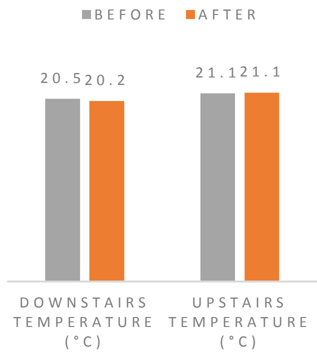


Property E28

Survey observations:

- thermal bridging at eaves
- cut-outs for services at rear





- Limited data, cannot draw conclusions on building performance before or after retrofit.

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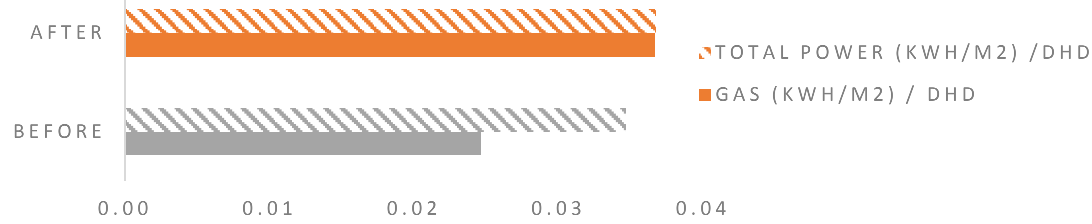
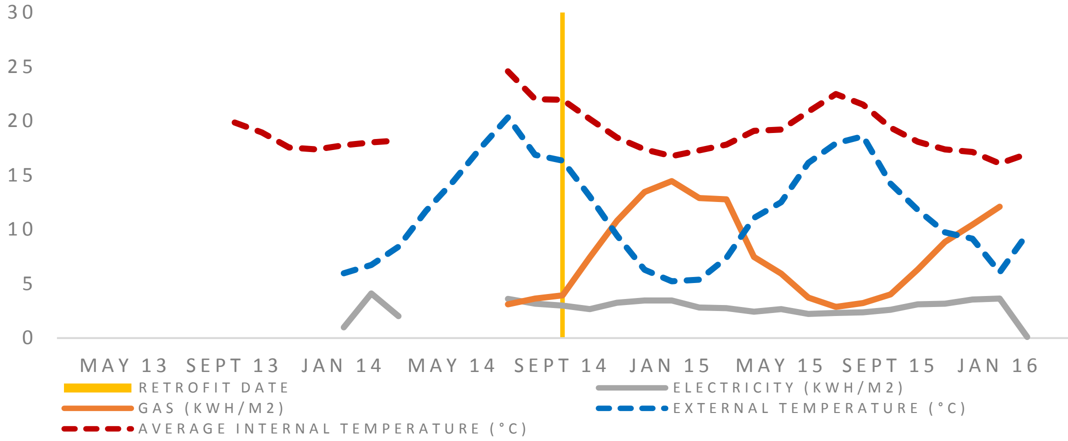
DECC, Leeds Go Early Energy Monitoring Project

End-terrace, Solid brick, EWI

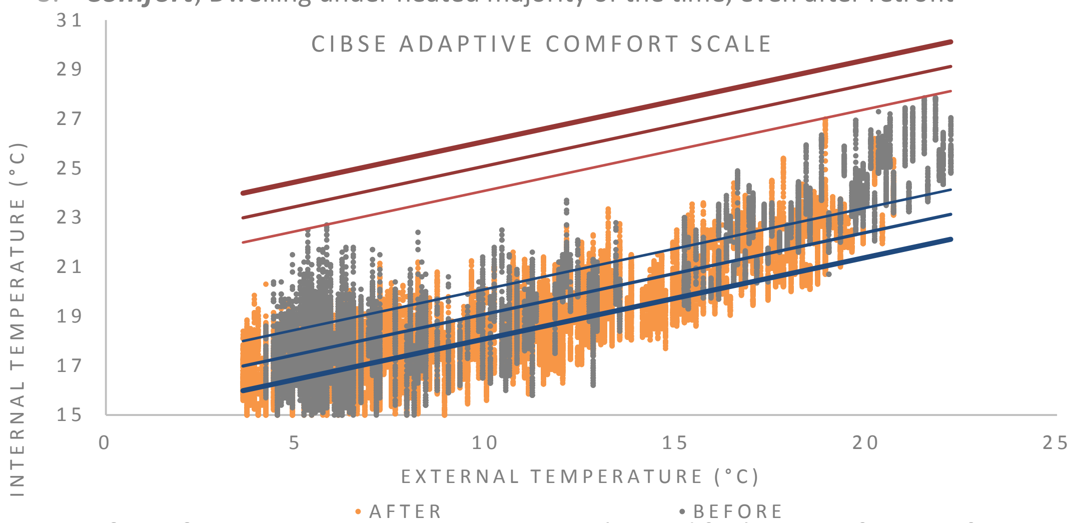
1. ***Summary***; Total energy use increases by 6% after retrofit



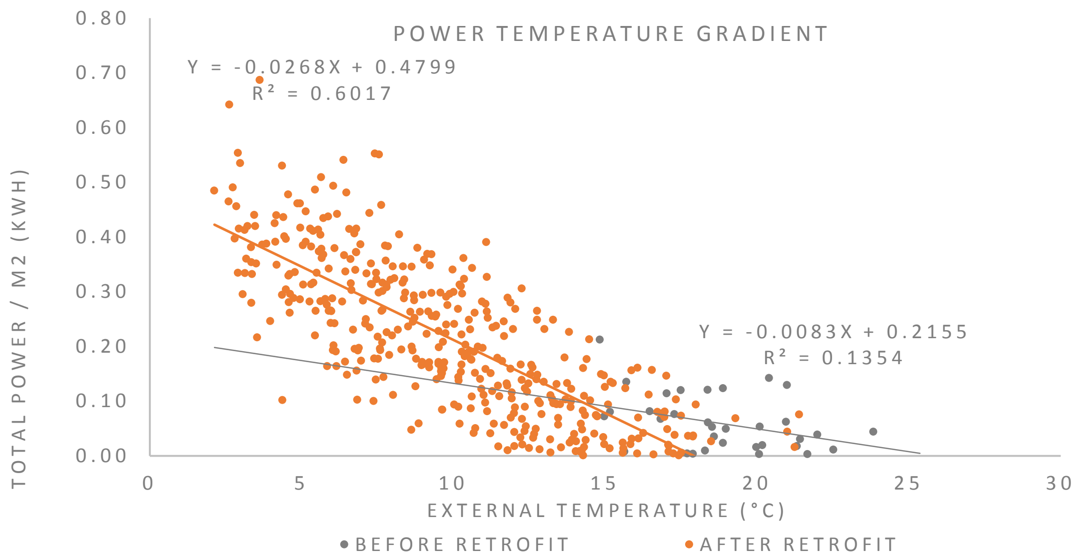
2. ***Data quality***; reliable data, though short before period increases uncertainty.



3. ***Comfort***; Dwelling under heated majority of the time, even after retrofit



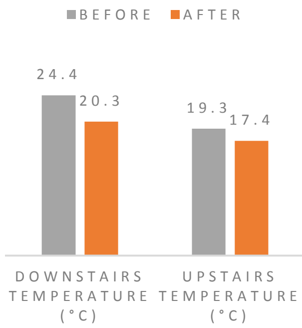
4. ***Retrofit performance; More energy appears to be used for heating after retrofit***



Property E29

Survey observations:

- thermal bridging at eaves & sloping eaves soffits
- EWI stops 200mm above finished ground floor
- no EWI to adjoining property, bridge at party wall
- rising damp historic chronic mould



- Total energy consumption increases after retrofit
- Limited before retrofit data increase uncertainty of results

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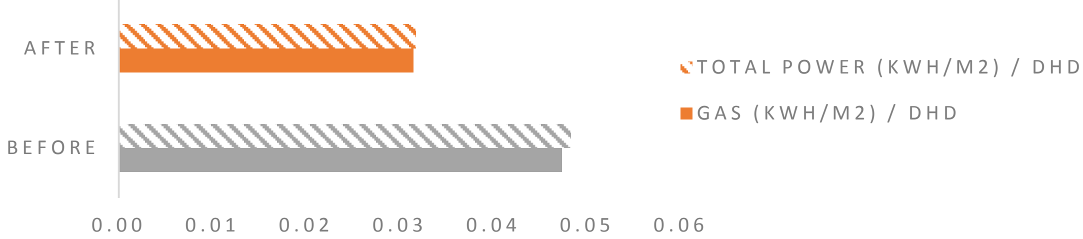
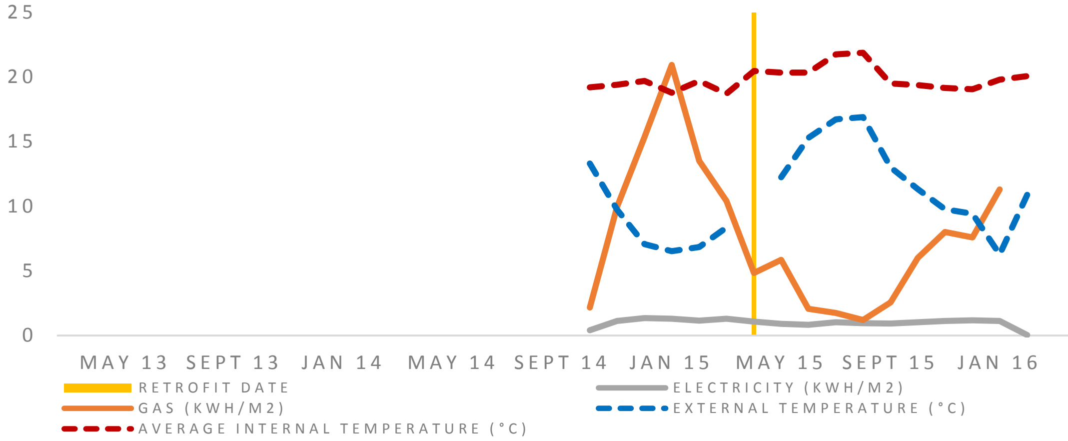
Mid-terrace, Solid brick, EWI

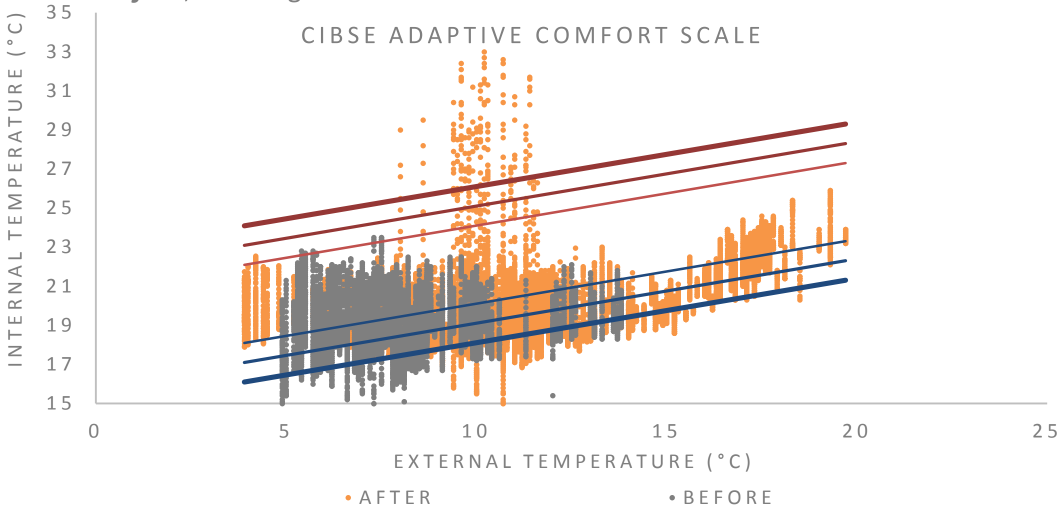
1. ***Summary***; Data suggests a 34% reduction in heating energy use



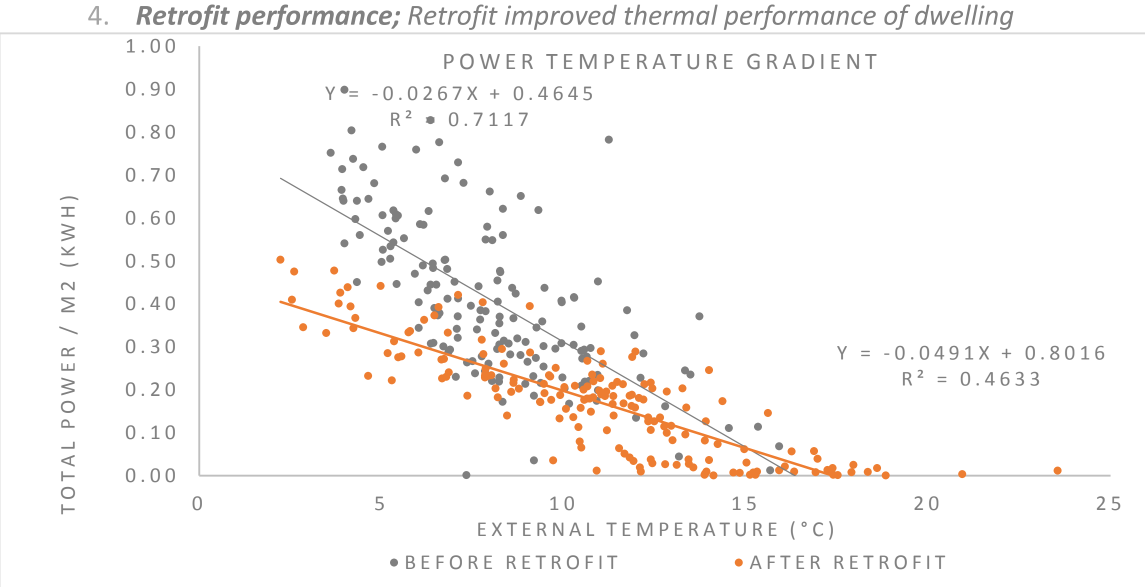
2. ***Data quality***; Reasonable quality of data, some drop outs



3. ***Comfort***; Dwelling is hard to control and often under heated. Some data anomalies



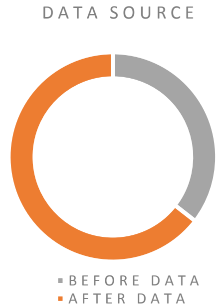
4. ***Retrofit performance;*** *Retrofit improved thermal performance of dwelling*

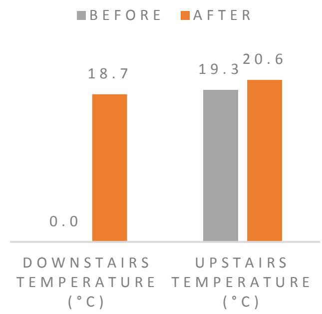


Property E30

Survey observations:

- IWI front, EWI rear
- no insulation to basement ceiling
- minimal rear ground level /services thermal break
- adjoining properties also treated





- Energy use is lower *after* retrofit
- Good distribution of before and after data
- Dwelling is often under heated
- Internal temperatures increase slightly after

