http://www.brighton.ac.uk/csbe

Thermal storage for low carbon buildings

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Outline

- Background
- Basic principles of thermal storage in buildings
- Recent thermal storage projects undertaken by CSBE
- Conclusions

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Environment impacts of buildings

- Buildings consume or are responsible for
  - **40%** of the world's total **energy** use
  - **35%** of the world's **CO_2 emissions**
  - **30%** of **raw materials** consumption
  - **50% of ozone-depleting**
  - **40% of municipal solid waste**
  - **…….**
- In the UK
  - **approx. 50% total energy consumption and CO_2 emissions…**
  - **Over 20% used to maintain indoor thermal comfort**

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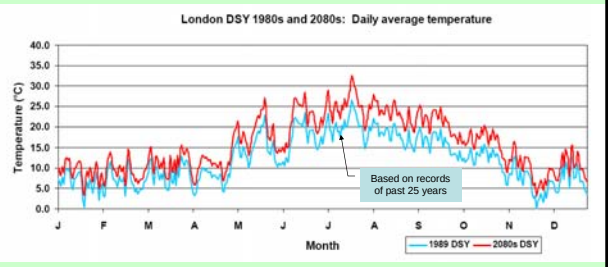
(Source: Worldwatch *Paper #124, UK DTI statistics*)

Effect of global warming on design summer year



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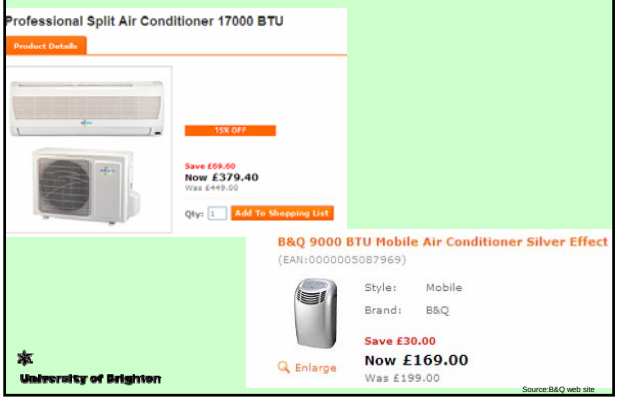
DUNSTER, B. (2005) *UK Housing and climate change - heavy weight vs. lightweight construction*, London, Ove Arup & Partners Ltd.

Solution for summer overheating?



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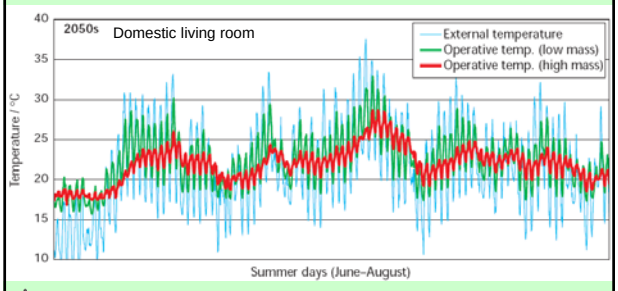
Source:B&Q web site

Impact of global warming to thermal comfort



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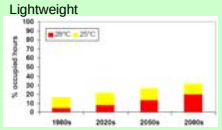
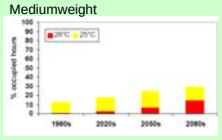
CIBSE (2005) *TM36 Climate change and the indoor environment: impacts and adaptation*, London, CIBSE.

Impact of global warming to thermal comfort[1]

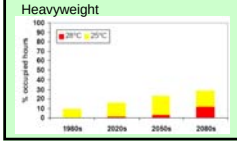
Lightweight



Mediumweight

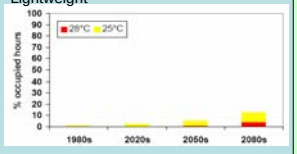


Heavyweight

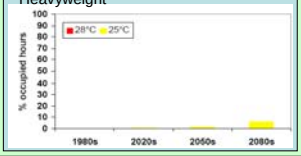


Shading at 95% + ventilation up to 6 air changes per hour

Lightweight



Heavyweight



DUNSTER, B. (2005) *UK Housing and climate change - heavy weight vs. lightweight construction.* London, Ove Arup & Partners Ltd.

