

# The effect of building design on urban energy supply and demand

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University of  
**Reading**



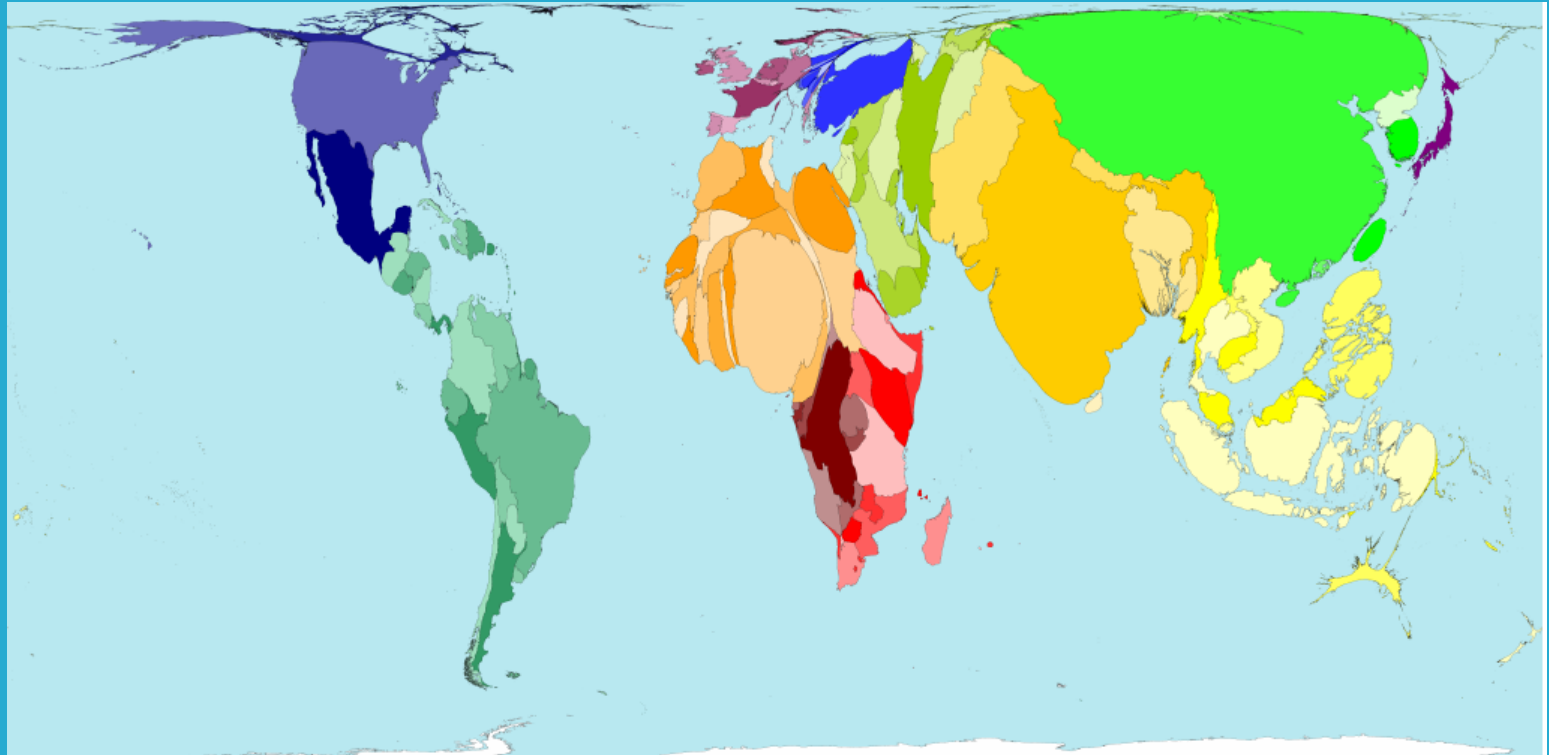
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# ACTUAL – Advanced Climate Technology Urban Atmospheric Laboratory.