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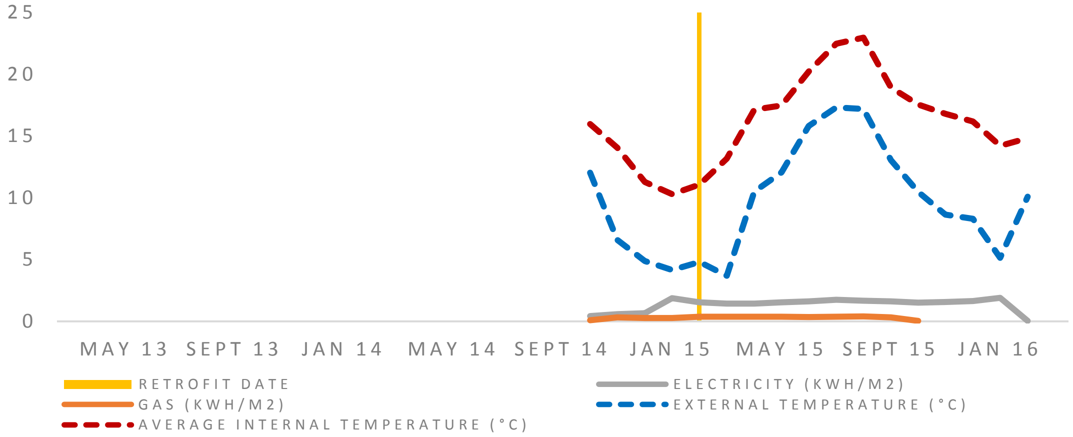
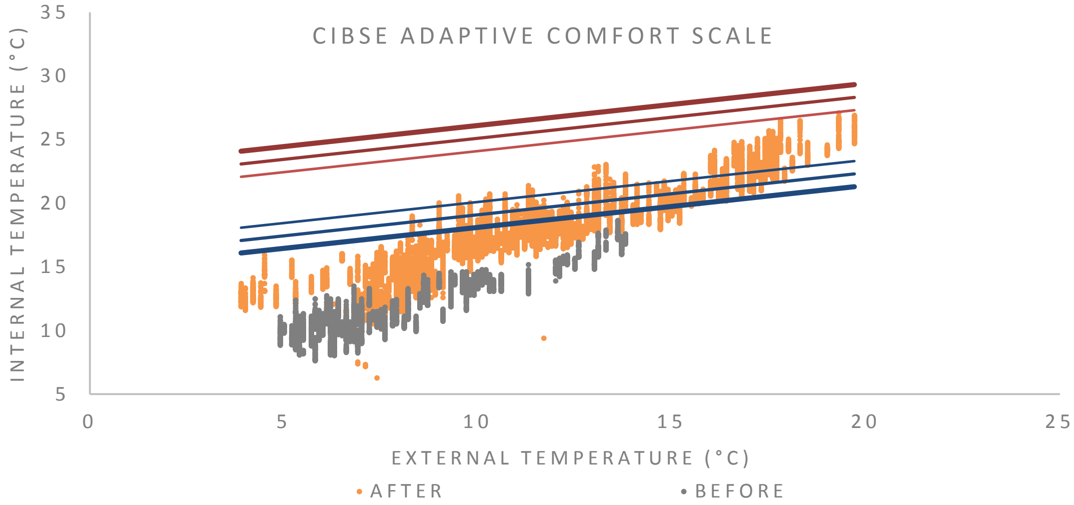
Mid-terrace, Solid brick, EWI

1. ***Summary***; reduction of 73% of total energy use, though gas use has almost doubled

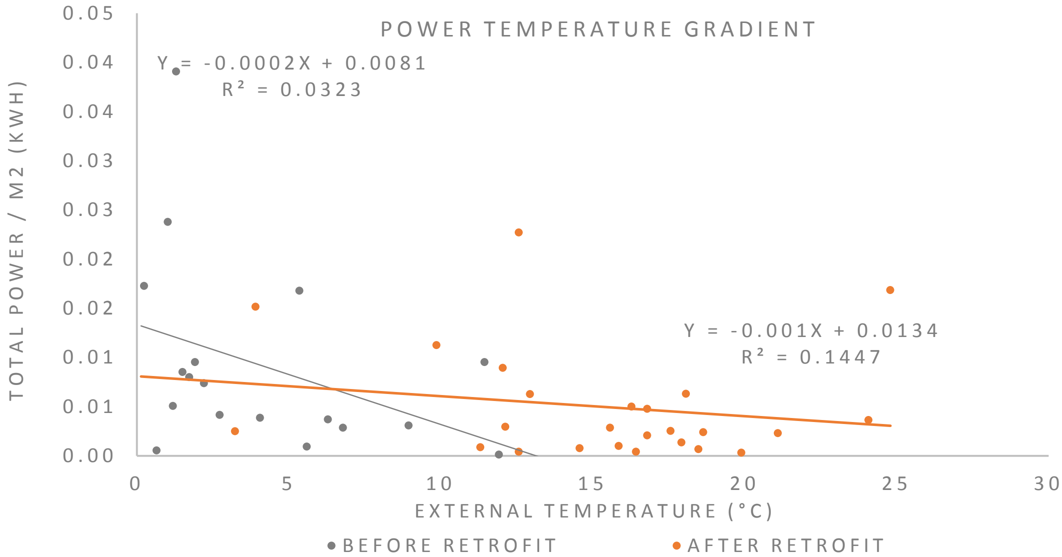
2. ***Data quality***; OK, smaller before period increases uncertainty



3. ***Comfort***; Dwelling is under heated for the majority of the time



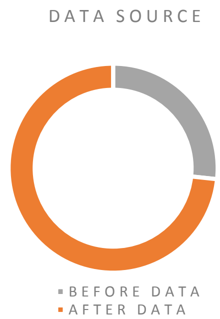
4. ***Retrofit performance;*** *It does not appear that the dwelling heating system is used*

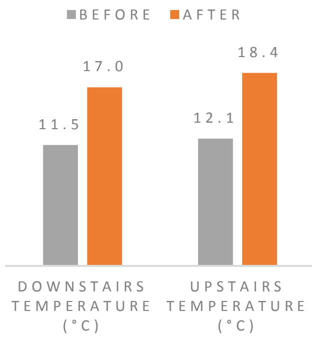


Property E31

Survey observations:

- EWI rear being placed on adjacent property (15)
- no insulation to walls, basement ceiling, attics
- walls especially rear very damp
- low internal temperature





- Overall energy use appears reduced after retrofit.
- Very low energy use and persistent under heating indicate dwelling is not actively being heated.
- Internal temperatures higher after retrofit

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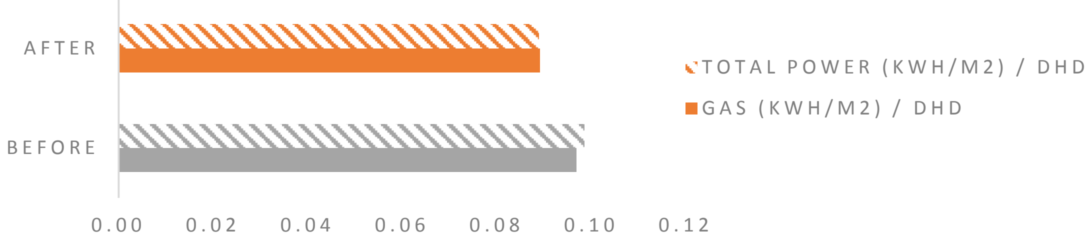
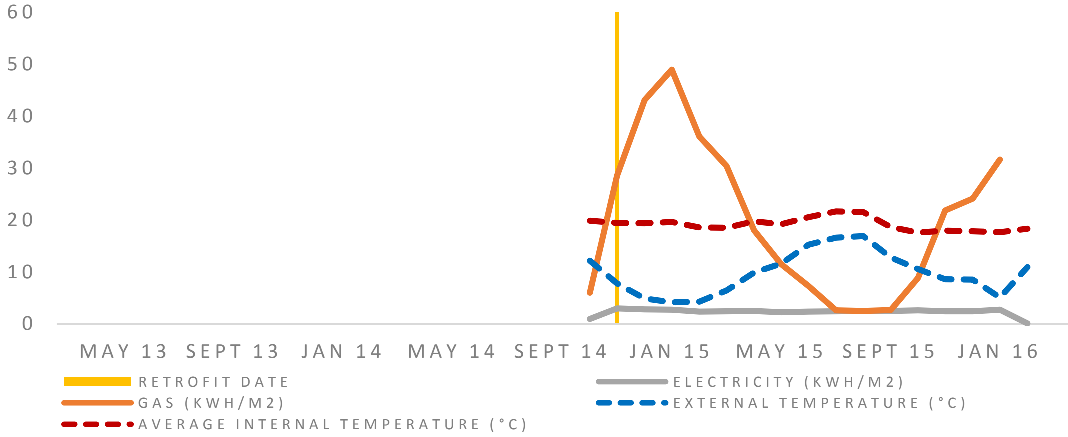
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Concrete panel, EWI

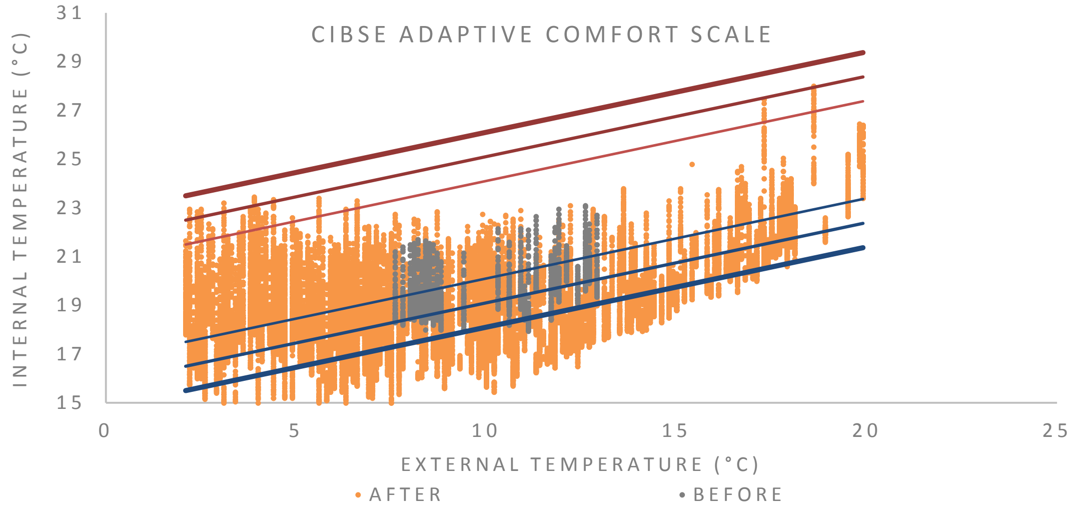
1. ***Summary***; Data suggests a 10% reduction in energy use



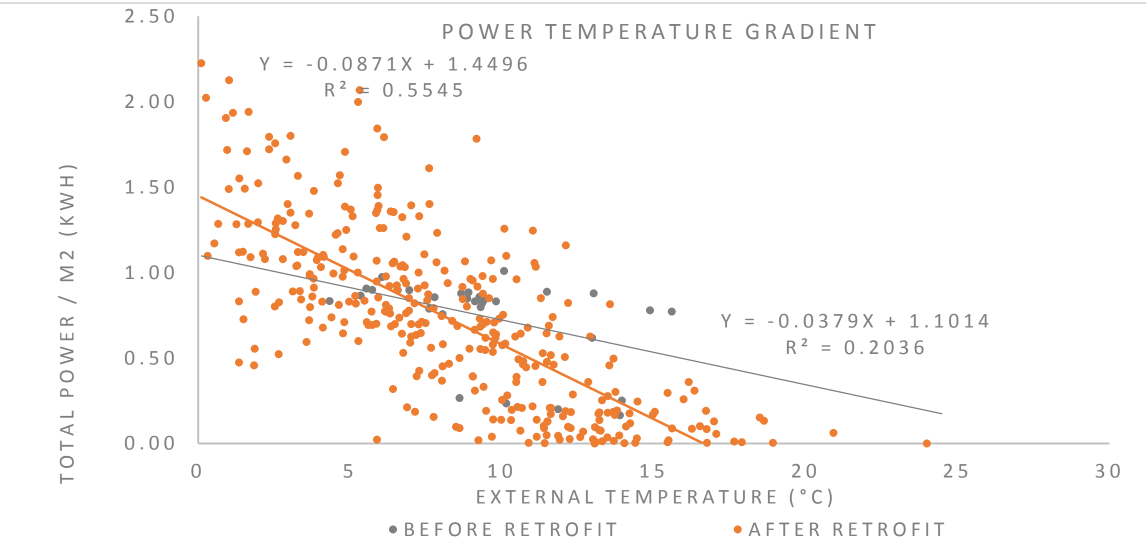
2. ***Data quality***; Good data, but short *before* period increases uncertainty.



3. ***Comfort***; Conditions are difficult to control and the dwelling is often under heated.



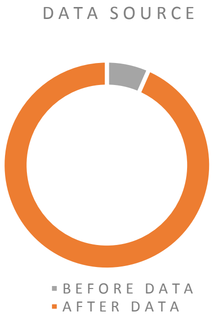
4. ***Retrofit performance; short before period makes improvement difficult to determine***

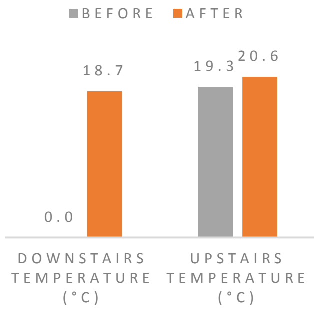


Property E32

Survey observations:

- no surveys





- Total energy use reduces after retrofit.
- Internal conditions difficult to control after retrofit
- Few *before* data points, increases the uncertainty.

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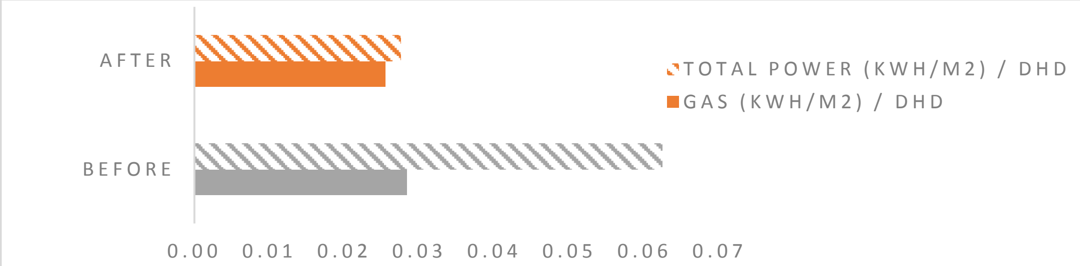
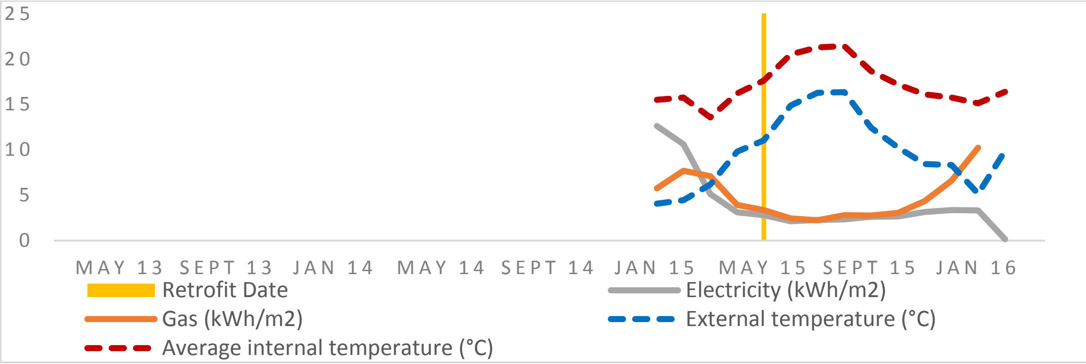
DECC, Leeds Go Early Energy Monitoring Project

End Terrace Flat (Top floor), No-Fines Concrete, EWI

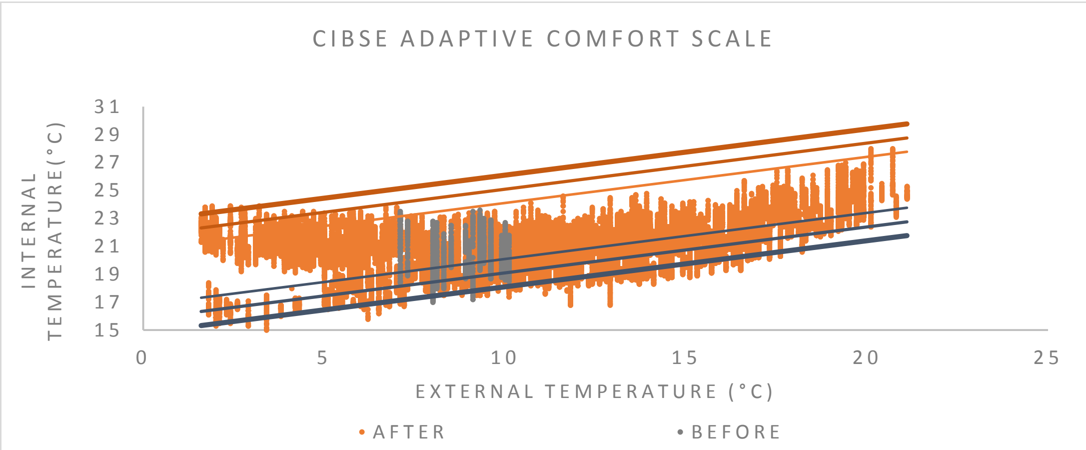
1. **Summary**; Data suggests a 56% reduction in total power



