Heat Workshop: Technology

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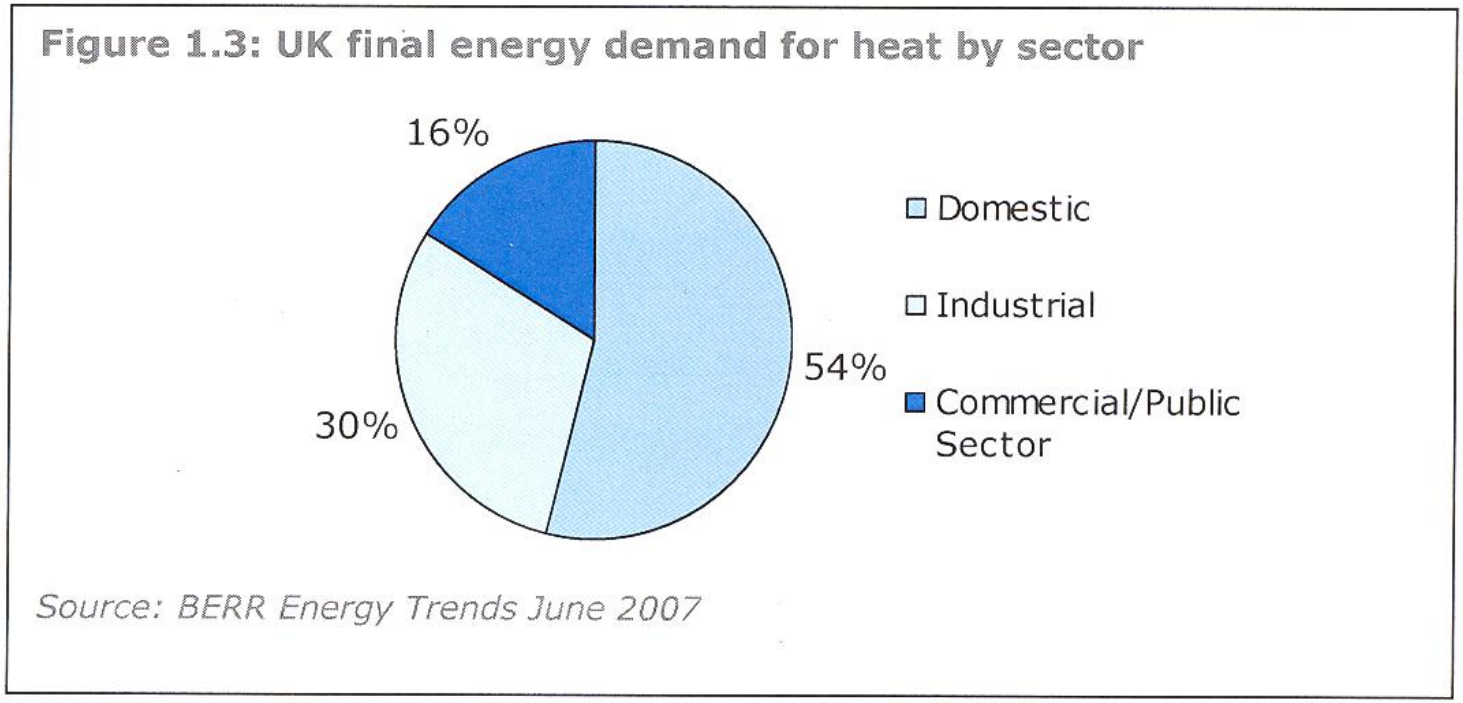
Overview

- UK built environment: demand for heat
- Current targets, challenges and technologies
- Potential future technologies and related issues

UK final energy demand for heat by sector

UK total heat demand (2005): 907 TWh…..70% used by buildings, three quarters of this being domestic use