Design options for applying thermal storage in buildings

Basic options:

- Seasonal or diurnal storage
- Sensible heat or/and latent heat storage

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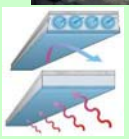
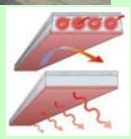
Sensible thermal storage for buildings

- By increasing/decreasing the temperature of storage medium without phase change
- Key factors: temperature difference, specific heat capacity
- Examples of storage media: concrete, brick, water





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Latent heat storage

- By latent heat due to phase change of storage medium
- Key factors: latent heat capacity, phase change temperature
- Potential added benefit: improved thermal comfort
- Examples of storage media (phase change materials – PCM): salt hydrates and organic wax

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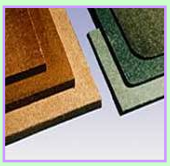
What are phase change materials (PCM)?

- Common PCMs used are organic paraffin waxes and inorganic salt hydrates, encapsulated in numerous different media



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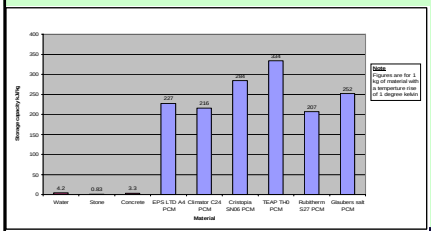
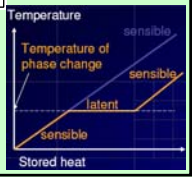
Benefits of using PCM



- High thermal storage capacity
- Phase change temperature can be used to maintain thermal comfort



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Recent thermal storage research projects

A. Seasonal thermal storage – sensible heat
   1. Earth-sheltered buildings - Earthship
   2. Ground heat exchanger - Earthduct

B. Diurnal thermal storage – latent heat
   3. Solar PCM underfloor space heating
   4. Solar/heatpump PCM hot/chilled water storage
   5. PCM wallcovering

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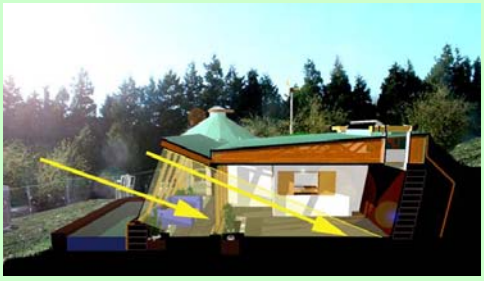
1. Seasonal storage: Earthship



Location: Stanmer Park, Brighton
(EU Durabuild case study)

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Earthship in Stanmer Park, Brighton

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Thermal storage by solid wall behind glass

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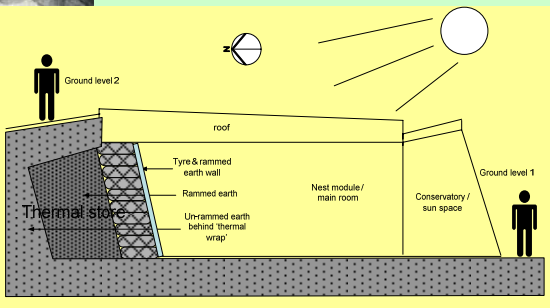
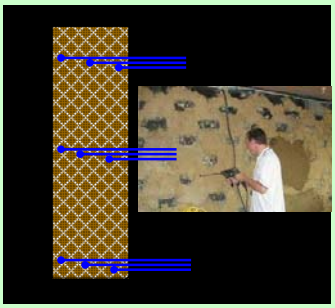
Thermal storage by rammed-earth tyre-wall



Temperature monitoring



- Rear wall in Main room
- Side wall in kitchen
- Soil temperature sensors at different depths and heights
- Provide a thermal grid of the Earthship

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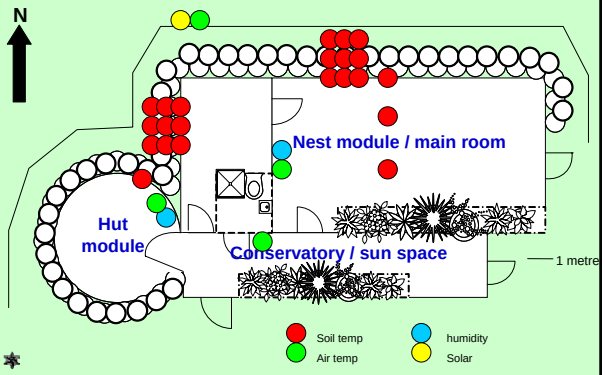
Earthship Monitoring



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Weather station and datalogger