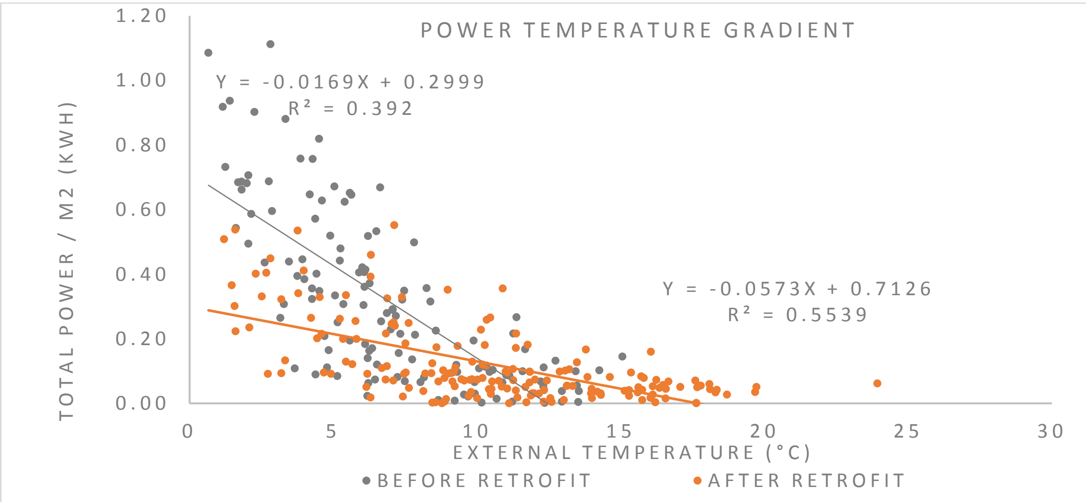
2. **Data quality**; Good dataset



3. ***Comfort***; Dwelling appears comfortable suggesting heating used regularly



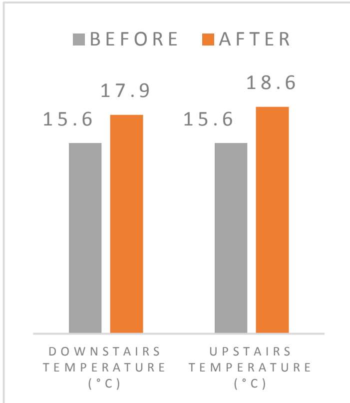
4. ***Retrofit performance;*** Apparent improvement in PTG



Property E33

Survey observations:

- Thermal bridging at eaves
- Poorly laid roof insulation
- No insulation under soffit of stairs
- Insulation cut-out at meter box, landing window etc.
- Historic mould on LR



- Energy use appears lower *after* retrofit.
- Thermal comfort appears good both *before* and *after* retrofit suggesting active use of heating system.
- PTG appears better *after* retrofit.

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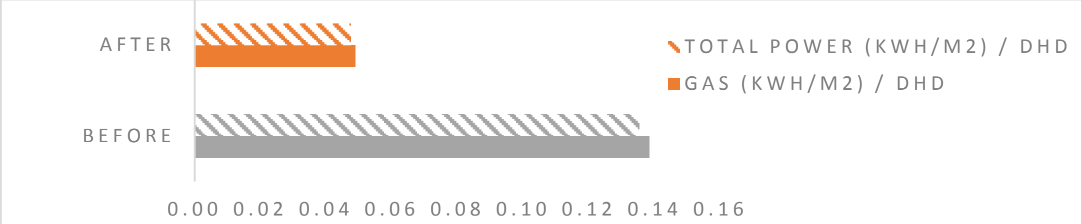
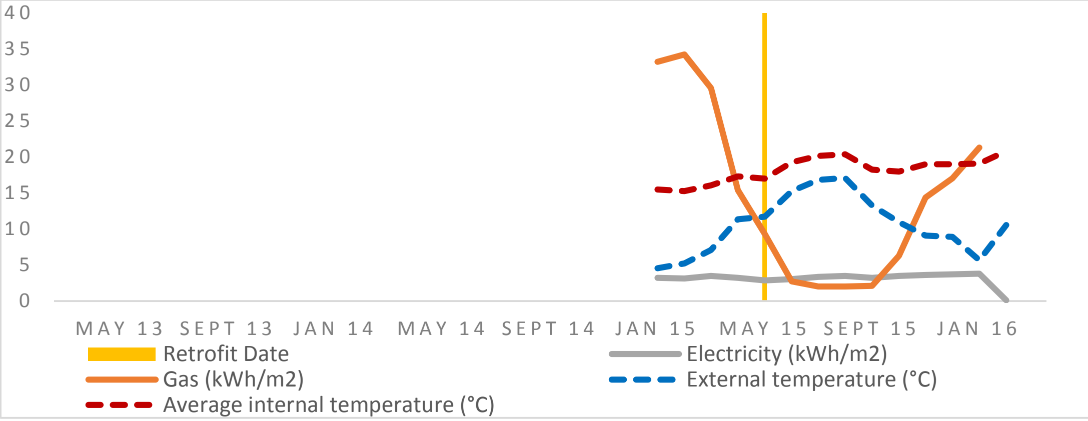
DECC, Leeds Go Early Energy Monitoring Project

End Terrace Flat (Top floor), No-Fines Concrete, EWI

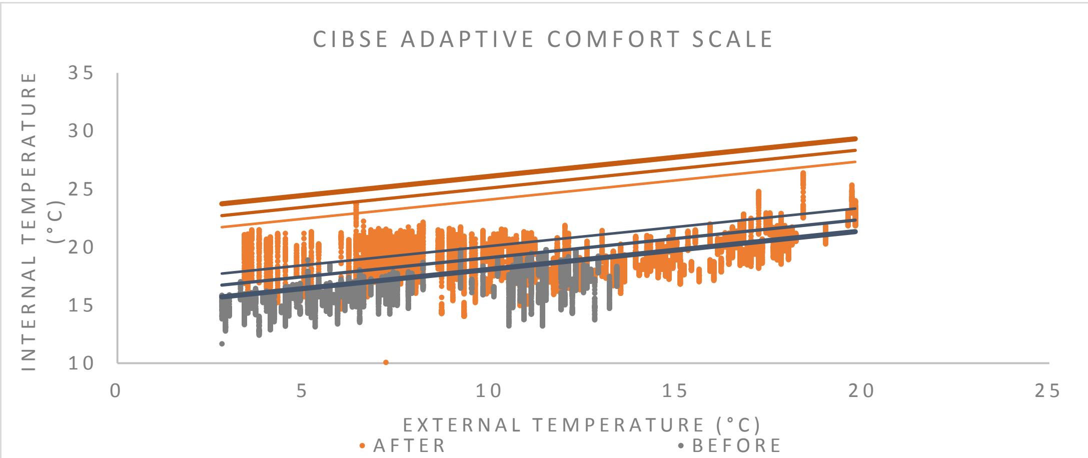
1. **Summary**; Data suggests a 60% energy reduction



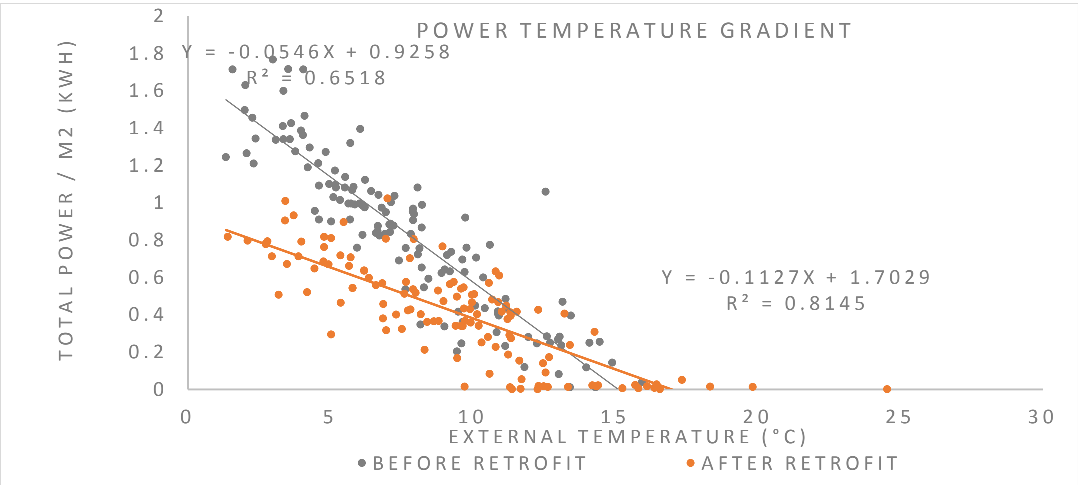
2. **Data quality**; OK, but the *before* period is very small so uncertainty is high



3. ***Comfort***; Dwelling appears more comfortable *after* retrofit



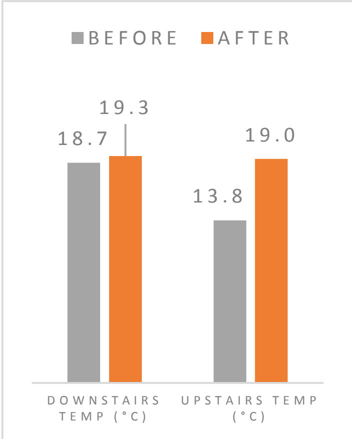
4. ***Retrofit performance;*** Apparent improvement in PTG



Property E34

Survey observations:

- Thermal bridging at eaves
- Poorly laid roof insulation
- No insulation under soffit of stairs
- Insulation cut-out at meter box, etc.
- Well ventilated internally



- Energy use appears lower *after* retrofit.
- Thermal comfort appears better *after* retrofit.
- PTG appears better *after* retrofit

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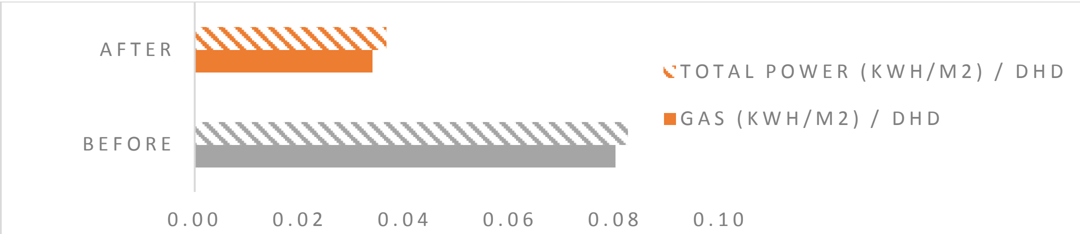
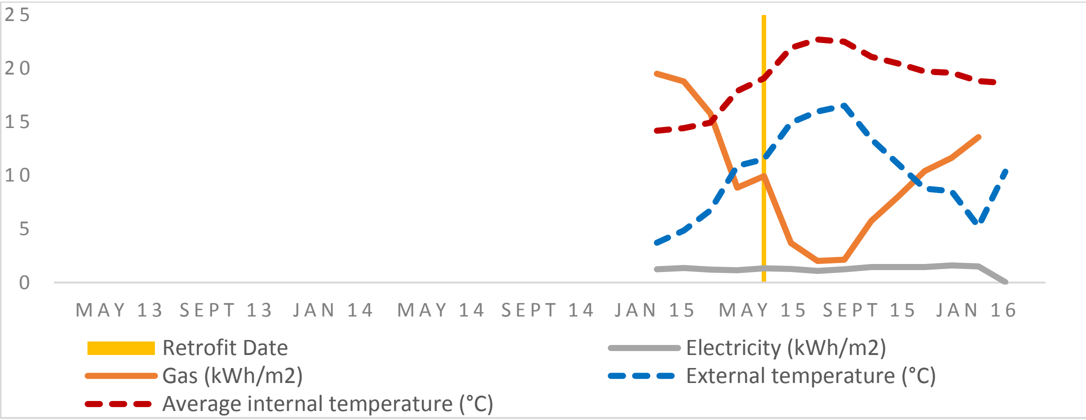
DECC, Leeds Go Early Energy Monitoring Project

End Terrace Flat (first floor), No-Fines Concrete, EWI

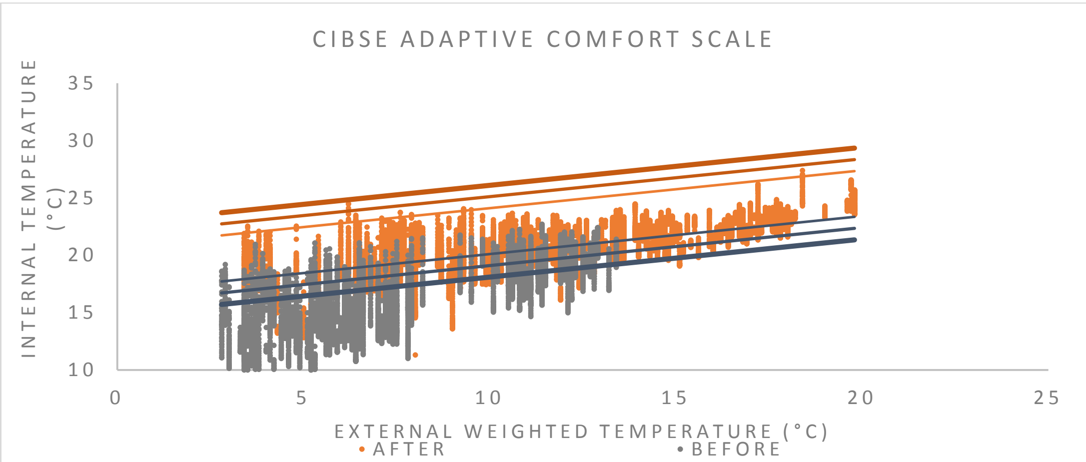
1. **Summary**; Data suggests a 56% energy reduction



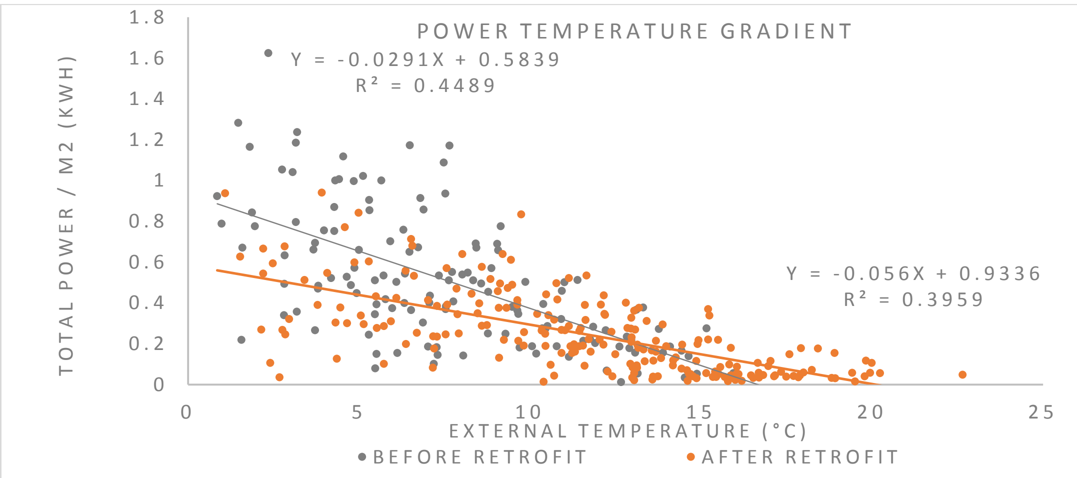
2. **Data quality**; OK, but the *before* period is very small so uncertainty is high



3. ***Comfort***; Dwelling appears more comfortable *after* retrofit



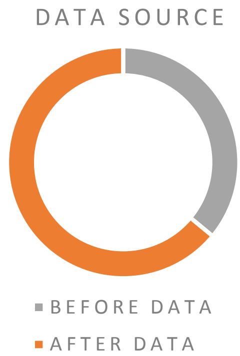
4. ***Retrofit performance;*** Apparent improvement in PTG



Property E35

Survey observations:

- Thermal bridging at eaves
- Poorly laid roof insulation
- No insulation under soffit of stairs
- Insulation cut-out at meter box, etc.