- The ACTUAL project aims to set up tools to monitor and simulate urban climate from city down to building scale.
- It is hoped that results will integrate directly into engineering and policy making.
  - This PhD focuses on small scale climate and micrometeorology.
  - I aim to answer the questions:
    1. How much of a problem is overheating in London?
    2. Exactly what causes overheating and how do buildings exchange heat with their microclimate?
    3. To what extent does overheating lead to increased summer time energy use?



The proportion of the world's population living in cities is increasing.



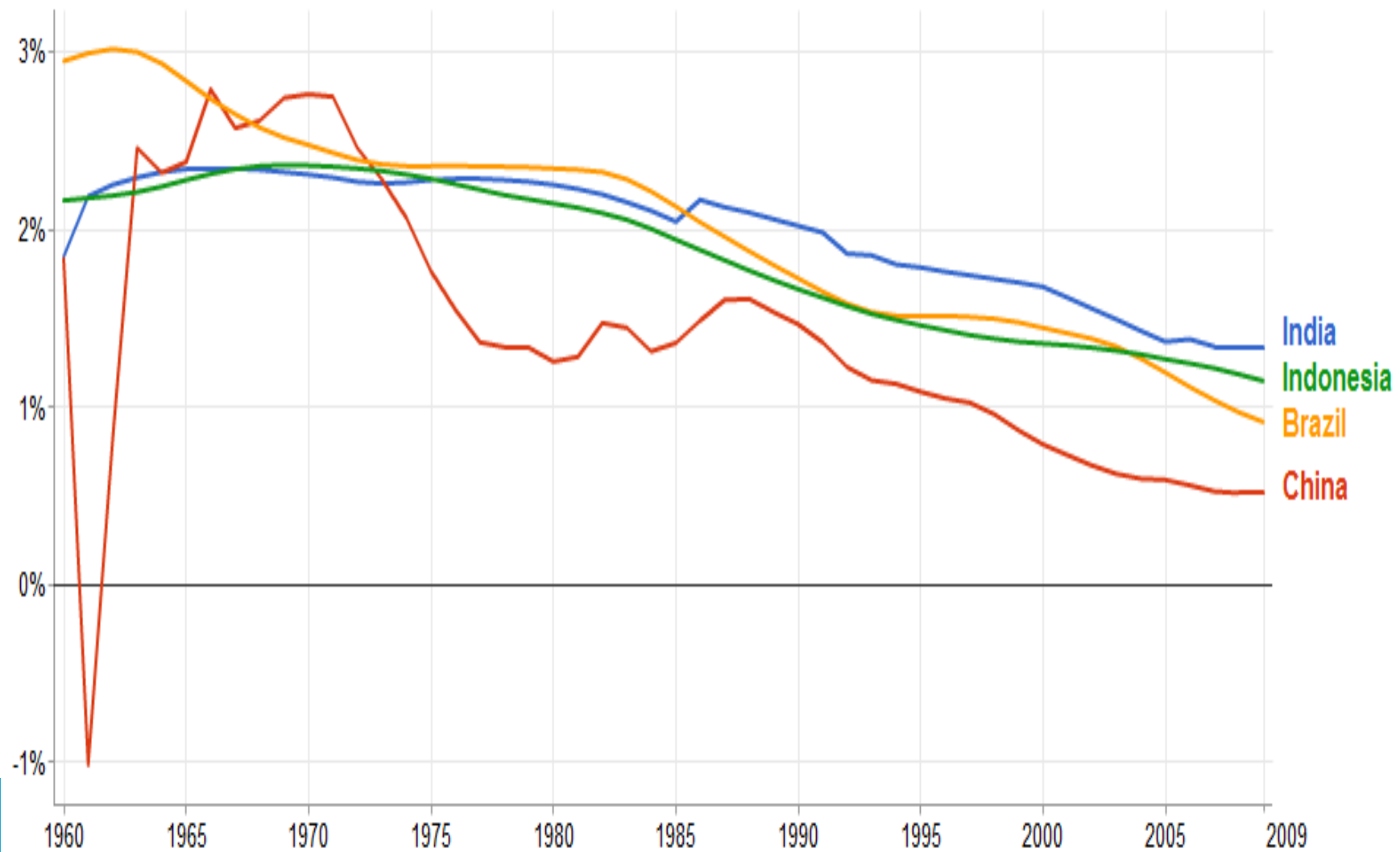
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This image illustrates projected urban population growth by 2015 from a 2002 baseline.

