Climate Change – A focus on Cooling

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Climate Change and Buildings – A Focus on Cooling

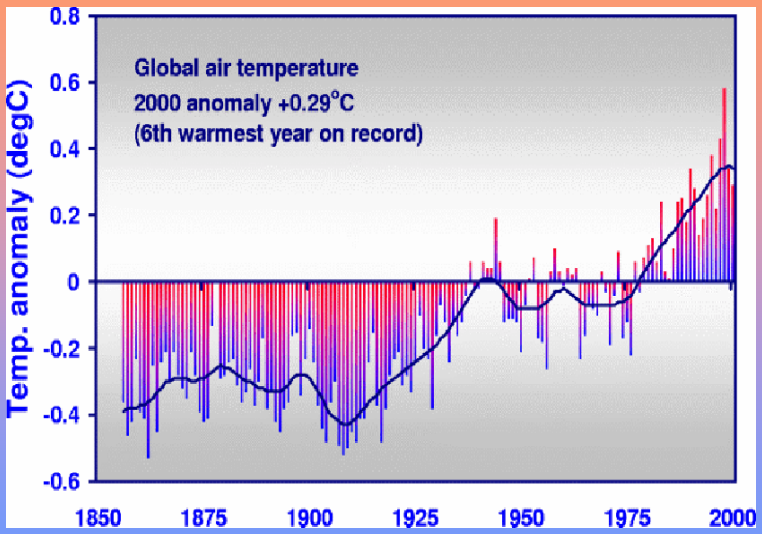
- How much climate change is expected?
- What kinds of changes?
- What will it mean for buildings?

How much climate change is expected? Is there climate change?

•now clear evidence of man's influence on climate change which the majority of scientists and engineers now accept.

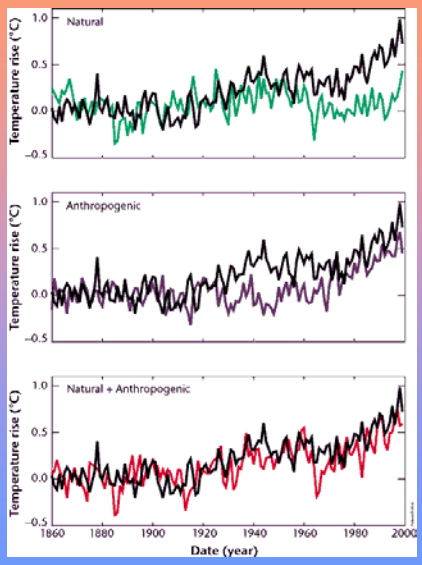
•IPCC, 1996: "*The balance of evidence suggests a discernible human influence on global climate*."

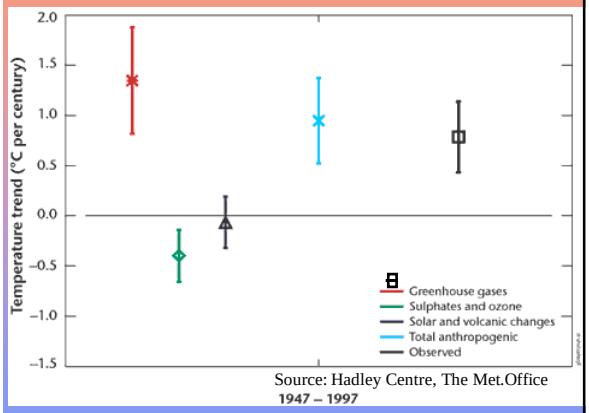
•IPCC 2001: "*Most of the warming observed over the last 50 years is attributable to human activities*."