Domestic heat use – mainly space and water heating

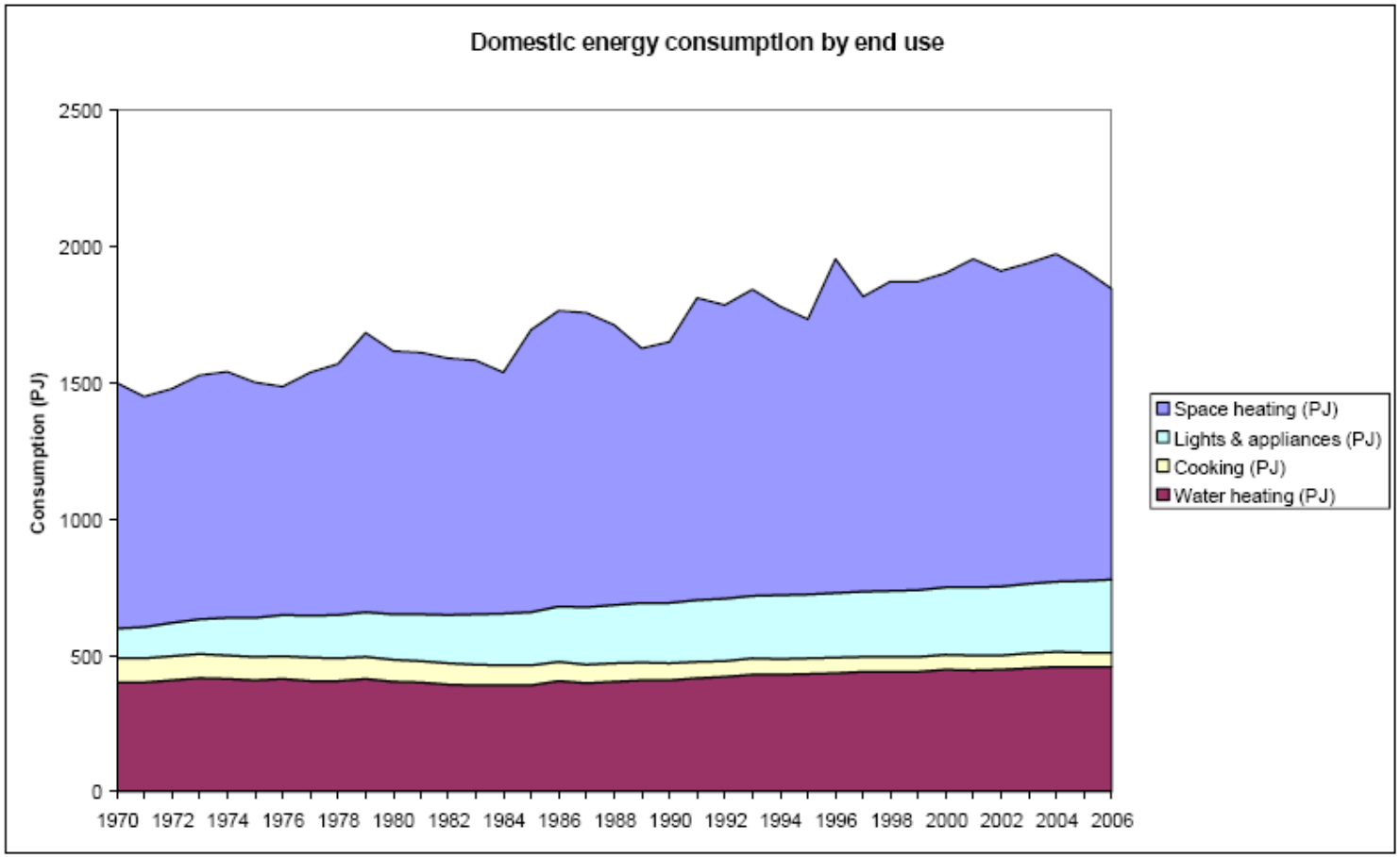
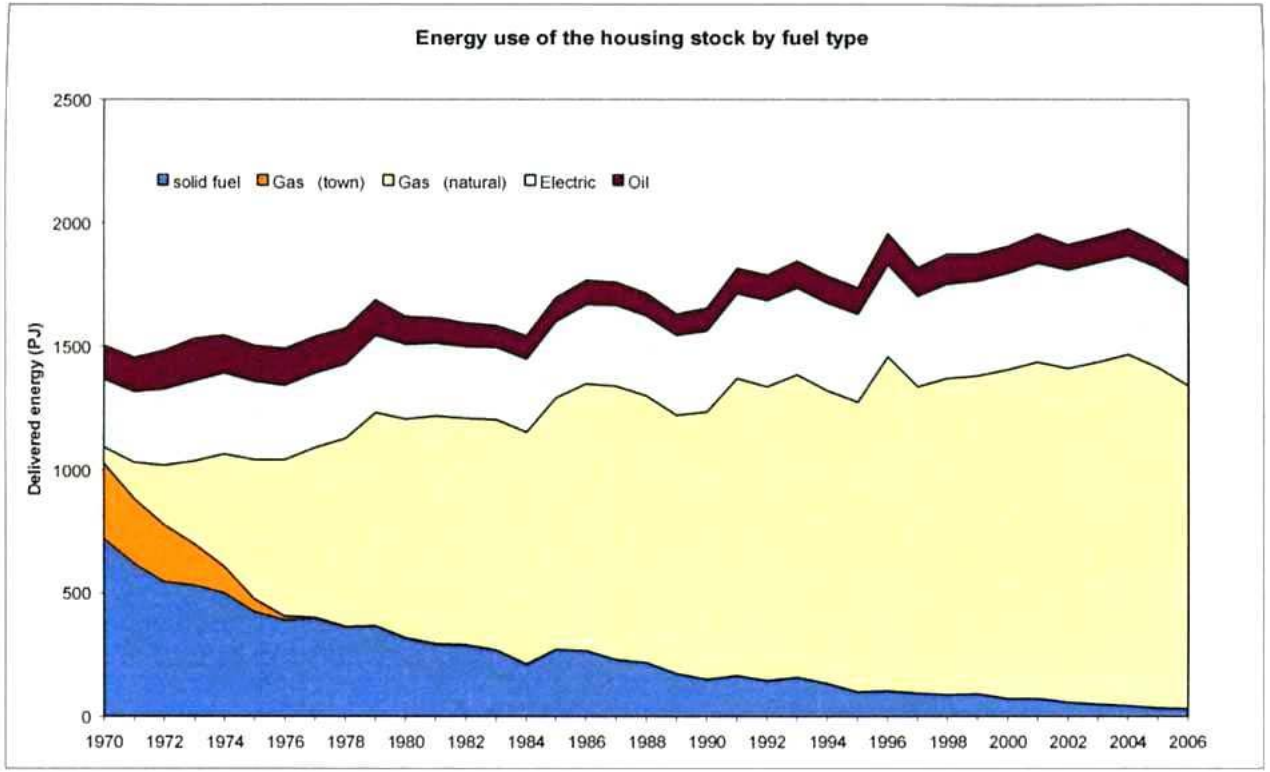