(from worldmapper.org, map 190).

## Population growth rate

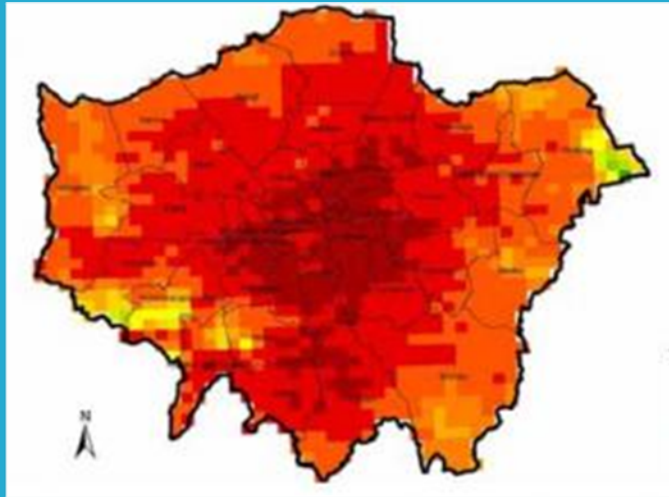
Percentage change of resident population compared to previous year.



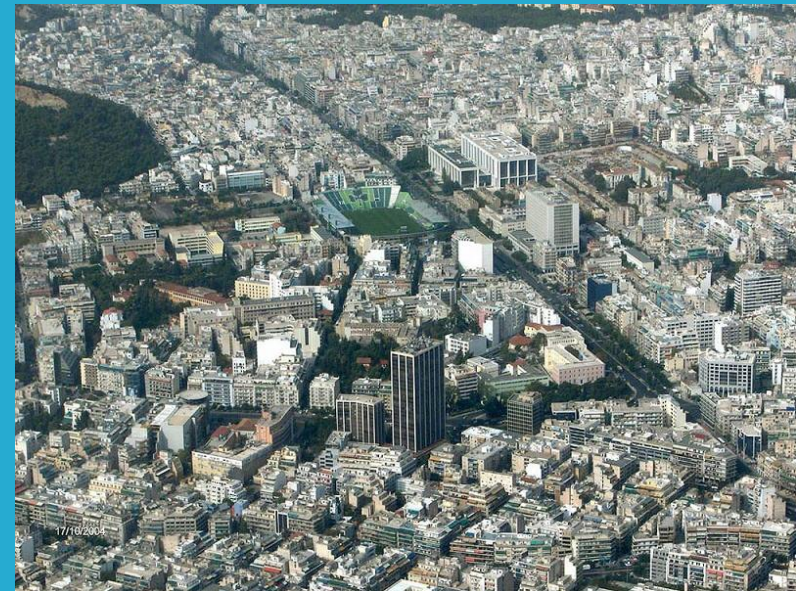
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(from World Bank, World Development Index)

# The Urban Heat Island (UHI) causes the city to be warmer than rural settlements.



Cities in warmer climates have adapted to cope with high heat. Often buildings are painted colours that reflect sunlight and are close together to increase shading at street level.



Historically London has not had a significant problem with overheating but it did in 2003 and will do more often as very hot summers become more regular.

The Surface energy balance describes how the ground exchanges energy with the atmosphere.

