GREEN DEAL CORE CITIES LEEDS

The good, the bad, and the risky

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Overview

1. About the LSI
2. About the Core Cities Report
3. The Good
4. The Bad
5. The Risky
6. Up coming projects

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1991

Stamford Brook (National Trust), Temple Avenue & Elm Tree Mews (Josepf Rowntree Housing Trust)
2003 to 2009

Party Wall heat loss in Building Regulations
2010

TSB Building Performance Evaluation Programme
2011

Coheating test protocol
2013

DECC Core Cities
2014

BEIS Thin Internal Wall Insulation
2017

BEIS SMETER
2018

BEIS DEEP
2019

2020

Professor Chris Gorse
LSI Director

Dr David Glew
Head of Energy Efficiency and Policy

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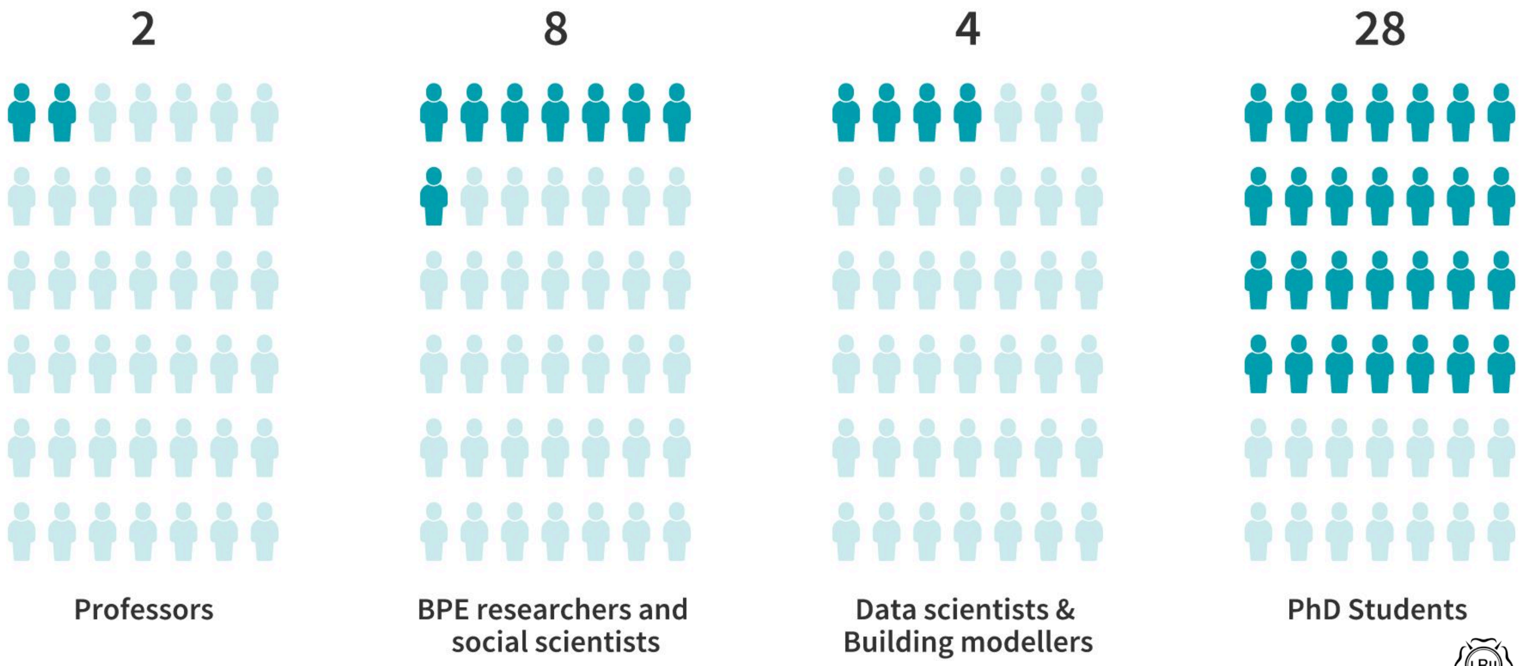
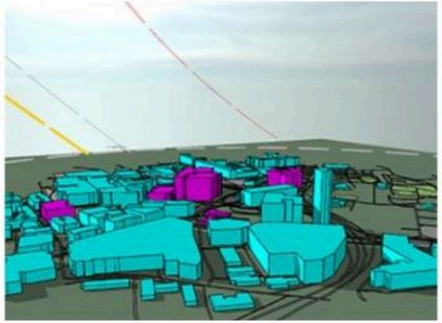
Head of Sustainable Behaviour

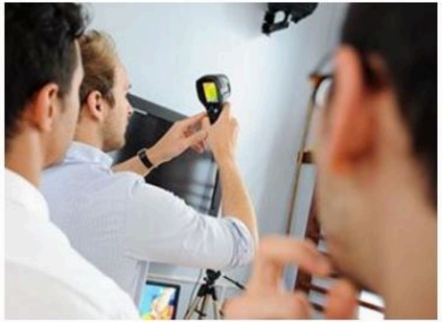
Dr Jim Parker
Head of Building Simulation



Our Areas of Research Expertise



Data Analysis, Modelling & Simulation ›



Behaviour Change & Post Occupancy Evaluation ›

Retrofit Performance Evaluation ›

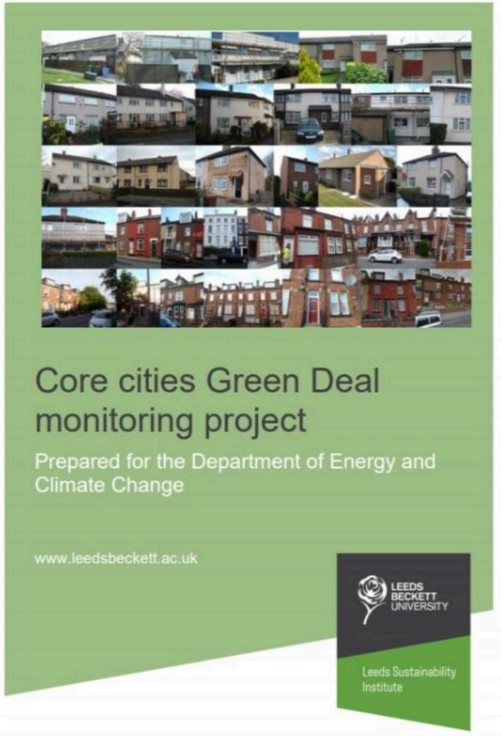
New Build Performance Evaluation ›

Product Developments & Patents ›

Regulations & Standards ›

Leeds Core Cities Project

Leeds Core Cities project



- **Department of Energy and Climate Change**

  now Business Energy and Industrial Strategy (BEIS)

- **2014 to 2017**

- **Leeds & Manchester designated a Green Deal Core City**

  Retrofits were funded (not via Green Deal)

- **Aims**

  Performance gap

  Unintended consequences

- **3 main contractors on framework**

https://www.gov.uk/government/publications/core-cities-green-deal-monitoring-project-leeds

Publications based on the Leeds Core Cities project


Assessing the quality of retrofits in solid wall dwellings

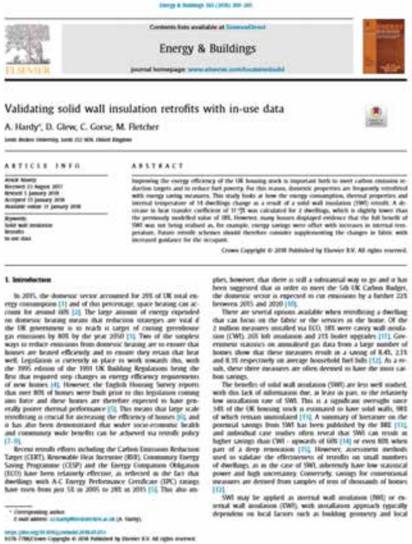
David Glew, Faculty of Arts, Environment and Technology, Leeds Beckett University, Leeds, UK
Melanie B. Smith, Leeds Sustainability Institute, Faculty of Arts, Environment and Technology, Leeds Beckett University, Leeds, UK
Dominic Miles-Shenton, Faculty of Arts, Environment and Technology, Leeds Beckett University, Leeds, UK, and
Christopher Gorse, School of the Built Environment and Engineering, Leeds Beckett University, Leeds, UK