Figure 26 Domestic energy consumption by end use

- Source: BRE Domestic Energy File, 2008

Fuels supplying domestic heat demand:

- Gas: 81% Electricity: 9% Heating oil: 8% Solid fuels: 2%

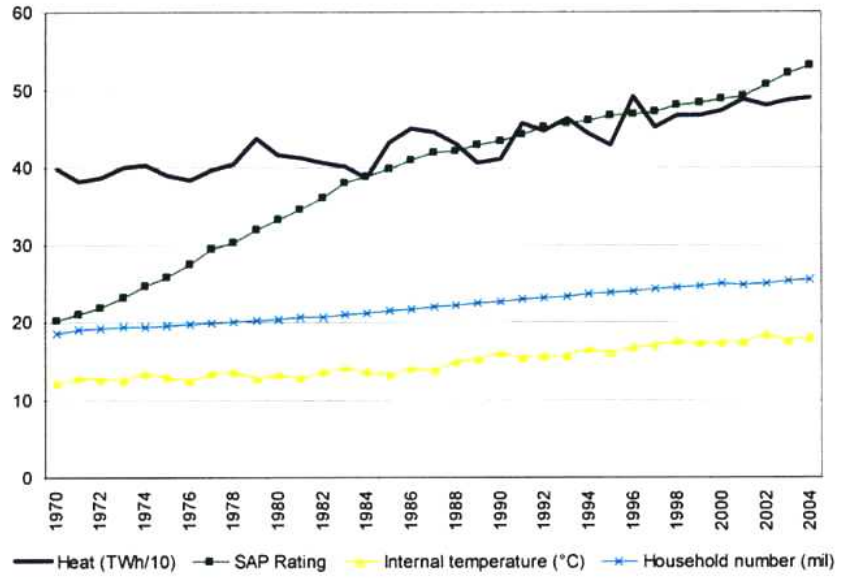


- Sources: BRE Domestic energy file, 2008; BERR Heat Call for Evidence

Growth in domestic heat demand 1970-2004

- Risen from 400 to 500 TWh p.a. over 30 years, despite better efficiencies
- Increase in average indoor temperature (central heating of more rooms, warmer temp. preferences)
- Increased number of households (by 40%)

Figure 1.2: Growth in domestic heat demand and contributing factors 1970–2004



Source: OCC using data from BERR(2007)

Reducing carbon emissions by buildings: current approaches

- Reduce demand via insulation:
  - Loft, cavity walls, double-glazing, draught-proofing

- Improved efficiency of equipment:
  - Condensing boilers

- Policy tools and targets:
  - Building Regulations, SAP ratings, EPCs, DECs, etc
  - Code for Sustainable Homes…zero carbon new homes by 2016
  - All new buildings zero carbon by 2019

- Main Government targets:
  - 15% of final energy demand from renewables by 2020
  - 80% cut in carbon emissions by 2050

Housing heat demand and predicted effect of measures

Housing Built…	Heat demand, MWh p.a. for Space Heating	Heat demand, MWh p.a. for Water Heating
…Pre 1996	13.5	5
…& with deep market penetration of insulation	9	5
…to current Building Regs	2	5
…to zero carbon standards	Approx 0	5