- Energy use appears lower *after* retrofit.
- Thermal comfort appears better *after* retrofit.
- PTG appears better *after* retrofit

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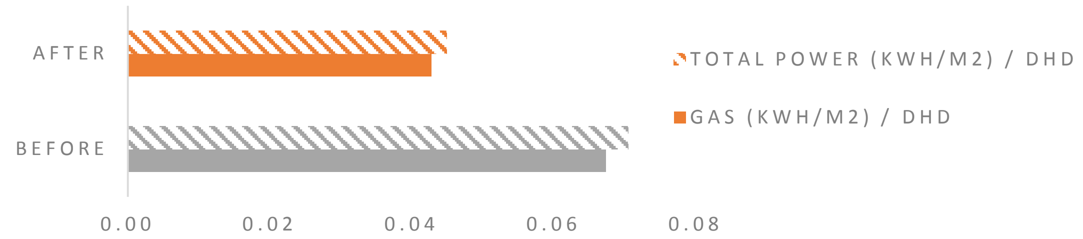
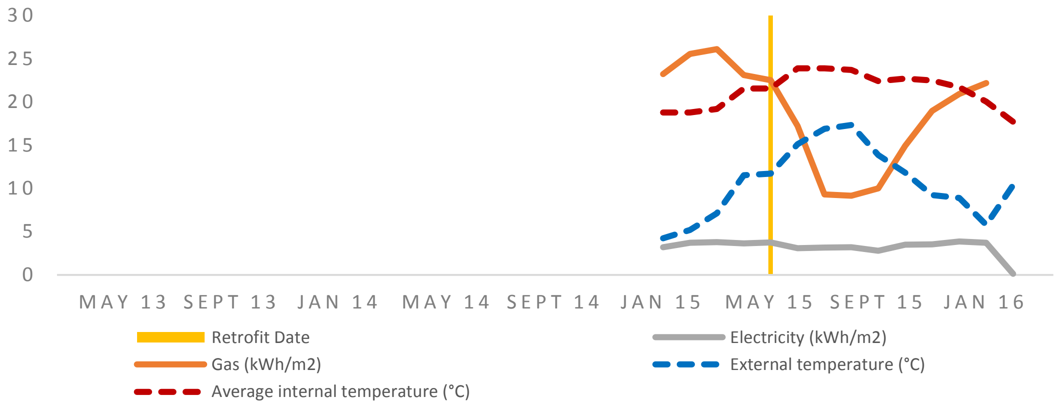
DECC, Leeds Go Early Energy Monitoring Project

End-Terrace Ground Floor Flat, No-Fines, EWI

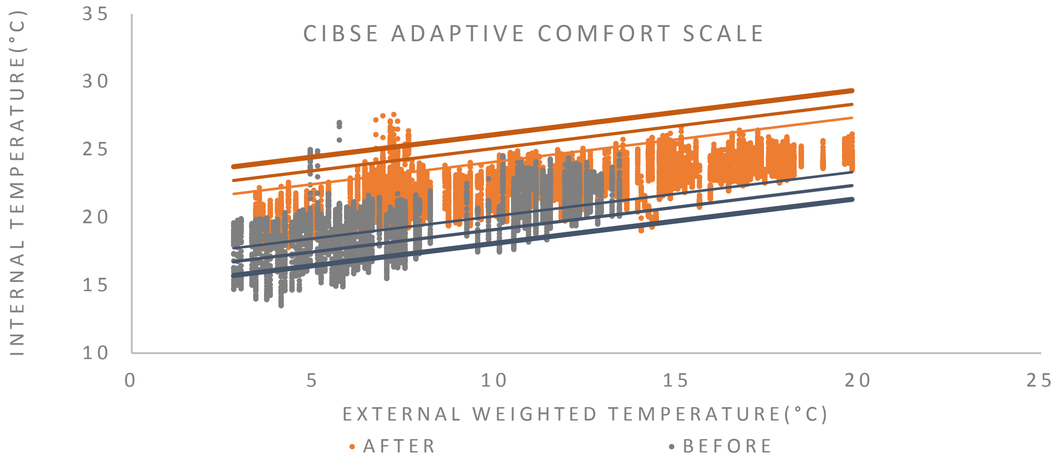
1. **Summary**; Data suggests a 37% energy reduction and £140 annual heating bill saving



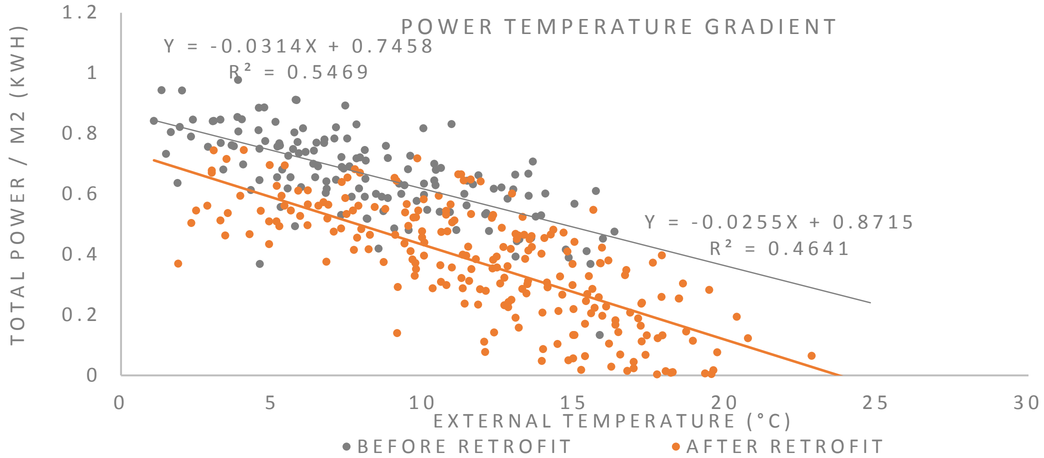
2. **Data quality**; OK, but the *before* period is small so uncertainty is high



3. ***Comfort***; Dwelling appears mostly comfortable, slightly warmer post-retrofit



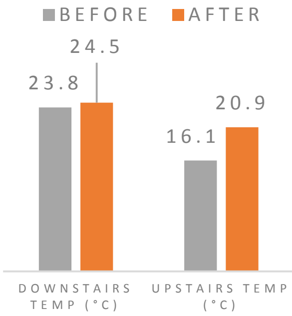
4. ***Retrofit performance;*** Data suggest an improvement in heating energy use



Property E36

Survey observations:

- Insulation cut-out at meter box, etc.
- No insulation to store wall forming external wall to bedroom
- Thermal bridge at ground floor level



- Energy use appears lower *after* retrofit, however this may be due to insufficient *before* data.
- Internal temperatures are comfortable, with possible slight improvement following retrofit.

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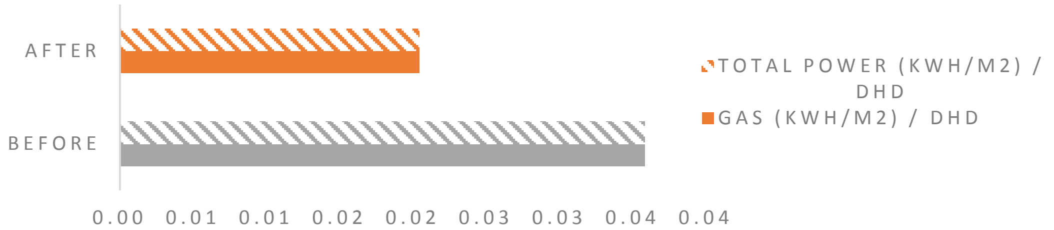
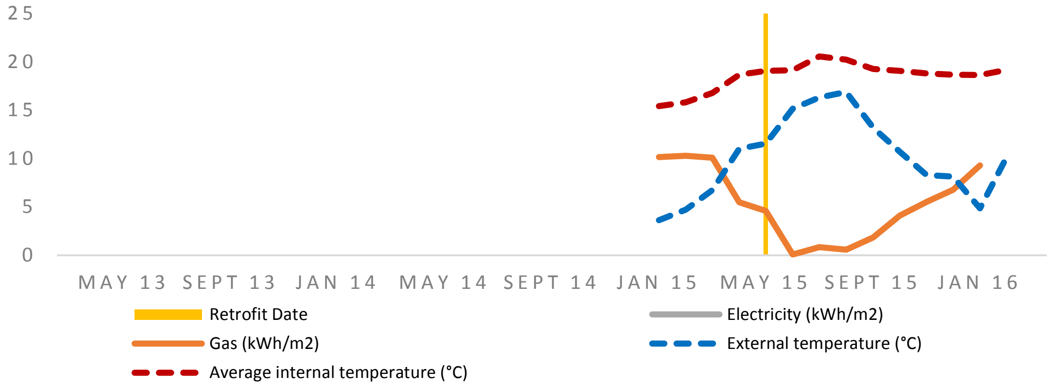
DECC, Leeds Go Early Energy Monitoring Project

Flat, No –Fines Concrete, EWI

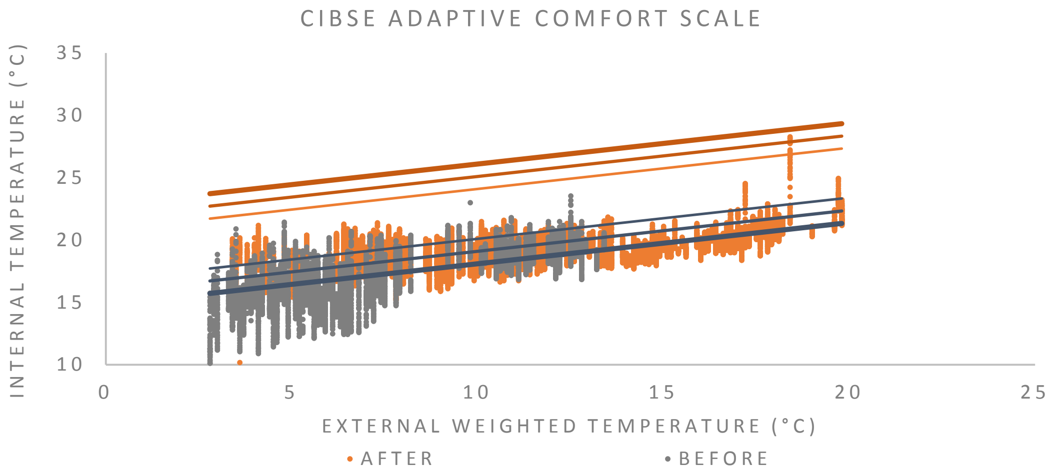
1. **Summary**; Data suggests a 45% energy reduction in energy use post-retrofit



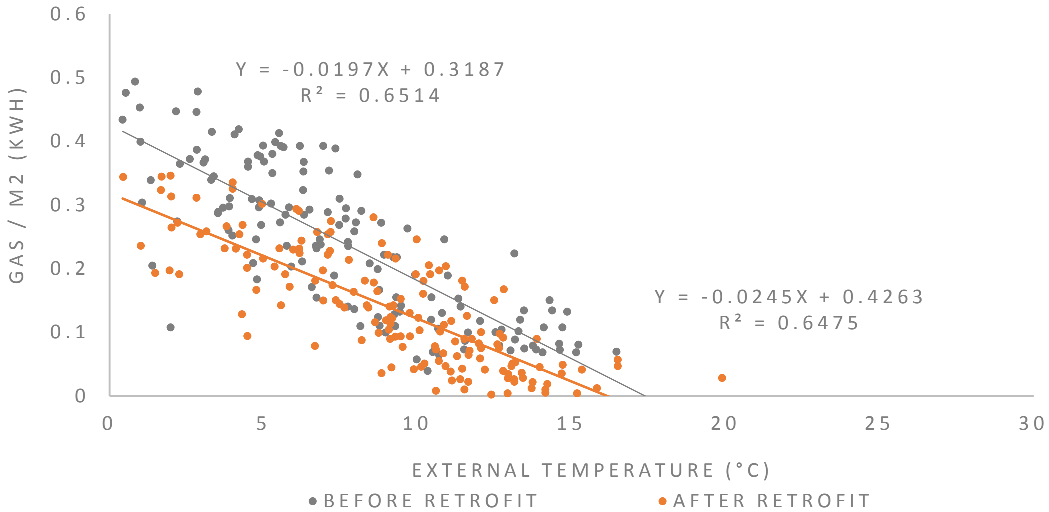
2. **Data quality**; OK, but the *before* period is small leading to uncertainty.



3. ***Comfort***; Dwelling appears more comfortable following retrofit



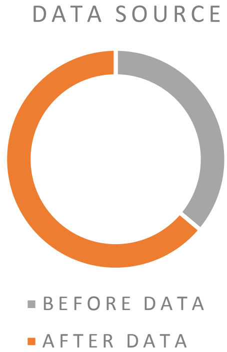
4. ***Retrofit performance;*** No electricity data, however gas appears reduced

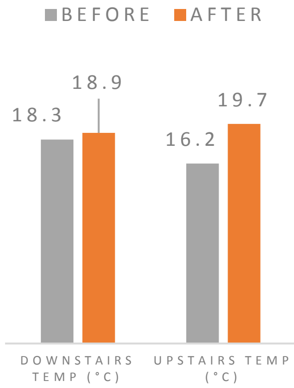


Property E37

Survey observations:

- Insulation cut-out at meter box, entrance porch roof, rear garden wall abutting house etc.
- Thermal bridge at eaves & ground floor level





- Energy use is lower *after* retrofit although this is inconclusive due to low winter *before* data
- Dwelling appears warmer *after* retrofit during cold periods.

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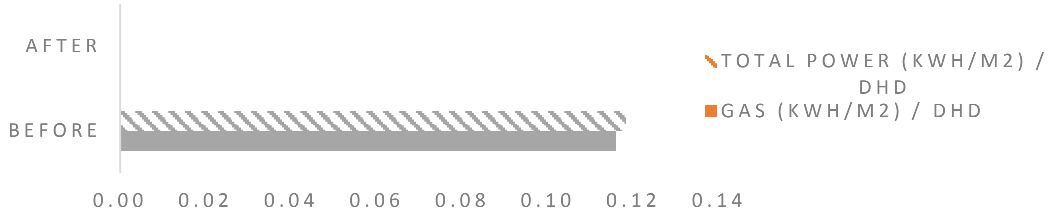
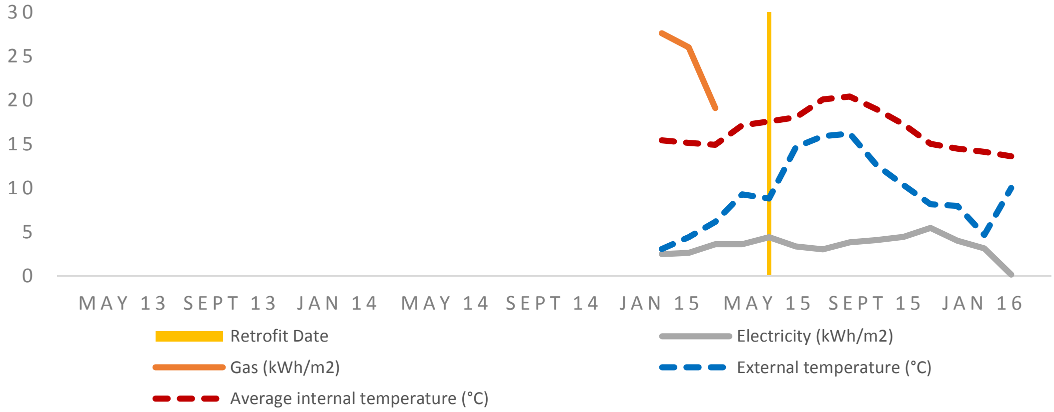
DECC, Leeds Go Early Energy Monitoring Project

Terrace, No-fines Concrete, EWI

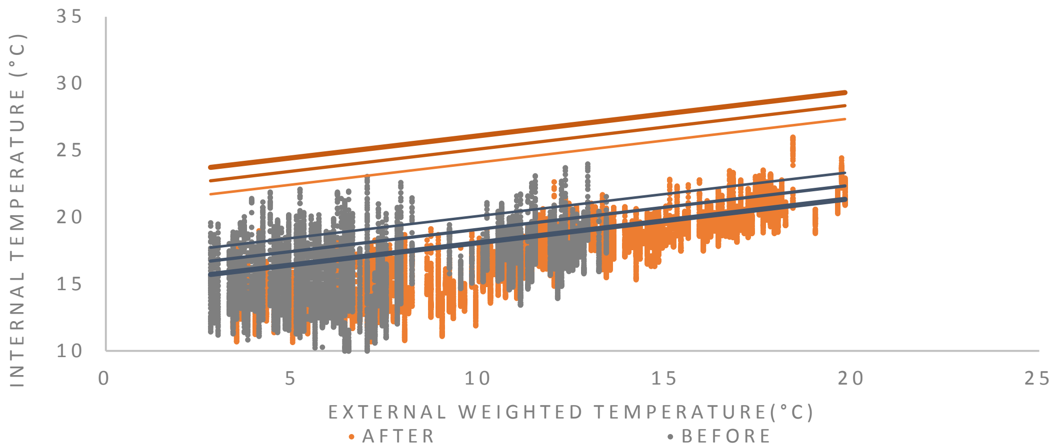
1. **Summary**; No *after* gas data limiting analysis