Energy Research & Social Science

Original research article

Reflections on retrofits: Overcoming barriers to energy efficiency among the fuel poor in the United Kingdom

Fiona Fylan, David Glew, Melanie Smith, David Johnston, Matthew Brooke-Peat, Dominic Miles-Shenton, Martin Fletcher, Patricia Aloise-Young, Christopher Gorse

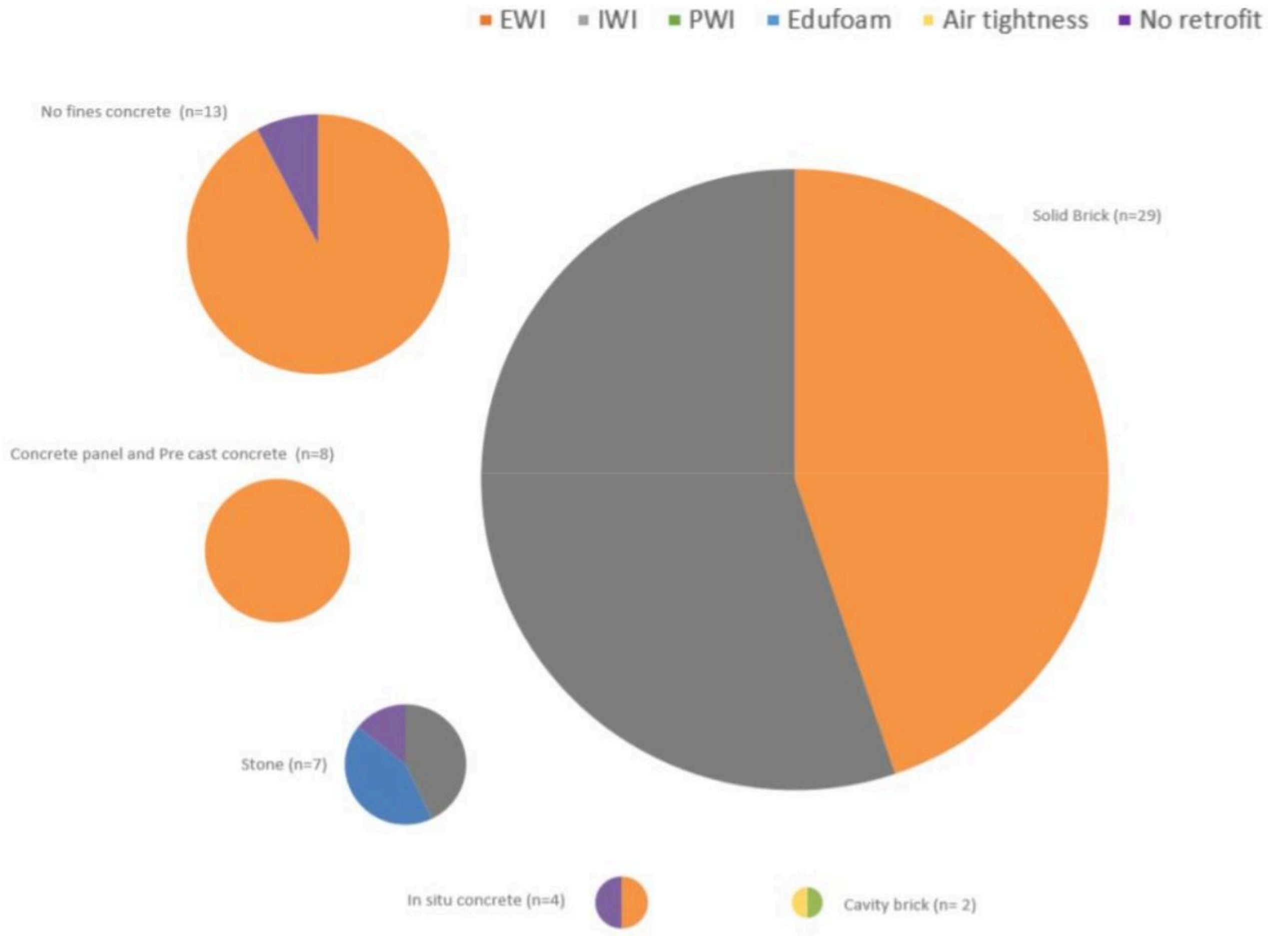

Energy & Buildings

Validating solid wall insulation retrofits with in-use data

A. Hardy, D. Glew, C. Gorse, M. Fletcher

Houses & retrofits

- Mostly solid wall
- Mostly Brick
- Mostly EWI
- Some IWI
- Mostly Leeds



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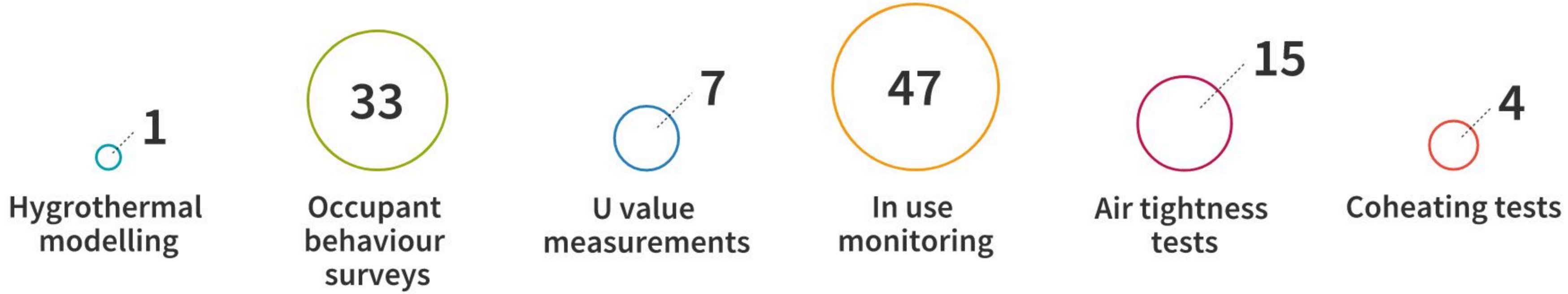
Retrofits in detail

- Mostly single measures
- No whole house approach
- PAS 2030:2014
- Pre Each Homes Counts
- Pre PAS2035

Dwelling ID	Wall type	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5
C-1	Solid Brick	IWI	Boiler			
C-2	Solid Brick	IWI	Boiler			
C-3	Cavity Brick	PWI	LI			
I-01	Solid Brick	IWI				
I-02	Solid Brick	IWI	LI	Windows	Floor	
I-03	Solid Brick	IWI				
I-04	Solid Brick	IWI	Boiler	Windows		
I-05	Solid Brick	IWI				
I-06	Solid Brick	IWI				
I-07	Solid Brick	IWI				
I-08	Solid Brick	EWI	IWI			
I-09	Stone	Edufoam				
I-10	Stone	Edufoam				
I-11	Stone	Edufoam				
I-12	Solid Brick	IWI				
I-13	Solid Brick	IWI				
I-14	Solid Brick	IWI				
I-15	Stone	IWI	LI	Windows	Floor	
E-1	No-fines concrete	EWI	LI			
E-2	No-fines concrete	EWI				
E-3	No-fines concrete	EWI				
E-4	Solid Brick	IWI	Boiler	LI	Windows	Controls
E-5	Solid Brick	IWI	Boiler	LI	Windows	Controls
E-6	Solid Brick	IWI	Boiler	LI	Windows	Controls
E-7	No-fines concrete	EWI	Boiler	Windows		
E-8	No-fines concrete	EWI	Boiler	Windows		
E-9	In-Situ Concrete	EWI				
E-10	In-Situ Concrete	None				
E-11	In-Situ Concrete	None				
E-12	Precast Concrete	EWI				
E-13	In-situ Concrete	EWI				
E-14	Concrete	EWI				
E-15	Concrete	EWI				
E-16	Concrete	EWI				
E-17	Stone	IWI	LI	Windows		
E-18	Solid Brick	EWI	IWI			
E-19	Solid Brick	EWI	IWI			
E-20	Solid Brick	EWI	IWI			
E-21	Solid Brick	EWI				
E-22	Solid Brick	EWI				
E-23	Solid Brick	EWI				
E-24	Stone	IWI				
E-25	No-fines concrete	EWI				
E-26	No-fines concrete	No retrofit				
E-27	Solid Brick	IWI				
E-28	Solid Brick	IWI				
E-29	Solid Brick	EWI				
E-30	Solid Brick	EWI				
E-31	Solid Brick	EWI				
E-32	Concrete panel	EWI				
E-33	No-fines concrete	EWI				
E-34	No-fines concrete	EWI				
E-35	No-fines concrete	EWI				
E-36	No-fines concrete	EWI				
E-37	No-fines concrete	EWI				
E-38	No-fines concrete	EWI				
E-39	Solid Brick	EWI				
E-40	Solid Brick	EWI				
E-41	Solid Brick	EWI				
E-42	Brick cavity	EWI				
E-43	Stone	IWI	Windows	Solar HW		
E-44	Concrete	EWI				
E-45	Concrete	EWI				
E-46	Concrete	EWI				
E-47	Stone	No retrofit				