Market penetration trends, home energy efficiency measures

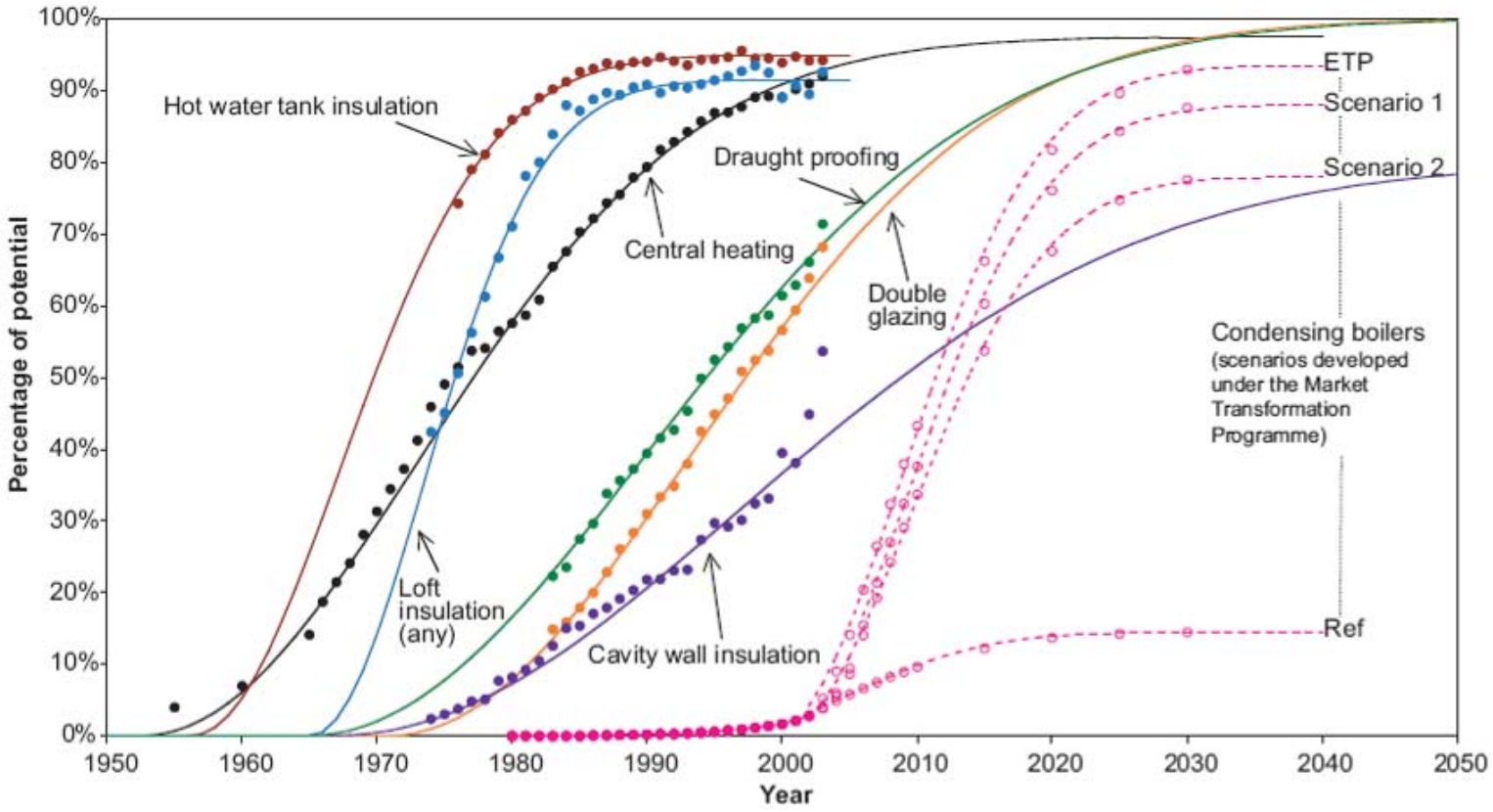
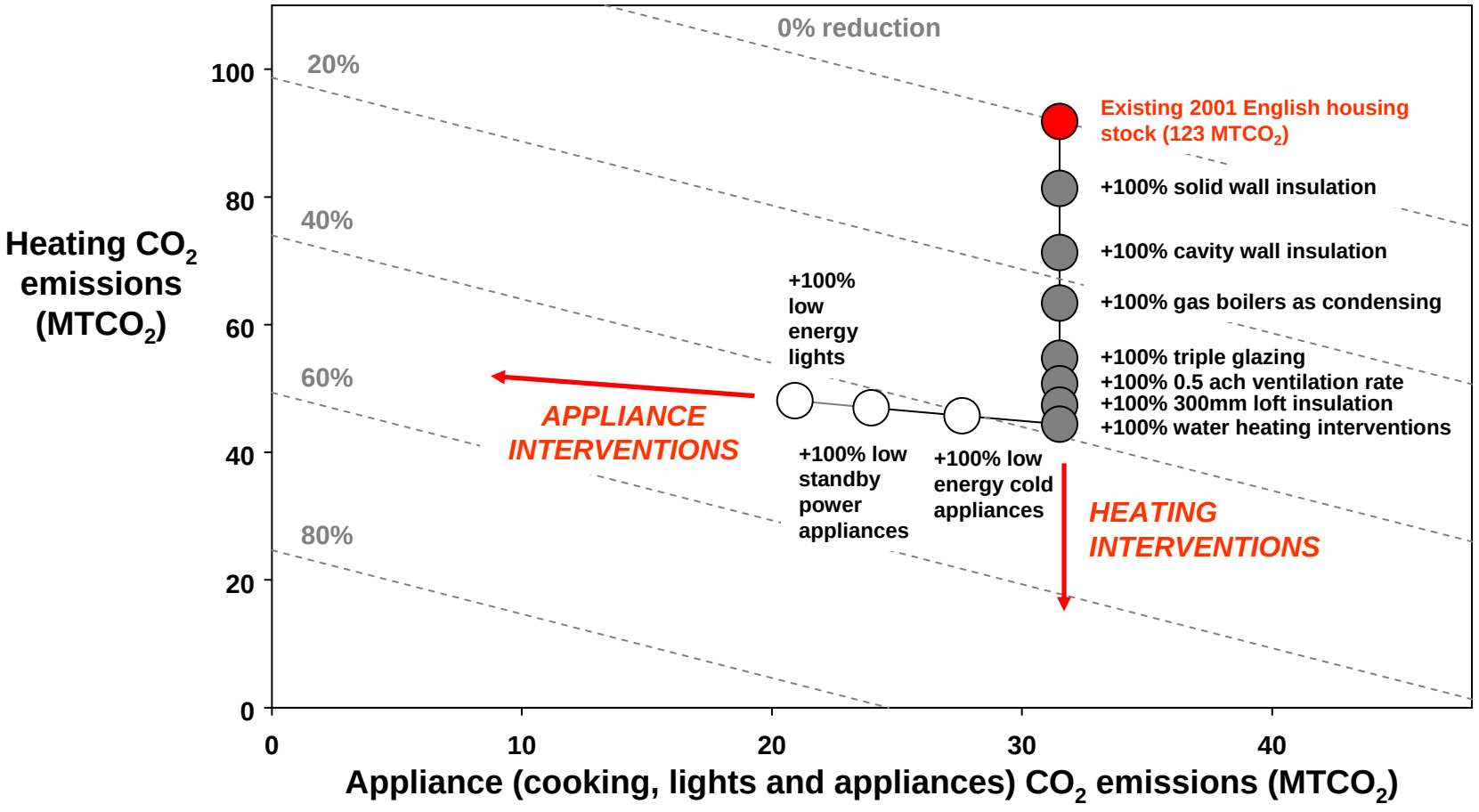


