Energy modelling in traditional Scottish homes

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HISTORIC SCOTLAND

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Background - Tarbase

"Technology Assessment for Radically Improving the Built Asset Base"

A 4 year consortium research project, funded under "Carbon Vision Buildings"

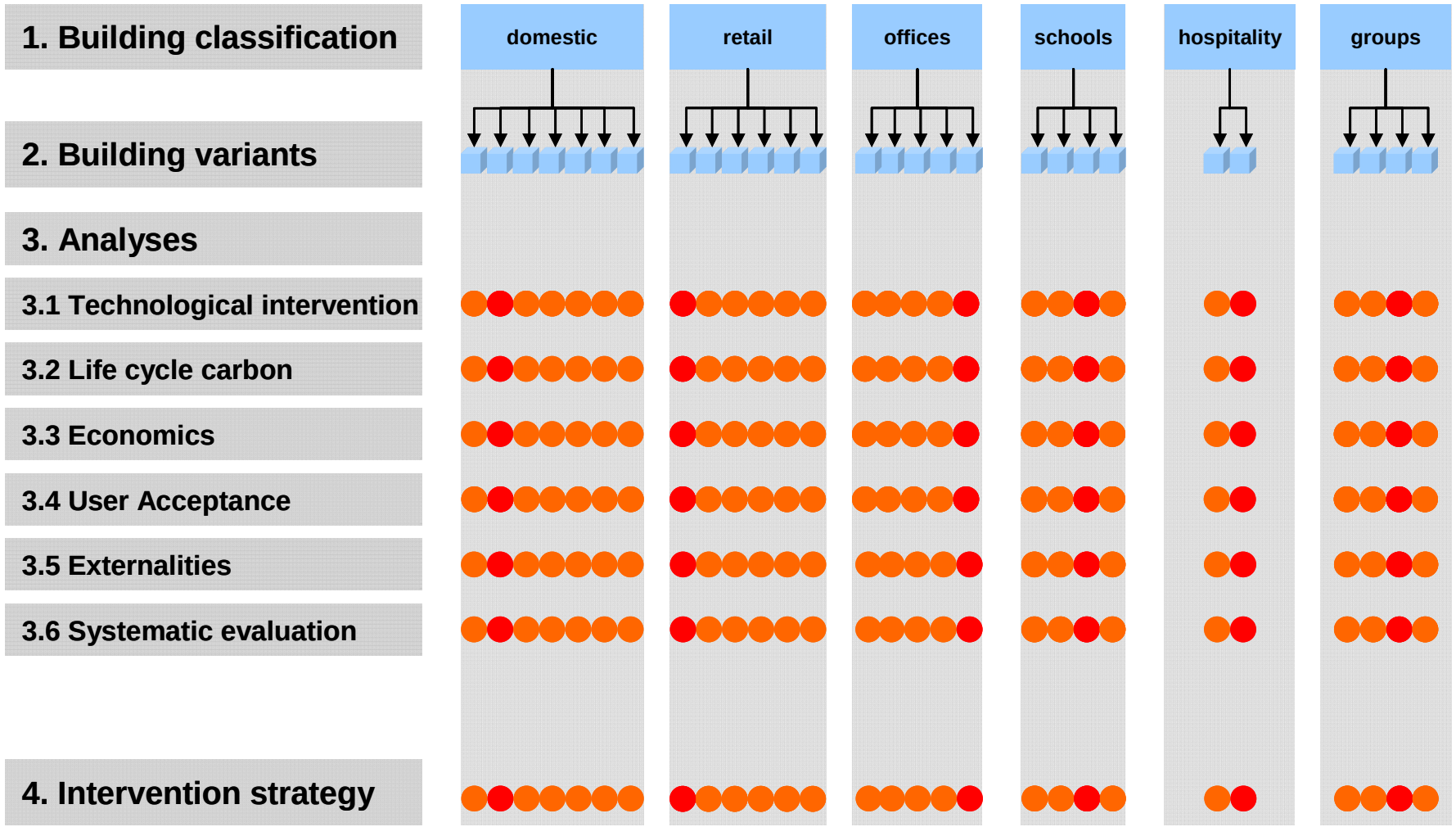
Aims to define technological intervention strategies and exemplars for reducing the CO_2 emissions from existing domestic and non-domestic buildings by 50% by 2030.

The Tarbase approach

The Tarbase approach:

- Uses stock models to identify common building variants
- Defines typical examples of those variants, including location and climate
- Defines occupancy patterns and lifestyle
- Studies the effect of interventions in fabric, equipment and renewable energy supply on the specified variants' 2005 baseline performance, using modelled predictions.

Tarbase research programme



Tarbase domestic model

Tarbase models the 2005 baseline using:

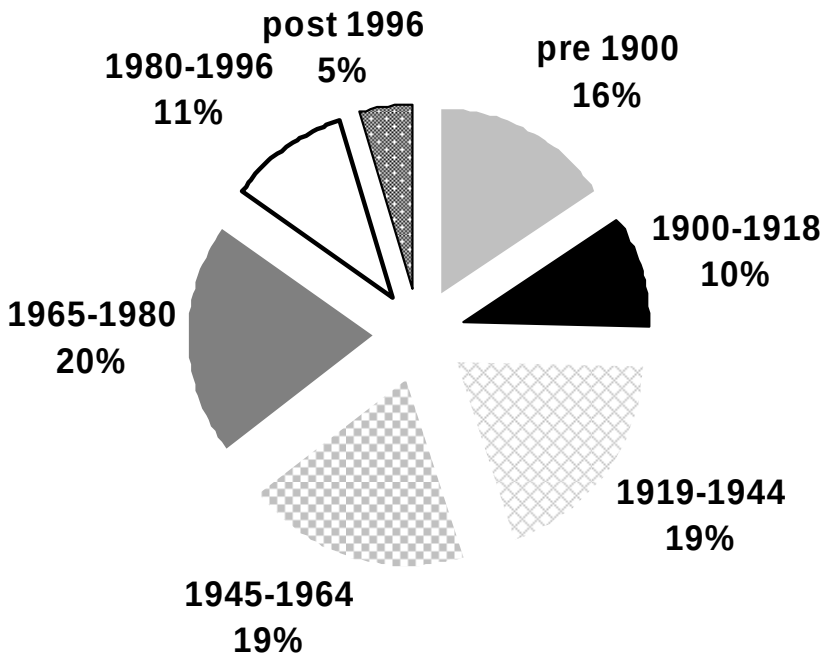
- some assumptions from SAP and others from our own research
- a steady state heat flow calculation
- attribution of CO_2 emissions associated with each feature of building fabric and activity.