Photovoltaic panel

Dome solarimeter

Ambient air temperature sensor

Data logger

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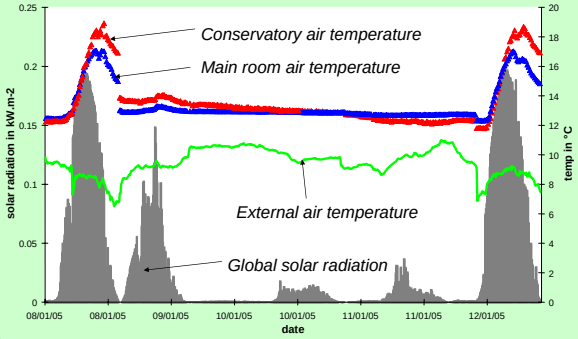
Measured Data: Global radiation and internal air temperatures



- Building unfinished, not occupied. little planting

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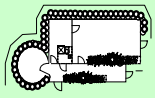
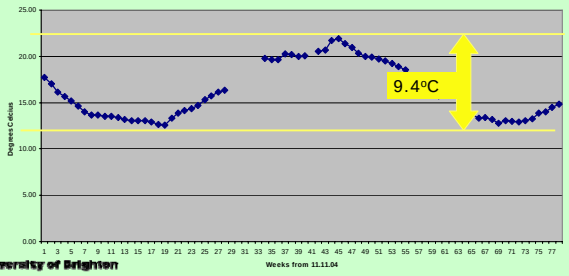
Temperature band



Building unfinished, not occupied, little planting

Average Store Temperature



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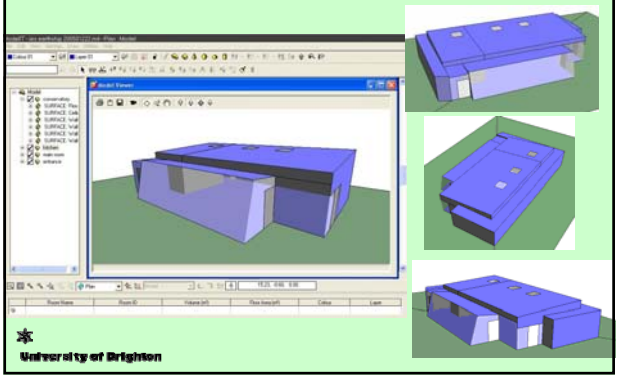
Computer thermal simulation



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‘Eco-heaven: a £500,000 mud house’

(Sunday Times 22nd April 2007)

- *“The 16 buildings …hillside overlooking the Channel near Brighton marina, called Earthships ….. made of mud, old tyres and tin cans ….Britain’s first self-sustaining eco-houses .. as much as £500,000 for three bedrooms”*

- Electricity will be provided by wind turbines and solar panels.
- One metre thick outside walls will be made of earth-filled tyres
- Internal partitions will be made from old bottles and cans

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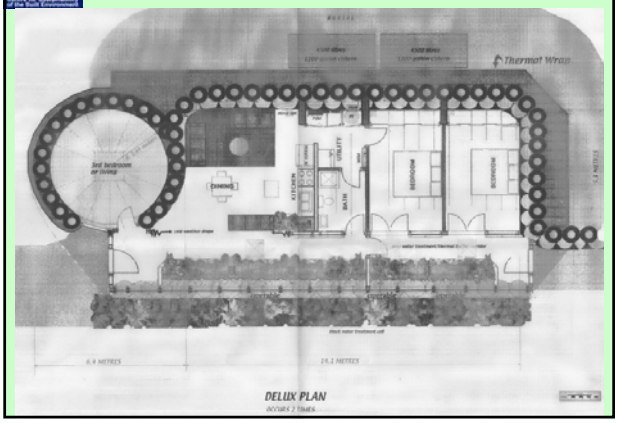

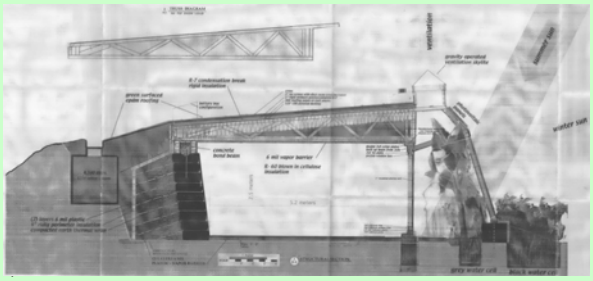

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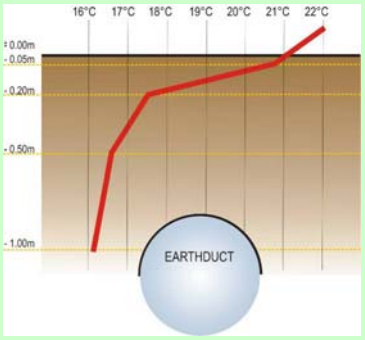
2. Seasonal storage: Earthduct