Figure 1 Market penetration of home energy-efficiency related measures

- **Source:BRE: domestic energy use and carbon emissions: scenarios to 2050 (Utley and Shorrock, 2005)**

Progress towards 80%...energy efficiency predictions: 2001 English housing stock



-Based on 1971 to 2000 average climate data. Source: CaRB project, Carbon Vision Partnership, funded by EPSRC

Going beyond 2020 target and the necessary insulation measures…there are further major challenges for demand reduction and de-carbonisation of buildings…

In 2050, 70% of housing stock will be pre-1990 properties

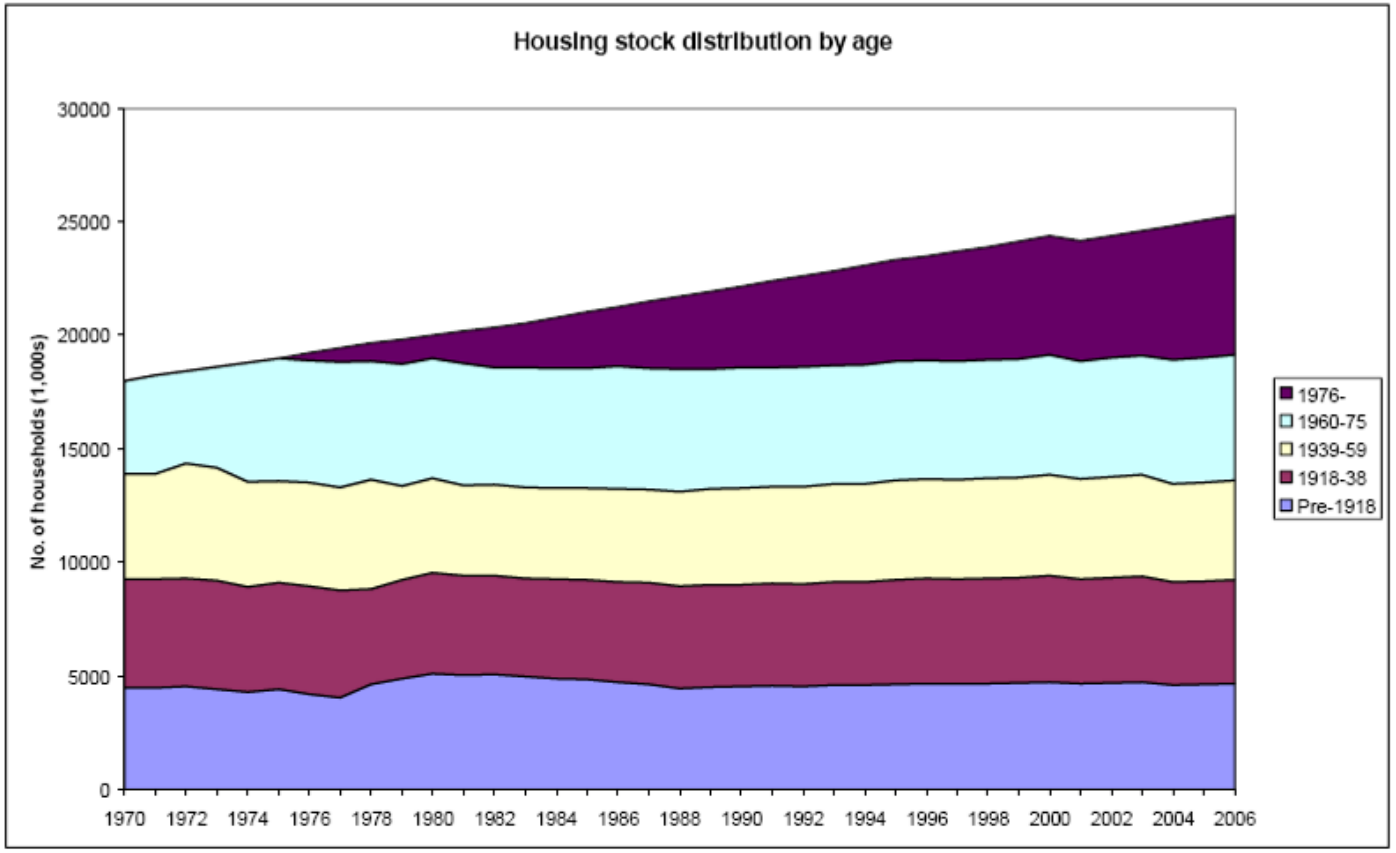
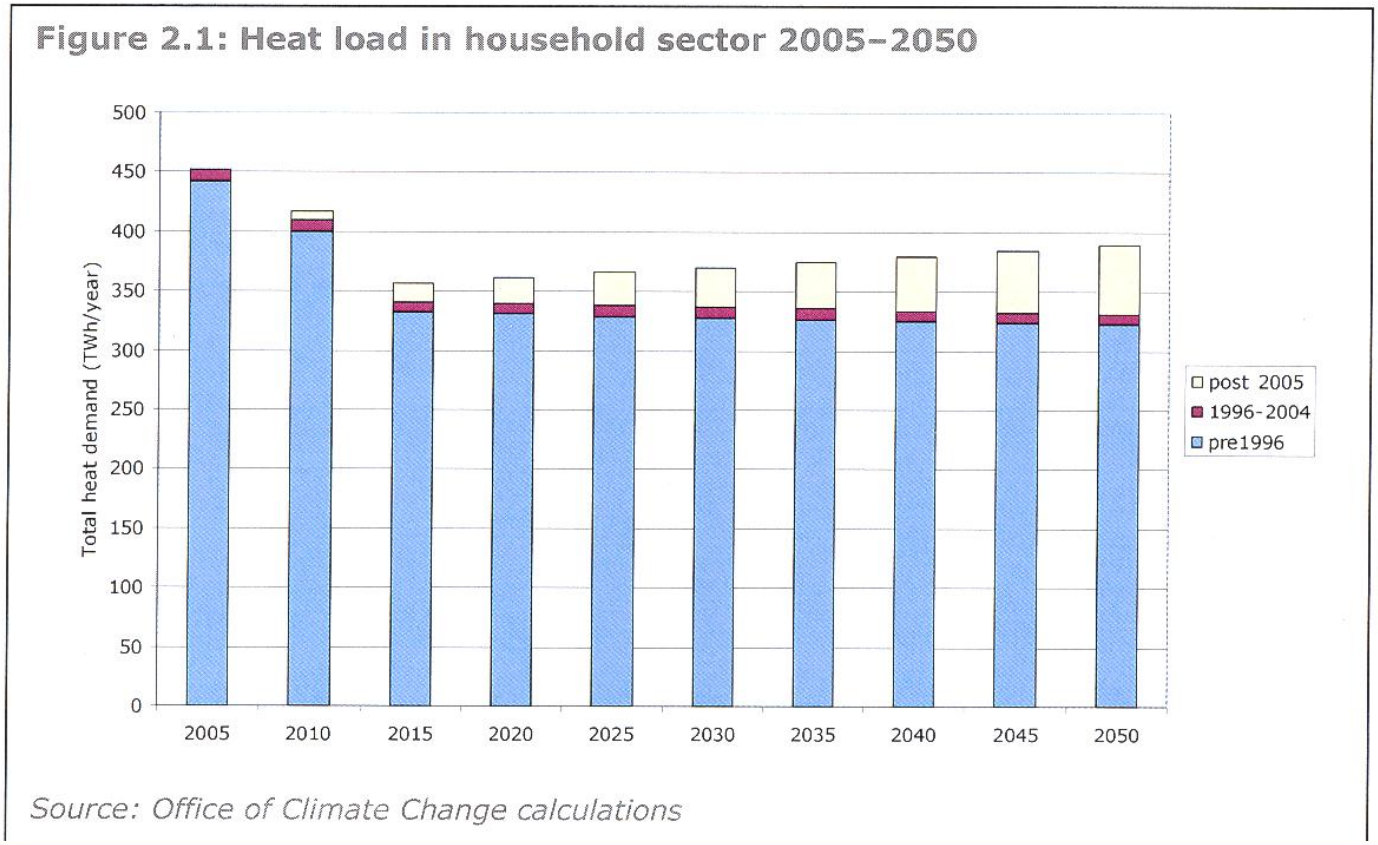


