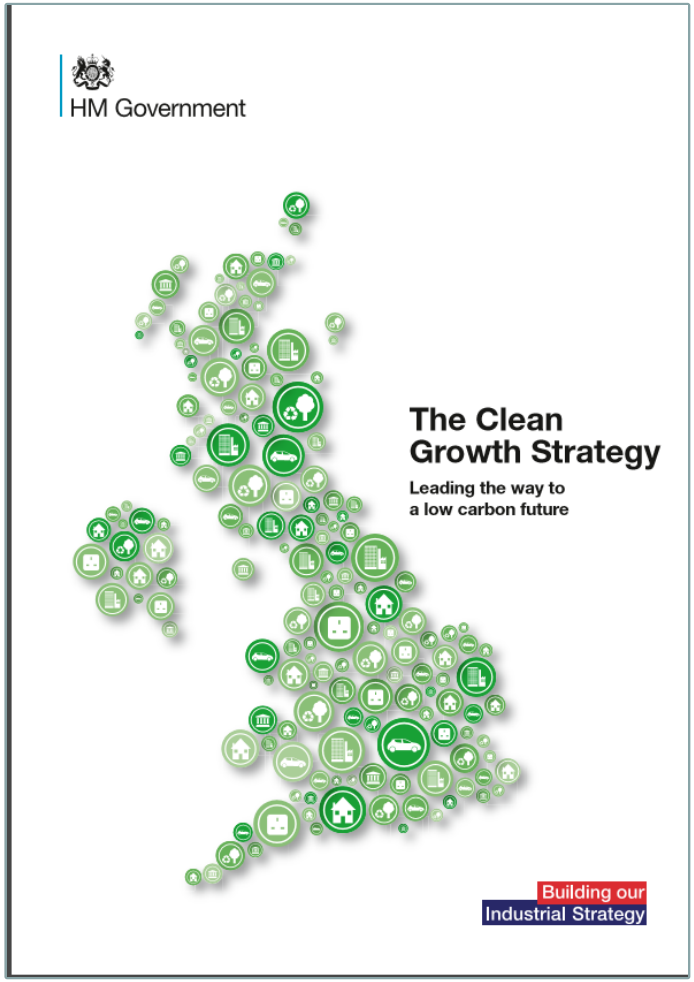
The Salford Energy House: An Overview

Stephen Todd

UK Government's Department for Business Energy and Industrial Strategy (BEIS) to create a low carbon future for the UK

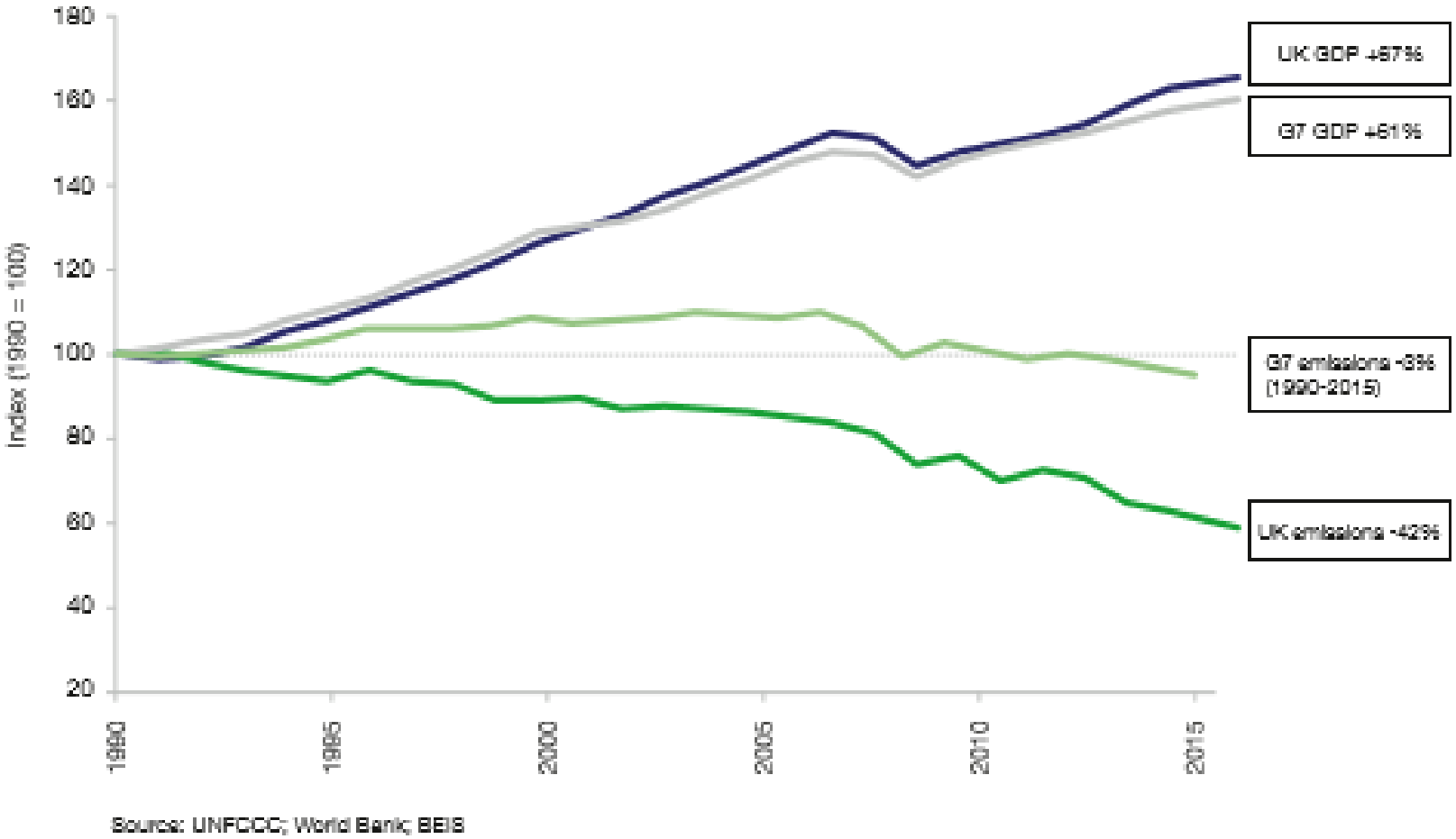


Climate Change Act 2008

- Committed to reduce energy emissions by at least 80% (of 1990 levels) by 2050
- By 2017 our emissions have been cut by 42%
  - Part of the reason behind this is that heavy industry has reduced dramatically and there are now less coal fired power stations.

UK and G7 economic growth and emissions reduction

Figure 1: UK and G7 economic growth and emissions reductions[8]