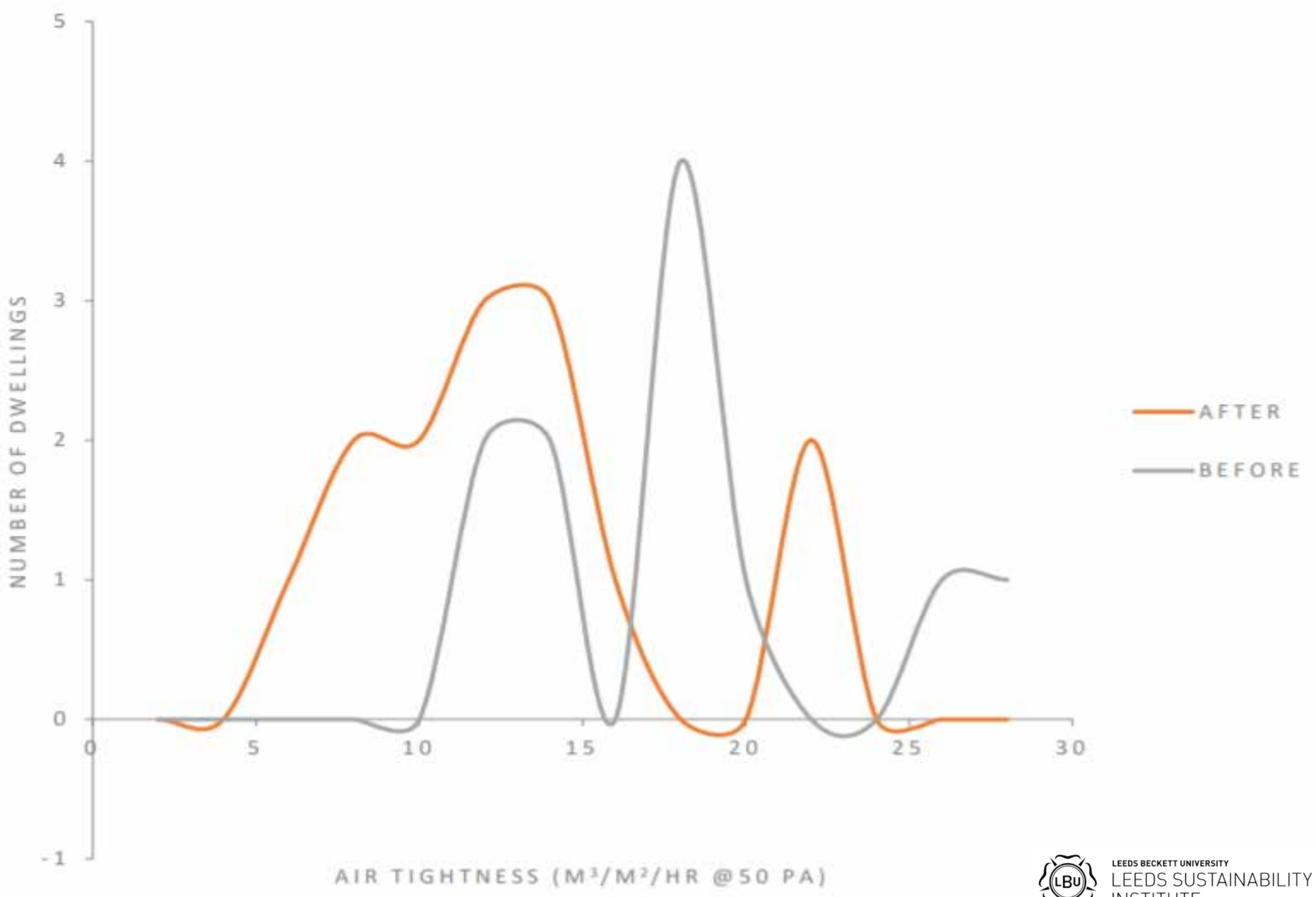
The tests


1
Hygrothermal modelling
33
Occupant behaviour surveys
7
U value measurements
47
In use monitoring
15
Air tightness tests
4
Coheating tests

The Good

- The retrofits improved airtightness in the dwellings by, on average 25%

Air tightness improvements from 15 IWI retrofits



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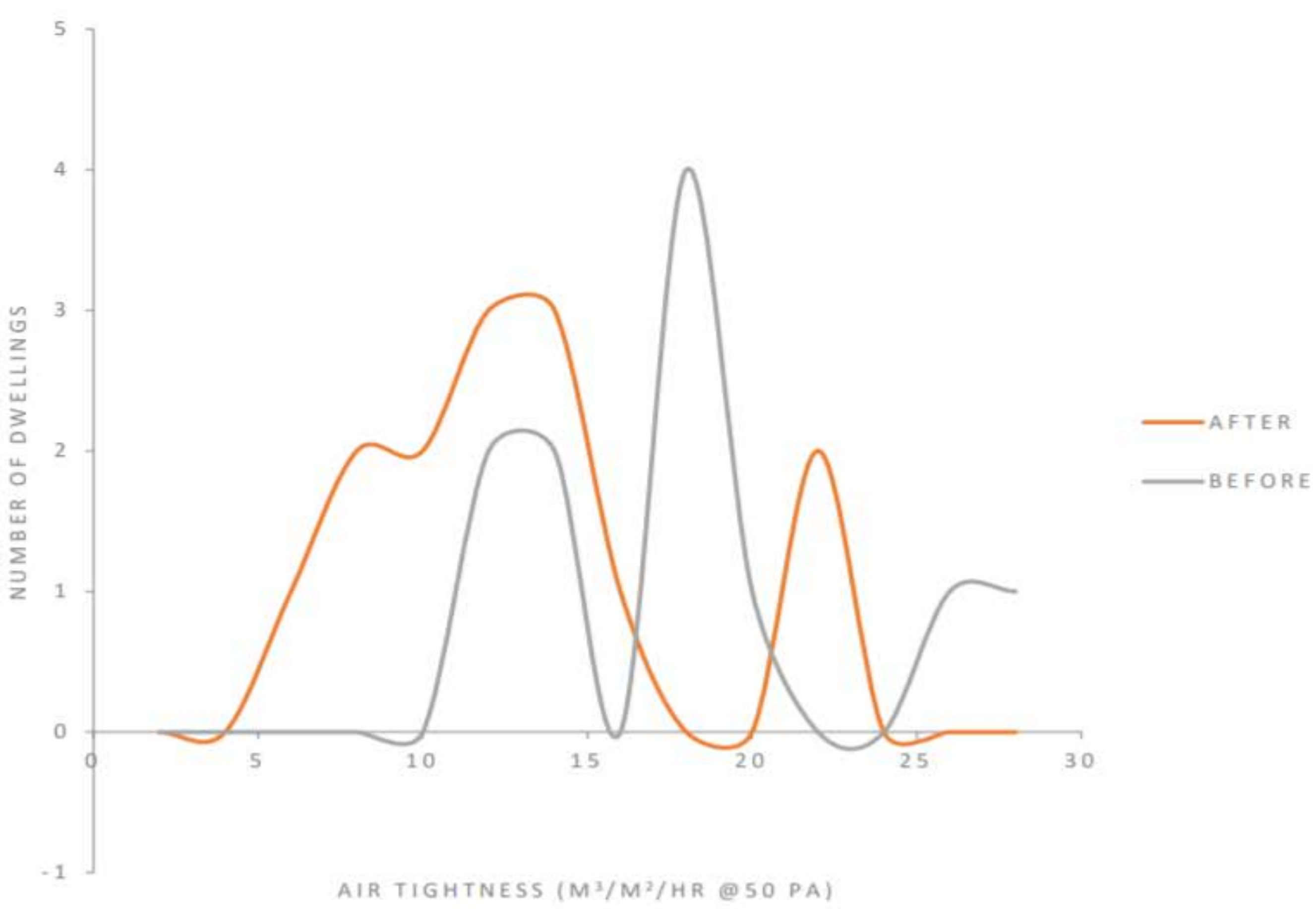
The greatest improvements in airtightness were achieved where a whole house approach was taken and specific designs for the air barrier were made.