And models the 2030 effects using

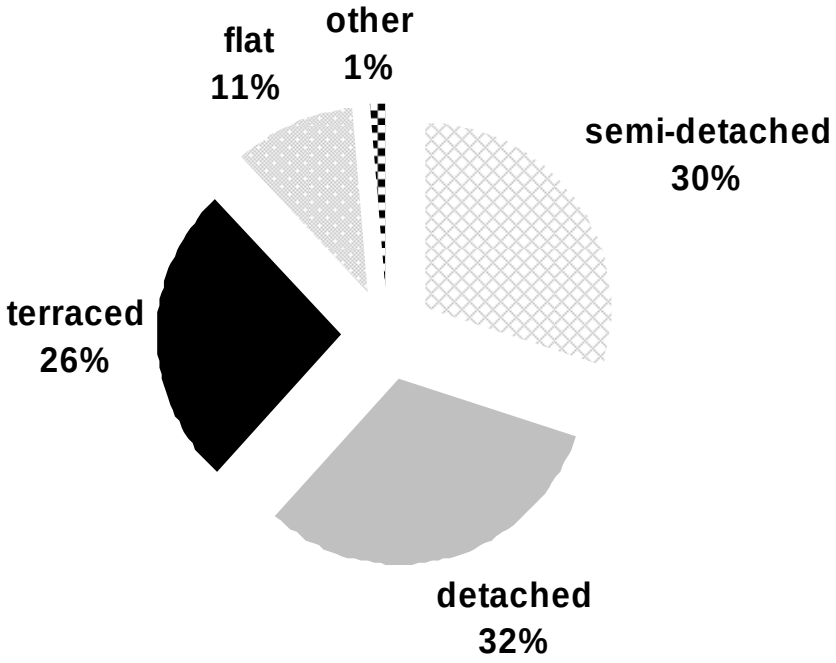
- performance of carbon-reducing interventions reported by research rather than manufacturers' claims
- CIBSE Test Reference Year climate files.

UK Domestic Stock

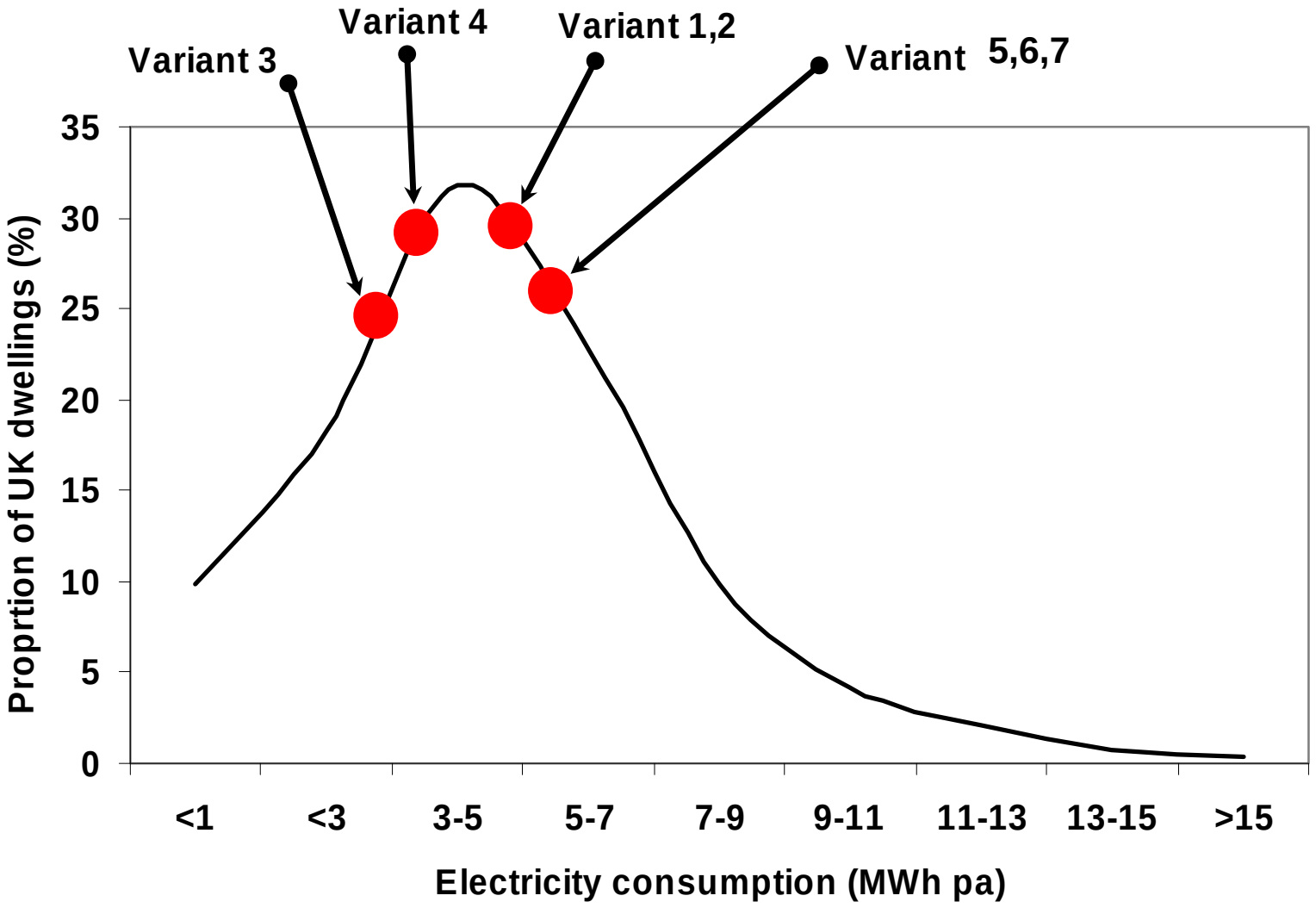
CO_2 emissions attributable to the UK domestic stock disaggregated by age of dwelling