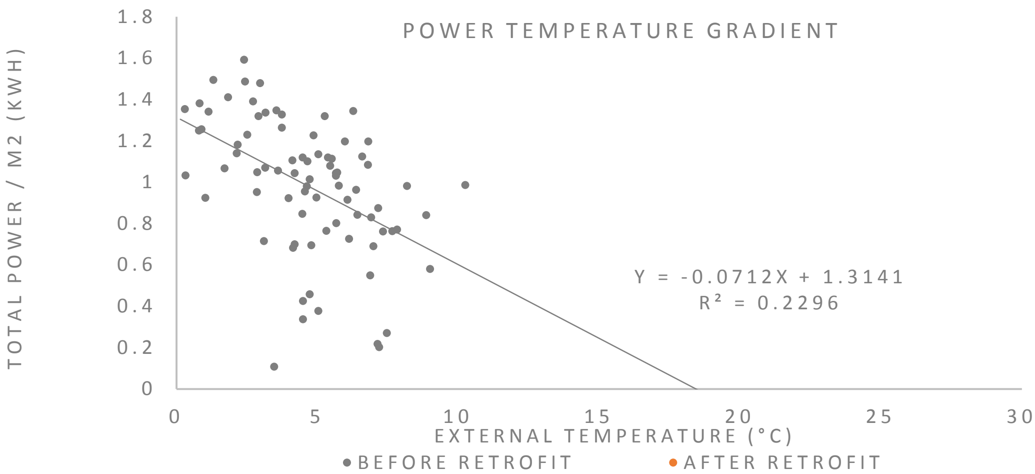
2. **Data quality**; OK, but the *before* period is very small so uncertainty is high



3. ***Comfort***; Dwelling appears cool both *before* and *after* retrofit



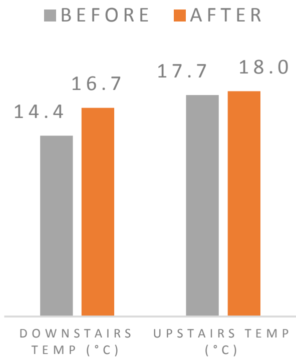
4. ***Retrofit performance; M**ore energy is used when it is cold outside*



Property E38

Survey observations:

- Insulation cut-out at meter box, entrance hall roof, adjacent property roof abutting gable etc.
- Thermal bridge at eaves & ground floor level



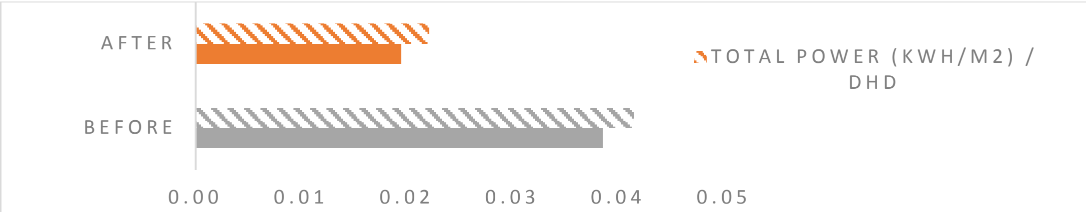
- Lack of gas use data limits analysis
- Internal temperature appears cool both before and after retrofit.

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

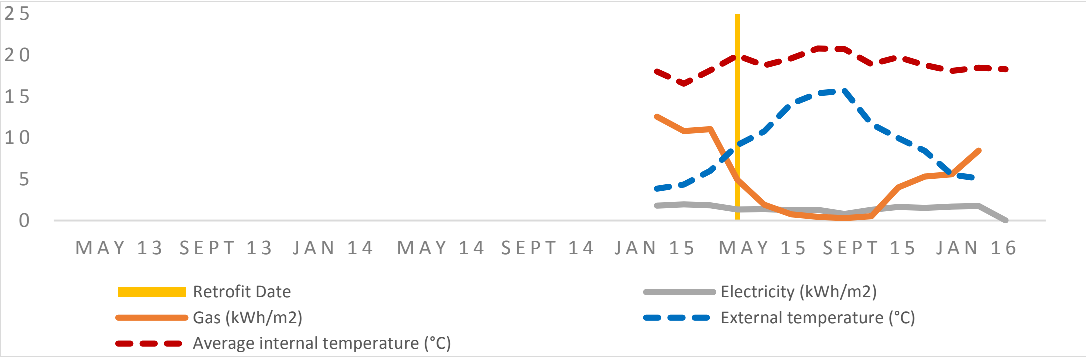
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Brick, EWI

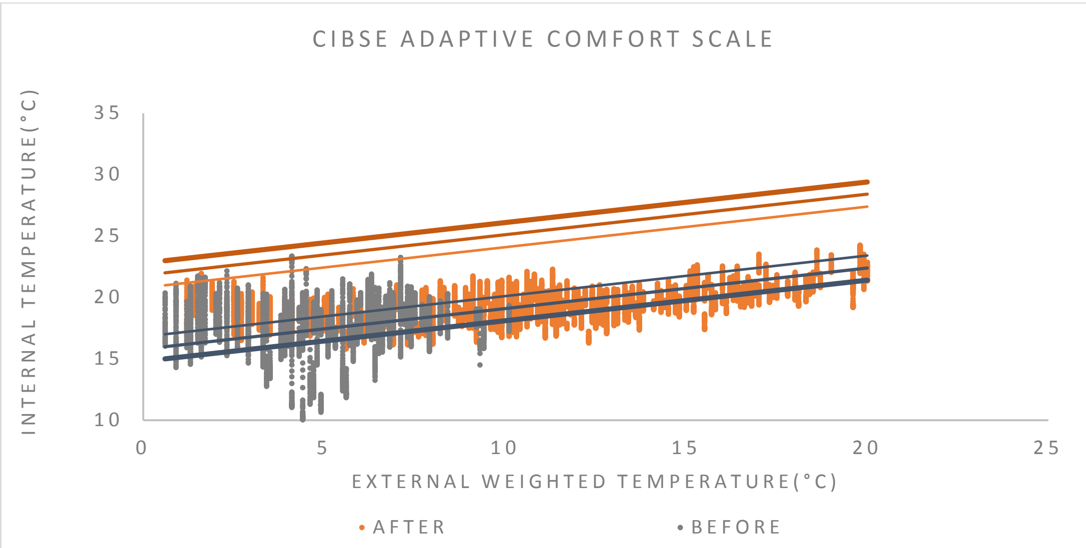
1. **Summary**; Data suggests a 47% reduction in energy use.



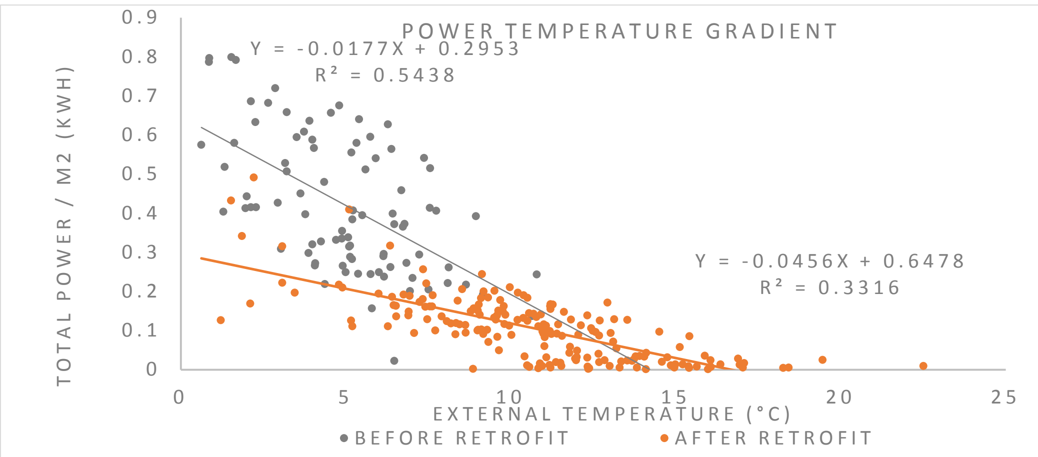
2. **Data quality**; OK, but the *before* period is small so uncertainty is high



3. ***Comfort***; Dwelling appears more comfortable *after* during colder period.



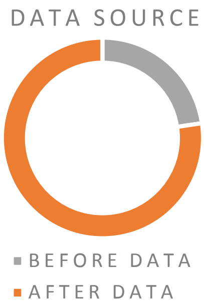
4. ***Retrofit performance;*** heating energy use appears reduced following retrofit

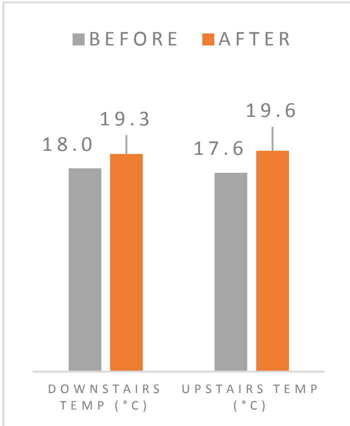


Property E39

Survey observations:

- Thermal break between kitchen and conservatory
- Thermal break at uninsulated stairs to basement & basement ceiling
- Thermal bridging at eaves sloping soffits





- Energy use is lower *after* retrofit
- Few *before* data points limits analysis.
- Heating energy use appears to improve following retrofit.

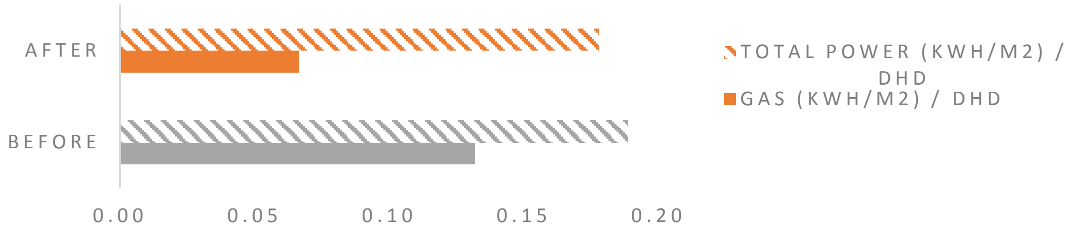
Leeds Beckett University
Leeds Sustainability Institute

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

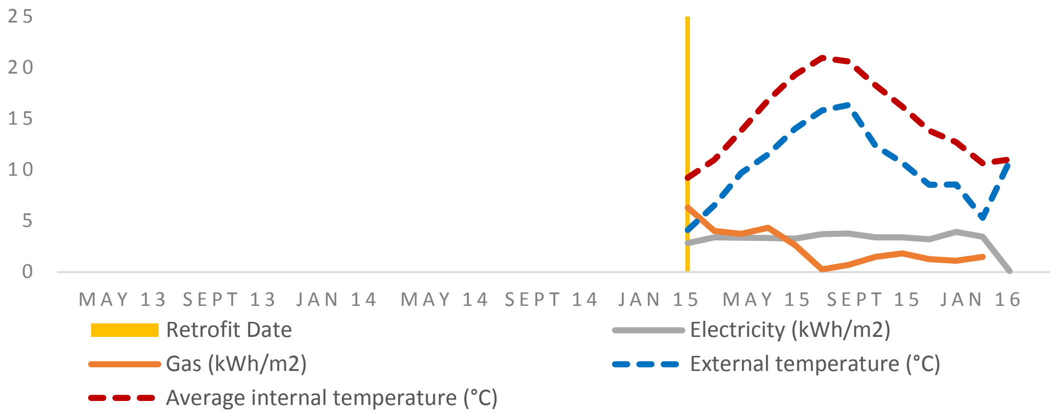
DECC, Leeds Go Early Energy Monitoring Project

Terraced Flat, Brick, EWI

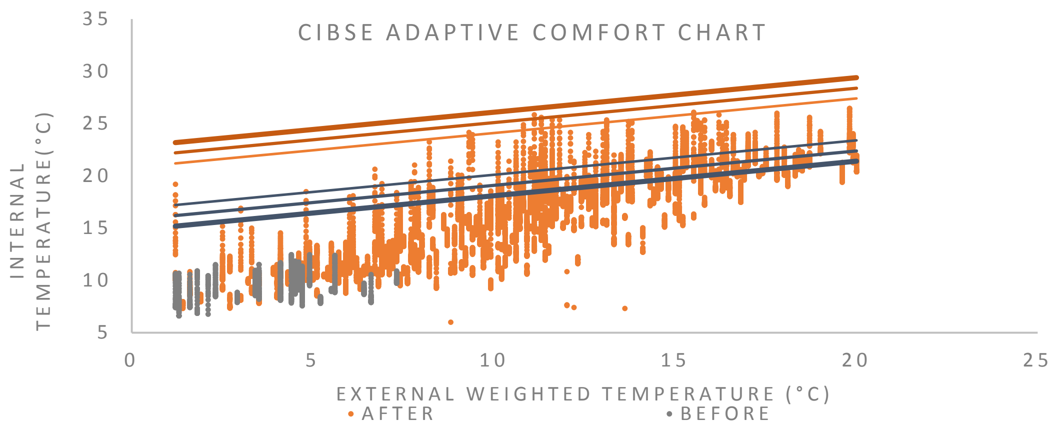
1. **Summary**; Data suggests a 50% gas reduction although *before* period is short.



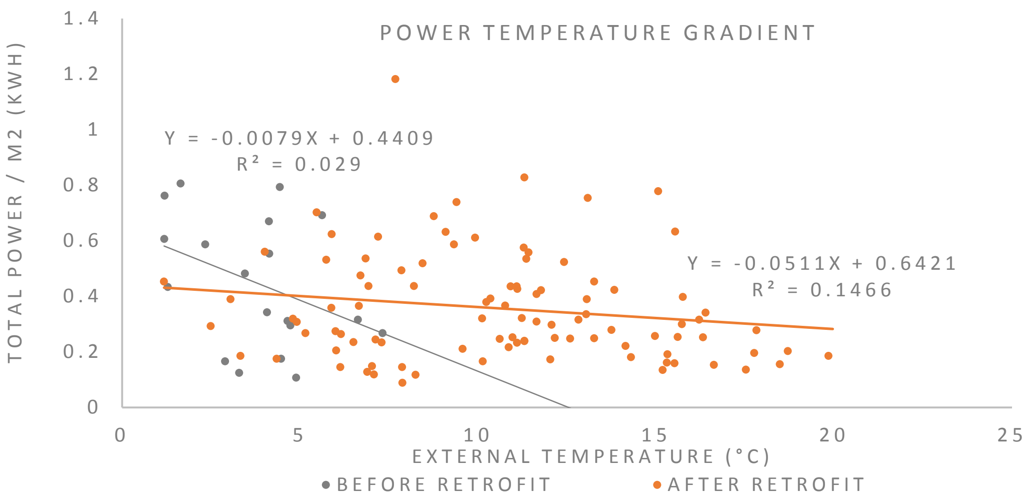
2. **Data quality**; OK, but the *before* period is very small so uncertainty is high



3. ***Comfort***; Dwelling appears uncomfortable *before* and *after* retrofit.