This resulted in an infiltration rate reduction of 61%.

Air tightness improvements from 15 IWI retrofits



3 Case study homes undergoing Coheating testing

2 x IWI

- Mid terrace
- 9 inch solid brick

- Sub contractor vs. Housing Charity

PWI

- 1957 Brick cavity wall
- Manufacturer’s own installation
- Separate loft replacement

C1, IWI Housing Charity

C2, IWI Sub contractor

C3, PWI Manufacturer

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Heat Transfer Coefficient

- All the retrofits reduced heat loss
- There was variation in performance due to specification and quality

- The housing charity IWI retrofits achieved reductions 56%
- The sub contractor retrofit achieved reductions of 25%
- Party wall cavity fill achieved reductions of 8%

Dwelling	HLC before intervention (W/K)	HLC after intervention (W/K)	Improvement in HLC (%)
C-01	138.2 (± 2.8)	60.9 (± 1.2)	56%
C-02	135.3 (± 2.5)	101.6 (± 3.8)	25%
C-03	180.2 (± 9.2)	166.4 (± 4.8)	8%

Ventilation vs. Fabric heat loss

IWI retrofits reductions:

- Fabric = 70-80%
- Ventilation = 20-30%

Ventilation heat loss reductions from C1 were similar to fabric heat loss reductions from C2

Table 4-3 Ventilation heat loss improvement

Dwelling	Before ventilation rate (ACH @ 50 Pa)	After ventilation rate (ACH @ 50 Pa)	Before heat loss (W/K)	After heat loss (W/K)	Improvement (W/K)	Percentage Improvement
C-01	20.85	7.99	38.9	14.9	24.0	62%
C-02	30.19	26.36	56	48.9	7.1	13%
C-03	17.81	16.11	40.2	36.3	3.9	10%

Table 4-4 Fabric heat loss improvement

Dwelling	Before U-value (W/m^2K)	After calculated U-value (W/m^2K)	After measured U-value (W/m^2K)	U-value performance gap (%)	Before heat loss (W/K)	After heat loss (W/K)	Improvement (W/K)	Percentage Improvement
C-1	2.08	0.14	0.17	21%	99.3	45.0	53.3	54%
C-2	1.57	0.29	0.31	7%	79.3	52.7	26.6	34%
C-3	0.3	n/a	-0.02	n/a	140.0	130.1	9.9	7%

Party wall retrofit savings were similar to loft replacement

More tests would be need to have certainty on PWI benefit

Table 4-3 Ventilation heat loss improvement

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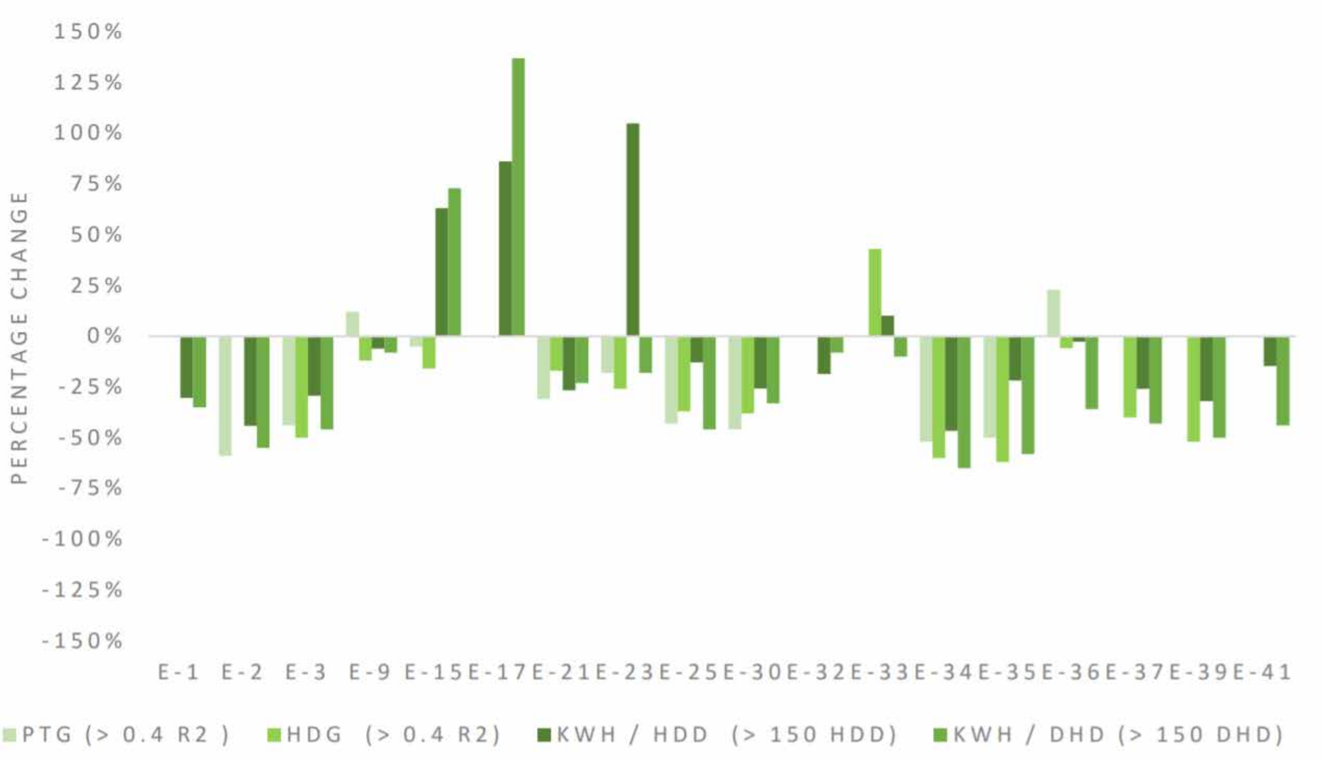
Heating demand reductions

- Variation in savings was very large
- Mean savings were estimated to be between 4% and 29% depending on the assessment method chosen

In use monitoring from 47 homes EWI & IWI



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In use monitoring from 47 homes EWI & IWI

- All analysis methods showed a reduction in heat demand on average

- Power Temperature Gradient (PTG) was less certain

- Accounting for internal temperatures improved accuracy

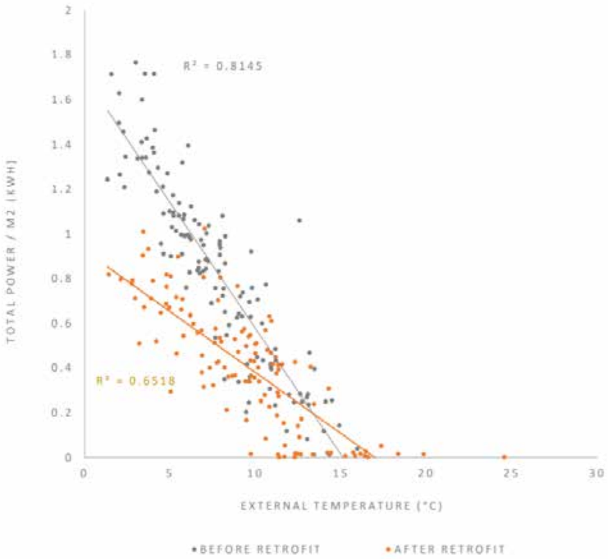

Figure 7-19 Dwelling E34 PTG

Figure 7-20 HDG for dwelling E-34

CIBSE Adaptive Comfort analysis

- Most homes became warmer after the retrofit
- 15 homes were considered “cold”
- 5 out of 8 “cold” homes, with reliable data, became “acceptable”