Figure 7 Housing stock distribution by age

- Source: Domestic energy fact file, 2008 (Utley and Shorrock)

Predicted heat load in housing 2005 - 2050

- Assumes zero-carbon new homes, and rigorous improvement policies reach full potential by 2015… refurbishment and retrofit is the major challenge
- Source: BERR Heat Call for Evidence 2008



Further technologies & measures to de-carb. building heat load….

Fabric interventions

- External cladding
- Mech ventilation with heat recovery
- Floor insulation
- Door replacement
- …could cost > £20K per household
- Source: BERR Heat Call for Evidence 2008

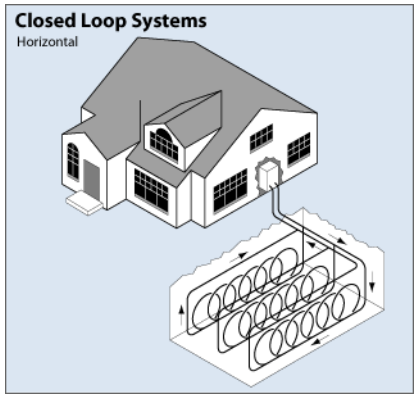
Renewable microgeneration

- Biomass boilers
- Heat pumps, air and ground-source
- Solar water heating
- …barriers are site and technology-specific, and include cost-competitiveness with current fuels
- Source: BERR Heat Call for Evidence 2008

Further technologies & measures to de-carb. building heat load….

Electric heating

- Using de-carbonised grid power
- In new homes with low loads
- In existing homes via heat pumps
- …but power plants will be fossil-fuelled for at least next decade
- Source: BERR Heat Call for Evidence 2008



District heating and cooling

- Uses low grade heat (< 150^{o}C)
- Good carbon savings
- …but major cost and infrastructure change for UK

De-carbonised gas

- Add bio-methane to grid-supplied gas

Biomass

- For households, can supply space / water heating via stove or boiler
- Typically uses wood as fuel
- Needs automated fuel feed (hopper)
- Relies on ready supply of woodchip, pellets, logs
- Main potential is rural (10% of households)
- Can be used with community heating schemes
- Barriers include: air quality questions, if large take-up; fuel supply chain

Sources: 40% House, ECI, Oxford 2005;
BERR Heat Call for Evidence 2008

Heat Pumps

- Can provide space / water heating, and space cooling
- Upgrades ‘low grade’ environmental heat
- Ground and air source
- Typical COPs in range 3-5
- Best with lower temp. / large area emitters
- Retrofit –some challenges (emitter and garden areas)
- Consumer barriers: unfamiliarity, maintenance availability, noise

Source: 40% House, ECI, Oxford 2005

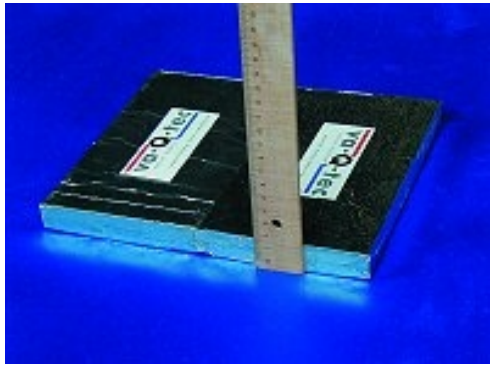
Solar Water Heating

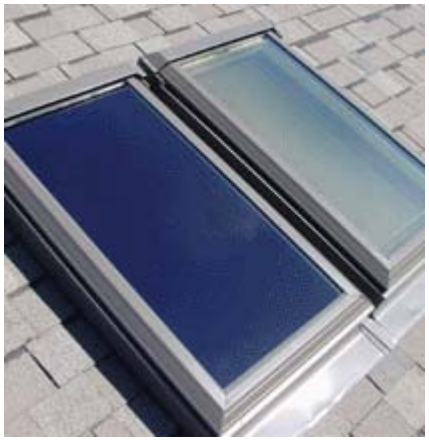
- Simple, reliable, well-known, widespread, and retrofittable
- Average house may need about 4 m^2 for 200 litre tank of water
- Can meet about 50-60% of year-round demand (hence other heat supply needed)
- Combined with biomass (wood-burning) stove in an efficient dwelling, 100% space / water heating could be met
- Thermosiphon systems are available
- Requires solar access / orientation