Tyndall Centre for Climate Change Research

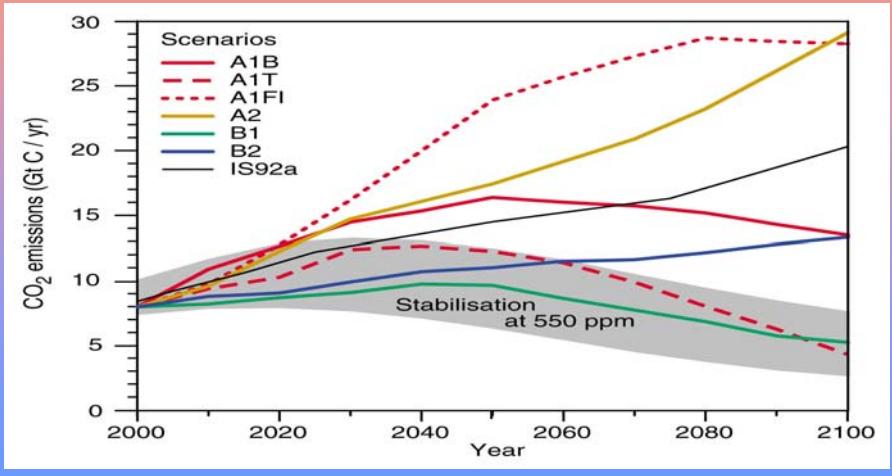
UMIST



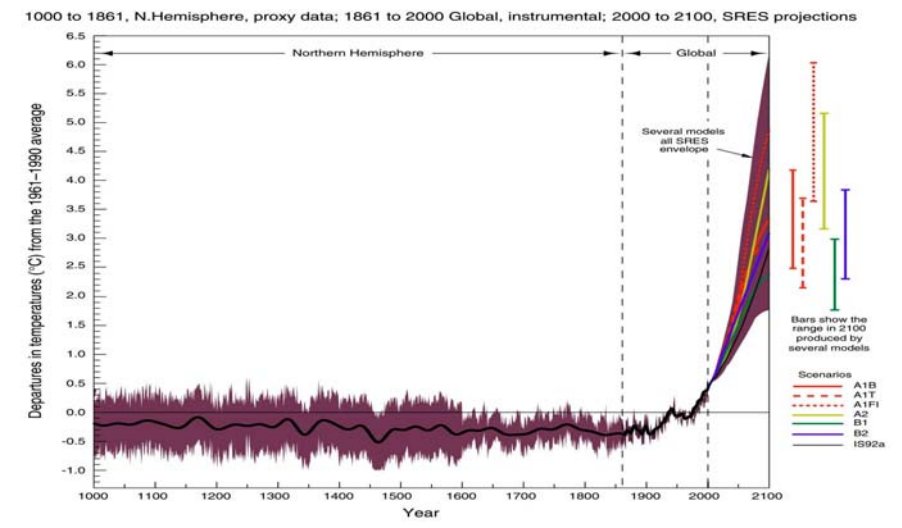


Source: Hadley Centre, The Met.Office
1947 – 1997

CO_2 emissions from the 6 IPCC SRES scenarios plus an earlier scenario, IS92A – showing stabilisation band



Variations in Earth's surface temperature 1000 to 2100



Climate Models (from UK Hadley Centre)

- HadCM3 (Atmospheric-Ocean Coupled Global Circulation Model (AOGCM)
- HadRM3 (Regional Climate Model (RCM); nested in an AGCM Atmospheric General Circulation Model higher resolution for a particular area and its geography.

Hadley Climate Models

- HadCM3
  - 4 Large Grid boxes for UK (~250km by 250km)
  - Continuous Daily Results (1860 – 2099)
- HadRM3
  - 50km by 50km grid boxes
  - Daily Results (1960-1990) and (2070-2100)

Hadley Climate Models

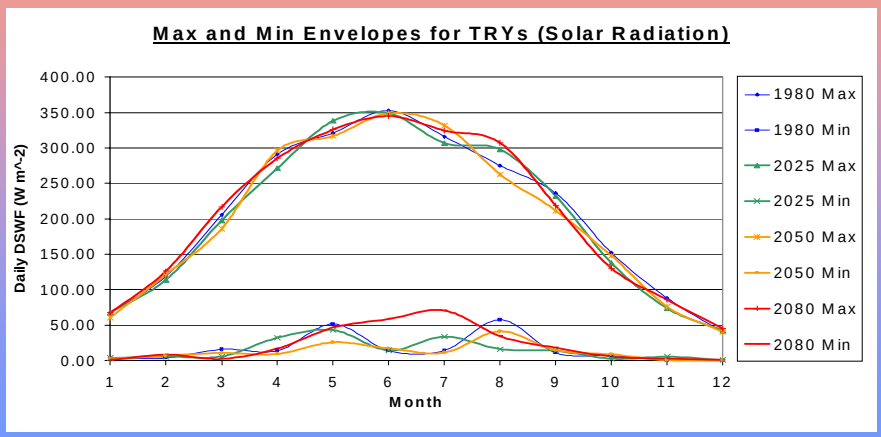
•Models only supply monthly and daily values

•Hourly Values need to be derived for use in simulation programs for building and plant design

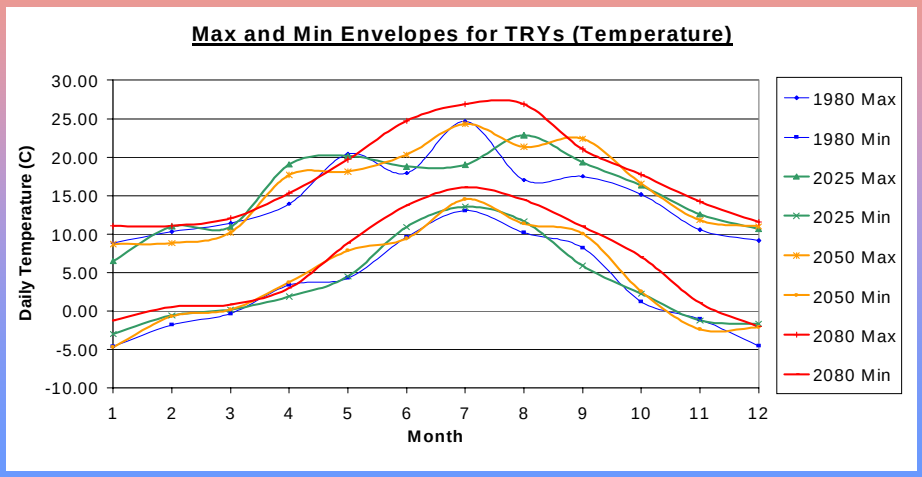
•Algorithms have been developed for generating hourly temperature and solar irradiation