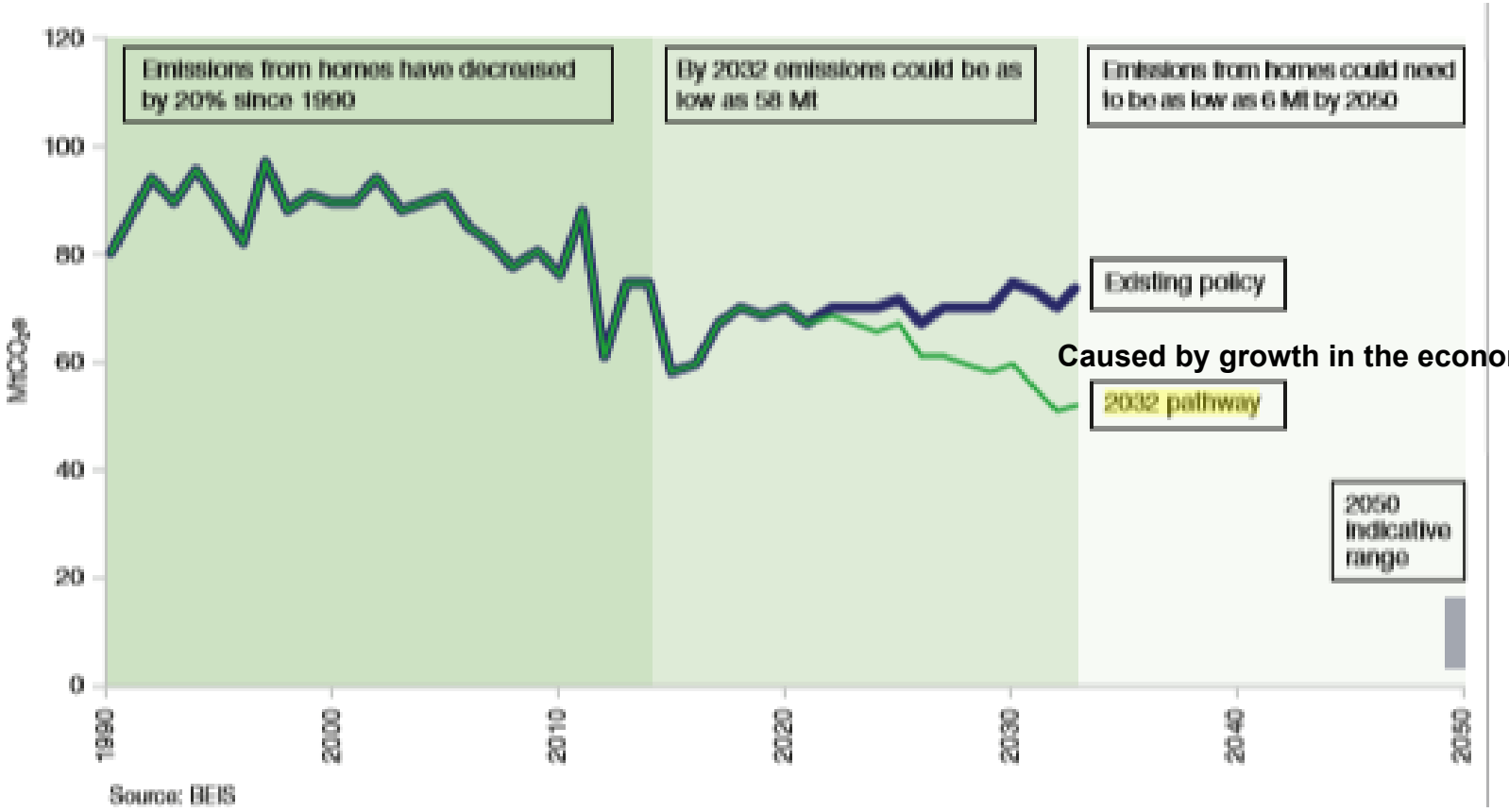
Source: UNFCCC; World Bank; BEIS

The Clean Growth Stategy

- It is accepted that cold homes contribute to ill health – costing the NHS £760 million a year
- The current trajectory of policy vacuum for homes will see carbon emissions actually rise – therefore action is required to ensure we follow the ‘2032 pathway’

The ‘do nothing pathway’

Actual and projected emissions in homes, taking into account the clean growth pathway, 1990-2050



Caused by growth in the economy

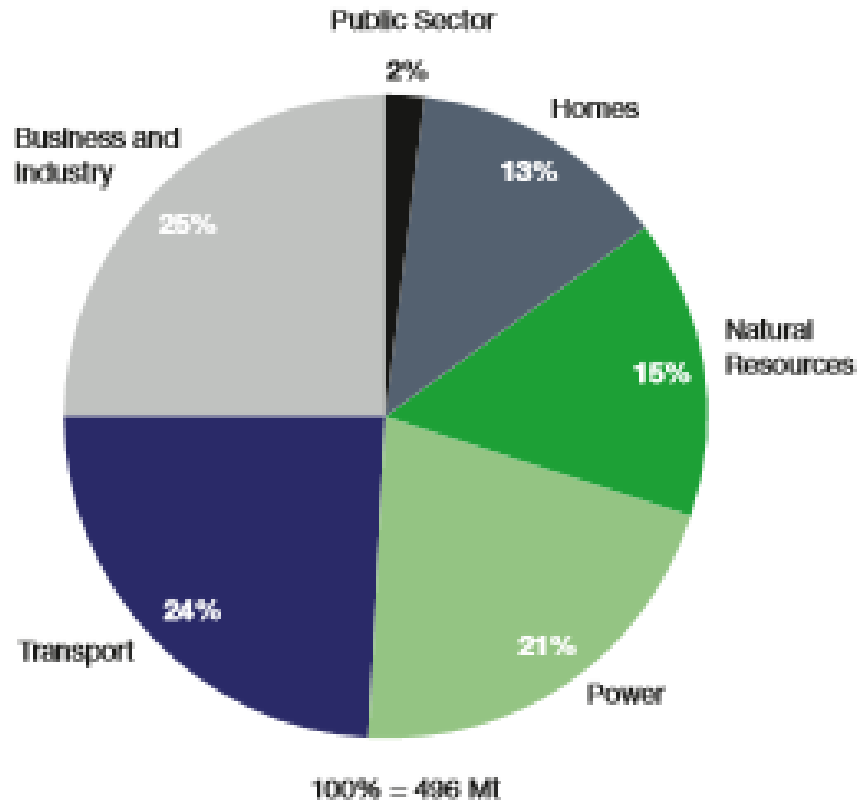
Existing Buildings

- Important to cut the carbon footprint from new build but 70% of homes in 2050 will be existing

- Building Regulations Part L1B
- Improvements to general U-values. Extensions continue to use elemental approach but able to use SAP for greater flexibility