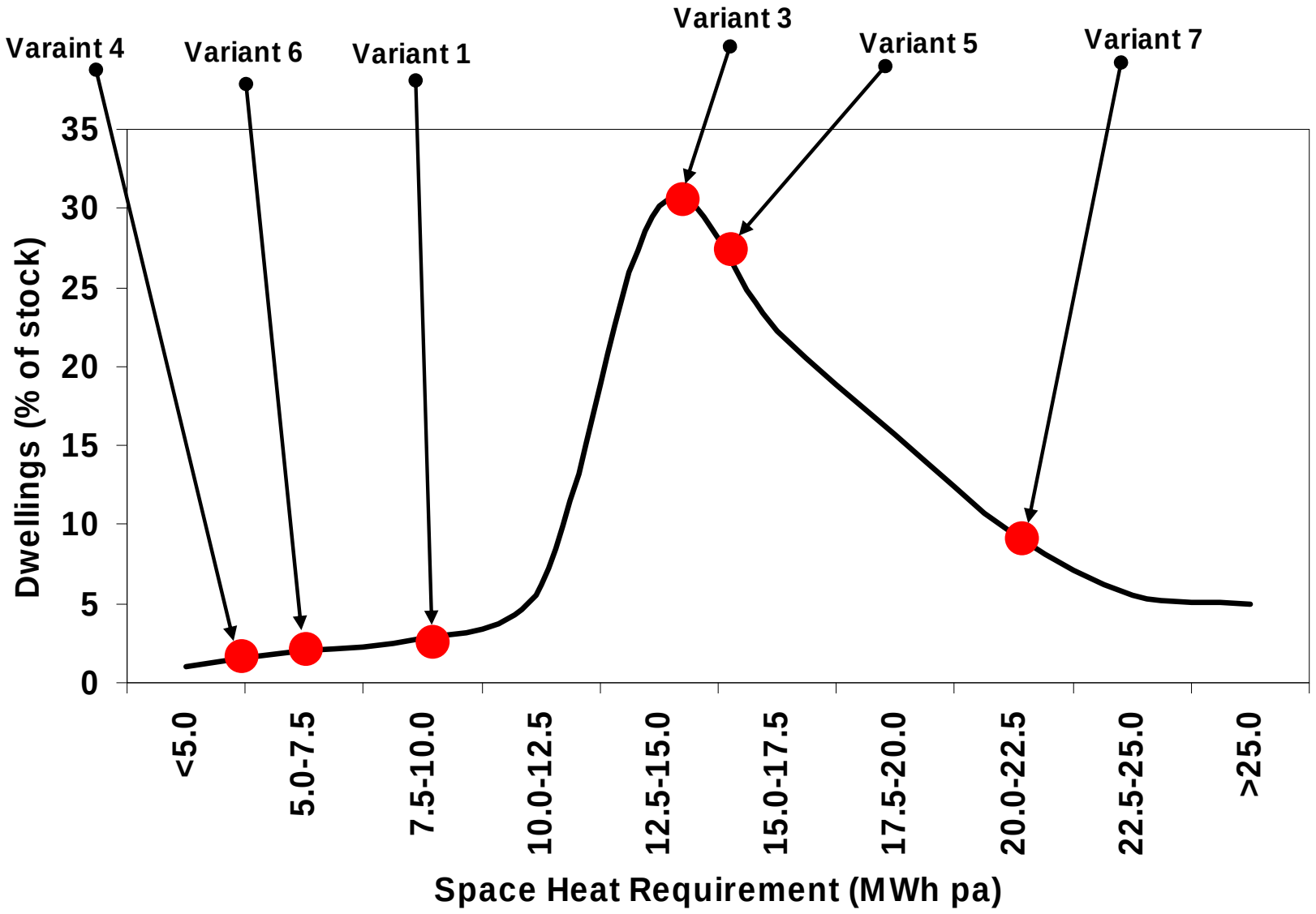
CO_2 emissions attributable to the UK domestic stock disaggregated by type of dwelling



Electricity consumption



Thermal requirement



Technological interventions

Building Fabric and Ventilation
Loft insulation
Cavity wall insulation
External wall insulation
Glazing
Reduced infiltration
MVHR

End use equipment
Lighting
Stirling cycle refrigeration
VIP refrigeration
Ovens
Washing machines
Dishwashers
TV's
PC's
Tumble dryers
Reduced standby loads