4. ***Retrofit performance; less energy used for heating after retrofit***

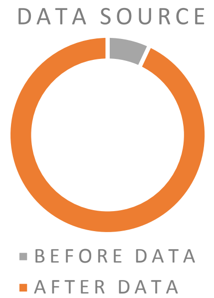


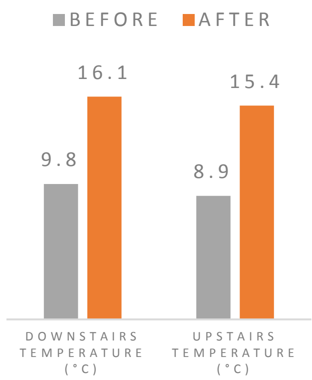
Property E40

No Image

Survey observations:

- No Survey





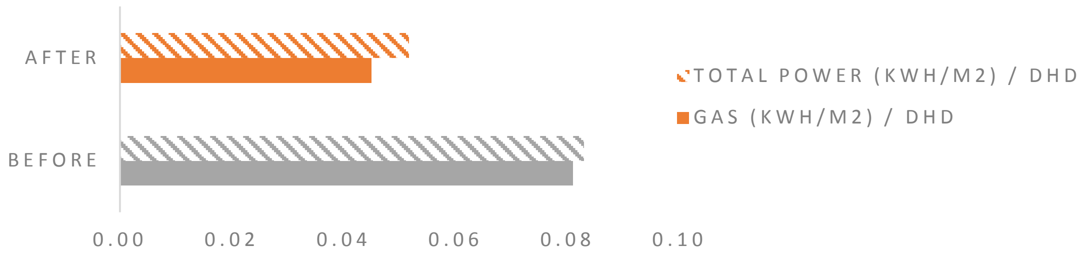
- Energy use appears lower *after* retrofit
- Few *before* data points cause high uncertainty
- Dwelling appears uncomfortably cool during winter.

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

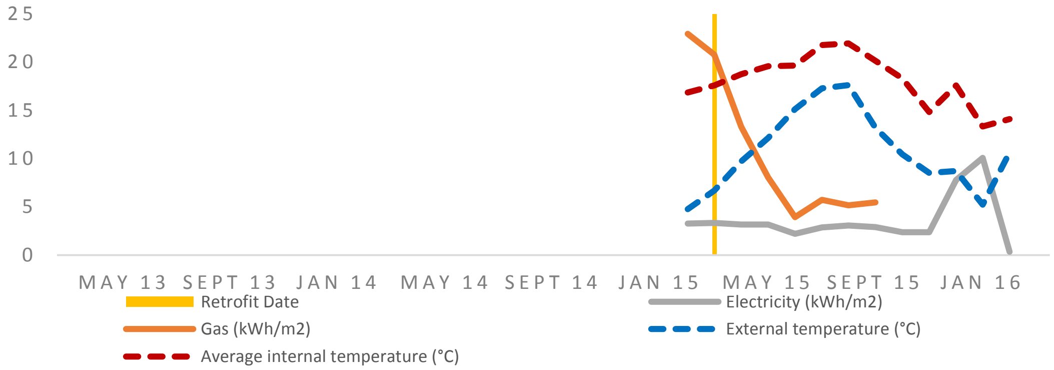
DECC, Leeds Go Early Energy Monitoring Project

End-terraced Flat, Brick, EWI

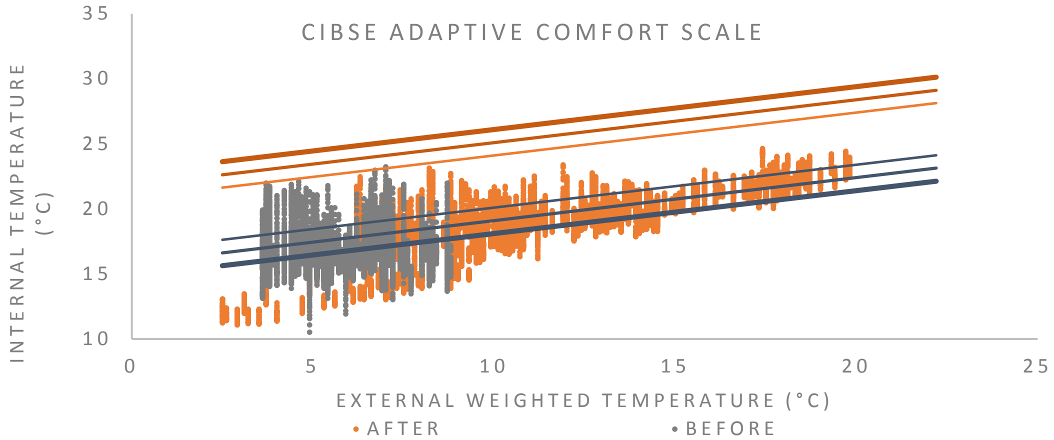
1. **Summary**; Data suggests a 38% reduction in total power.



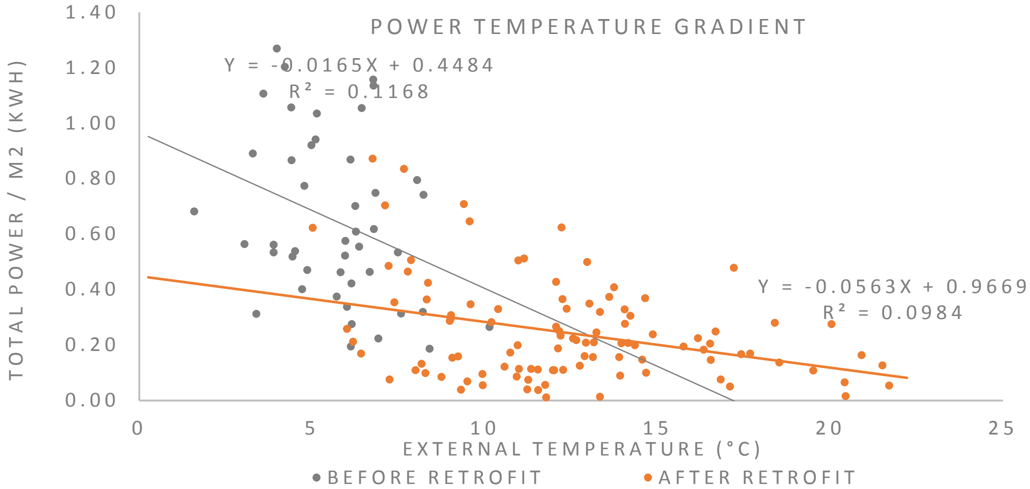
2. **Data quality**; *Before* period is very small and loss of Gas data, uncertainty is high



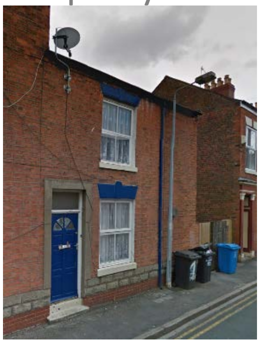
3. ***Comfort***; Dwelling appears largely comfortable *before* retrofit, and less so *after*.



4. ***Retrofit performance;*** Apparent improvement in heating energy consumption

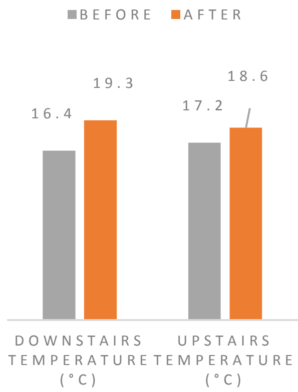


Property E41



Survey observations:

- No Survey



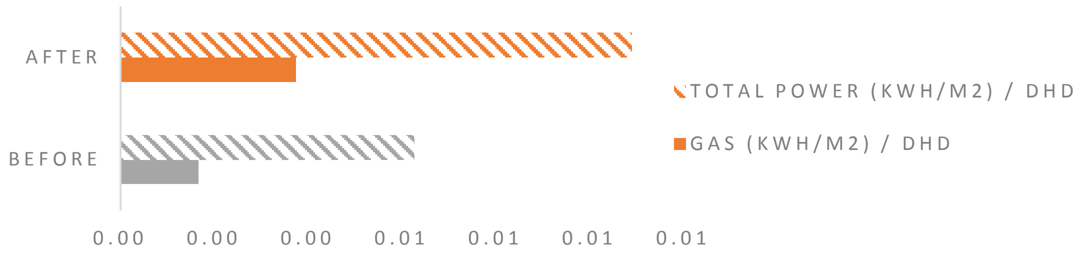
- Energy use appears lower *after* retrofit
- Few *before* data points cause uncertainty
- Temperatures appear less comfortable during winter following retrofit.

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

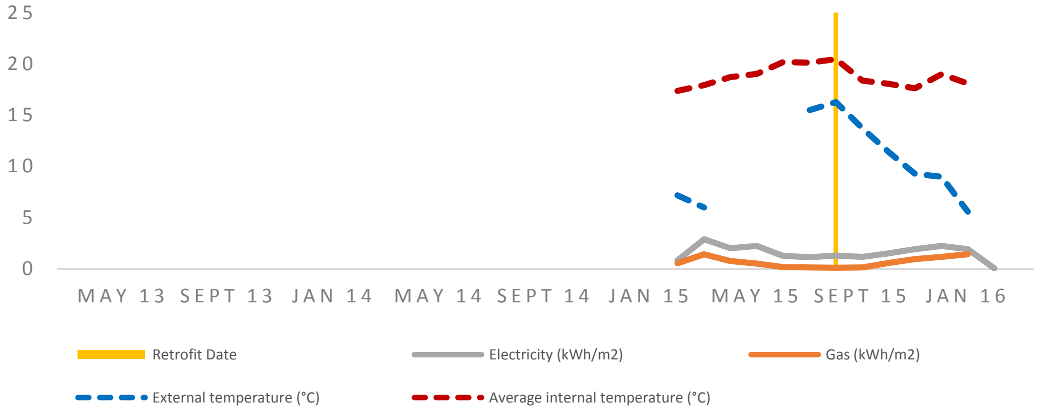
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Brick/Block, EWI

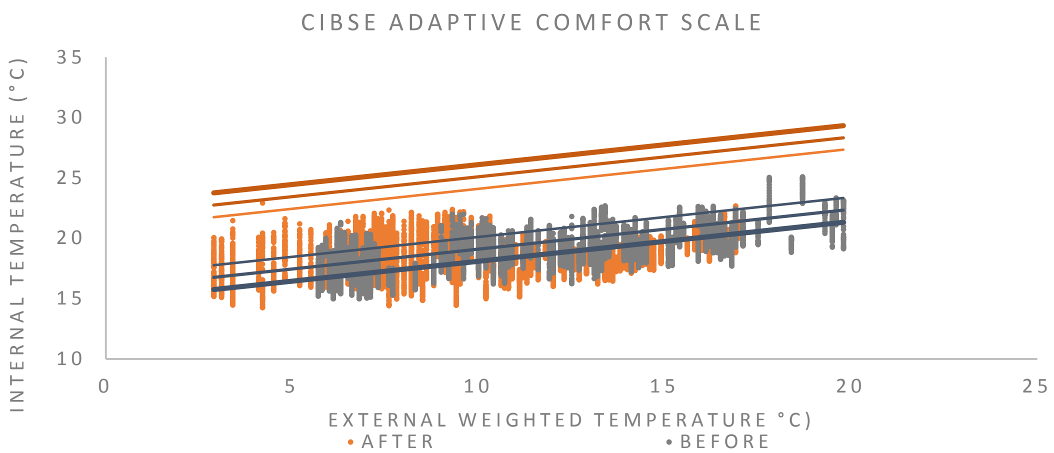
1. **Summary**; Data suggest property is using double the energy post-retrofit.



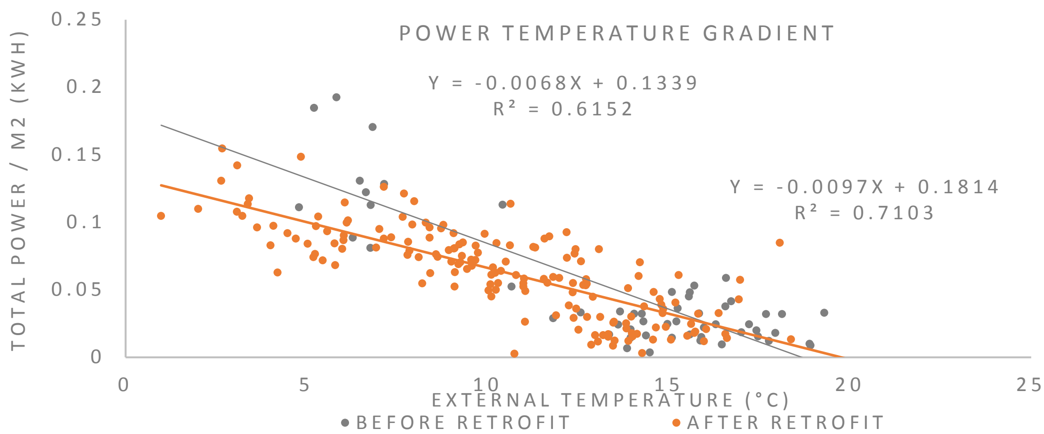
2. **Data quality**; Short monitoring period with little before weather data.



3. ***Comfort***; Dwelling appears mostly comfortable, with no change post-retrofit.



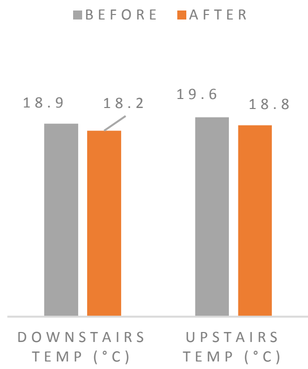
4. ***Retrofit performance; Less energy used for heating after retrofit***



Property E42

Survey observations:

- No survey



- Energy use is higher *after* retrofit – likelihood is that this is due to majority of *after* period during colder months.
- PTG suggests improvement over longer term.

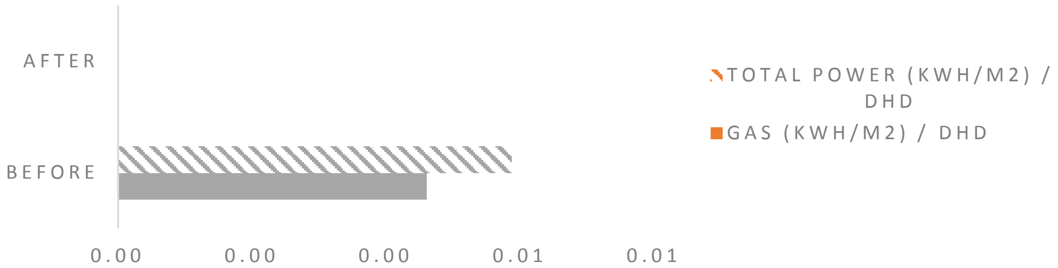
Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

DECC, Leeds Go Early Energy Monitoring Project

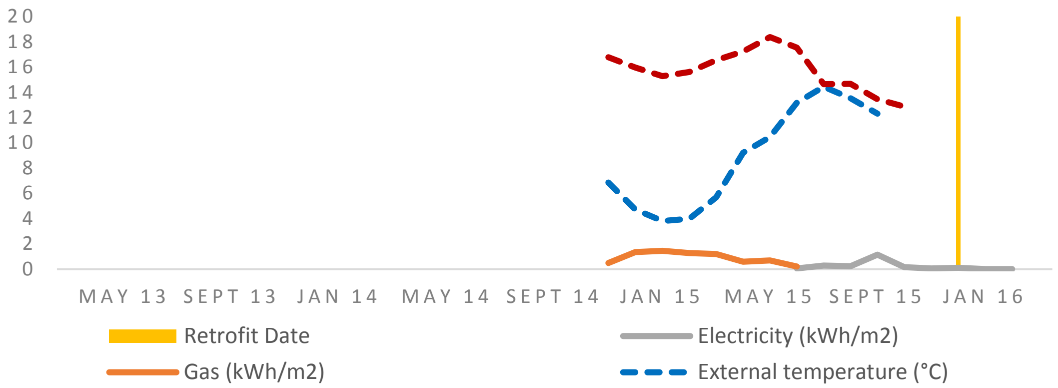
Property E43

Detached, Stone, IWI and loft insulation

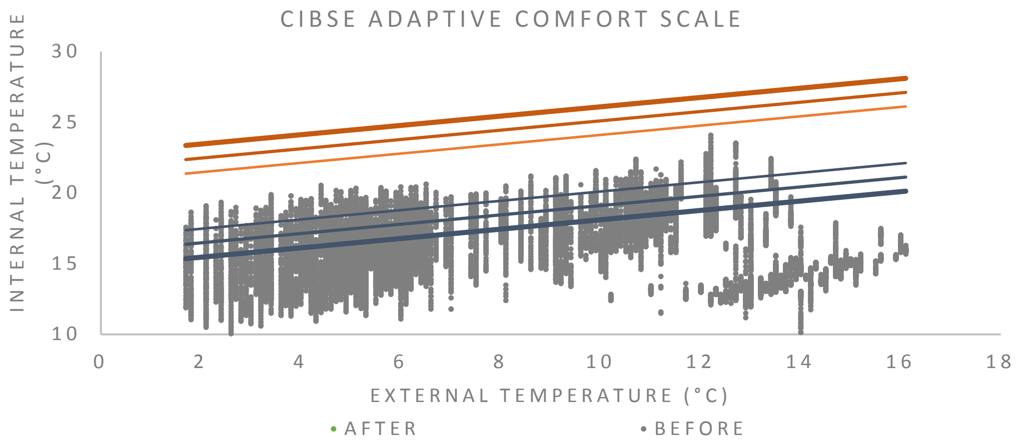
1. **Summary**; bespoke retrofit but *after*-retrofit comparison data unavailable.