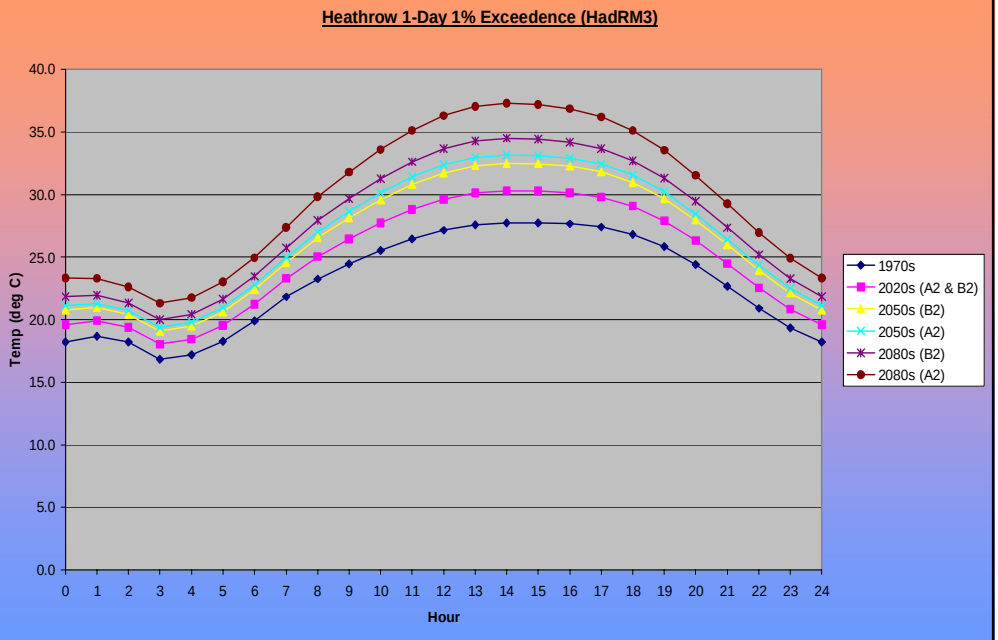
What kinds of changes?

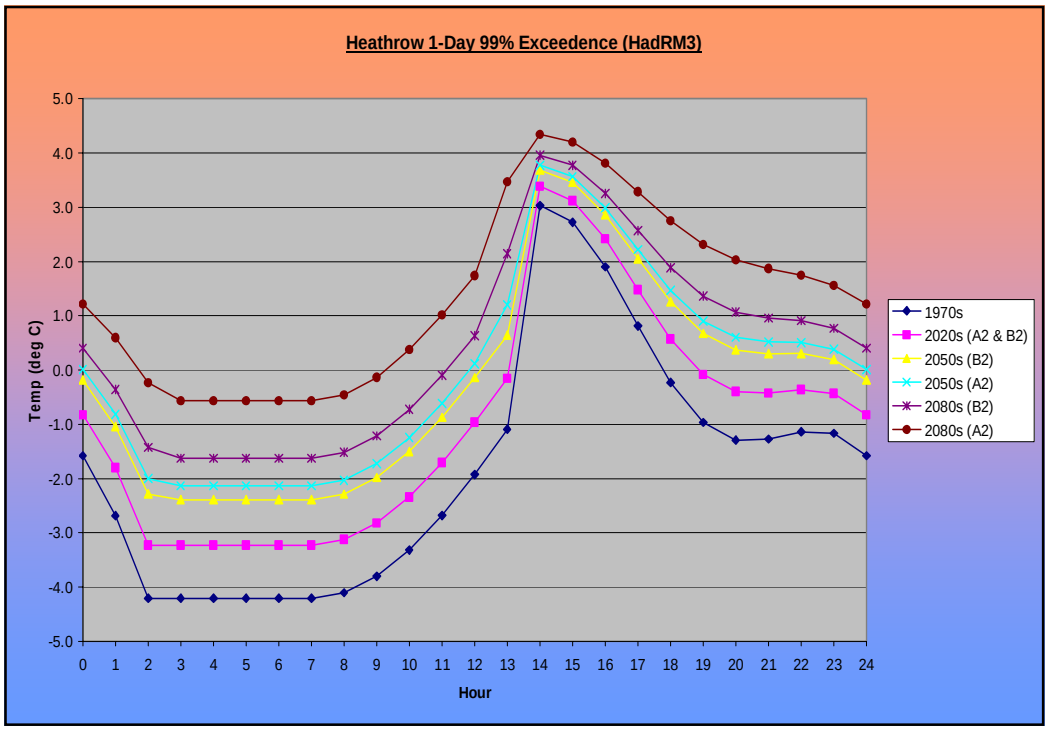
Max and Min Envelope of TRYs Had CM3 (Solar Irradiation)