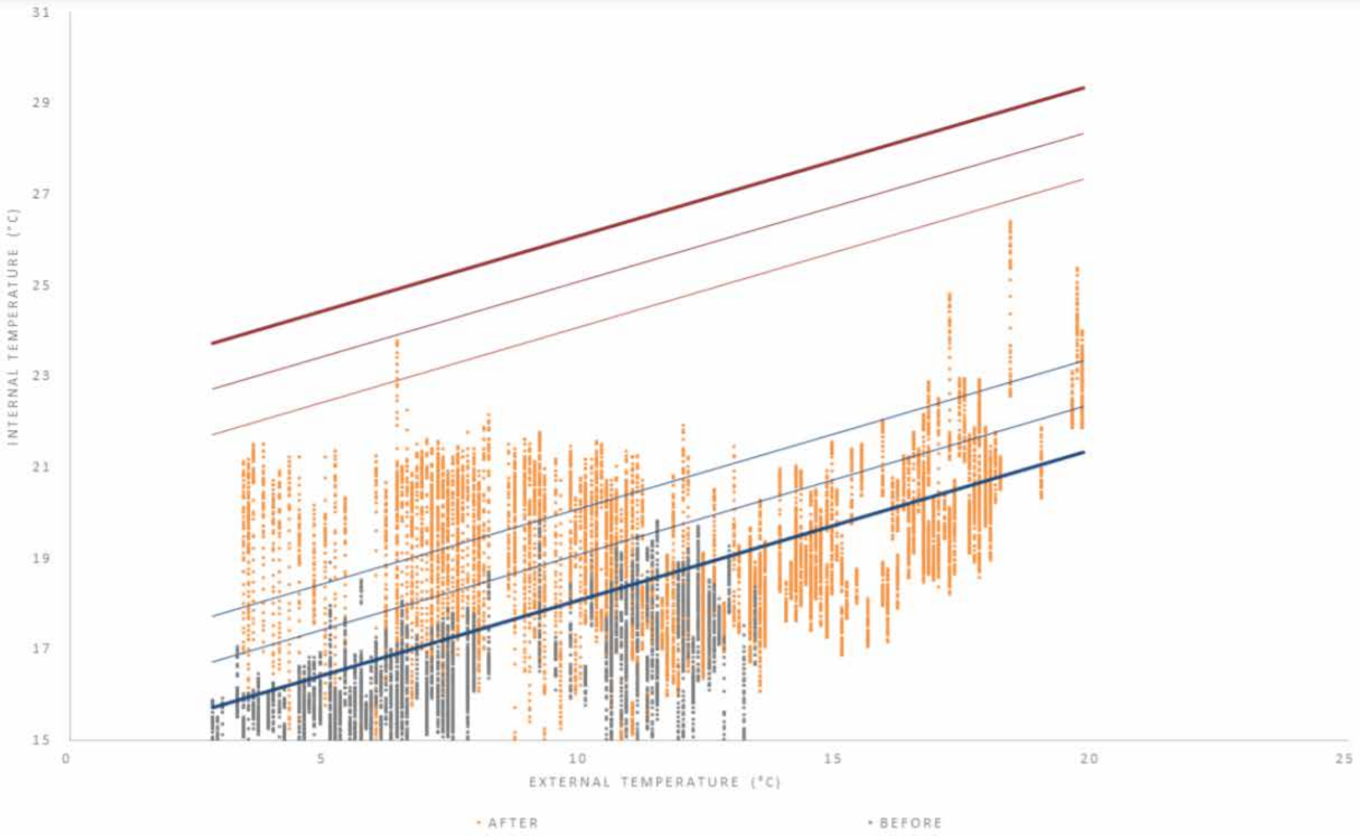

Figure 7-15 Dwelling E-34 thermal comfort assessment

- Most participants reported having good control over their thermal comfort after the retrofit
- This increase was not statistically significant
- There was no change in their ratings of their home becoming too warm

Occupant reported comfort

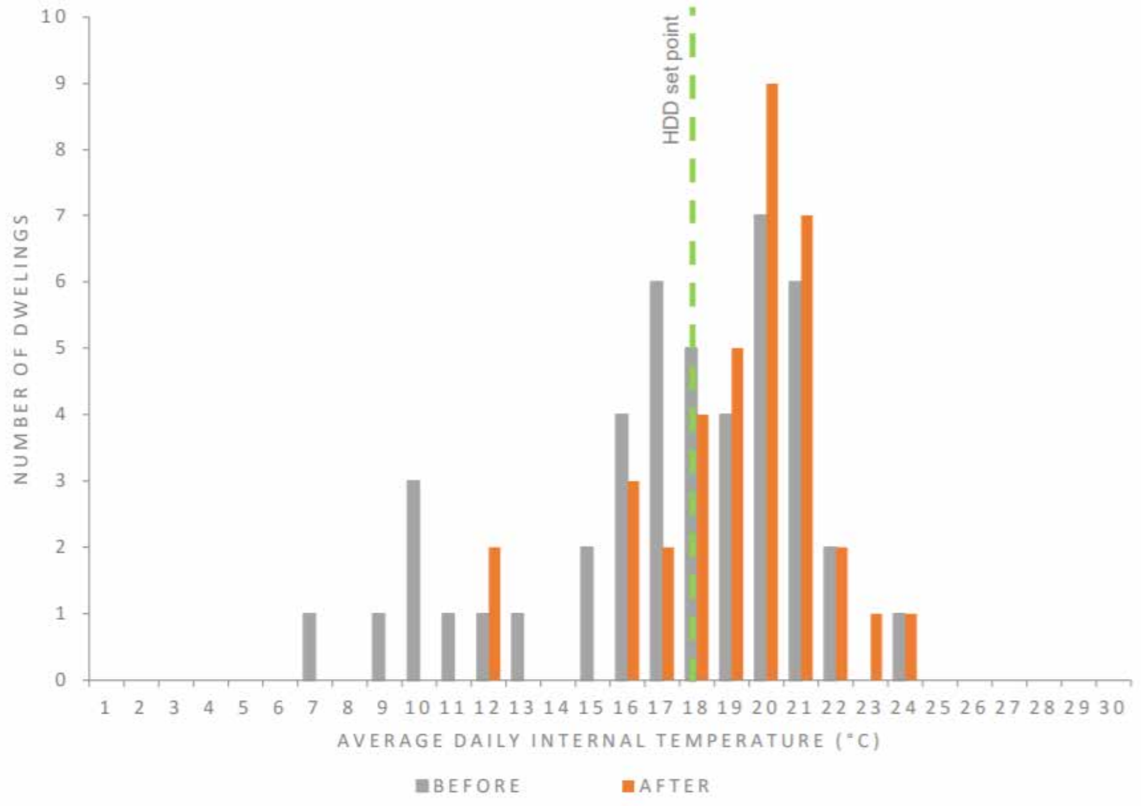

Figure 9-1 Internal daily average temperatures observed in dwellings

Wider benefits

- Occupants were generally pleased that they had the retrofits
- Some confusion over benefits
- Some concerns over risks

"Nearly all of the occupants had positive experiences of the retrofit they received (although they had usually not paid for the installation) and described their homes as being warmer, easier and cheaper to heat as they retained heat for longer and in some cases were less draughty"

"one of the major occupant centred benefits of the retrofits was the indirect improvements to the streetscape, making the appearance of the homes and neighbourhood more pleasant and enjoyable to live in"

The Bad

Generally poor levels of air tightness across the sample

There were some dwellings with unacceptable air leakage after retrofits

10 of 18 houses tested after retrofit had air tightness levels worse than the minimum allowable for new builds

Air tightness is often not addressed in retrofits

Figure 3-7 Dwelling C-02 under depressurisation following refurbishment.

Insulation did not always achieve its designed U values :

- Performance gap for Housing Charity IWI was 7%
- Performance gap for the subcontractor IWI was 21%

Performance gaps were observed

Installers who have a whole house approach to the retrofit and who give attention to detail to air barriers, achieve better outcomes than retrofits performed by sub-contractors.

Performance gaps could not be calculated since the retrofits did not require before and after heat loss calculations to access funding and so it was not possible to compare the predicted with the observed savings.