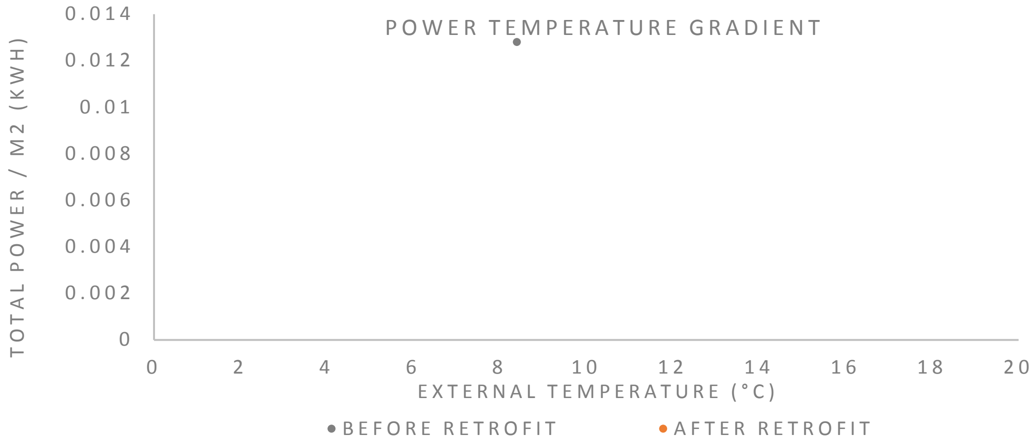
2. **Data quality**; only *before* data for temperature with little *after* data. Sensor failure



3. ***Comfort***; Dwelling cool before retrofit. Difficult to control

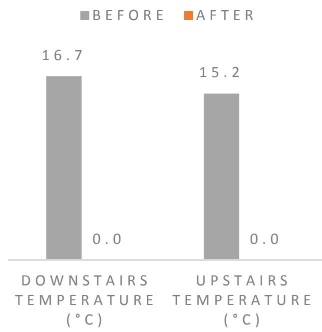


4. ***Retrofit performance;*** Insufficient data for comparison



Survey observations:

- Minimal thermal breaks designed in
- Some reduced insulation sections due to building design



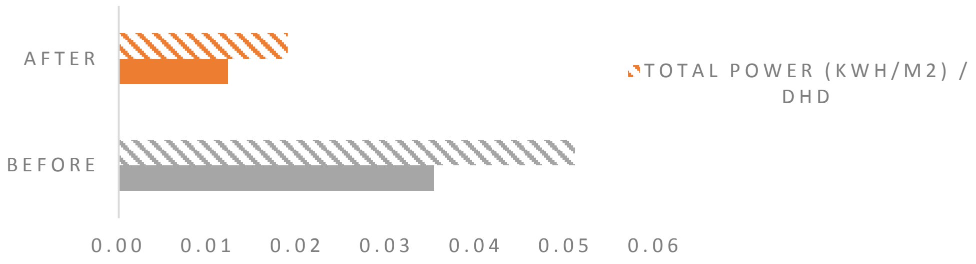
- Insufficient data for analysis.
- Low temperature pre-retrofit.

Contact: Dr David Glew

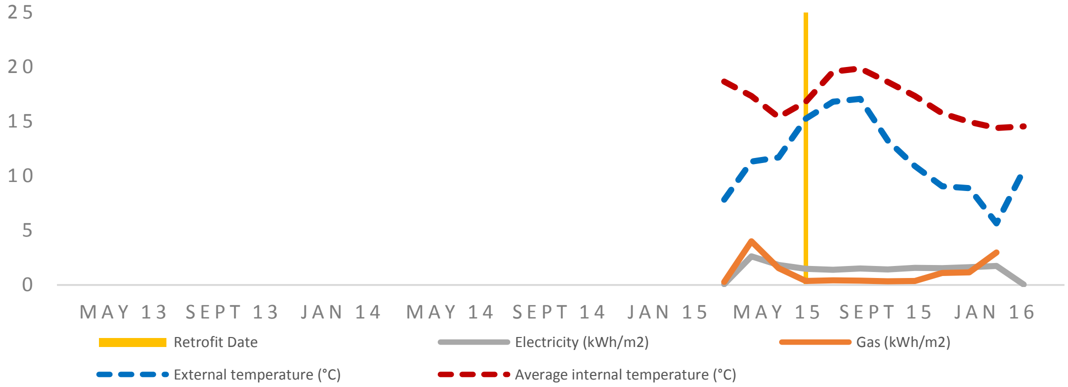
DECC, Leeds Go Early Energy Monitoring Project

Flat, Concrete, EWI

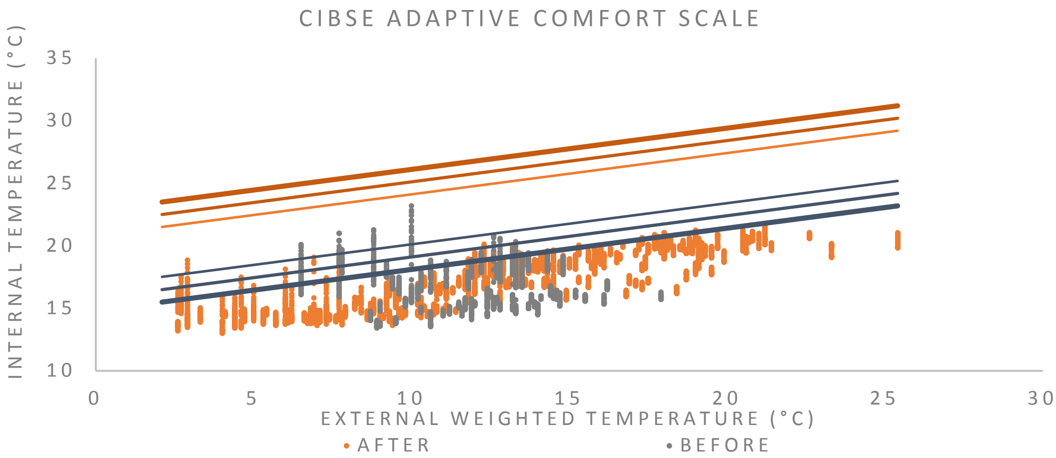
1. **Summary**; Data suggests a 60% energy reduction and £145 annual heating bill saving



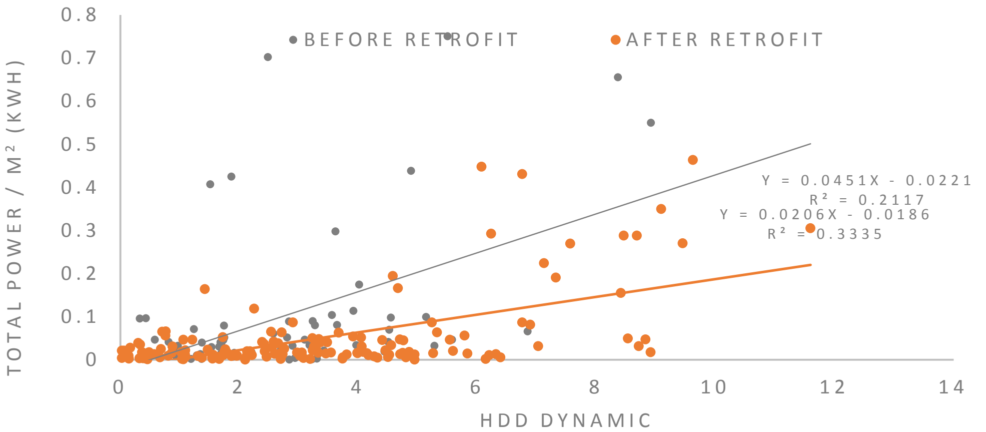
2. **Data quality**; OK, but the *before* period is small so uncertainty is high



3. ***Comfort***; Dwelling appears cool both before and after retrofit.



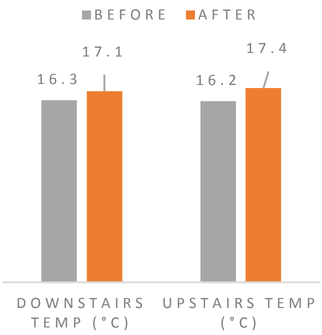
4. ***Retrofit performance;*** Energy performance appears to improve following retrofit.



Property E44

Survey observations:

- No Survey



- Energy use is lower *after* retrofit
- Few *before* data points
- Temperatures remain low after retrofit.

Leeds Beckett University
Leeds Sustainability Institute

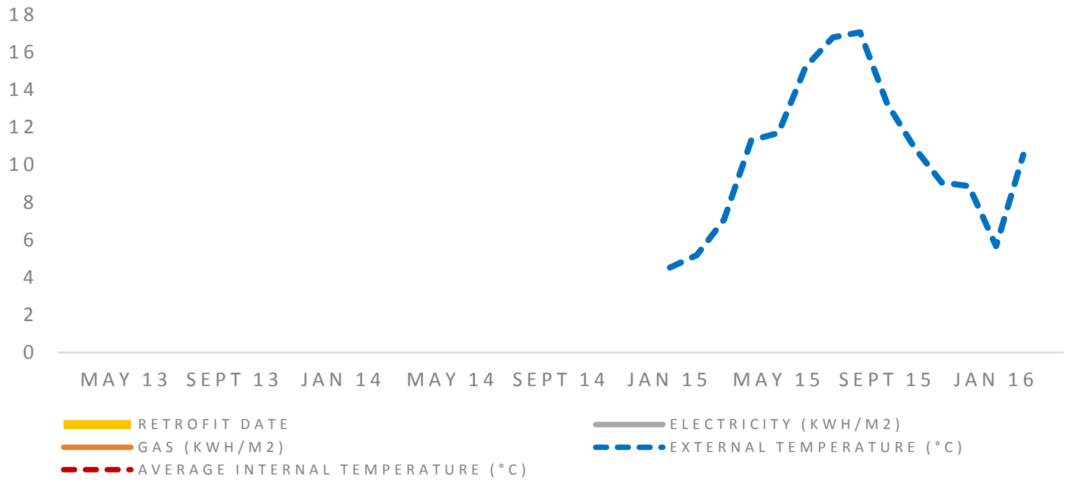
Contact: Dr David Glew

DECC, Leeds Go Early Energy Monitoring Project

Intermediate level flat, Concretes, EWI

1. **Summary**; UNTRUSTWORTHY DATA SET – very high uncertainty

2. **Data quality**; Poor, no *before* data and no gas use data



3. ***Comfort***; Insufficient data

No Data

4. ***Retrofit performance;*** unknown due to lack of before data

No Data

Property E45

Survey observations:

- Historic mould from condensation pre-treatment not cleared
- Bathroom/rear balcony wall still damp with mould

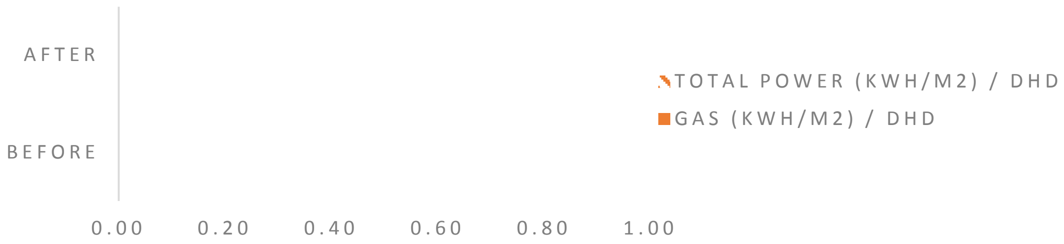
- No before data to allow savings comparison.
- Occupant chooses to have low internal temperature.

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

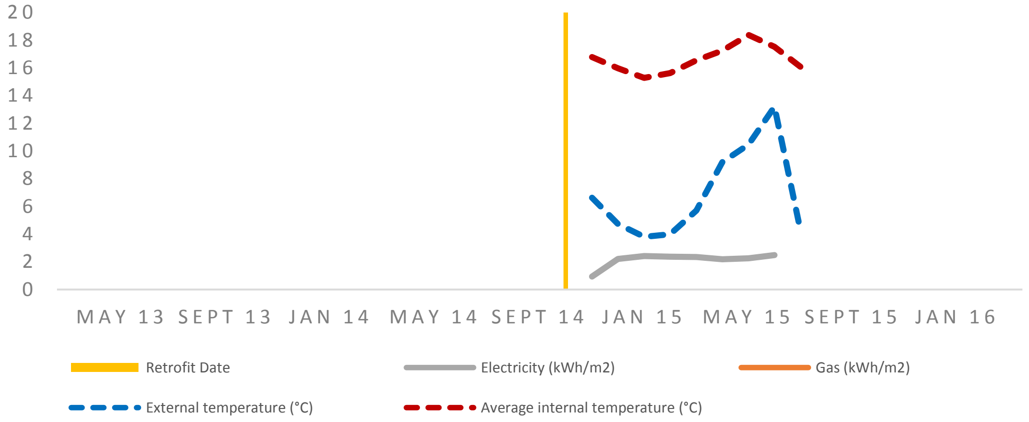
DECC, Leeds Go Early Energy Monitoring Project

Semi-detached, Steel frame and concrete, EWI

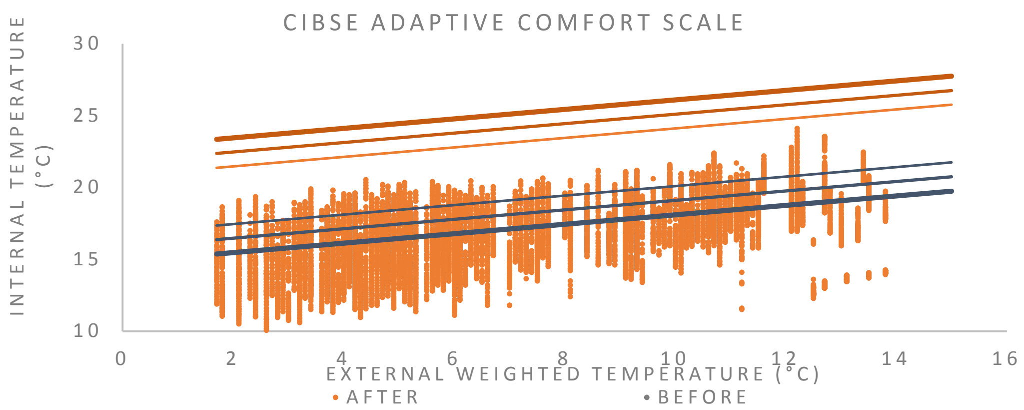
1. **Summary**; No Gas data



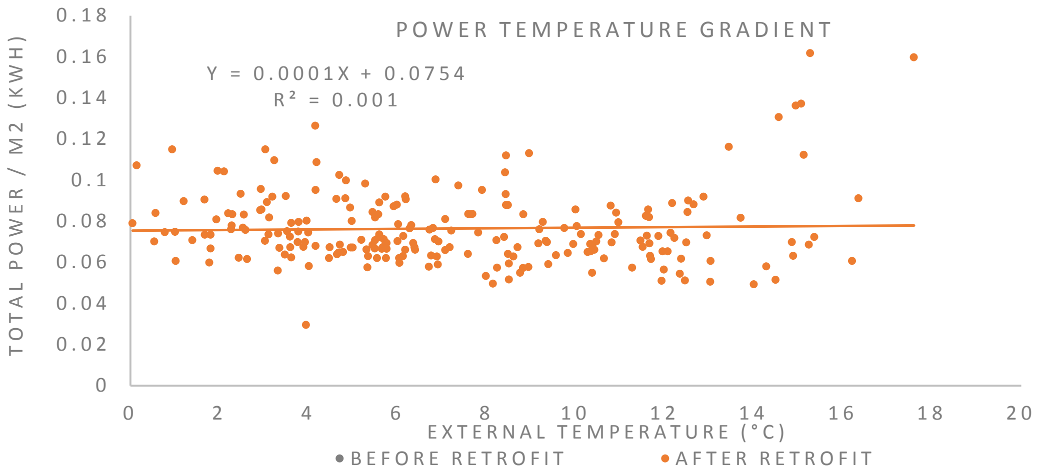
2. **Data quality**; Poor, no *before* data and no gas use data



3. ***Comfort***; Dwelling cool with conditions variable – occupant choice.