Max and Min Envelope of TRYs HadCM3 (Temperature)







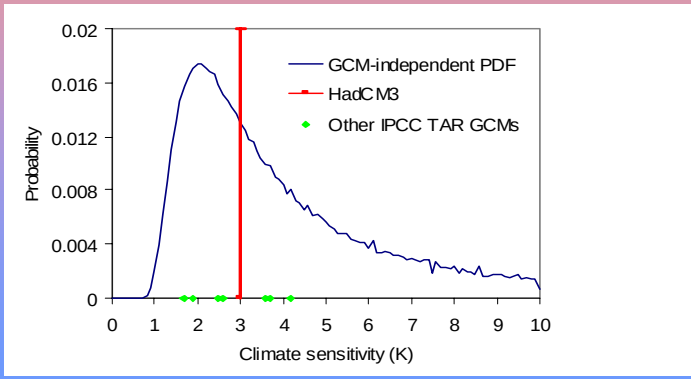
UMIST findings

	T_{MAX} increase	T_{MIN} increase
Summer	5	3.5
Winter	2.5	2

Table (1): Changes in 20-year averaged daily Summer and Winter T_{MAX} and T_{MIN} from 2000 to 2090 under A2 scenario

Climate variable	**Level of confidence**
Atmospheric CO2 concentration	**High Confidence**
Global mean sea level	
Global mean temperature	
Regional seasonal temperature	
Regional temperature extremes	
Regional seasonal precipitation	
Regional cloud cover	
Regional potential evapotranspiration	
Changes in wind speed	
Changes in climatic variability	**Low Confidence**

Hadley and other models sensitivities (dT for x 2 CO_2)



Temperature changes

- 2080s annual average UK temperature may rise 2°C to3.5°C,
- greater warming in South East than North West
- greater in summer and autumn than winter and spring.
- high summer temperatures more frequent, very cold winters increasingly rare.
- a very hot August (e.g. 1995);
  - 1 year in 5 by the 2050s
  - 1 year in 3 by the 2080s.

Precipitation

- Winters will become wetter and summers drier in all parts of the UK.
- Largest changes in South and East
  - summer precipitation decrease 50% 2080s.
  - winter precipitation increase by 30% by 2080s.
- Snowfall amounts will decrease significantly in all areas.
- Heavy winter precipitation more frequent, more intense, increasing the risk of flooding.

Sea level

- continues to rise around the UK shoreline,
- faster rises in South East than NW (adjustments from last ice age.)
- this, with more common storm surges, increases coastal flooding.

Humidity

Relative humidity will decrease in all parts of the UK, with the highest falls likely in the south of England.

Solar radiation

- summer cloud cover decreases, especially in the south, (increased solar radiation).
- winter cloud cover increases (2 – 3%) over most of UK; small fall in solar radiation.

Wind speed and storms

very difficult to predict future. present best estimate: wind speeds similar to present.

With more energy in the climate system, it is possible that storms could become more severe in future, but the climate models do not give consistent findings.

Impacts
Consequences for Building

- Internal Temperatures / Comfort
  - –Mean temperatures will increase improving winter comfort conditions, but causing problems with overheating in the summer when *careful design will be needed to avoid full* air conditioning.
- Energy Consumption
  - –Winter energy consumption for heating will reduce, but use of air conditioning in the summer could offset this.

What will it mean for buildings?

- Buildings last from 50 to 100 years.
- Computer Simulation.
- Test Reference Years.
- Near Extreme Summers.
- How Buildings Perform.

Impacts
Consequences for Building Services

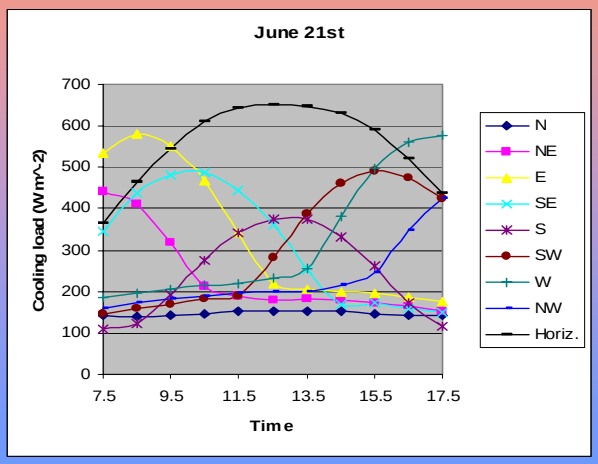
- Condensation and Mould Growth
  - –Condensation and mould growth may decrease.
- Internal Pollution
  - –Higher temperatures could increase problems with indoor air quality, this could have health implications for occupants.
- Water Supply
  - –Reduced summer water supply in the South East
- Legionella Risk
  - –Use of air conditioning and warmer and more humid internal environments could lead to increased risk of legionella problems.