Energy production
Micro-CHP
Solar PV
Micro-wind
Solar Thermal
Heat Pumps
Biomass

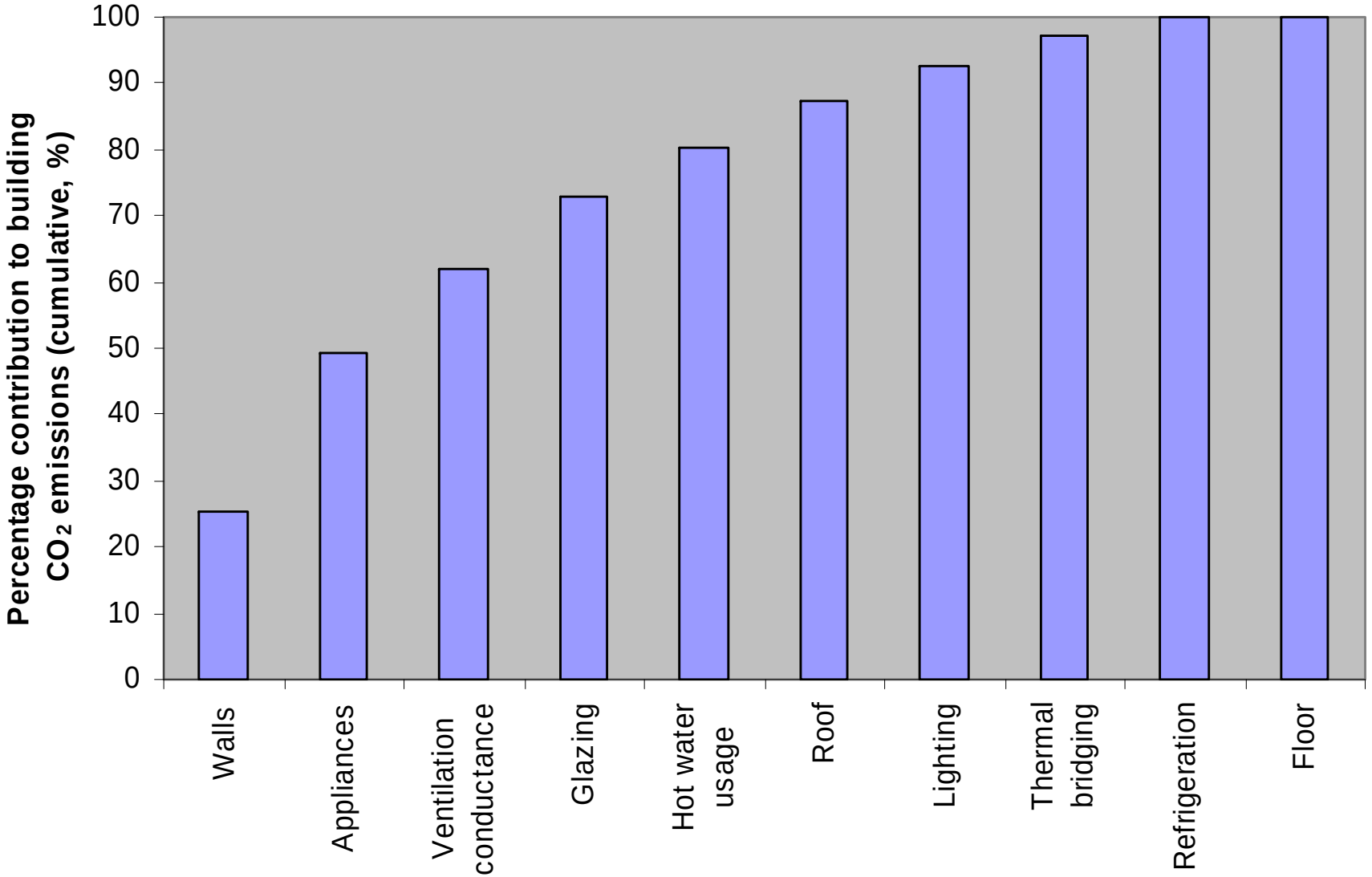
This project…

- Apply Tarbase methodology to investigate possibilities for traditionally constructed homes in Scotland
- Use currently available technology (i.e. not 2030)
- Three real-life baseline case-studies
  - Terraced flat
  - Rural cottage
  - Detached House

Case-study 1 (Flat)

- Top floor terraced flat
- ~1820's construction
- Solid-walled, sash windows
- 110m^2 total floor area
- Gas combi boiler
- Roof insulation present
- B-listed status

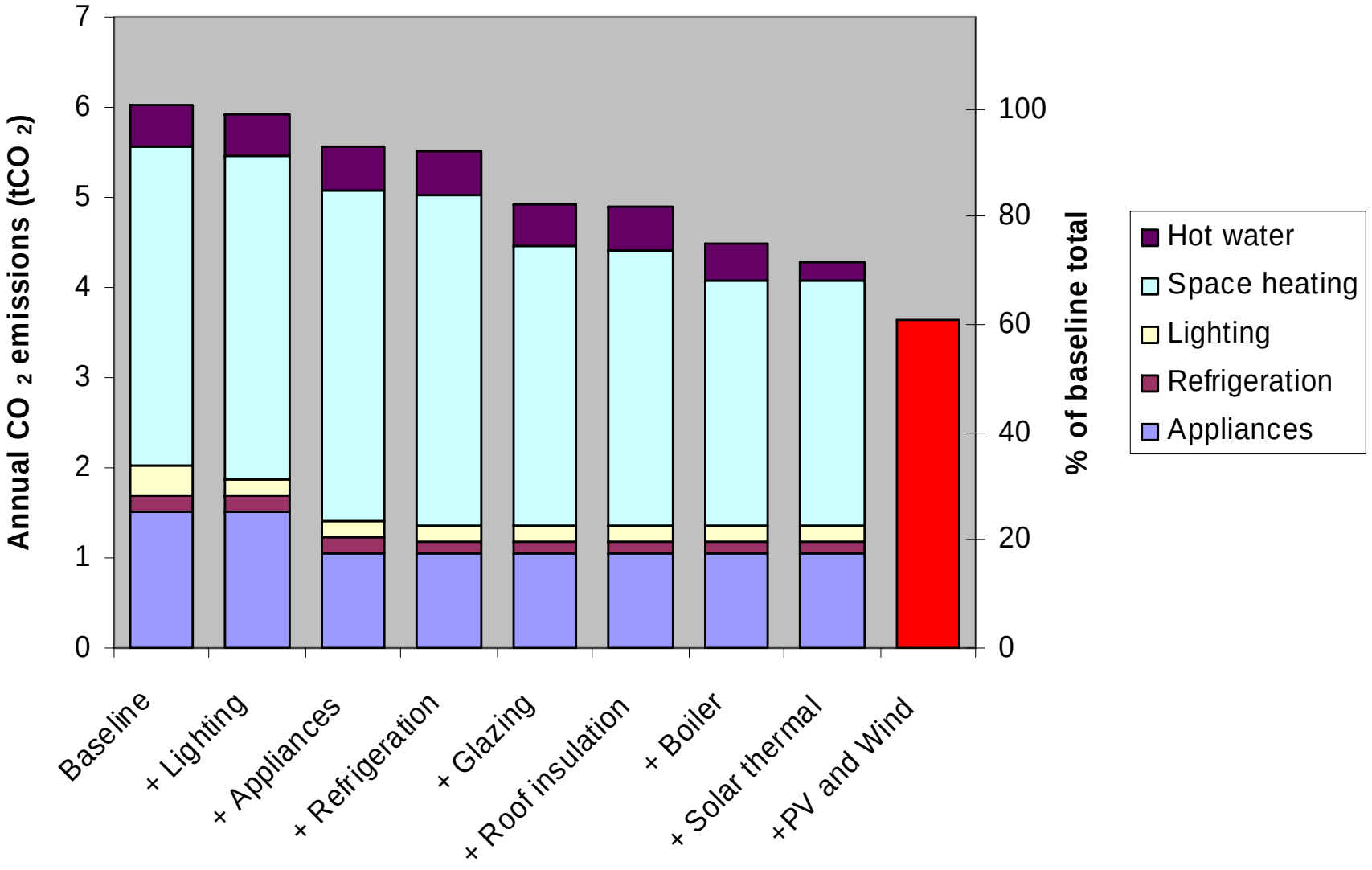
CO_2 emissions (Flat)