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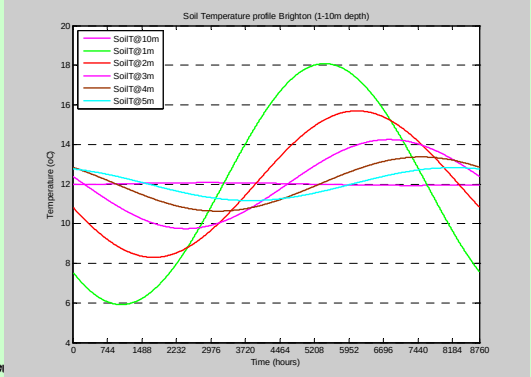
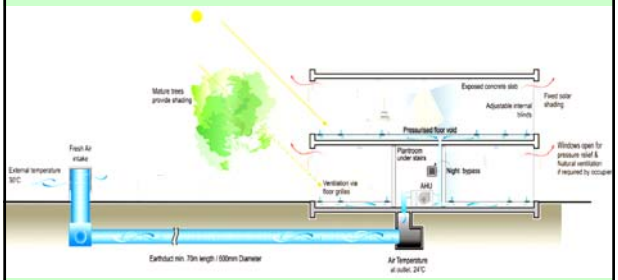
Source: http://www.resource05.com/presentations/day2/Patrick%20Bellew2.pdf

Soil temperature - Brighton



First UK application - Butterfield Business Village, near Luton



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Butterfield Business Village – Feb 2007

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Performance evaluation

- Lack of design information although acknowledged as a Low or Zero Carbon Emission technology
- Current study
  - Review of thermal models
  - Analysis by computer thermal simulation
  - Measurement and validation
  - Performance optimisation
  - Evaluate for potential use in the UK

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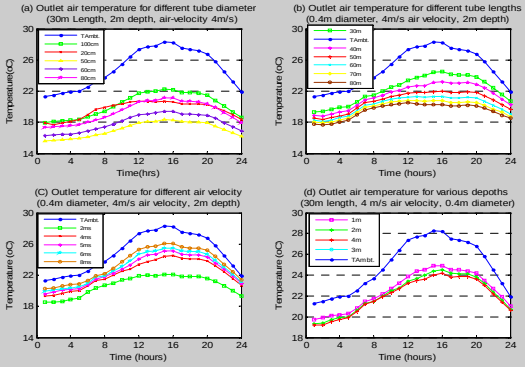
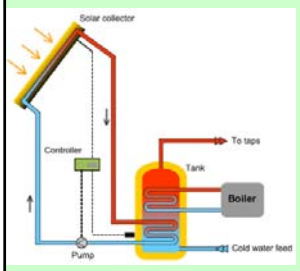
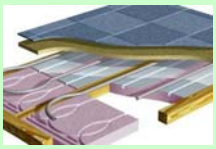
Simulated results of outlet air temperatures



3. Diurnal storage: Solar phase change thermal storage underfloor space heating





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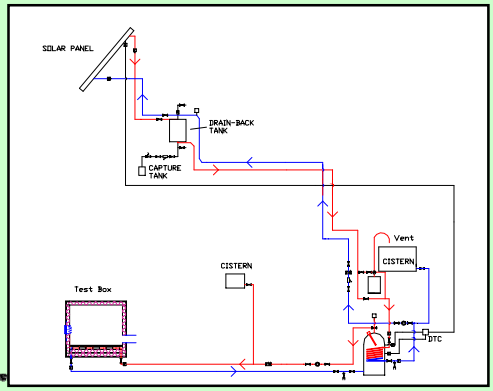
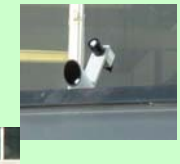
http://www.greenenergy.org.uk/sta/solarenergy/howwork.htm

http://www.designbuild-network.com/contractors/water_supply/wavin-plastic/wavin-plastic2.html

Experimental setup



Solar panel and weather station



Recording and control equipment

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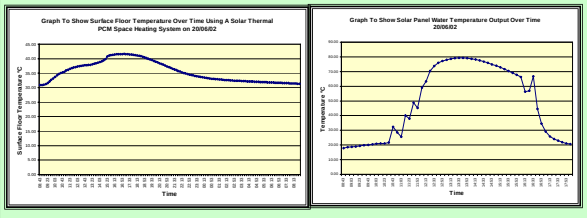
Test box