Other impacts of less direct relevance to building services engineers are :

- more rain penetration and dampness problems;
- increased flooding, both from rivers due to more frequent heavy rain and in coastal areas due to sea level rise and more frequent storm surges;
- increased subsidence due to drier soils in summer;
- increased activity by soil contaminants including radon.
- increased UV degradation of e.g. plastics

Activity on building sites will be disrupted more often by hot weather in the summer and increased flooding and, maybe, stronger winds in the winter.

Cooling load vs heating load



1m^2 clear glass:

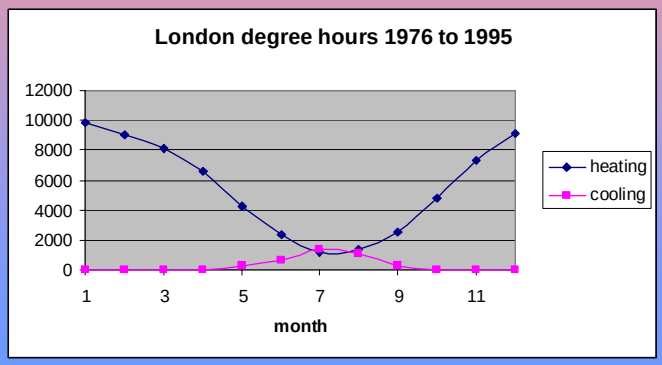
London:

Winter heat load: 86 W

Summer solar cooling load peaks at 600 W

Cooling load vs heating load

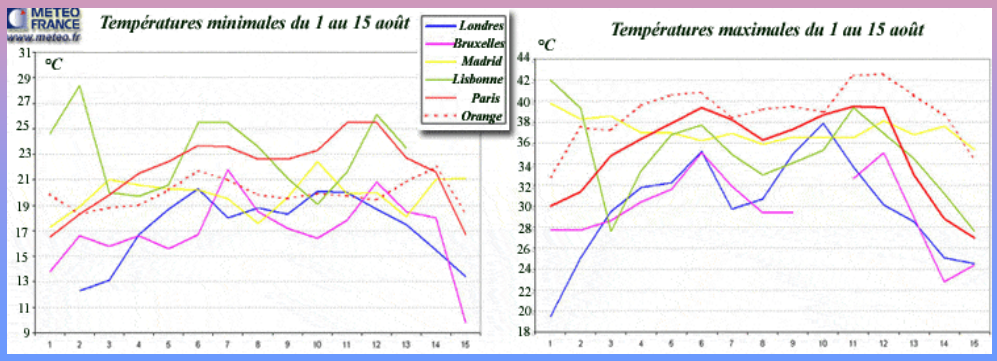
But the duration of the peak heating and cooling periods are different.



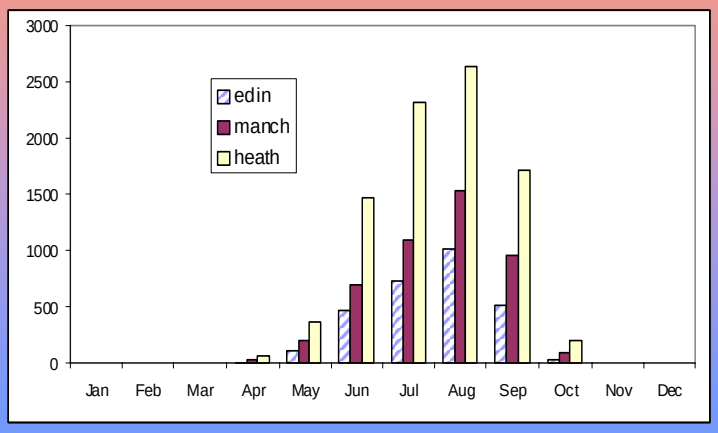
Heating vs cooling

Can keep warm with extra clothes, and heating is basic (a fire).

High temperatures for a few days can be dangerous to the vulnerable (France 2003)



Increase in cooling hours, (18C base)1970s to 2080s (A2) in the UK.