Carbon-saving measures (Flat)

- Appliances/equipment/lighting
  - Suggested by Tarbase project
- Secondary glazing added (new U-value 2.3W/m^2K) with draughtproofing
- Additional roof insulation (+50mm)
- Condensing boiler
- Solar thermal (50% of DHW)
- 1kW Solar PV (830kWh); 1.5kW micro-wind (390kWh)

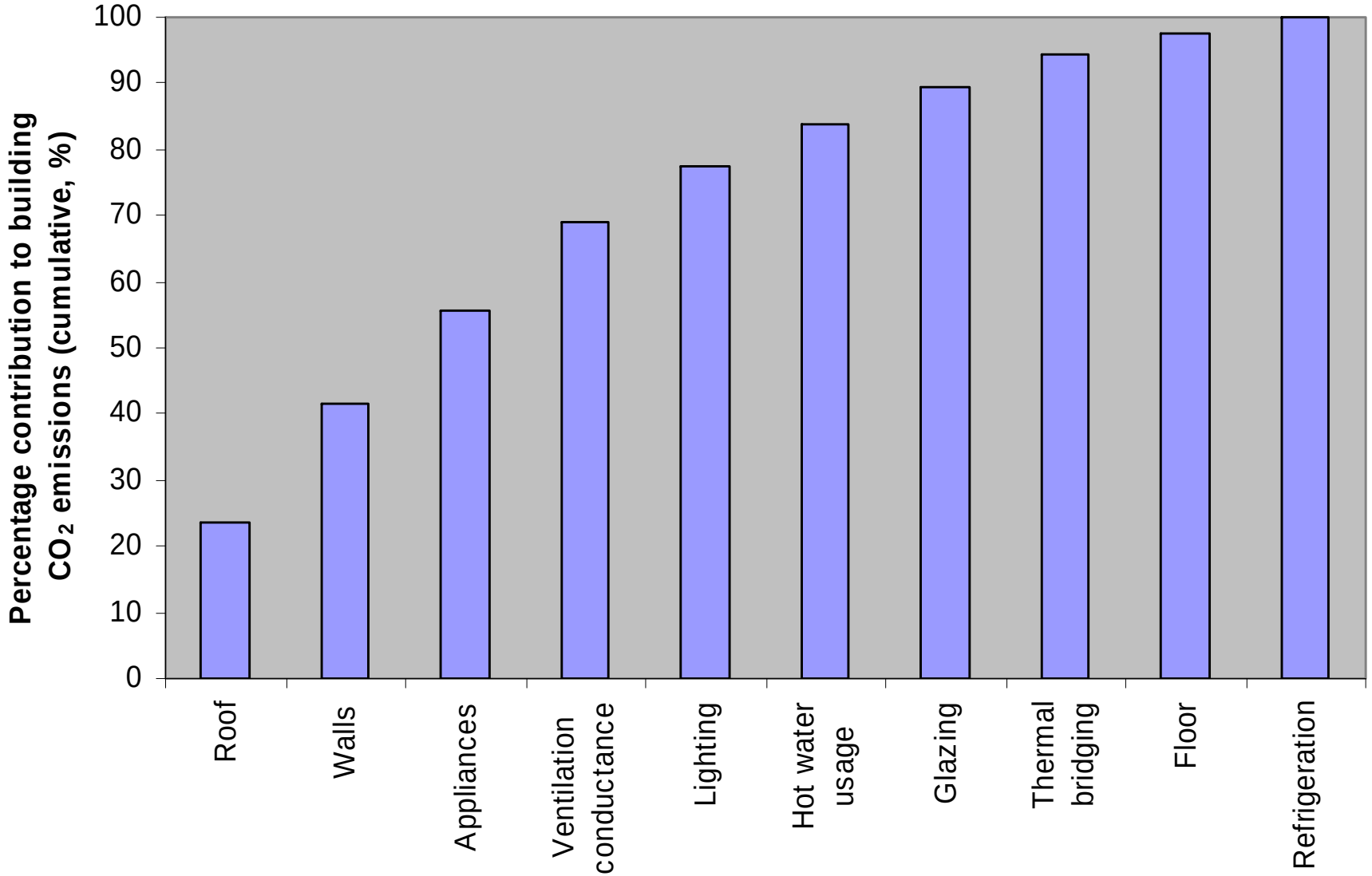
Carbon-saving measures (Flat)