- Surveyor visited each retrofit site before and after where possible
- Most sites had more than one issue
- Not simple to quantify the impact on performance

Surveyor observations of poor quality

Gaps in insulation (e.g. around wall mounted objects)

Penetrations and fittings not being adequately sealed

Thermal bridging at element interfaces

Ventilation pathways blocked up

Missing insulation around jambs, sills and lintels

Lack of access to install insulation (no IWI behind kitchens, EWI stopping before party wall etc.)

Multiple examples of “work arounds” causing unsightly installs and thermal bridges

- Services
- Utility meters
- Complex geometry
- Obstructions

Figure 2-6 Thermal breaks at insulation cut-outs at external pipes, services, walls, doors, gates etc: these are typical for pre-1919 terraces where these services are not being amended in the EWI works

Some examples of poor workmanship:

- Seals
- Drainage
- Existing damp

Figure 2-5 Effects of water ingress through an imperfect seal at the top of EWI

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Field work data collection problems

- In use monitoring often failed
- Only 18 of 47 homes could be analysed
- Householders did not always cooperate
- Installer companies did not fully engage

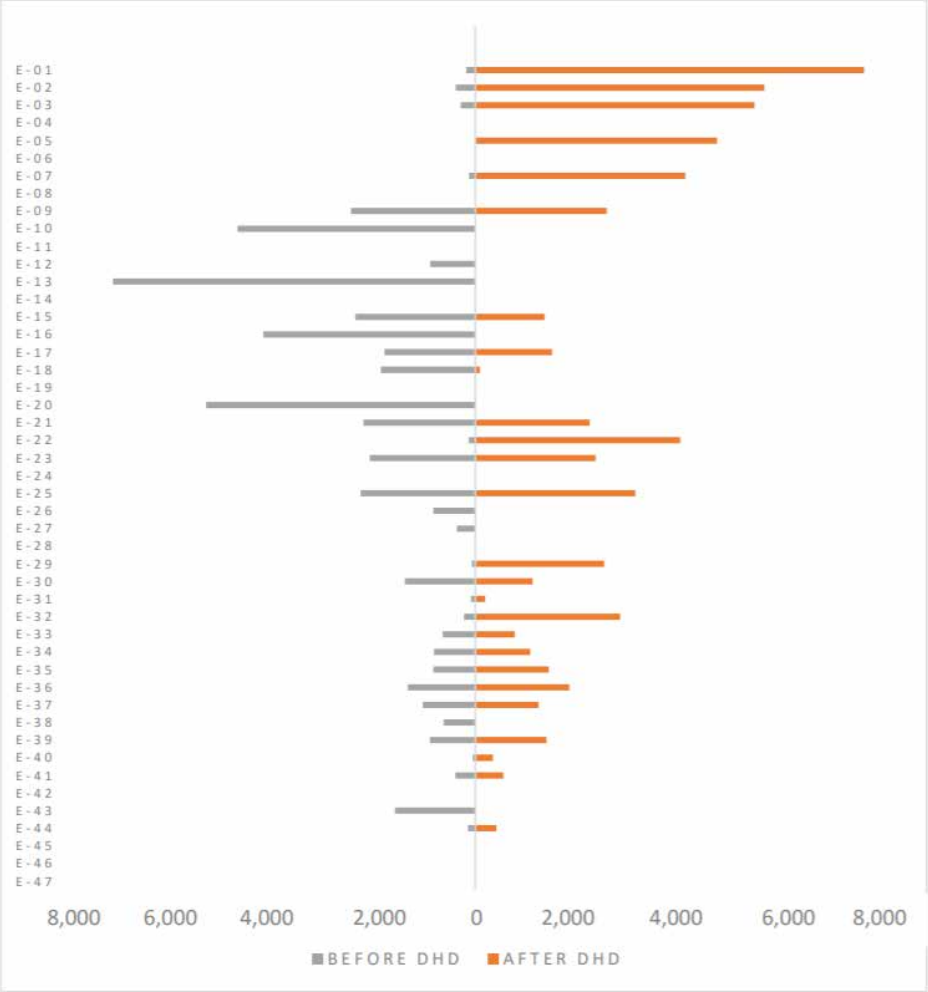


Figure 7-11 Data collection before and after retrofit

The Risky

Risks to the neighbour from IWI

IWI returns can increase thermal bridging at party walls by more than 60%

Returning IWI on the party wall could reducing neighbours' internal wall surface temperature to a level that may promote condensation

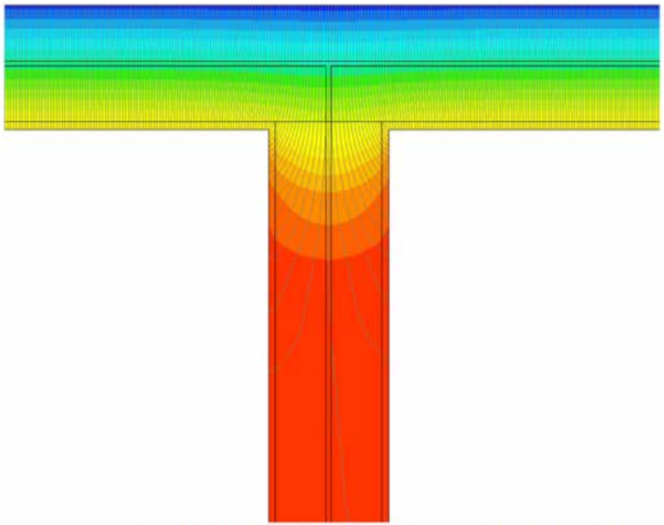


Figure 5-1 Temperature distribution for uninsulated party wall junction (TB/12)

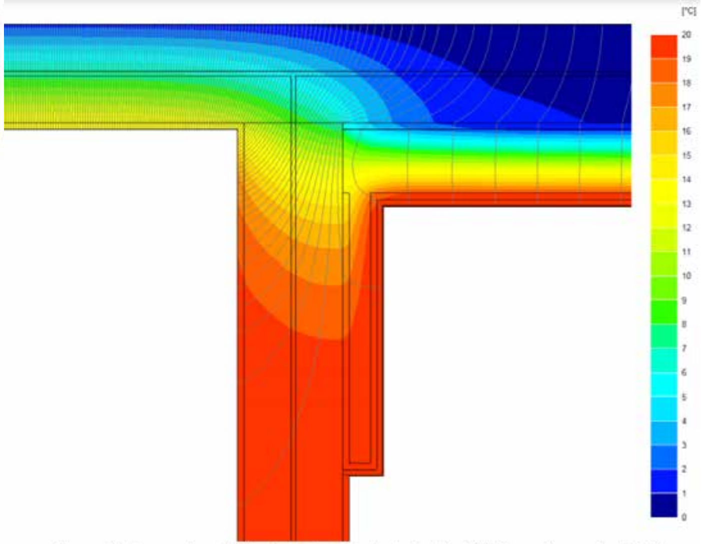


Figure 5-2 Temperature distribution of party wall single-sided IWI thermal upgrade (TB/07)

Moisture build up following IWI

- WUFI models undertaken to predict risk of moisture accumulation
- Moisture balance occurs after a longer period