- Building Services Compliance Guide sets replacement standards

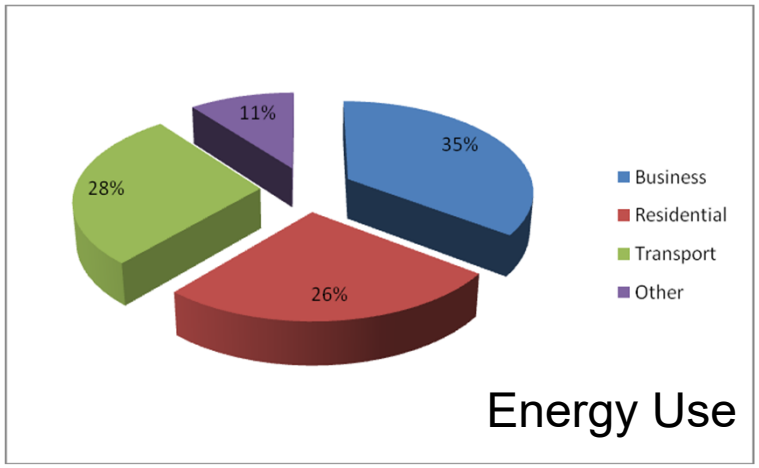
UK Emissions by sector

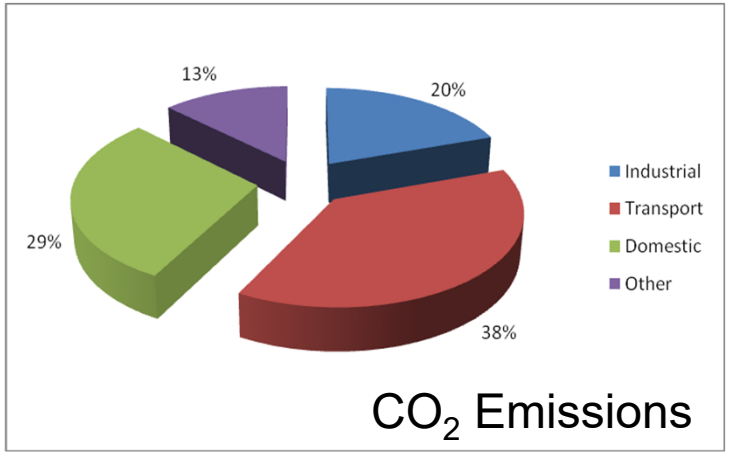


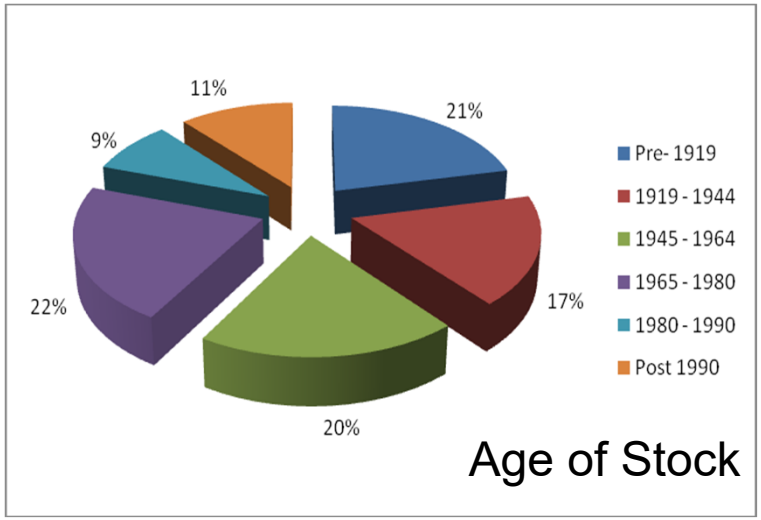
Heating in buildings and industry creates around 32% of total UK emissions

Source: BEIS

Why A Salford Terrace







Replacement rate <1%

Approximately 70% of existing properties will remain in 2050

How will government do it?

- Reinstate a ‘Clean-Growth Inter-Ministerial Group’ to monitor the implementation.
- Set up a Green Finance Task Force’ to provide investment in low carbon heating.
- Continue support for ECO
- Minimum standards ‘where practical, cost effective and affordable’
  - Private rented sector to be at least Band C (EPC) by 2030 and
  - Aim for ‘as many owner occupied homes as possible are Band C by 2030.
- 2019 – explore changes in Building Regulations to deliver innovative solutions.
- There is a need to address HMOs and Listed Buildings
- There is also a need to Reduce Fuel Poverty

Applied Buildings and Energy Research Group

Why are we researching retrofit (UK)?

- Solid wall properties such as those represented by the Energy house currently number approximately 7.5 million in the UK. Of these approximately 180,000 (2.4 %) have had some form of solid wall insulation. (Consumer Focus, 2011)
- The hard to treat will be the ones left behind/ until last
- Paradoxically the older the building the greater the need for research/technology/ innovation to make efficient.

The Salford Energy House: Vision & Aims

- To develop an Energy Theme, that acts as a catalyst and promotes world-class excellence through interdisciplinary research, industry-informed teaching and engagement.
- To test knowledge and understanding of how and where energy is used within the domestic environment.
- To consider Fuel Poverty issues as world energy costs continue to rise.
- Europe's fist energy house in a fully controllable environmental chamber.
- The house is a pre 1920s Victorian Terrace. This house was on its original site in Salford some 5 years ago. It was demolished and re-constructed within the Labs on Campus.

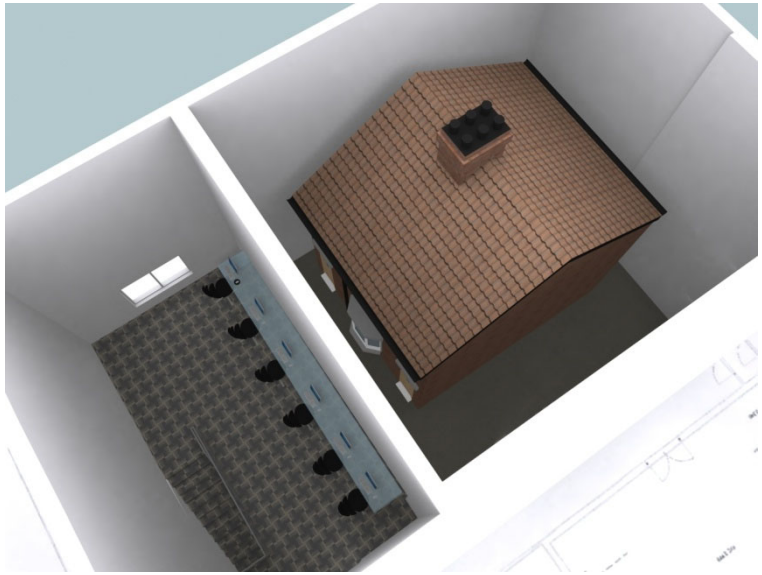
Applied Buildings and Energy Research Group

- How did we respond to this challenge?

- The external environment surrounding a dwelling can potentially make a significant difference to how much energy is required to heat the building. It is for this reason that we have developed the chamber to recreate a series of external weather conditions:

  - Temperature ranges from -12C to +30C (with an accuracy of +/- 0.5C)
  - Wind (Localised and chamber wide) up to 10 m/s
  - Rain (up to 200mm each hour)
  - Snow