Increase in percentiles for design 1970s to 2080s

Historic Percentiles

1970s

%	Heathrow (C)
0.4	-3.16
1	-2.06
99	22.92
99.6	25.19

A2 (medium high) scenario, 2080s

%	Heathrow (C)
0.4	-0.07
1	1.21
99	29.92
99.6	32.08

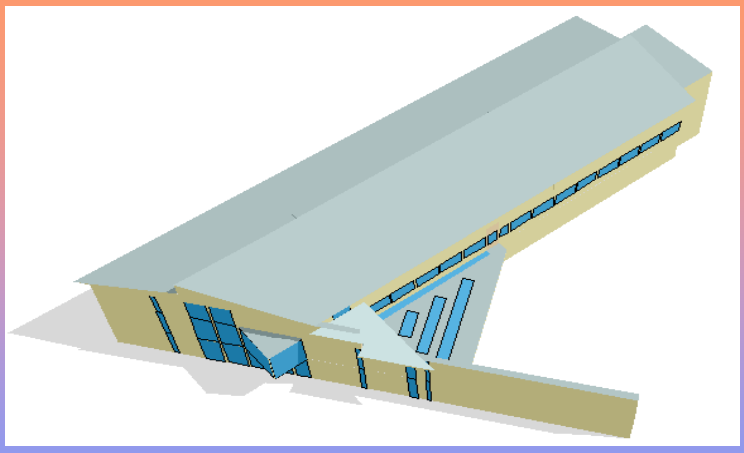
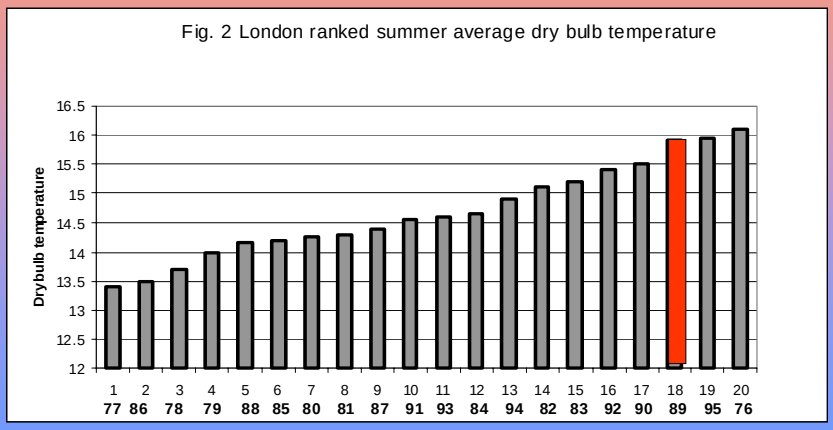


Fig.1 The clinic building with solar shading viewed from the north west

Example clinic building

Selection of Near-Extreme Summers



Example: Near Extreme Summer (1976 – 1995)

Comfort criteria

overheating criterion for dynamic, hourly simulation

(UK by CIBSE):

dry resultant temperature should not exceed 25oC for more than 5% of the occupied year.

Need a near-extreme design weather year for simulation.

ROOM SPECIFICATION East side office	number of hours > 25C
EXTERNAL WEATHER DATA London design summer 1989	283
Clear double glazing, single sided vent during occupation only (~5ach), no shade	393
Clear double glazing, single sided vent day and night (~5ach), no shade	312
Clear double glazing, single sided vent and night (~5ach), external solar shade	222
Antisun double glazing, single sided vent day and night (~5ach), external solar shade	184
Antisun double glazing, single sided vent day and night (~5ach), external, adjustable, extensive solar shading	93

A windcatcher ventilation device

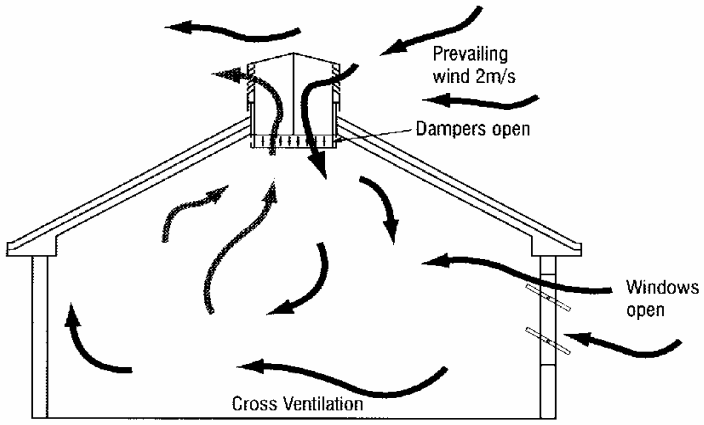
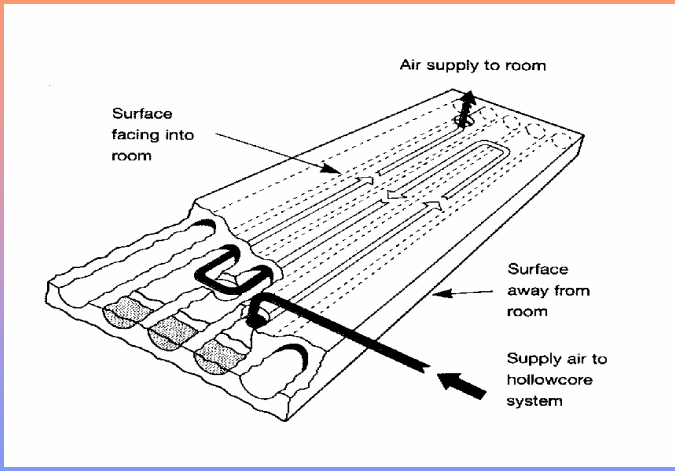
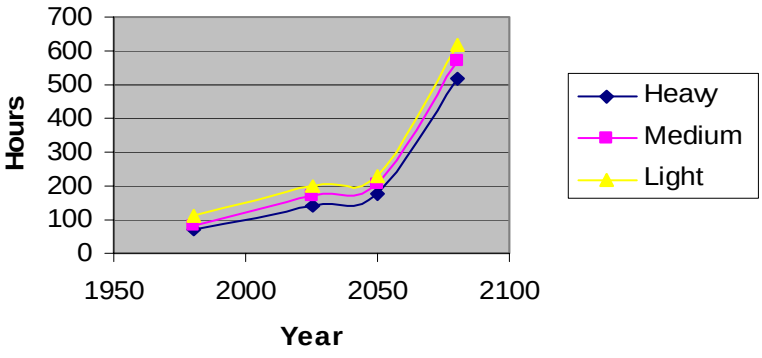