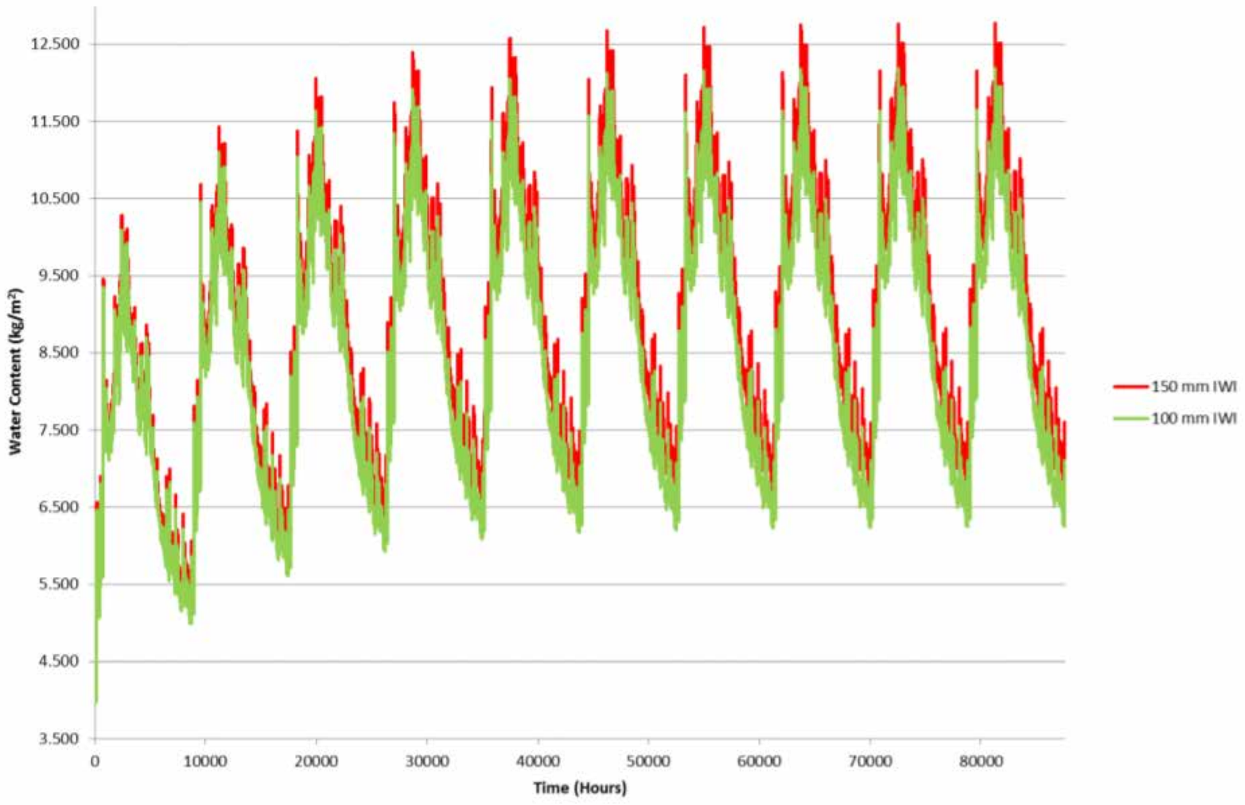


Figure 6-5 Total Water Content 10 Years

IWI leads to reduced heat input into the wall acts as a moisture barrier causing a risk of rot to embedded timbers.

IWI requires further longitudinal monitoring to explore the impact and the ability to mitigate and control long-term moisture risks.

Moisture build up following IWI

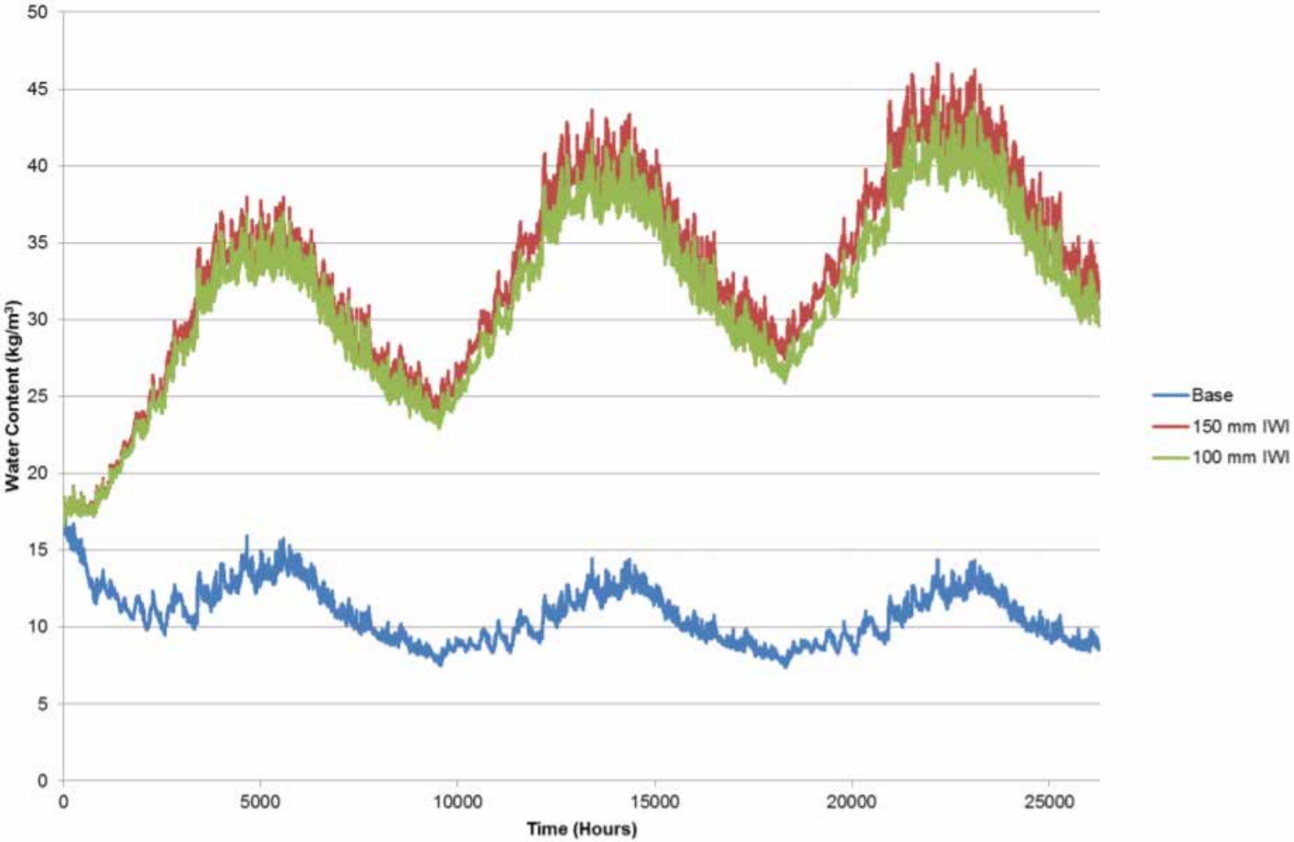


Figure 6-6 Water Content of Masonry Inner Leaf

Common architectural features can create thermal bridges

Thermal bridging reduces surface temperatures in homes

Roof wall junctions were particularly problematic

Figure 2-1 Thermal breaks introduced to top floor wall/ceiling junctions: pre-1919 terraces and back-to-backs

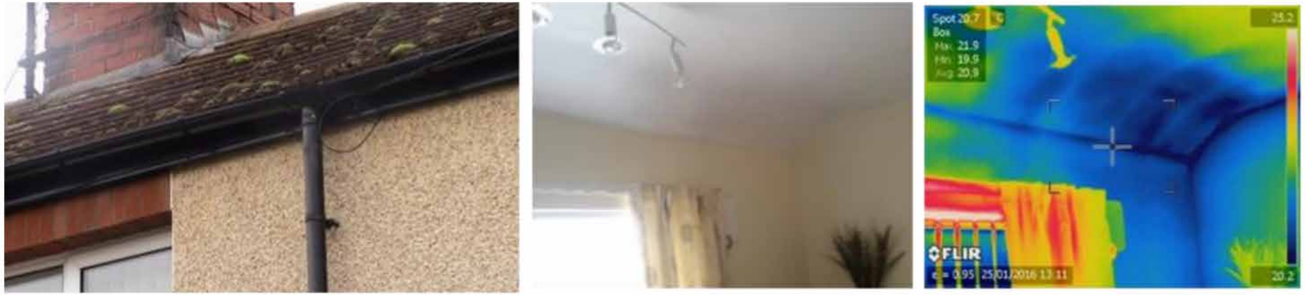


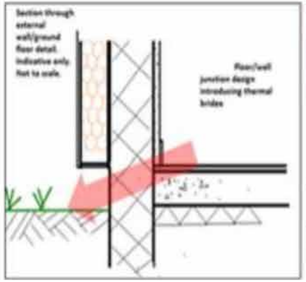
Figure 2-2 Thermal breaks introduced to top floor wall/ceiling junctions: the above three pictures are of the same property and show a typical 1919-1940s solid brick semis and terraces where the top floor is partially in the roof void with a sloping ceiling against the rafters

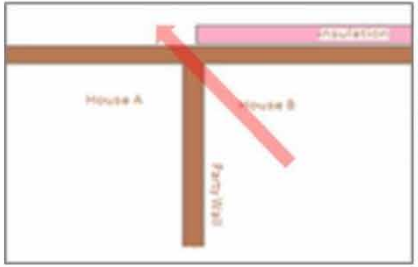
Figure 2-4 Thermal imaging for thermal break at top floor wall/ceiling junction for a 1970s no-fines end terrace

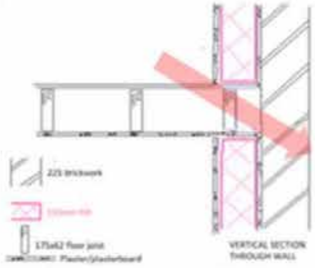
Thresholds, party walls and floor wall junctions were common areas of thermal bridging.

