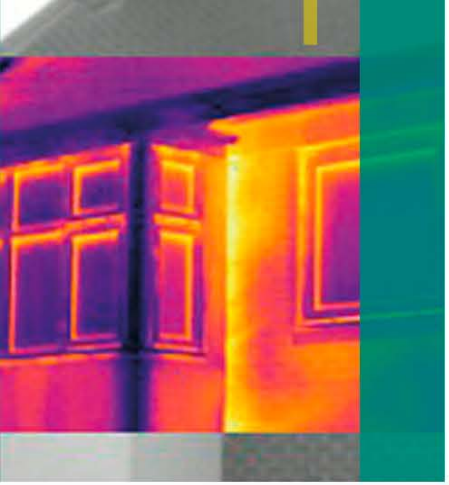


CALEBRE

Professor Dennis Loveday, Loughborough University
Project Principal Investigator

Presentation to:
CIBSE Homes for the Future Group, 18 July 2013

Key Findings from the **CALEBRE** Research Project

e·on UK

Research Councils UK Energy Programme For a Low Carbon Future

University of Oxford

The University of Warwick

Heriot Watt University

Loughborough University

University of Ulster

The University of Nottingham

What is Project ‘CALEBRE’ ?

- **C**onsumer-**A**ppealing **L**ow **E**nergy technologies for **B**uilding **RE**trofitting (October 2008 – April 2013)

- Research project funded by E.ON / RCUK (£2million)

- Address challenges of UK domestic energy efficiency refurbishment
  - **Principally solid wall, ‘hard to heat, hard to treat’**
  - **Selected current, medium and longer-term technologies**
  - **Householders’ perspectives at heart of our thinking**

- Multi-disciplinary collaboration - laboratory testing; simulation modelling; test house field trials; user engagement methods

Project ‘CALEBRE’ – the Team

- A partnership of six leading UK Universities: Heriot-Watt, Loughborough, Nottingham, Oxford, Ulster and Warwick
- 24 research associates, doctoral students and academics
- 8 Advisory Board members: CIBSE, BRE, Edward Cullinan Architects, David Strong Consulting, Aachen and Loughborough universities, University College London, E.ON and RCUK

CALEBRE - People and Expertise

Expertise Area	CALEBRE Team Members and Universities
Heat Pumps	Bob Critoph, Steve Metcalf (Warwick) Neil Hewitt, M S Khoushestani (Ulster)
Vacuum Glazing	Phil Eames, Saim Memon (Loughborough) Trevor Hyde, Farid Arya (Ulster)
Field Trials	Mark Gillott, C Spataru (Nottingham) Phil Griffiths (Ulster)
Modelling	Phil Banfill, Sophie Simpson, Andrew Peacock (Heriot Watt)
Householders	Vicky Haines, Val Mitchell, Becky Mallaband, Steve Bayer (Loughborough)
Advanced Materials	Matthew Hall, Sean Casey (Nottingham) Edman Tsang, Abdullah Khan (Oxford)
Manufacturing & Business Models	Svetan Ratchev, Rob Darlington, Kobby Agyapong-Kodua (Nottingham)
Project Leadership and Thermal Comfort	Dennis Loveday, Keyur Vadodaria (Loughborough)

CALEBRE and solid-wall housing: our approach

- 8.3 million solid wall properties
- 34% of UK housing stock
- 50% of domestic carbon emissions
- Refurbishment necessary, but challenging
- Limited choices for reducing wall heat loss

CALEBRE and solid-wall housing: our approach

So, we focussed on:

- Other means to reduce heat demand:
  - Airtightness
  - Mechanical ventilation with heat recovery
  - Advanced window treatments – vacuum glazing
  - Advanced surface treatments for moisture and temperature control
- Efficient heat supply:
  - Gas heat pump technology
  - Electric heat pump technology
- Householders and behaviour:
  - Attitudes to refurbishment
  - Retrofit practices
  - Personal energy tracking
  - Domestic thermal comfort