The Hub – The House

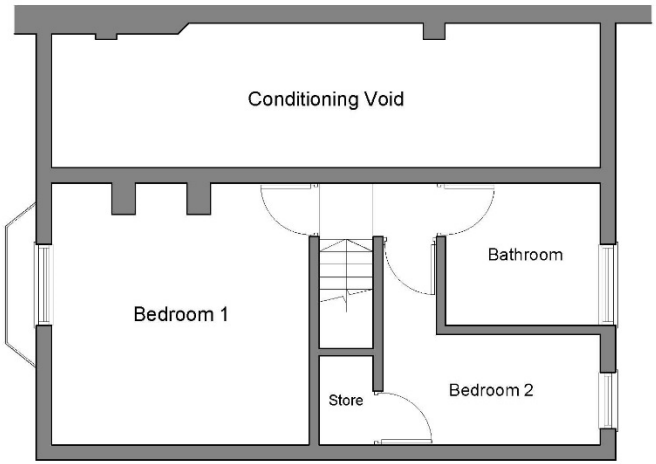


Climate Change Minister Greg Barker
and Vice Chancellor Prof Martin Hall

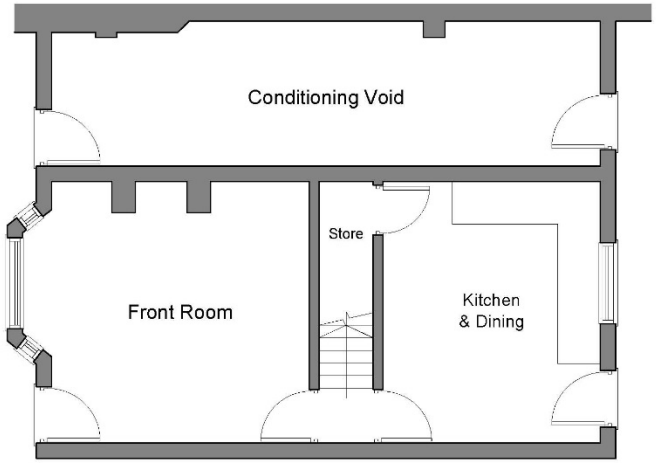
The Hub – The House


JOULE TERRACE

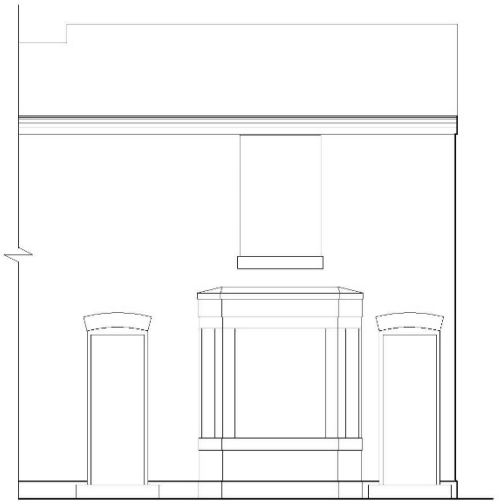
The Hub – The House



Proposed Terrace - Ground Floor



Proposed Terrace - Ground Floor



Proposed Front Elevation

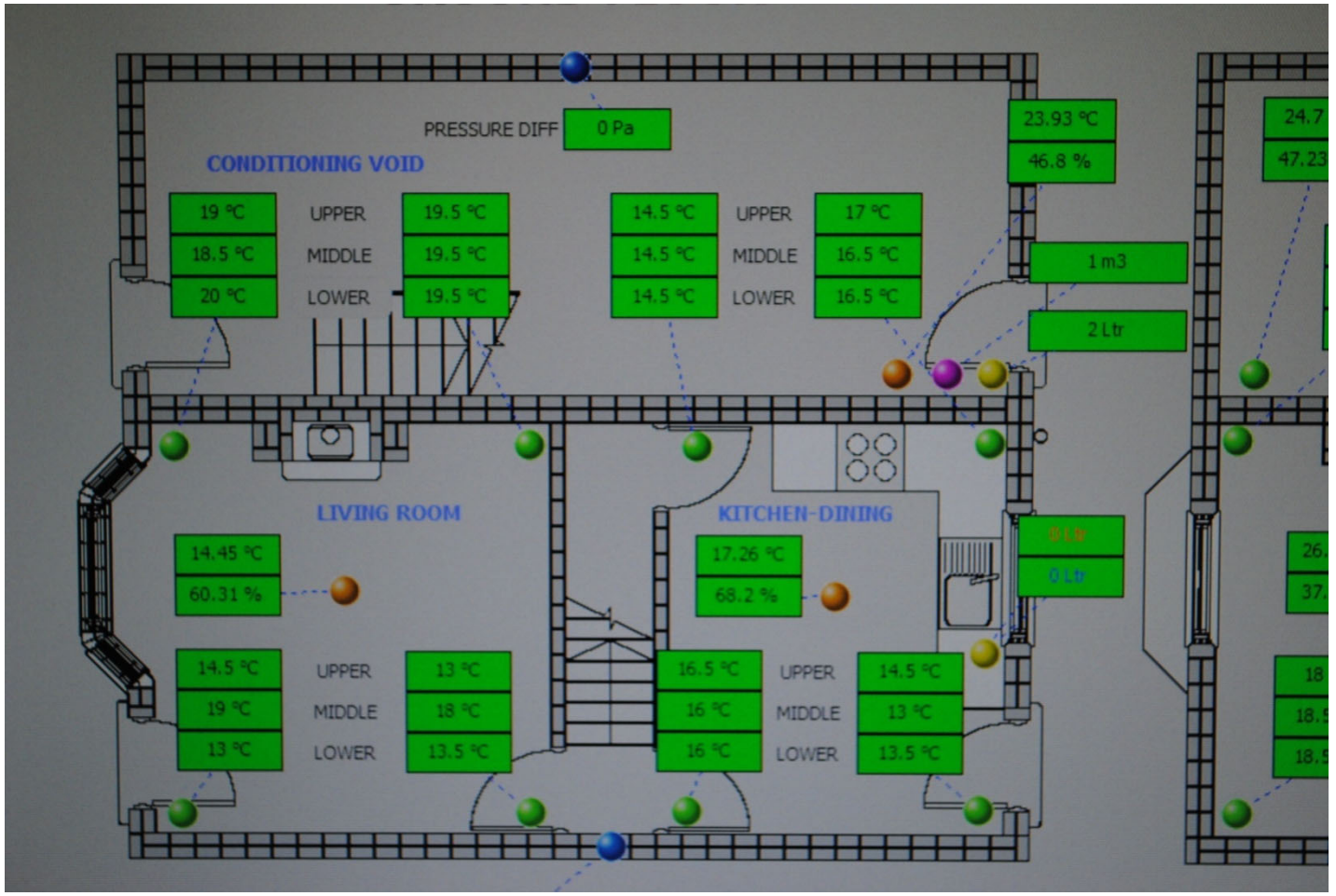
	First Issue Issued for Comment/Application	28.01.10	GB
	STAGE C		
Revision	Description	Date	Drawn

Halliday Meecham architects
Halliday Meecham Architects Limited
architecture
interior design
town planning
urban planning
project management
planning supervision

Client	University of Salford
Project	Energy Hub
Phase / Location	Cockcroft Building
Drawing	Proposed Victorian Terrace - Floor Plans & Front Elevation

Scale @ A1	Date	Drawn	Checked	Job No.	Drawing No.	Revision
1:50	27/01/10	GB	HJR	4111	(SK-) 16	-

Monitoring


PRESSURE DIFF
0 Pa
CONDITIONING VOID
19 °C
18.5 °C
20 °C
UPPER
MIDDLE
LOWER
19.5 °C
19.5 °C
19.5 °C
14.5 °C
14.5 °C
14.5 °C
UPPER
MIDDLE
LOWER
17 °C
16.5 °C
16.5 °C
23.93 °C
46.8 %
1 m3
2 Ltr
LIVING ROOM
14.45 °C
60.31 %
KITCHEN-DINING
17.26 °C
68.2 %
0 Ltr
14.5 °C
19 °C
13 °C
UPPER
MIDDLE
LOWER
13 °C
18 °C
13.5 °C
16.5 °C
16 °C
16 °C
UPPER
MIDDLE
LOWER
14.5 °C
13 °C
13.5 °C

Unique Features of the Energy House

Allows us to control and recreate weather conditions. *This includes:*

- Temperatures ranging from -12 to +30°C with a 0.5 degree °C tolerance.
- Humidity ranging from 20% to 90% RH.
- Rain up to the equivalent of 150mm per hour.
- Snow up to 100mm depth.
- Light wind can be applied from all directions approximately 2-3 m/s.
- The house is fully functional from heating systems through to domestic appliances.
- It includes the latest innovative monitoring technologies.
- Monitor in real time the use of water, gas and electricity at appliance level.
- Continual monitoring of room temperatures, pressures airflow and heat leakage.

The Energy House allows:

- Academics to collaborate with industrial partners to develop and test new products and systems to improve the energy efficiency of dwellings.

- Tests on insulation products
  - Solid walls (hard to treat)
  - Challenge max level of insulation without losing space and aesthetics.
  - Occupants attitudes to retrofit and cost in use studies.

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Effect of Curtains: Results

U Values (the higher the number the greater the heat loss):

With Curtains U value Average over 24 hr.	**Living Room**	**Kitchen Blind**	**Bedroom 1**	**Bedroom 2**	**Bathroom Blind**
Average U value W/m²K	5.18	4.15	4.32	4.43	3.81
Without Curtains U value Average over 24 hr.	**Living Room**	**Kitchen Blind**	**Bedroom 1**	**Bedroom 2**	**Bathroom Blind**
Average U value W/m²K	7.45	5.28	5.13	5.15	5.67
Total reduction in U Value %	**30.46%**	**21.30%**	**15.71%**	**14.01%**	**32.73%**

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Effect of Curtains: Results

Transmission of Heat (the actual amount of energy transferring through the window)

	Living Room W/m²	**Kitchen W/m²**	**Bedroom 1 W/m²**	**Bedroom 2 W/m²**	**Bathroom W/m²**
Heat Energy Loss **WITH** curtains	69.78	55.17	50.23	55.67	44.75
Heat Energy Loss **WITHOUT** curtains	96.45	62.91	52.80	62.03	63.14
Reduction	**26.68**	**7.74**	**2.57**	**6.35**	**18.39**

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Effect of Curtains: Summary

For this test:

The savings are not huge, in terms of £.