Case-study 2 (Cottage)

- Rural detached cottage
- ~1870's construction with 1950's extension
- Solid wall and cavity walls; double and single glazing
- 75m^2 total floor area
- Oil boiler
- Attic room present

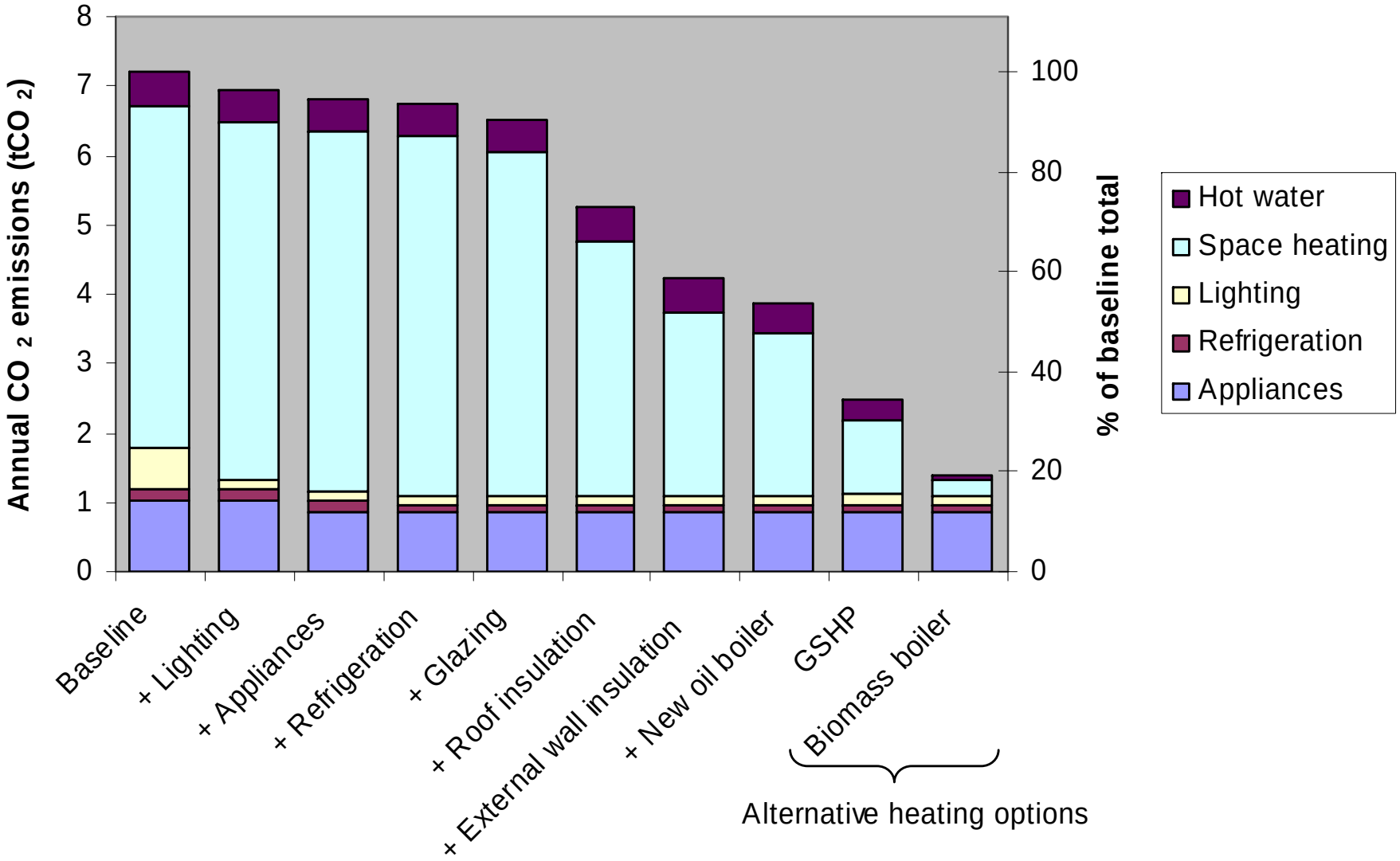
CO_2 emissions (Cottage)



Carbon-saving measures (Cottage)

- Appliances/equipment/lighting
  - Suggested by Tarbase project
- Secondary glazing added (new U-value 2.3W/m^{2}K) with draughtproofing
- Roof insulation around attic room
- External insulation with render
- Oil condensing boiler (option 1)
- Ground-source heat pump (option 2)
- Biomass boiler (option 3)
- No electrical generation