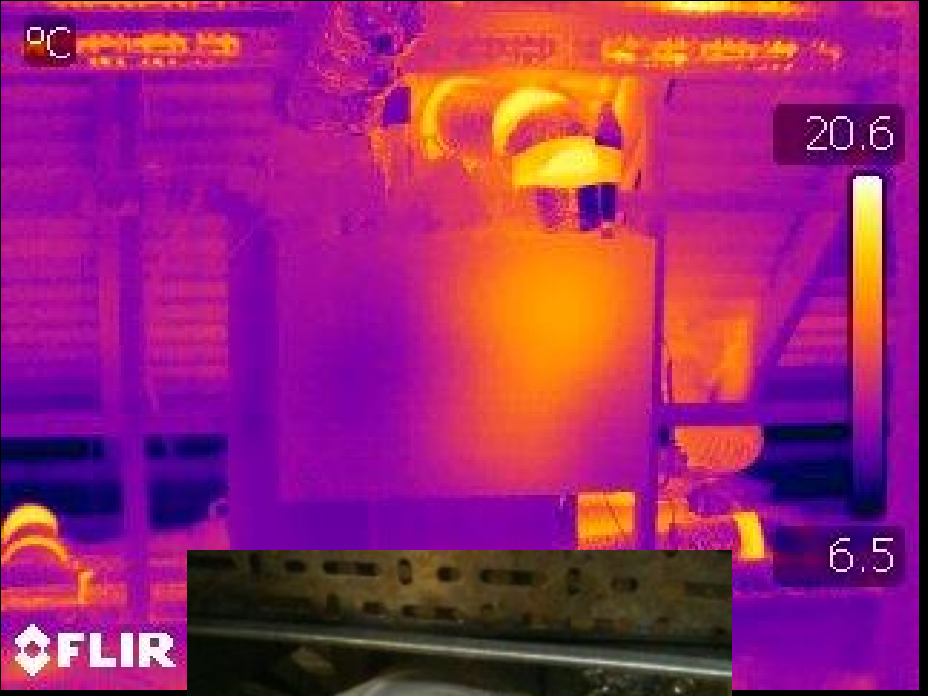
CALEBRE Briefing Notes

- Key findings summarised
- Handy format
- To assist the growing refurbishment industry
- To guide future policy
- To help further research
- Full set in booklet format for reference purposes available soon, and downloadable

Key findings: Reducing heat demand - Airtightness, MVHR

Through practical trials in a test house, evidence for, and indication of:

- Airtightness values achievable in practical refurbishment…
- …challenging but practically realisable
- Levels of detailing required
- Quality of workmanship through training that is required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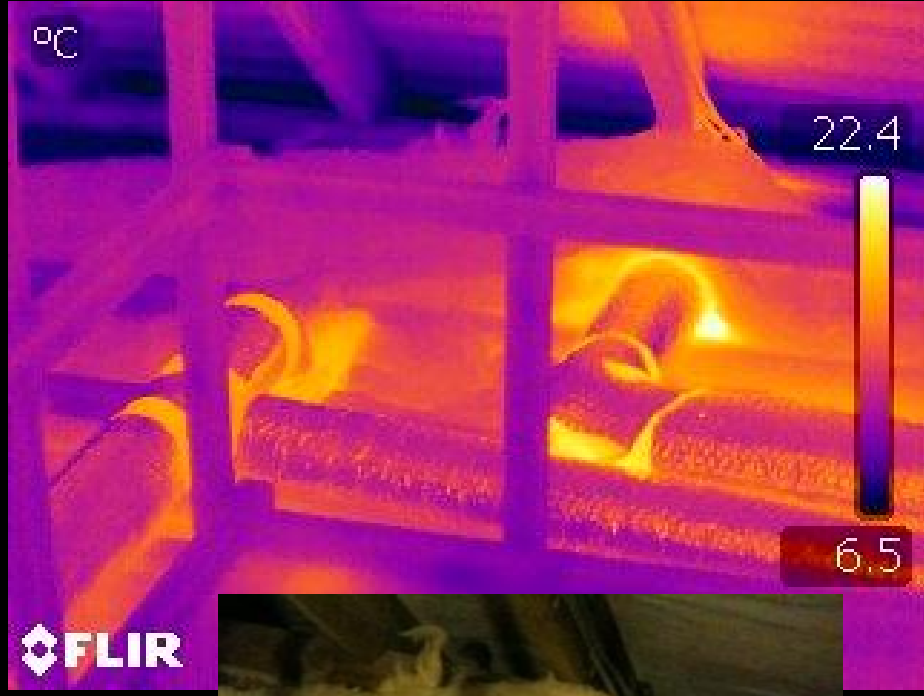
°C
22.4
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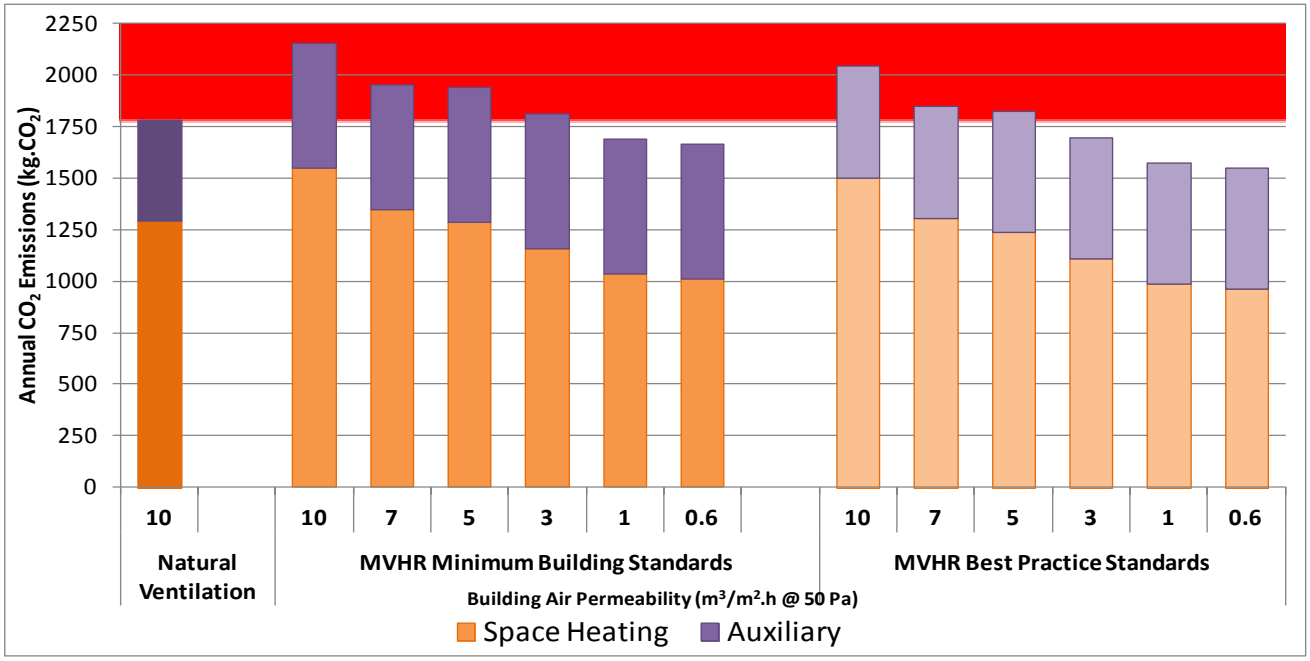
Key findings: Reducing heat demand - Airtightness, MVHR

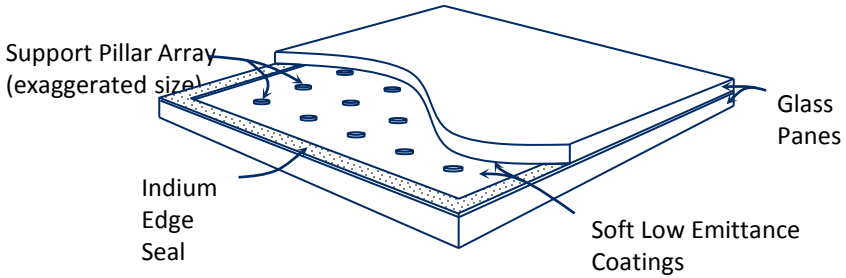
And through dynamic thermal modelling of the test house:

- Airtightness levels needed for MVHR to save energy and carbon
- Install properly and balance, in a sufficiently airtight house