EWI rarely extends below damp proof course

Intermediate floors appeared to not always be insulated







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Upcoming projects

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TIWI: Thin Internal Wall Insulation (BEIS)

To be published in winter 2020

Thin Internal Wall Insulation (TIWI)

Measuring Energy Performance Improvements in Dwellings Using Thin Internal Wall Insulation

Annex A; Introduction to TIWI

Literature, Household & Industry Reviews

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Thin Internal Wall Insulation (TIWI)

Measuring Energy Performance Improvements in Dwellings Using Thin Internal Wall Insulation

Annex B; TIWI Field Trials

Building Performance Evaluation (BPE)

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Thin Internal Wall Insulation (TIWI)

Measuring Energy Performance Improvements in Dwellings Using Thin Internal Wall Insulation

Annex C; Predicting TIWI Impact

Energy & Hygrothermal Simulations

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Thin Internal Wall Insulation (TIWI)

Measuring Energy Performance Improvements in Dwellings Using Thin Internal Wall Insulation

Annex D; Moisture Risks of TIWI

Laboratory Investigations

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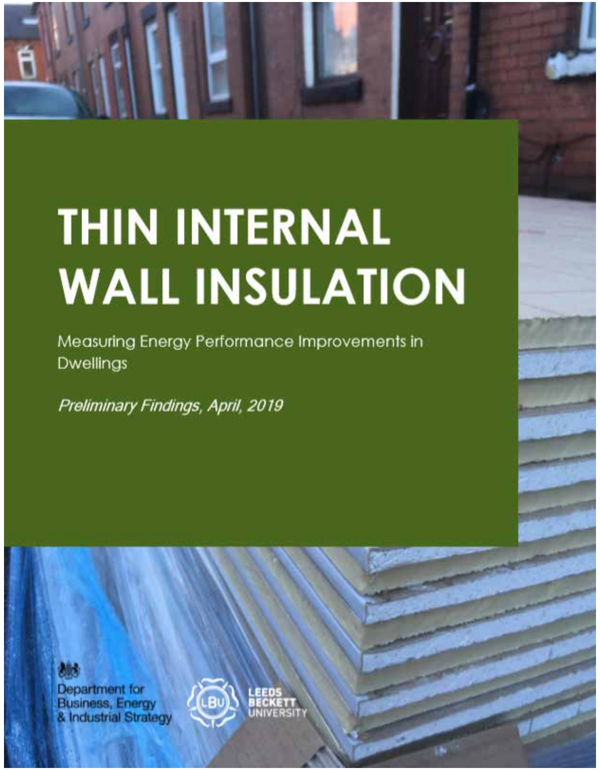
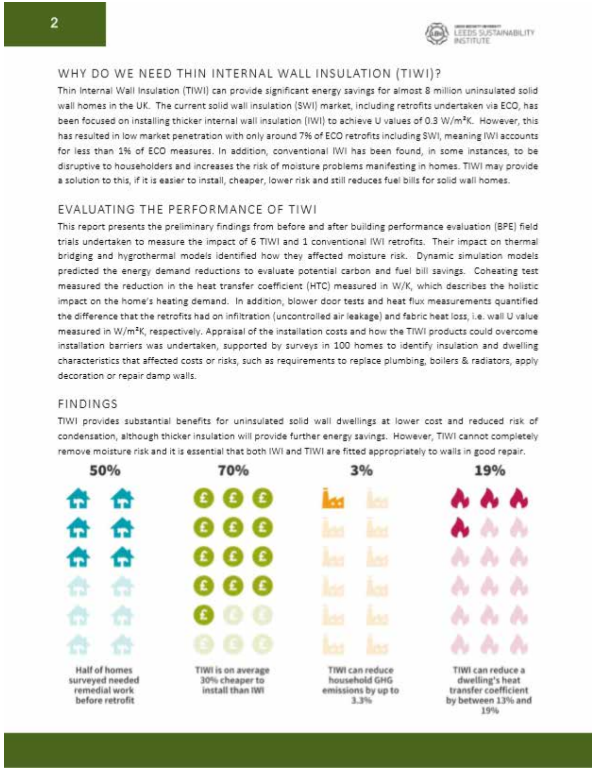
TIWI can reduce risks of condensation

Doubling the insulation thickness between the IWI and TIWI no. 1, only resulted in an additional 13% reduction in U-value and 3% better HTC reductions.

90% of homes require remedial work

TIWI Preliminary Findings





2

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WHY DO WE NEED THIN INTERNAL WALL INSULATION (TIWI)?

Thin Internal Wall Insulation (TIWI) can provide significant energy savings for almost 8 million uninsulated solid wall homes in the UK. The current solid wall insulation (SWI) market, including retrofits undertaken via ECO, has been focused on installing thicker internal wall insulation (IWI) to achieve U values of 0.3 W/m²K. However, this has resulted in low market penetration with only around 7% of ECO retrofits including SWI, meaning IWI accounts for less than 1% of ECO measures. In addition, conventional IWI has been found, in some instances, to be disruptive to householders and increases the risk of moisture problems manifesting in homes. TIWI may provide a solution to this, if it is easier to install, cheaper, lower risk and still reduces fuel bills for solid wall homes.

EVALUATING THE PERFORMANCE OF TIWI

This report presents the preliminary findings from before and after building performance evaluation (BPE) field trials undertaken to measure the impact of 6 TIWI and 1 conventional IWI retrofits. Their impact on thermal bridging and hygrothermal models identified how they affected moisture risk. Dynamic simulation models predicted the energy demand reductions to evaluate potential carbon and fuel bill savings. Coheating test measured the reduction in the heat transfer coefficient (HTC) measured in W/K, which describes the holistic impact on the home's heating demand. In addition, blower door tests and heat flux measurements quantified the difference that the retrofits had on infiltration (uncontrolled air leakage) and fabric heat loss, i.e. wall U value measured in W/m²K, respectively. Appraisal of the installation costs and how the TIWI products could overcome installation barriers was undertaken, supported by surveys in 100 homes to identify insulation and dwelling characteristics that affected costs or risks, such as requirements to replace plumbing, boilers & radiators, apply decoration or repair damp walls.

FINDINGS

TIWI provides substantial benefits for uninsulated solid wall dwellings at lower cost and reduced risk of condensation, although thicker insulation will provide further energy savings. However, TIWI cannot completely remove moisture risk and it is essential that both IWI and TIWI are fitted appropriately to walls in good repair.

50% — Half of homes surveyed needed remedial work before retrofit

70% — TIWI is on average 30% cheaper to install than IWI

3% — TIWI can reduce household GHG emissions by up to 3.3%

19% — TIWI can reduce a dwelling's heat transfer coefficient by between 13% and 19%

https://www.leedsbeckett.ac.uk/TIWIReport

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Other projects in the LSI

BEIS, Smart Meter Enabled Thermal Efficiency Ratings (SMETER) Innovation Programme
2018 to 2021

EPSRC, Smart Energy Research Lab,
2020 to 2022

NIC, H21: Public perceptions of converting the gas network to hydrogen Social Sciences Study
2018 to 2020

For more information contact Dr David Glew at d.w.glew@leedsbeckett.ac.uk

Demonstration of Energy Efficiency Potential (DEEP)

2019 to 2022

- BEIS funding (£2.7 million)
- Alternative solutions to SWI
- Impact of missing PAS out of whole house retrofit
- Mimic national retrofit journey
- Evaluate deterioration in insulation over time

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