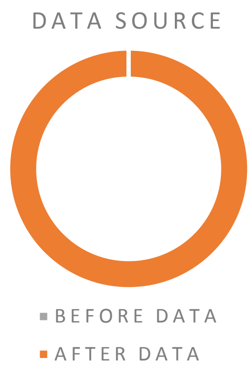
4. ***Retrofit performance;*** unknown due to lack of before data

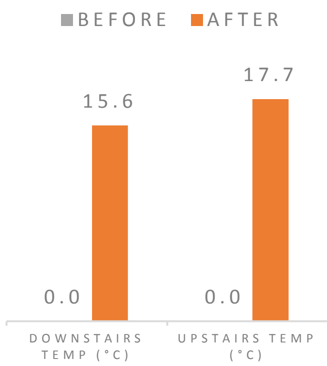


Property E46

Survey observations:

- Occupant has low level of heating
- EWI finishes above FFL
- BCIS system dry-lined, possible thermal bypass
- Insulation cut-outs
- Minimal loft & flat roof insulation





- No before data to allow savings comparison.
- Occupant chooses to have low internal temperature.

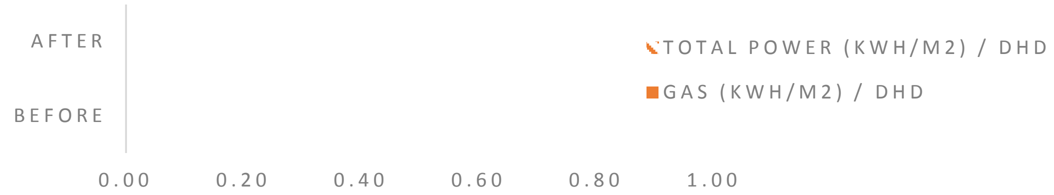
Leeds Beckett University
Leeds Sustainability Institute

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

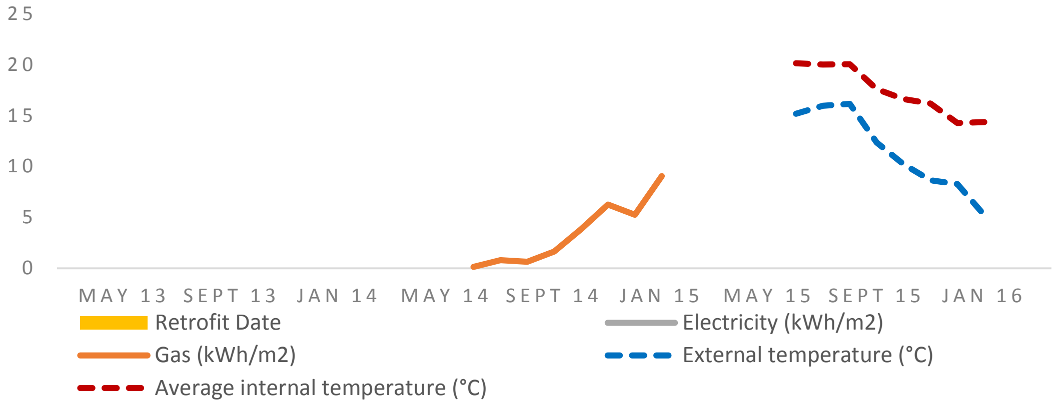
DECC, Leeds Go Early Energy Monitoring Project

Detached, Stone, 1880s, NO INTERVENTION

1. **Summary**; No Intervention



2. ***Data quality***; Very poor, no period of concurrent energy and temperature data.



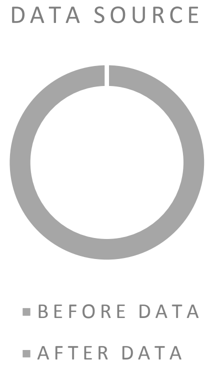
Property E47

No Image

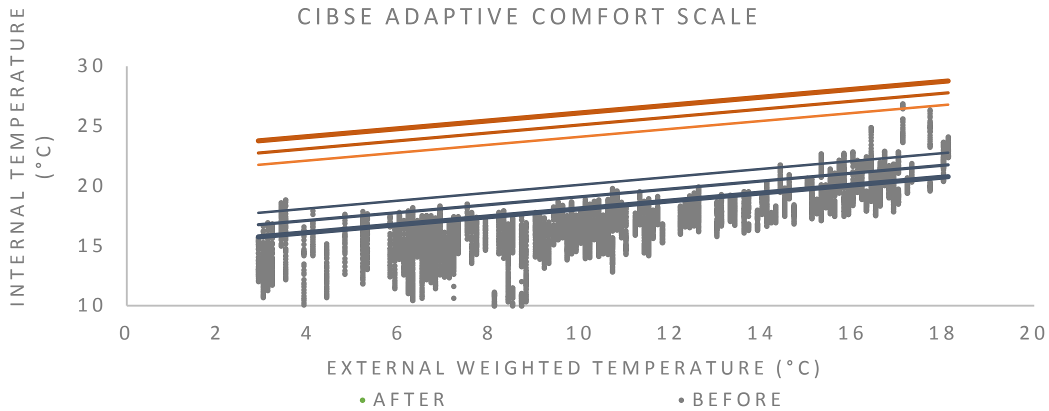
Survey observations:

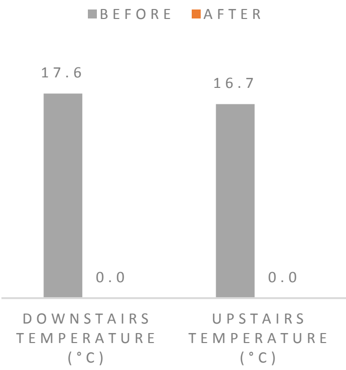
- No Survey

3. ***Comfort***; Dwelling

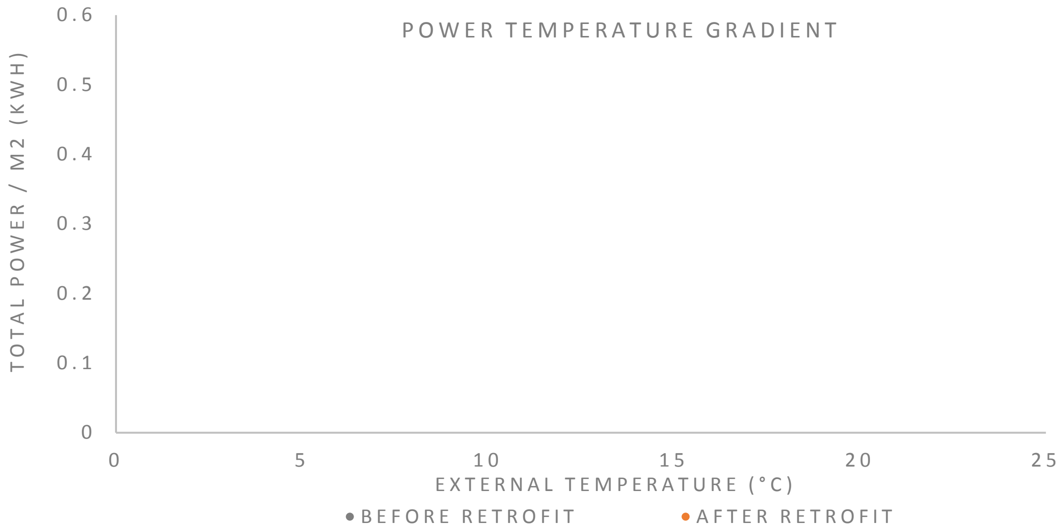


appears uncomfortably cold.





4. ***Retrofit performance;*** Insufficient data



- Insufficient data to draw meaningful conclusions.
- Zero *After* data points
- Temperature appears uncomfortable cool.

Contact: Dr David Glew
d.w.glew@leedsbeckett.ac.uk

Appendix J. T1 Interview guide

DECC Green Deal Go Early T1 Interview Topic Guide

Version 2

Briefing and consent

1. **First of all I'd like to talk about your home.**
   How long have you lived here? Is it rented or owned? If rented, who from? Who lives here with you? What is a typical day for you: are you in most of the day, or out or does it vary? What about the evenings? What do you like about your home? What do you dislike? How do you heat your home? (prompts: central heating, gas or electric fires, extra heating such as portable heaters) Do you tend to heat all the house or just the rooms are you using? Why? Are you happy with how warm your house gets? Why/why not? How much it costs to heat? Why/why not? How do you pay your energy bills? (pre-pay, weekly/monthly or per bill) Are your energy bills easy for you to pay or is it a bit of a struggle? Roughly what proportion of your income do you spend on energy bills? Do you make any special efforts to reduce your energy bills at the moment? (What and why?) How do you control the temperature? (prompts: heating controls, easy to use, understandable, effective) Do you tend to turn the heating up as much as you need, or not? Why? (prompts: cost, heating controls, different people's preferences) Are you happy with the air quality, such as how stuffy or humid it gets? Why?

2. **Now I'd like you to show me what we've been talking about – can you walk me around your home to show me the rooms - where it is warm enough and where it is cold or drafty?**
   How do you use this room? Does it get warm enough? Will there be any improvements in here? What difference do you think it will make? Why?

3. **Now I'd like to talk about the improvement scheme.**
   How did you hear about the scheme? (prompts: LCC contact, media, word of mouth). What did you think of the scheme? Why? What appealed to you about it? (prompts: saving money, being warmer, help health conditions, being eco-friendly, other people are doing it, subsidised or free improvements) Did anything put you off it? What do your friends and family think about it? Why? What improvements are you going to get? What made you decide on these?

4. **Finally, I'd like to talk about the difference the improvements will make.**
   What difference do you think it will make to you? Your family? To how you use your home? To your family's health? To your carbon footprint? To your energy bills? How much warmer do you think your home will get? How much money do you think you will save? Why? What is the most important thing that will change? Why is that most important?

Anything else we've not yet talked about?

Thank you and debrief.

Appendix K. T2 Interview guide

DECC Green Deal Go Early T1 Interview Topic Guide

Version 2

Briefing and consent

1. **First of all I'd like to talk about your home.**
   How long have you lived here? Is it rented or owned? If rented, who from? Who lives here with you? What is a typical day for you: are you in most of the day, or out or does it vary? What about the evenings? What do you like about your home? What do you dislike? How do you heat your home? (prompts: central heating, gas or electric fires, extra heating such as portable heaters) Do you tend to heat all the house or just the rooms are you using? Why? Are you happy with how warm your house gets? Why/why not? How much it costs to heat? Why/why not? How do you pay your energy bills? (pre-pay, weekly/monthly or per bill) Are your energy bills easy for you to pay or is it a bit of a struggle? Roughly what proportion of your income do you spend on energy bills? Do you make any special efforts to reduce your energy bills at the moment? (What and why?) How do you control the temperature? (prompts: heating controls, easy to use, understandable, effective) Do you tend to turn the heating up as much as you need, or not? Why? (prompts: cost, heating controls, different people's preferences) Are you happy with the air quality, such as how stuffy or humid it gets? Why?

2. **Now I'd like you to show me what we've been talking about – can you walk me around your home to show me the rooms - where it is warm enough and where it is cold or drafty?**
   How do you use this room? Does it get warm enough? Will there be any improvements in here? What difference do you think it will make? Why?

3. **Now I'd like to talk about the improvement scheme.**
   How did you hear about the scheme? (prompts: LCC contact, media, word of mouth). What did you think of the scheme? Why? What appealed to you about it? (prompts: saving money, being warmer, help health conditions, being eco-friendly, other people are doing it, subsidised or free improvements) Did anything put you off it? What do your friends and family think about it? Why? What improvements are you going to get? What made you decide on these?

4. **Finally, I'd like to talk about the difference the improvements will make.**
   What difference do you think it will make to you? Your family? To how you use your home? To your family's health? To your carbon footprint? To your energy bills? How much warmer do you think your home will get? How much money do you think you will save? Why? What is the most important thing that will change? Why is that most important?

Anything else we've not yet talked about?

Thank you and debrief.

Appendix L. T3 Interview guide

DECC Green Deal Go Early T3 Interview Topic Guide

Briefing and consent

1. **First of all I'd like to talk about the improvements that you have had done.** What improvements did you have done? Did the work happen as you expected? Are you happy with the quality of the work? Why/why not? What difference did you think it would make? Has it actually made any difference? E.g. How drafty your house is? How warm it is? How quickly your home heats up? How warm it stays? How long you have the heating on for? How much it costs to heat?

2. **Let's look at the information the sensors have been collecting.**
This is how much gas/electricity you've used. Does this feel about right to you?
This is the internal temperature in your home. Have you noticed this difference?

3. **Now I'd like to check if anything about your family has changed since the improvements.** Who lives here with you? Has that changed? Has anything changed in the way in which you're using the different rooms in the house? Through the day? In the evening? Do you put the heating on for as long as you would like? Has this changed since the improvements? Have you changed anything about your energy supplier? [Do you ever think about changing energy supplier? Why/why not?] How you pay for your bills? Any special efforts to reduce your energy bills? When people have these improvements, some keep their house warmer than before and spend the same amount of money and others keep their house the same temperature and save money. Which do you think that you have done? Why?

4. **Now I'd like you to show me what we've been talking about – can you walk me around your home to show me the rooms?**
How do you use this room? Does it get warm enough? Have there been any improvements in here? Has it made any difference? Why?/Why not? Have you noticed any signs of damp?

5. **Finally, I'd like to talk about any other differences the improvements have made.** Other than energy bills, what difference have the improvements made to you? Your family? To how you use your home? To your family's health? To your carbon footprint? What are the best changes? What is the most important thing that has changed (including lower bills)? Why is that most important? Has anything not changed that you thought it would? Why do you think it hasn't changed? Have there been any disadvantages of having the improvements? How could these have been overcome? Is there anything you know now that you'd have liked to have known at the beginning of the process? Would you recommend the improvements to other people? Why/why not?

Anything else we've not yet talked about?

Thank you and debrief.

Appendix M. Comfort taking questionnaire

How comfortable is the temperature in your home?

1. Generally, how comfortable is the temperature in your home? (Please circle one)

Very Poor   Poor   Average   Good   Very Good

2. Is your home ever too warm? (Please circle one)

Never   Occasionally   Sometimes   Often   Always

3. Is your home ever too cool? (Please circle one)

Never   Occasionally   Sometimes   Often   Always

4. How do you rate the air quality in your home? (Please circle one)

Very Poor   Poor   Average   Good   Very Good

5. Thinking about when you might feel uncomfortable in your home how much control do you have over making it more comfortable? (Please circle one)

No control   Little control   Average   Good control   Very good control

6. Which room are you currently in? ___________________________________

7. Which of these best describes what you are wearing? (Please tick all that apply)

Legs	**Arms and Torso**	**Head and Hands**
Shorts	Short Sleeve Shirt/ Top	Light Hat/ Cap/ Hood
Short Skirt	Long Sleeve Shirt/ Top	Heavy Hat/Hood
Long Skirt	Heavy Top	Scarf
Light Trousers	Light Jacket	Light Gloves
Heavy Trousers	Heavy Jacket	Heavy Gloves
Additional Layers	Heavy Coat	

8. Which of these best describes your physical activity in the last hour?

Very Inactive	Inactive	Some activity	Quite active	Very active

9. When was the last time you were outside?

Less than 10 minutes ago	10-30 minutes ago	30-60 minutes ago	1-2 hours ago	More than 2 hours ago

10. At present how do you feel?

Much too cool	Too cool	Comfortably cool	Comfortable	Comfortably Warm	Too Warm	Much Too Warm

11. How would you prefer to feel?

Much cooler	A little cooler	No change	A little warmer	Much warmer

12. How do you rate the air quality right now?

Very Poor	Poor	Average	Good	Very Good

13. How good or bad is your health TODAY? One a scale of 0 to 100, where 100 is the best health you can imagine, and 0 is the worst health you can imagine, how is your health today?

…………………

13. Who lives here with you? ………….Adults …………Children Pets ………..

14. When are people usually in your home? (please tick the one that best describes)

Most of the days and evenings	Mainly just the days	Mainly just the evenings	People are in and out all the time	People are out most of the time

When did you fill in this questionnaire? Date ………..…. Time ……………...

Have the energy improvements been complete yet? Yes No

Name ____

Address ____