Underfloor pcm module

Heat exchange to pcm

Results

- Results being analysed



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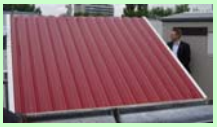
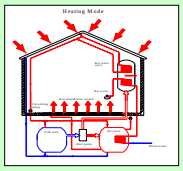
4. Phase change thermal storage – hot and chilled water

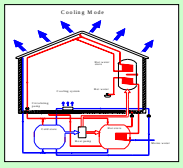
- Partner of an EU funded project - Endohouse

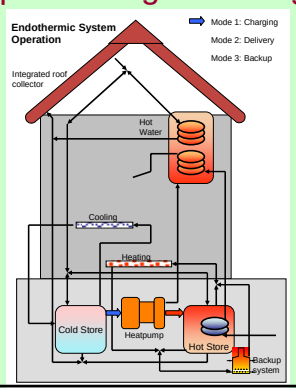


ENERGIE

Heat pump - heating & cooling







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Prototype - PCM thermal store

Store size reduced by up to 80%

2m³ Cold (0-20C):
2m³ Hot (30-50C):

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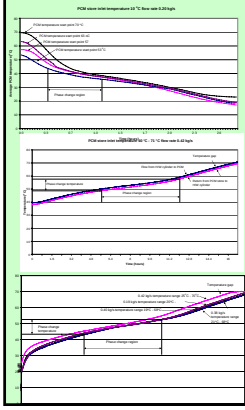
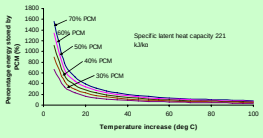
Results





5. Diurnal storage: Phase change wallcovering

- To develop a Wallcovering containing PCM
- Funded by Teaching Company Scheme (now KTP)
- Industrial partner: Omnova Wallcovering Co. Ltd
- UOB Innovation award 2006

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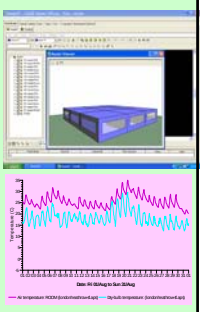
Simulate optimum quantity of PCM

North

31.23 kg 0.78 kg/m²	17.56 kg 0.39 kg/m²	14.87 kg 0.37 kg/m²
43.68 kg 0.97 kg/m²		25.34 kg 0.56 kg/m²
44.80 kg 1.12 kg/m²	33.18 kg 0.74 kg/m²	43.21 kg 1.08 kg/m²

West East

South



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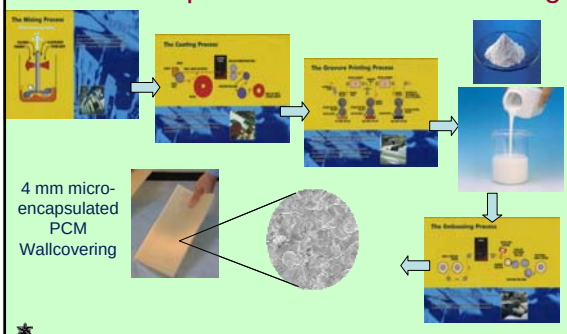
Manufacturing of micro-encapsulated PCM Wallcovering



4 mm micro-encapsulated PCM Wallcovering

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Performance evaluation




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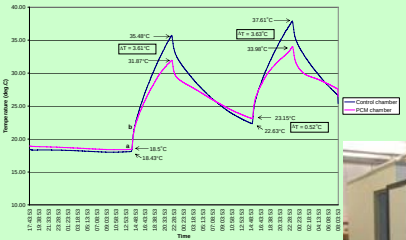
Results being analysed

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Conclusions

- Buildings are responsible for a significant proportion of greenhouse gas emissions
- Global warming is likely to cause summer overheating in some existing and new buildings
- New or refurbished buildings should be designed to avoid future dependence of air-conditioning to counteract summer overheating
- Thermal storage is a low or zero CO_2 emission technology for maintaining indoor thermal comfort. It can help to achieve the 60% UK CO_2 reduction target by 2050
- There are numerous research opportunities to explore novel and conventional thermal storage design options to enhance the sustainability of new and existing buildings

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Thermal storage group

- Thermal storage group
  - Prof. Andrew Miller
  - Dr. Kenneth Ip
  - Ms. Dianne Dyball
  - Mr. Abdullahi Ahmed
  - Mr. Jonathan Gates
- For more information & publications
  - Visit Centre for Sustainability of the Built Environment web site http://www.brighton.ac.uk/csbe

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