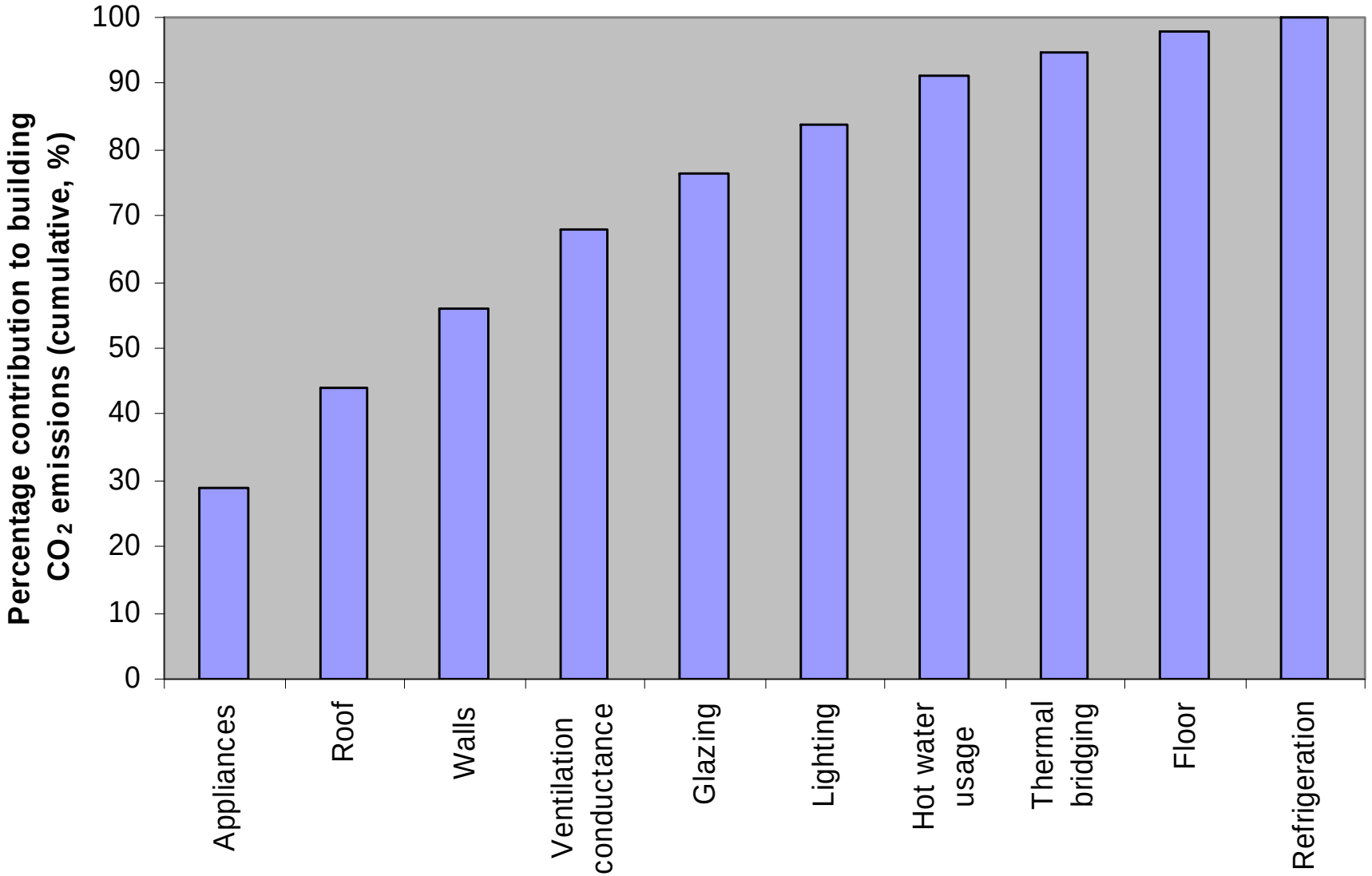
Carbon-saving measures (Cottage)



Case-study 3 (House)

- Detached house
- Late C19th construction
- Solid-walled, sash windows
- 98m^2 total floor area
- Gas combi boiler

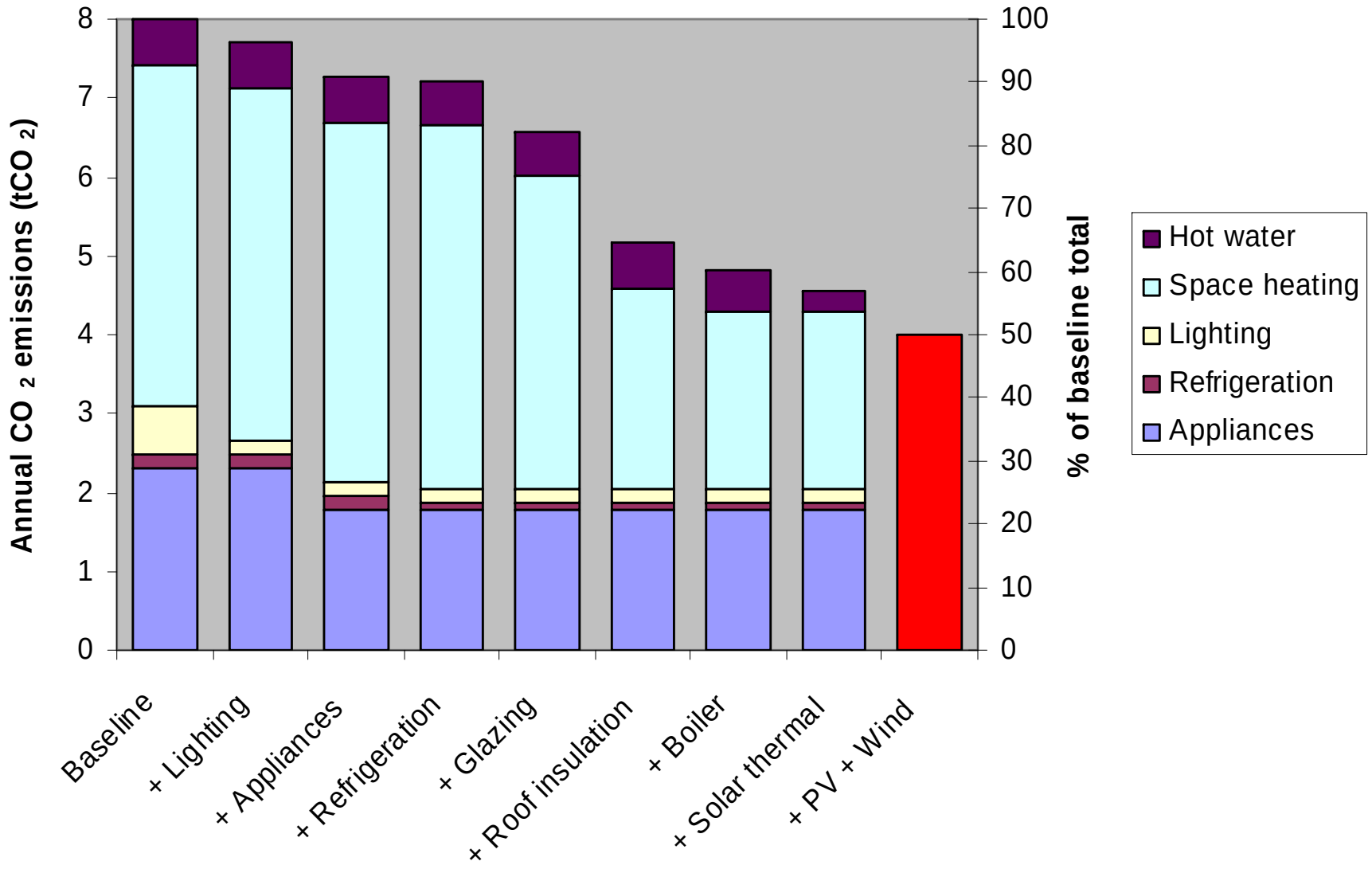
CO_2 emissions (House)