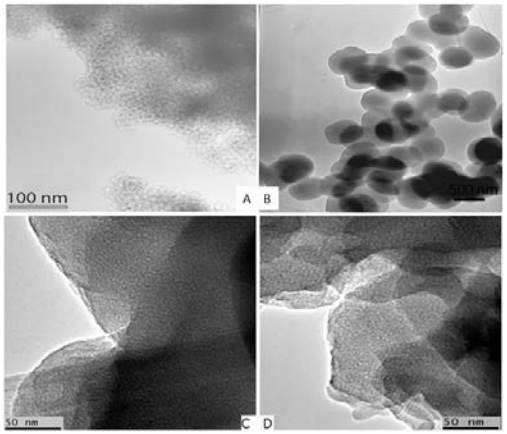
Key developments: Reducing heat demand - Vacuum Glazing technology

- Slimmer than standard double glazing
- New, lower-cost edge seals developed
- A step closer commercially
- U values of 0.26 $Wm^{-2}K^{-1}$ achievable with triple vacuum glazing
- Can improve performance of solid-wall (and other) envelopes
- Supported by manufacturing business models



Key developments: Advanced surface material for moisture control

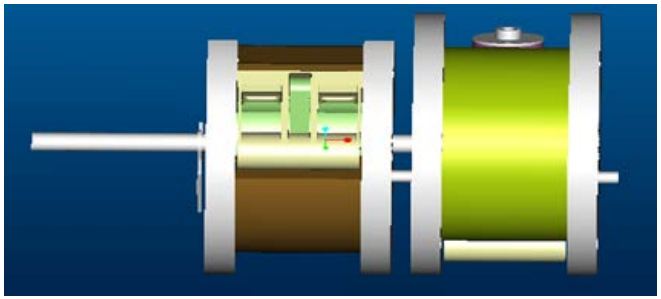
- Materials successfully engineered for rapid response humidity and temperature buffering
- Two orders of magnitude better than traditional interior building surface materials
- Expensive now – research for bulk manufacture needed
- Potential to control indoor moisture using relatively small surface areas

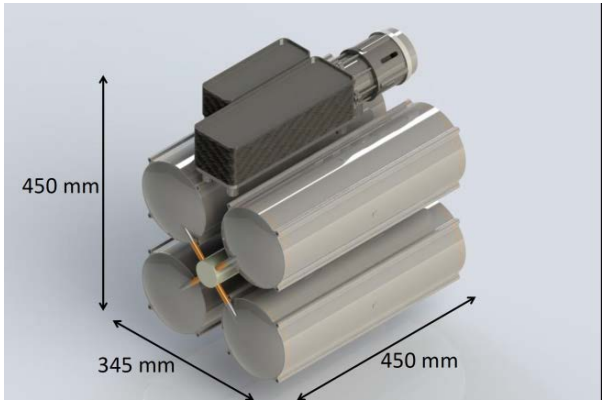


Key developments: Efficient heat supply - Heat Pumps technology

New technologies developed for air-source heat pumps:

- Designed for ease of retrofit
- Boiler replacement
- Operate with existing radiators (output at 60^{o}C)
- Still give good performance
- Supported by manufacturing business models





The gas-fired air-source heat pump

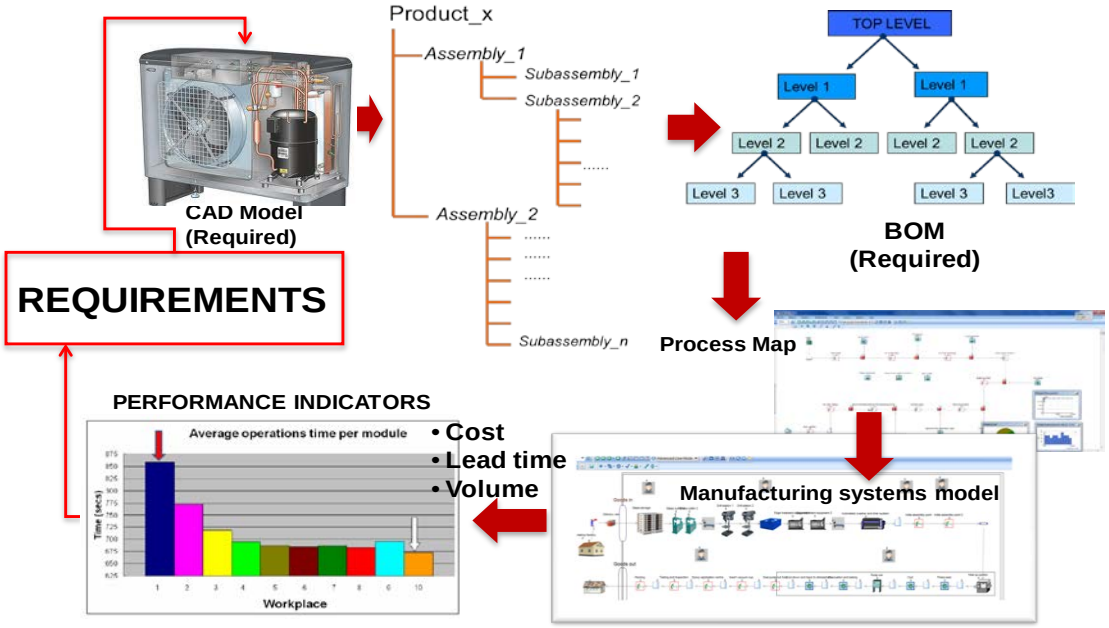
- New technology – thermal compressor
- Box-for-box exchange for old boiler
- Split system, saves garden space
- 30% annual fuel savings
- Payback time < 3 years
- Commercial development continuing…
- …spin-out ‘Sorption Energy’ formed