Small house, wall to window ratio is high

Moderate conditions, both inside and out

There are far superior curtain hanging methods, insulated pelmets. Tucking behind radiator DOES save more energy, we have tested this, also working on new super-insulant materials (data analysis taking place)

	Living Room	Kitchen	Bedroom 1	Bedroom 2	Bathroom	Total
Savings in Watts	84.30	12.92	4.86	6.92	34.21	**143.21**
One day consumption in winter 5C outside 21C/18C inside	£0.026	£0.004	£0.001	£0.002	£0.011	**£0.04p**

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Window Films

We recently completed a similar test on a DIY window film system, on average better than curtains, but with obvious disadvantages.

Reductions in Heat Loss Across Centre Pane

Living Room	Kitchen Blinds	Bedroom 1	Bedroom 2	Bathroom Blinds
28.58%	28.18%	25.83%	26.47%	23.21%

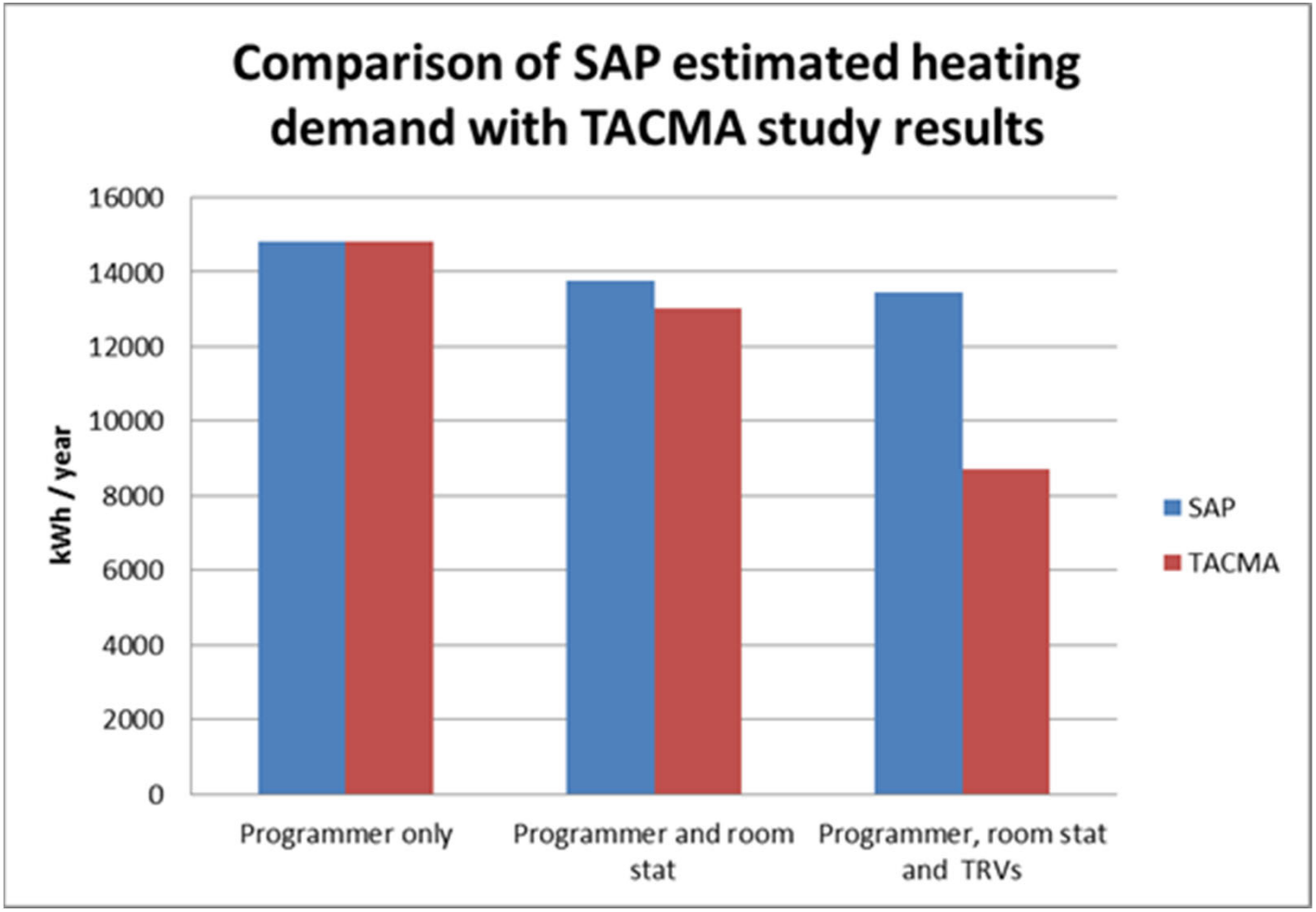
Larger Scale Tests

Heating Controls

Localised Controls

Test		Energy cost (24 hr)	Savings
1	No controls	£5.31	-
2	Room stat	£4.68	12%
3	Room stat + TRVs	£3.15	41%

Heating Controls



The Association of Control Manufacturers (TACMA)
SAP Standard Assessment Procedure

Heating Controls

Boiler Energy Management Systems (Full Systems)

- Savings between 14% on Start-up heating cost (applicable during the heat up period of the home only, and not the whole profile of the day) and an average saving over a 2 day period of 6.7% for another unit.

- We discovered that the savings made using these units are sometimes dependant on the heating system and can sometimes over-perform and underperform dependant on the type of control.