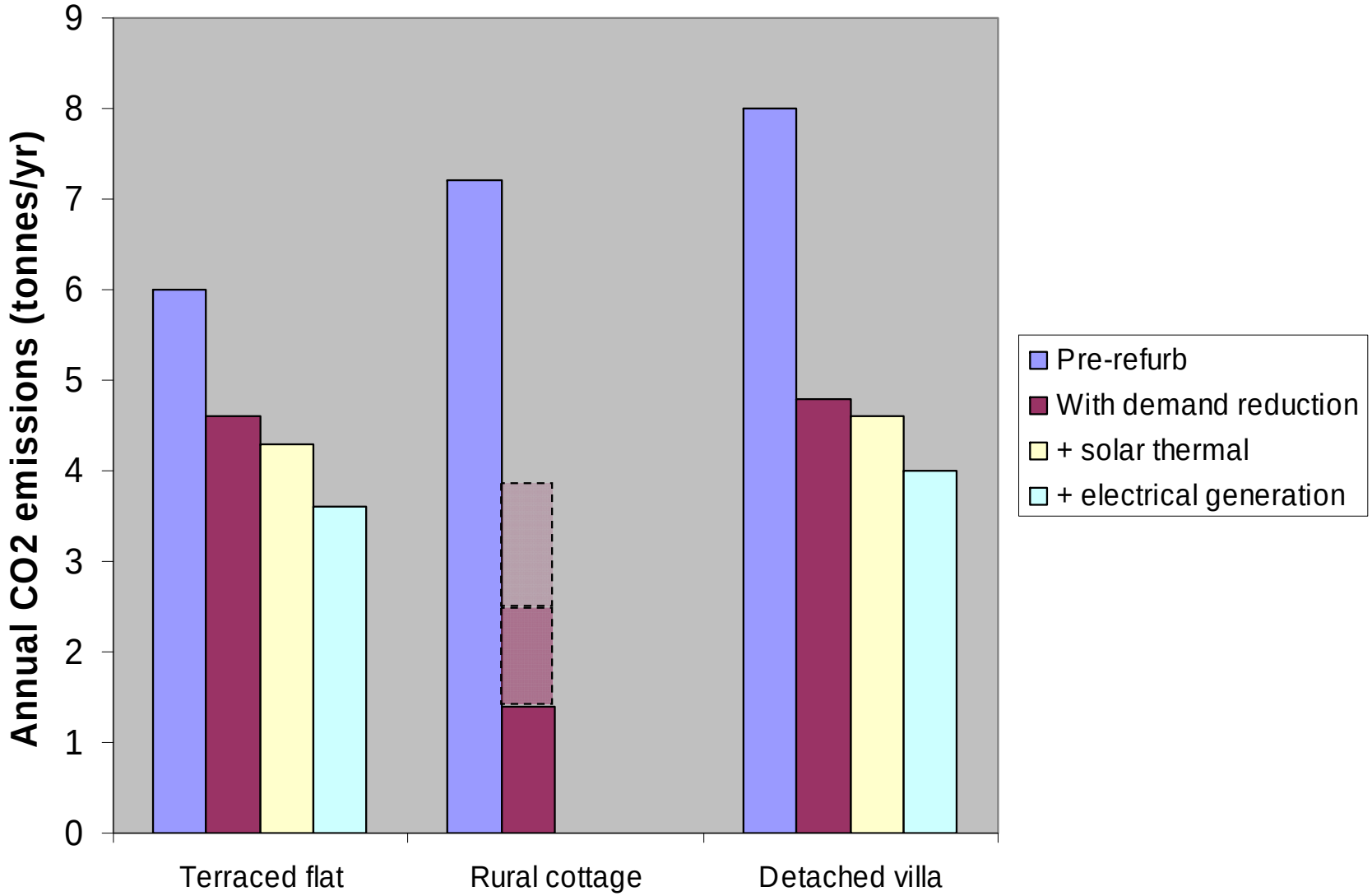
Carbon-saving measures (House)

- Appliances/equipment/lighting
  - Suggested by Tarbase project
- Double glazing installed (new U-value 2.0W/m^2K) with draughtproofing
- Roof insulation added (250mm)
- Condensing boiler
- Solar thermal (50% of DHW)
- 1kW Solar PV (830kWh); 1.5kW micro-wind (277kWh)

Carbon-saving measures (House)



Overview


Annual CO2 emissions (tonnes/yr)
0
1
2
3
4
5
6
7
8
9
Terraced flat
Rural cottage
Detached villa
Pre-refurb
With demand reduction
+ solar thermal
+ electrical generation

General conclusions

- “Hard-to-treat” does not mean impossible to treat
- Some limitations on choice but scale of potential savings is large – 40-80% CO_2 reductions possible
- Must be sensitive to building-specific issues
  - Moisture problems/building aesthetics
  - Need for post-occupancy data
- For traditional buildings is onsite generation worth the effort?