The electric air-source heat pump

- New technologies – economised vapour injection (EVI) and compressor-expander (CE)
- High temperature for direct retrofit
- In lab, CE gave COP (heating) of 4.31, but needs further development
- EVI is a viable product, competitive with cascade units
- Energy storage required to manage tariffs and electrical demand

Key developments: Business models for manufacture

- Requirement specifications developed for the heat pumps and vacuum glazing
- Systems design and manufacturing methodology defined



Key findings: Householders and Behaviour – Attitudes to refurbishment

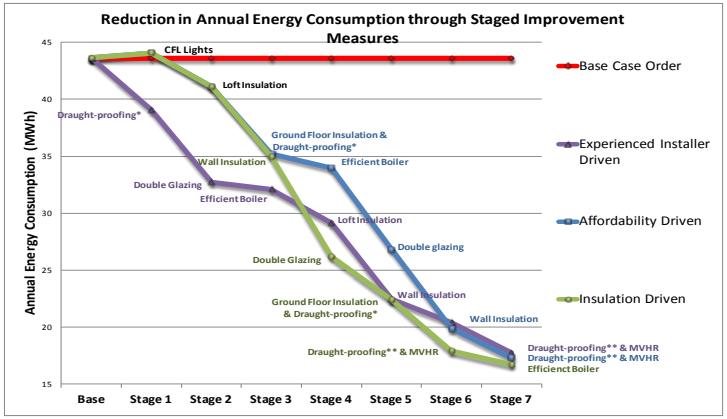
Older properties - barriers and opportunities identified relating to:

- Motivation, timing & cost (e.g. repair and comfort are key drivers, not energy)
- Original house features (e.g. windows)
- The refurbishment process
- Issues of trust
- Attitudes to airtightness and ventilation
- Types of home improvers identified