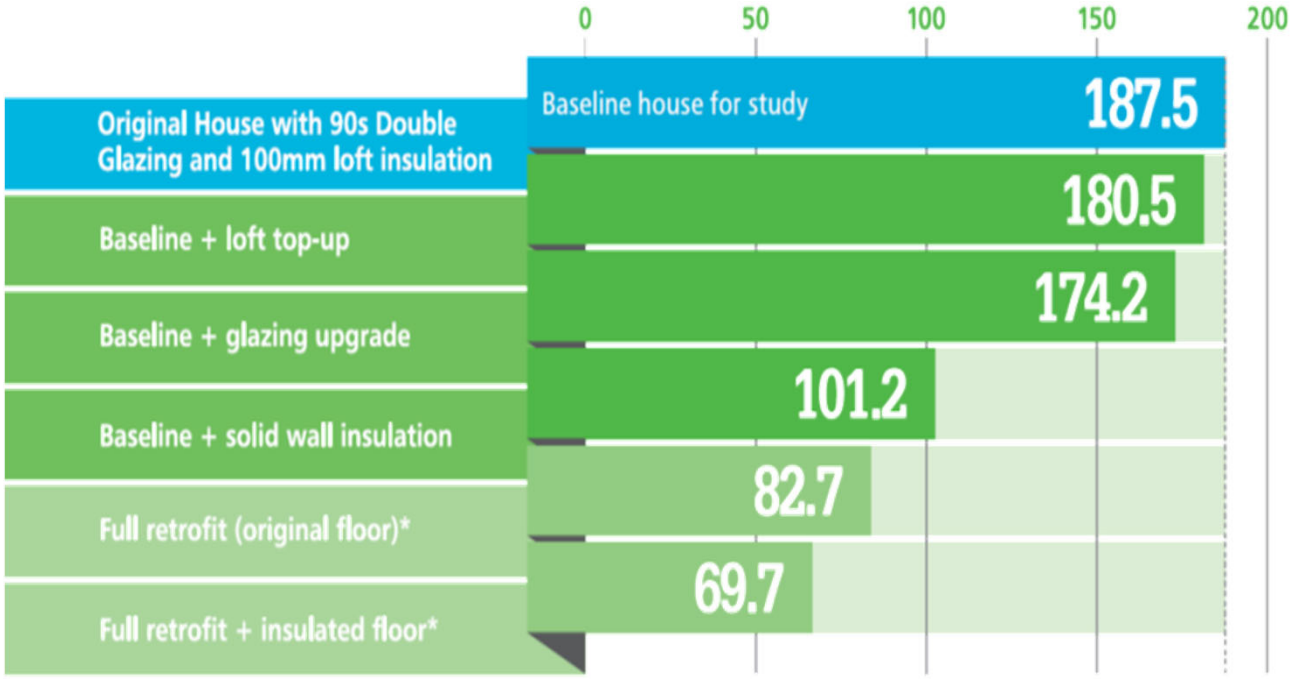
Fabric Improvements

Whole House Retrofit with Saint Gobain and Leeds Beckett University.

- Loft Top Up
- External Wall Insulation Side and Rear
- Internal Wall Insulation Front
- Floor Insulation

Doors and Windows Upgraded before retrofit

Whole House Heat Loss

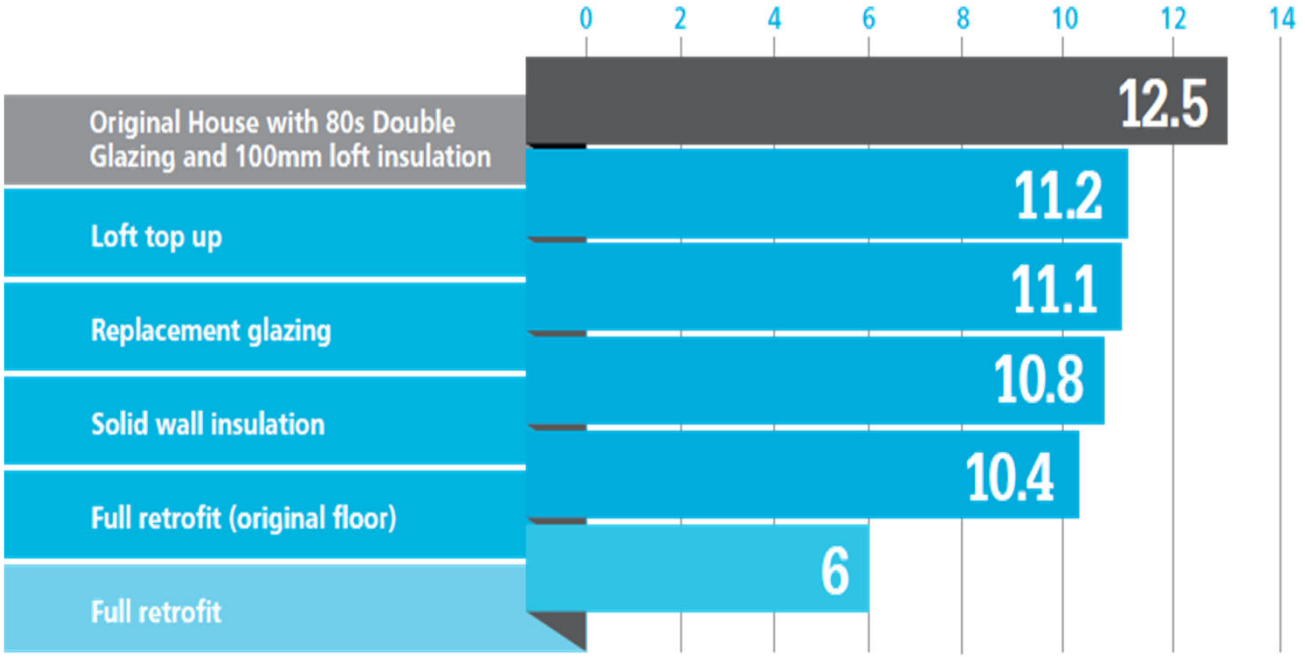


*Multiple measures installed

63%

Reduction in heat lost from the building following full Saint-Gobain retrofit

Airtightness Results



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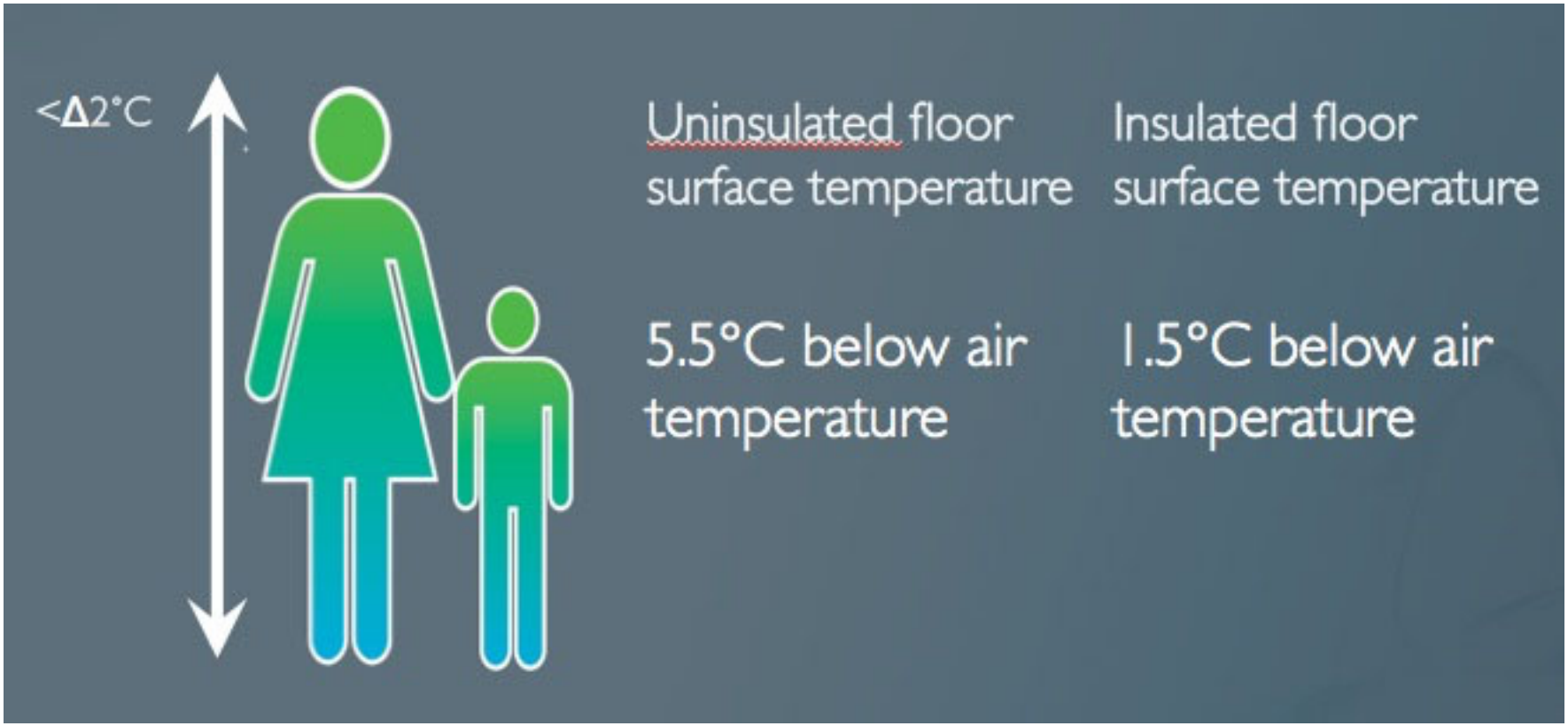
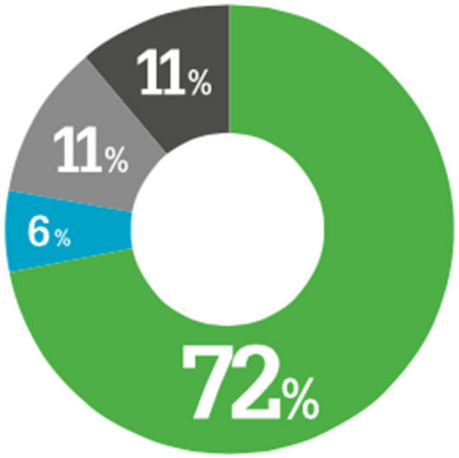
Comfort Findings