Fig nv.5 A windcatcher (courtesy of Monodraught Ltd)

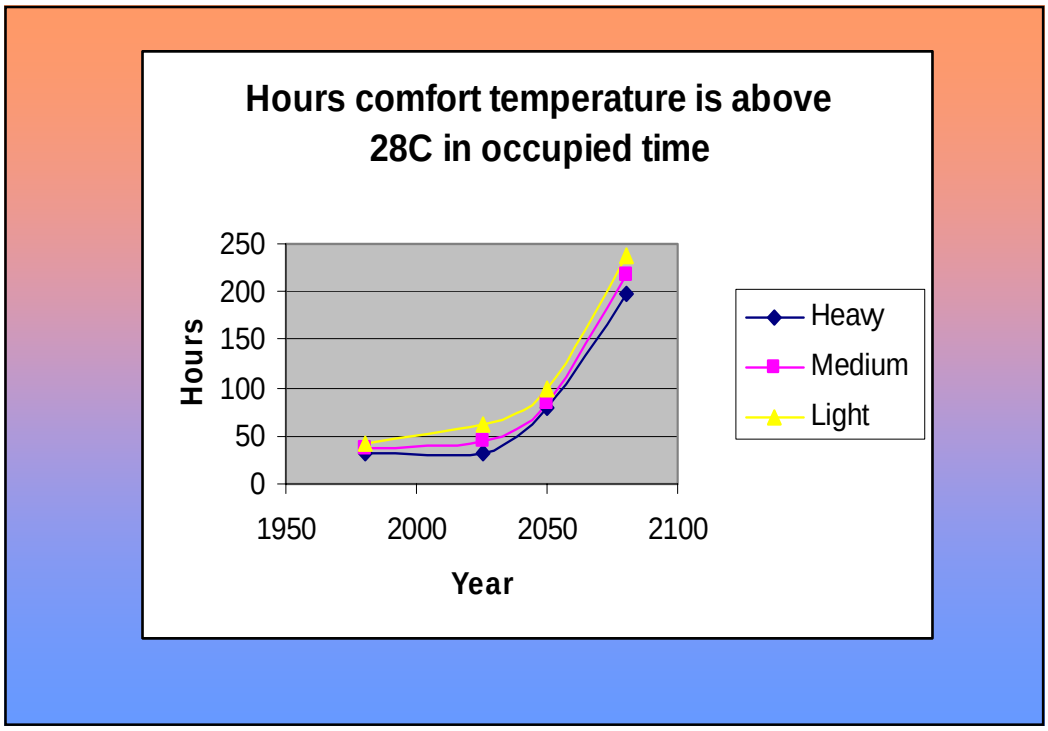
Ventilation through a floor slab

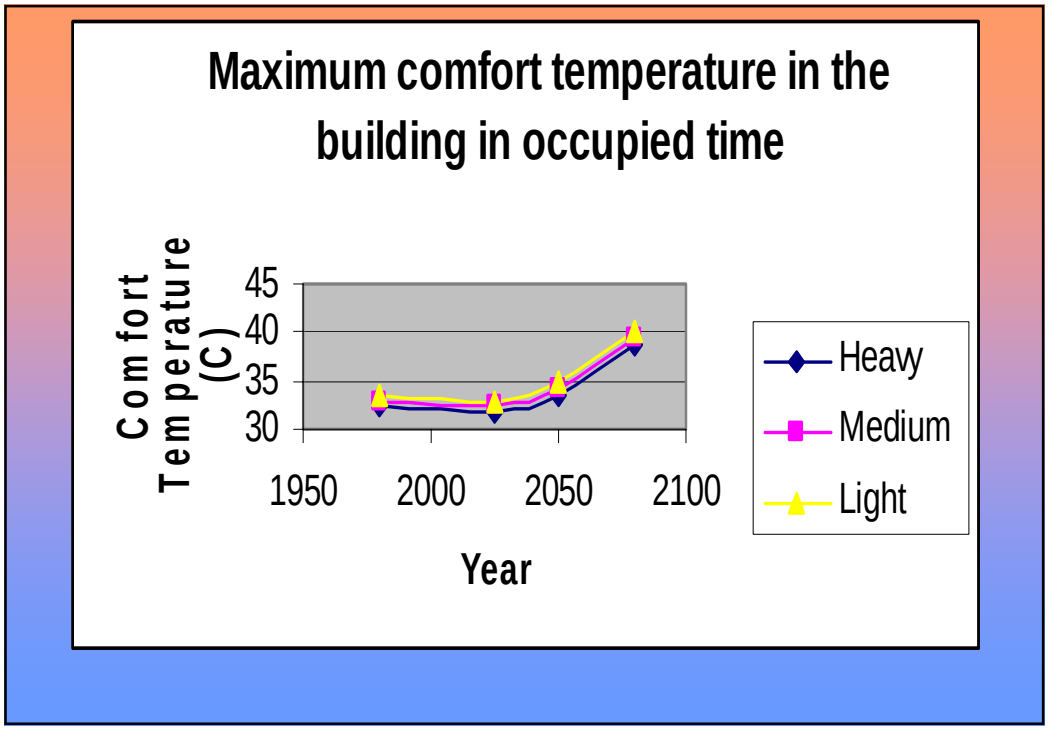


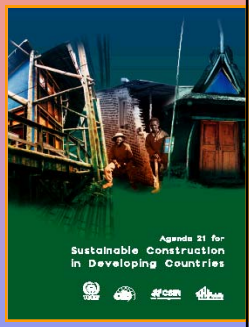
Hours comfort temperature is above 25C in occupied time



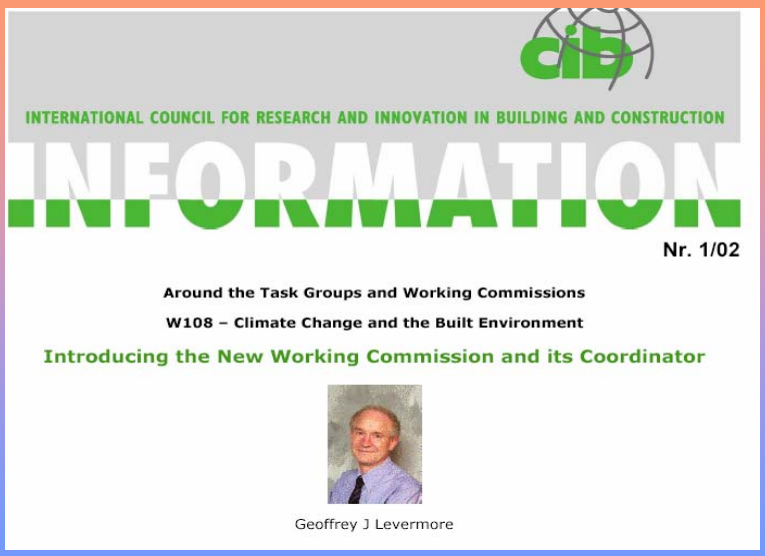
For a TRY


Hours comfort temperature is above 28C in occupied time
250
200
150
100
50
0
Hours
1950
2000
2050
2100
Year
Heavy
Medium
Light


Maximum comfort temperature in the building in occupied time
Comfort Temperature (C)
45
40
35
30
1950
2000
2050
2100
Year
Heavy
Medium
Light



International Council for Research and Innovation in Building and Construction



Objectives

1. To exchange weather data, climate change scenarios, research findings and form joint research projects on the impacts of climate change on construction and the built environment.

2. To transfer of research findings to practitioners to change building design, adaptation, standards and codes to reflect impacts of climate change.

Raising Awareness of Climate Change in Users of the Built Environment (RACCUBE)

Proposed Co-ordination Action to FP6 Priority 1.1.3: Nanotechnology and nanosciences, knowledge-based multi-functional materials, new production processes and devices

Conclusions

- Rise in maximum resultant temperature much more than minimum.
- An increasing need for summer-cooling, natural ventilation not sufficient.
- Winter-warming requirement stays about the same.

Conclusions

- In UK summer overheating will be a problem by 2025
- Need for low energy airconditioning
- Need for mitigation and adaptation

Conclusions

- W108 Climate Change and the built Environment
- FP6 OCCALBE
- Simulation with climate data from same model for different countries.
- Collaboration with IEA.