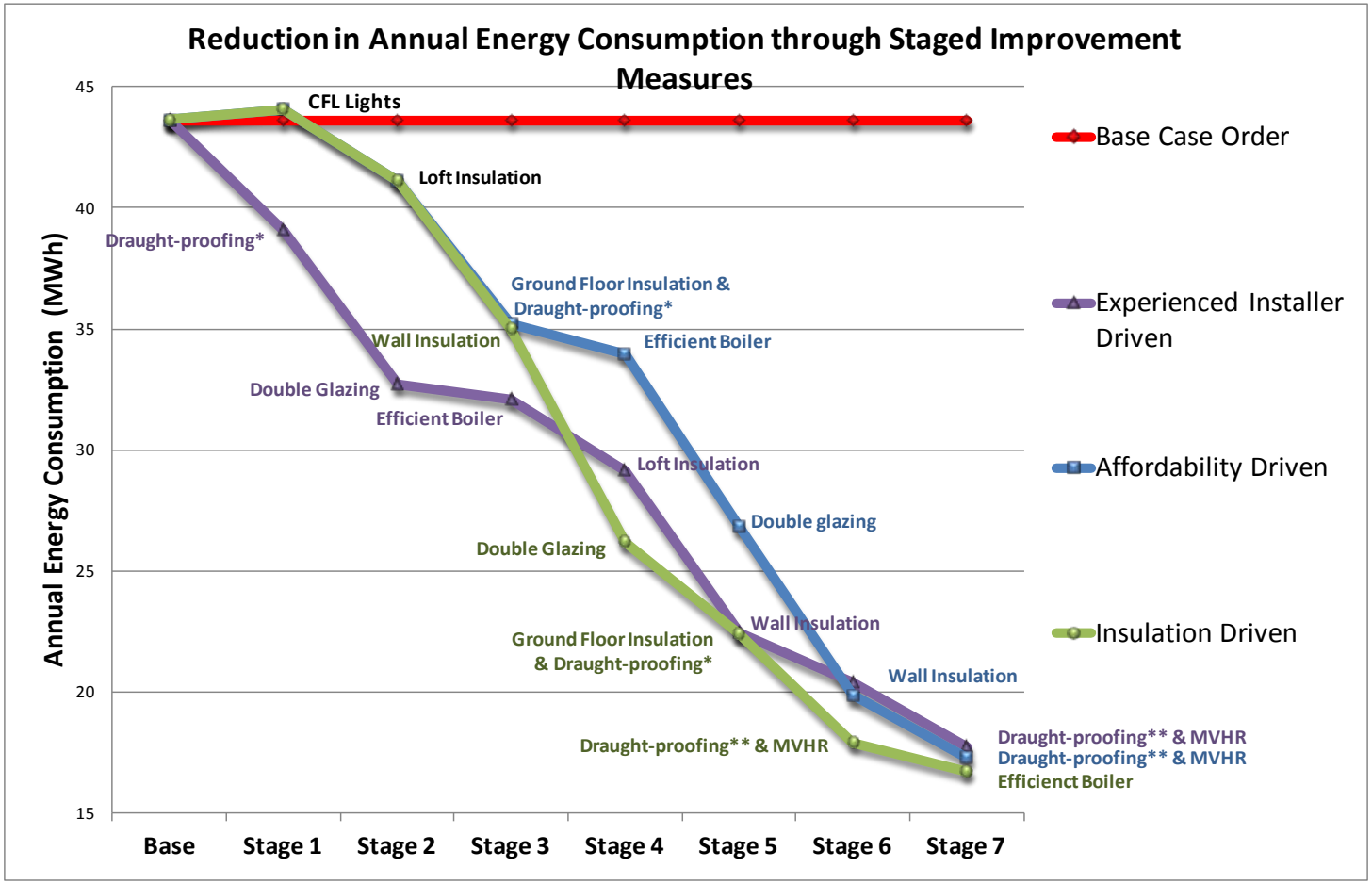
Key findings: Householders and behaviour - Orders of Retrofit

Using dynamic thermal modelling of the test house:

- Sequences for retrofit of standard measures investigated
- Benefits and payback times of individual measures varies, depending on preceding measures installed
- Can impact upon the Green Deal and ‘Golden Rule’
- Early implementation of measures like wall insulation, double glazing, yield greatest cumulative savings