Contribution to Reduction

- Solid wall insulation
- Loft insulation (top up)
- Floor upgrade (suspended timber)
- Replacement glazing

Contribution of each thermal upgrade measure to the reduction in whole house heat loss of the fully retrofitted test house.

Reduction in energy cost (£)

Based upon a notional property with similar heat loss characteristics, installing these Saint-Gobain measures saves significant energy costs.

The improved heat loss coefficient and improved air permeability reduces heating bills in the property from £554 to £206 per year, or put another way, down to less than £4 per week.

Performance Gap

Performance gap is now well researched:

Measured energy - Modelled energy = Performance gap.

So all tests work?

We know that there are gaps in the energy models (U values can't be correct for all parts of all buildings). UK values for brick walls are currently being changed from 2.1 to around 1.7 W/m^2K. This has a significant effect on the pre/post retrofit issue.

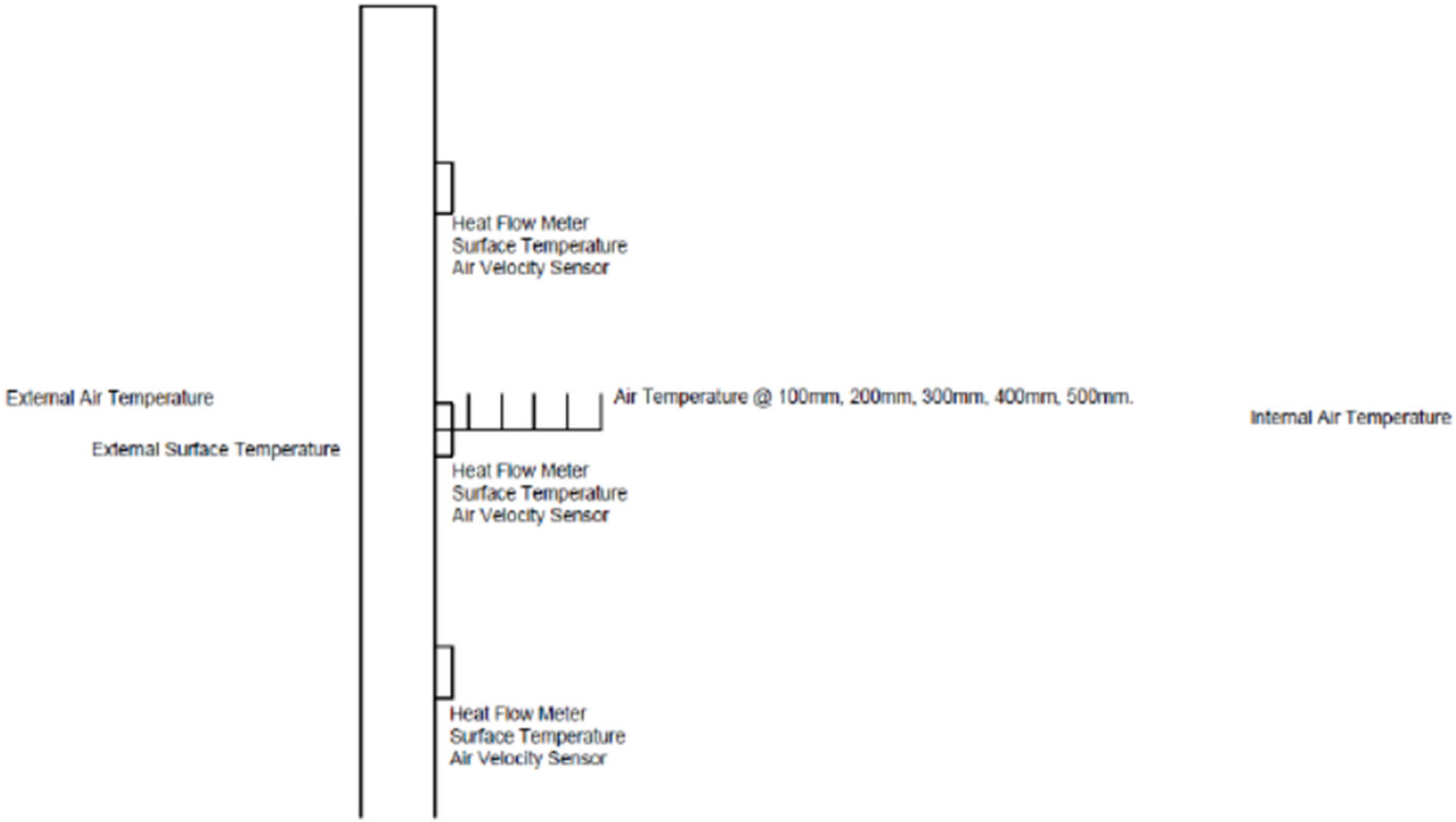
We have proven a significant difference in the savings offered by even the most basic of heating controls.

Also found a significant gap in how energy efficiency measures are measured, "measurement gap"

U-value measurement gap

Simple experiment:

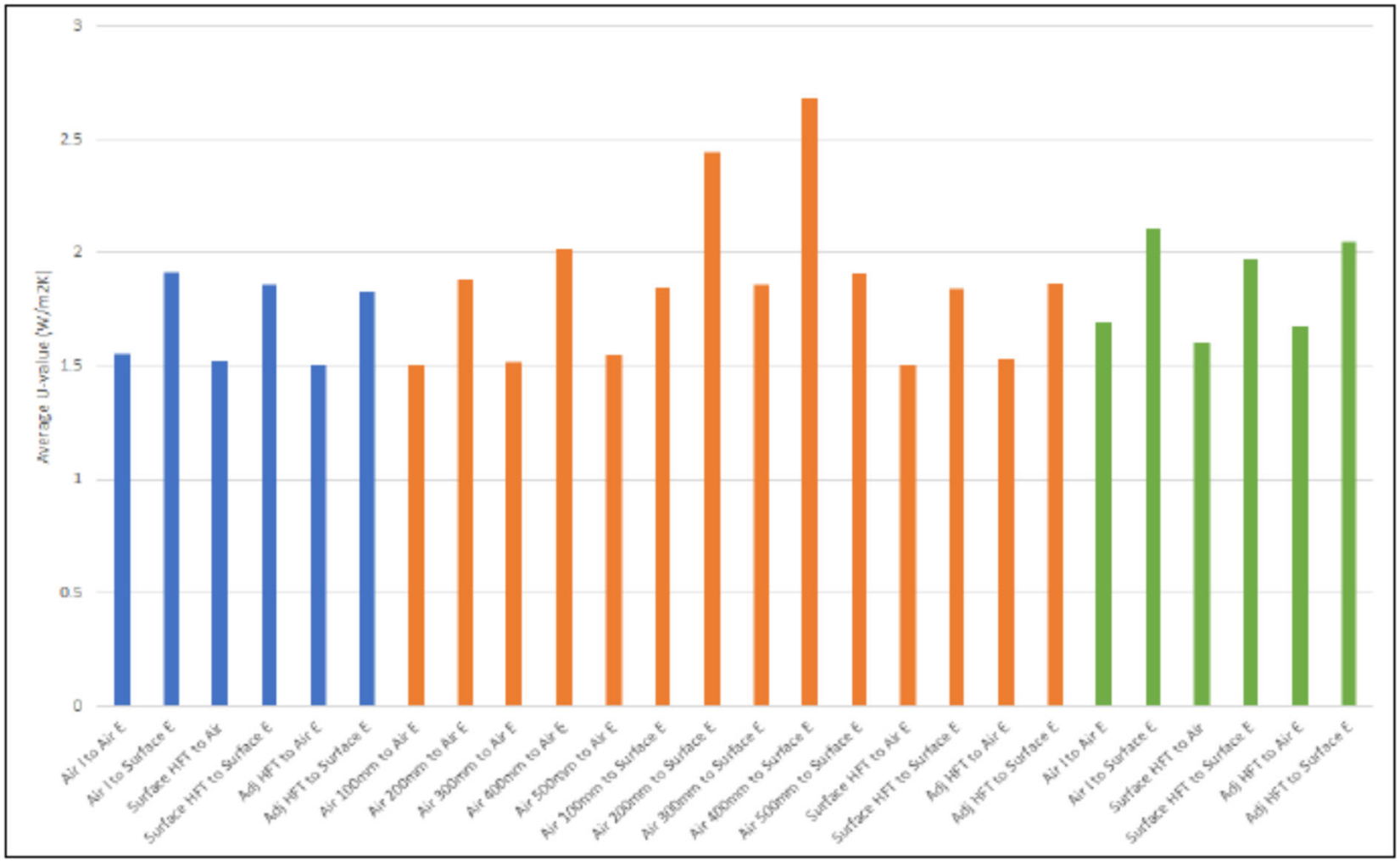
How many U values can we get from one simple setup, and could this be used to “play” results?


Heat Flow Meter
Surface Temperature
Air Velocity Sensor
External Air Temperature
Air Temperature @ 100mm, 200mm, 300mm, 400mm, 500mm.
Internal Air Temperature
External Surface Temperature
Heat Flow Meter
Surface Temperature
Air Velocity Sensor
Heat Flow Meter
Surface Temperature
Air Velocity Sensor

Average R-values, U-values (average method) and U-values (dynamic method): No Fan

Location	Internal	External	Average R Value (m^2K/W)	Average U-value (Average Method) (W/m^2K)	Average U-value (Dynamic Method) (W/m^2K)
Top	Air	Air	0.642	1.557	1.561
	Air	Surface	0.523	1.912	1.920
	HFT	Air	0.657	1.522	1.596
	HFT	Surface	0.537	1.861	1.971
	Surface	Air	0.666	1.502	1.582
	Surface	Surface	0.546	1.830	1.952
Middle	Air 100mm	Air	0.662	1.510	1.500
	Air 200mm	Air	0.531	1.883	1.880
	Air 300mm	Air	0.659	1.518	1.511
	Air 400mm	Air	0.495	2.020	2.012
	Air 500mm	Air	0.646	1.548	1.546
	Air 100mm	Surface	0.540	1.850	1.846
	Air 200mm	Surface	0.409	2.446	2.435
	Air 300mm	Surface	0.537	1.863	1.859
	Air 400mm	Surface	0.373	2.680	2.654
	Air 500mm	Surface	0.524	1.909	1.906
	HFT	Air	0.664	1.505	1.572
	HFT	Surface	0.544	1.839	1.953
	Surface	Air	0.652	1.533	1.586
	Surface	Surface	0.537	1.864	1.970
Bottom	Air	Air	0.590	1.694	1.686
	Air	Surface	0.475	2.107	2.098
	HFT	Air	0.624	1.603	1.682
	HFT	Surface	0.508	1.968	2.090
	Surface	Air	0.596	1.679	1.701
	Surface	Surface	0.488	2.051	2.113

Average U-values (average method) for each permutation: No fan



Highest U-value = 2.446W/m^{2}K Lowest U-value = 1.502W/m^{2}K

DB Appraisal: No Fan

Weather File: Manchester

Highest U-value: 2.446 W/m^2K

Annual Space Heating Energy Consumption: 8084.81 kWh

Annual Space Heating Energy Cost: £395.35

{British Gas 12/16 @0.0489p/kWh}

Lowest U-value: 1.502 W/m^2K

Annual Space Heating Energy Consumption: 5971.13kWh

Annual Space Heating Energy Cost: £291.99

{British Gas 12/16 @0.0489p/kWh}

Consumption Difference: 2113.68 kWh

Cost Difference: £103.36

Highest U-value = 2.446W/m^2K Lowest U-value = 1.502W/m^2K

People and the Salford Energy Hub

The importance of people

- People are key:
  - Retrofit technologies exist but are still not widely deployed
  - People continue to consume excessively (often needlessly)
  - Individual use almost offsets all changes to the infrastructure through retrofit
  - Massive impact of individual behaviour (10-40% of energy use)
- Relish project – Woking Homes – provided £6.5K improvements + provision of 1:1 support to different households
  - 4 conditions in order of most effectiveness:
    1. Improve + Support
    2. Support only – this provided more benefits than just providing the basic measures
    3. Improve only
    4. Nothing (control)

There are many areas where people are involved in energy use

- Effective energy demand/carbon reduction - requires:
  - Increased confidence in products/technologies
  - Improvements in the understanding of home energy efficiency
  - Understanding of affordability (i.e. FITs, Green Deal etc.)
  - Better appreciation of how people use technologies (important for both designers and users)
  - Understanding of habits (in order to change them)
  - Increased public support for something needing to be done

Information alone will probably not engage everyone..

Research conducted in 2008 by Exeter University showed that the longest and the most frequent flights were taken by those who were most aware of environmental issues! **Therefore we need to work to understand people**

There are a variety of things we need to understand

- What are peoples' energy behaviours, norms and views?
- How do our physical and social environments shape our energy behaviour and how we reason?
- What role do emotions and the actions of others on our reasoning?

There are a variety of things we need to understand

- How do issues like tenure, age, ethnicity, etc impact on energy use

- What are the barriers to adopting retrofit? Finance, lack of trust, awareness, fear the unknown and potential disruption

There are a variety of things we need to understand

- What messages have the most impact?
- What would make you change your behaviour/adopt retrofit measures?? Do you even know?

Research at Salford

- We will be looking at the following issues:
  - Habitual use of energy and how this can be manipulated - using the energy house as a lab to test how people respond to different stimuli whilst observing on CCTV
  - How people use energy in real time – attaching monitors to people to log the various energy consuming behaviours

Research at Salford

- How people make their decisions when faced with different incentives and options
- How approaches to social marketing can facilitate greater up take of retrofit measures.
- If there are differences in energy use across different demographics (e.g. BME, tenure, age etc.)
- How technology can best respond to the behavioural patterns people have
- Test rig for underfloor heating
- Performance of fungicidal washes on tiles
- Thermography with different insulation/details

Any Questions

Get In Touch…

We are always looking for sponsors and partners for our research.

- Richard Fitton (Energy House Manager) r.fitton@salford.ac.uk
- Ben Roberts (Researcher) b.i.roberts@salford.ac.uk
- Stephen Todd, Senior Lecturer (Energy House, Modelling improvements, Housing Sustainability) s.todd@salford.ac.uk
- Philip Brown, Professor (People and Energy) p.brown@salford.ac.uk