Source: 40% House, ECI, Oxford

Other potential technologies for buildings include:

- **Demand reduction:**
  - Advanced window systems (triple glazing, vacuum glazing, aerogel replacement)
  - Vacuum insulation panels (VIPs)
  - ‘Super-insulation’ to permit heating by internal gains (‘Passivhaus’)
- **Thermal control:**
  - Advanced glazings (electro-chromic, thermochromic) and automated shading
  - More use of phase-change materials (thermal mass effects)
  - More use of evaporative cooling (e.g direct, indirect, advanced ceiling tiles)





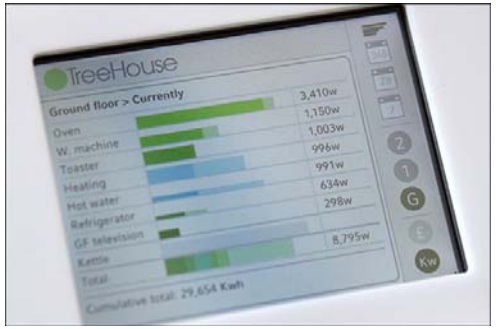
Other potential technologies for buildings include:

Heating:

- Cheaper, more effective heat pumps
- Communal scale solar thermal and storage
- Biogas / biomass CHP for mixed use communities (offices, retail, homes)
- Fuel cell based CHP (requires hydrogen supply)

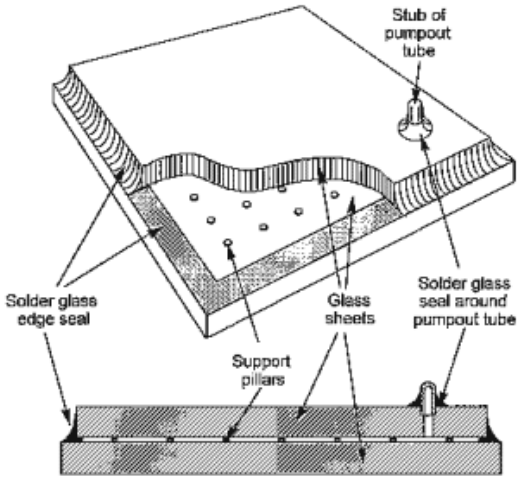
Techno-human interface:

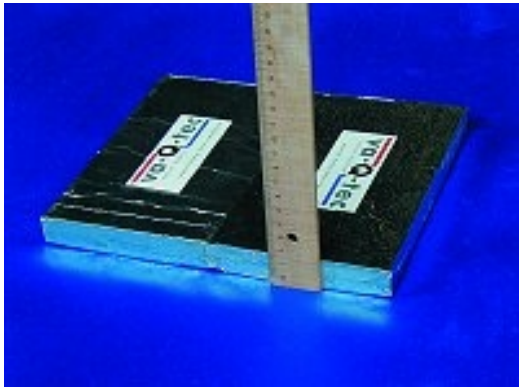
- Advanced controls (e.g self-learning, predictive, optimal)
- Smart metering
- Human thermal comfort ‘adaption’ (eg tolerance of wider range of thermal conditions)



Vacuum Glazing and Vacuum Insulated Panels (VIPs)

- Vacuum between two layers
- Small support pillars maintain spacing
- U-values –
  - Vacuum glazing:
  - 0.2 - 0.6 $Wm^{-2}K^{-1}$
  - Standard double glazing:
  - 2.3 $Wm^{-2}K^{-1}$
- VIPs:
  - Factor of 10 improvement to standard insulation
  - Drawbacks include lifespan and cost
  - Need research on buildings applications





Advanced controls and energy management

- Building Management Systems common in commercial buildings
- Limited deployment to date in dwellings
- Can support advanced control of systems for heating, cooling and other functions
  - Adaptive, predictive, self-learning
  - Condition monitoring and fault detection
- May offer about 20% savings (Murakami et al, 2007)
- Good retrofit potential

Cooling for buildings

- Demand rising for space cooling
  - 20 TWh p.a. by 2020 (689TWh p.a. for heating by 2020)
- Electrically-powered air conditioning:
  - Usually for commercial space
  - Residential usage is a risk

- Could be addressed via:
  - Passive building design (shading, natural ventilation, mass, night cooling)
  - Heat pumps (reverse cycle) with de-carbonised electricity
  - Evaporative ceiling panels (emerging technology)
  - Absorption chillers with distribution (‘district cooling’)

Conclusions

- Buildings have major heat demand, esp issues of existing stock
- Achieving 2020 and 2050 targets presents major challenges, requiring commitment, support, policy and leadership
- Refurbishment and retrofit to existing stock is key
- There is no ‘magic bullet’ technical solution
- Whilst technology-based solutions play a vital role…
- …of equal importance are solutions addressing socio-technical, socio-economic factors, skills base, supply chain and infrastructure.