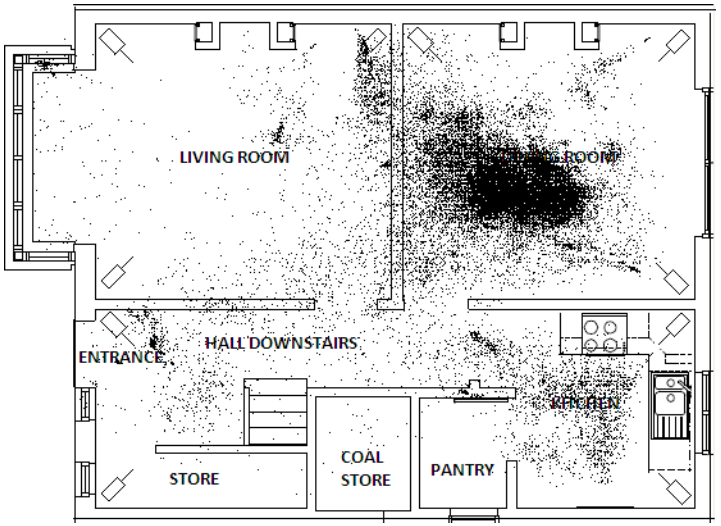


Key findings: Orders of Retrofit



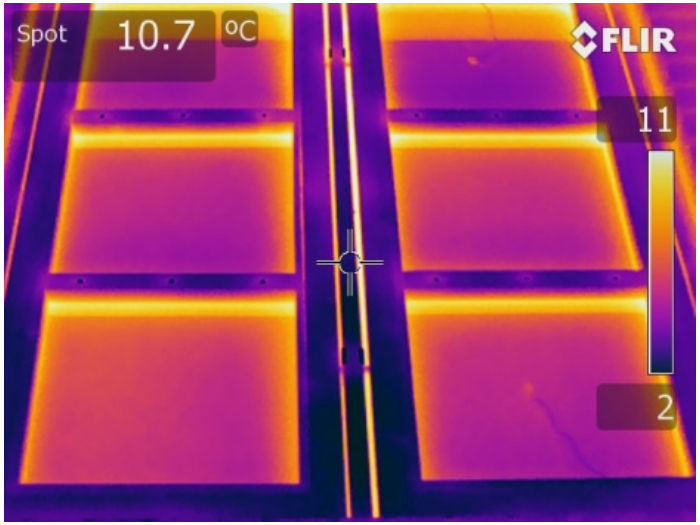
Key developments: Householders and behaviour - Occupant energy tracking in real time

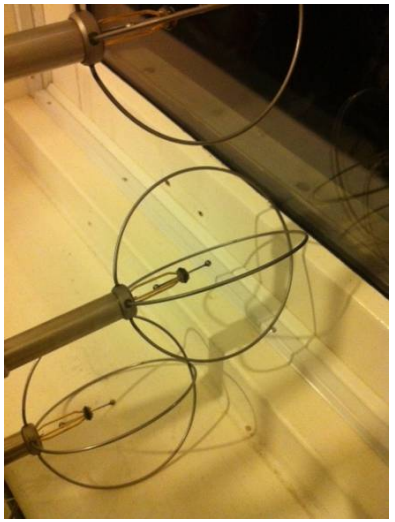
- Real-time location and energy tracking system developed
- Occupancy behaviour and energy use – personal carbon footprint
- Monitors space usage in response to indoor environmental conditions and interventions (e.g. retrofit)
- Can evaluate in-use performance of homes – a metric of occupants' behaviour



Key developments: Householders and behaviour – Domestic thermal comfort

- Thermal comfort evaluation of technologies: vacuum glazing
- Review of indoor temperatures in UK dwellings, 1969 – present
- Development of a domestic thermal comfort model (on-going)





CALEBRE and solid-wall housing: bringing findings together

- **The effective retrofit:** Householders and trust, use of professionals, airtightness, MVHR, quality of installation, orders of retrofit

- **Fit with existing systems:** Heat pumps and existing radiators, slender vacuum glazing for period windows and envelope thermal improvement

- **Space efficiency:** split heat pumps in boiler space, saving small garden space, advanced surface treatments

CALEBRE and the Green Deal

GD Assessors:

- Order of retrofit, variable payback and ‘Golden Rule’
- Also if people go it alone

GD Installers:

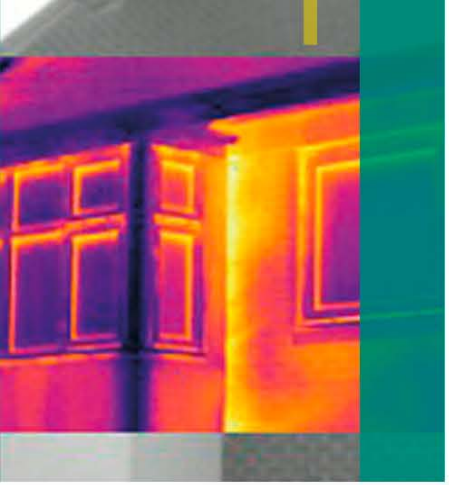
- Training, quality of installation – closing the ‘gap’

GD Provision:

- Tailor to needs of different householders

GD Approval:

- Modified heat pumps, vacuum glazing – process?



CALEBRE

Summary

- Householder perspectives in older properties
- Guidance on current refurbishment practice:
  - Airtightness, MVHR, installation quality & training
- Advances to technologies, near & longer terms:
  - Heat pumps, vacuum glazing, advanced materials
- Contributions to Green Deal, and solid-wall challenge

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Summary

- CALEBRE Briefing Notes - booklet for referencing available soon
- Will be available for download at our website
- Visit us at: www.calebre.org.uk
- Thank you for listening….!