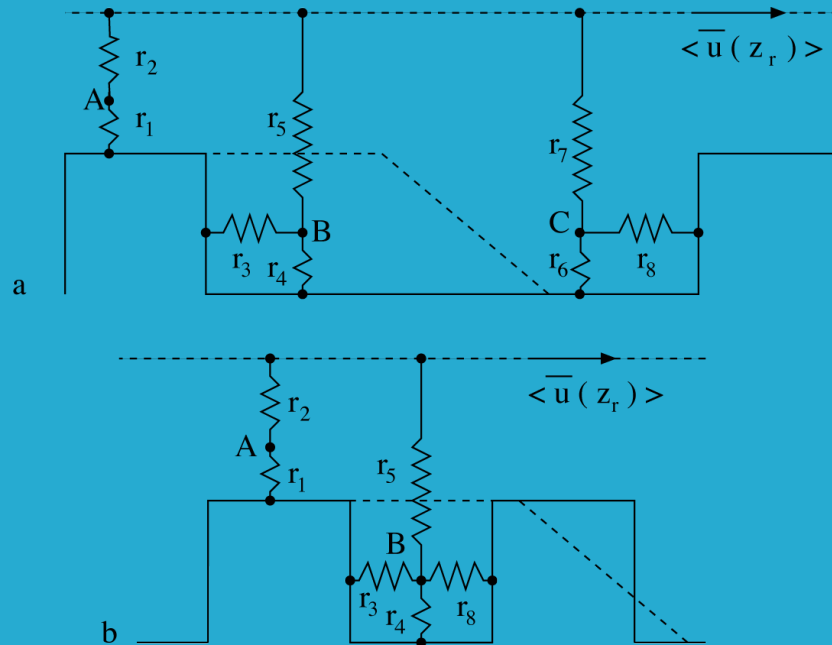
$$R_n - G = H + \lambda E$$

$R_n$  is net radiation.  $G$ ,  $H$  and  $\lambda E$  are fluxes of ground, sensible and evaporative heat.

- The UHI is caused by buildings and roads heating during the day and releasing heat slowly at night.
- UHI Intensity is the urban – rural temperature difference. In London this is typically 4-8°C at night.



# The resistance network model of the urban atmospheric boundary layer.



- The street canyon is used as the basic unit of urban geometry.
- Cross canyon wind component can create recirculation and ventilation zones depending on aspect ratio.
- Heat transfer between each point is described using a one dimensional resistance.

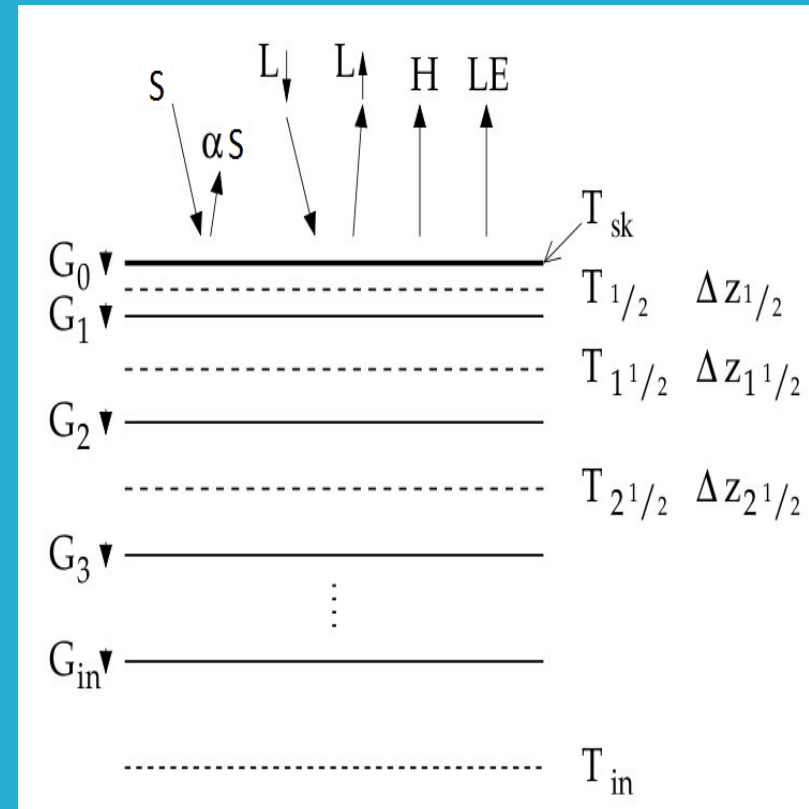
$$H = \rho c_p \frac{T_s - T_a}{r}$$



(From Harman et al., 2004)

# The resistance network model makes some simplifications.

1. The heat transfer within the substrate is modelled through vertical discretisation. Buildings are treated as solid blocks.
2. Evaporative heat flux is neglected so the model assumes surfaces are dry.
3. There is no anthropogenic heat release, but air conditioning units release heat into the air.



(From Harman et al., 2004)

# Experimental Comparison with ACTUAL rooftop weather station.

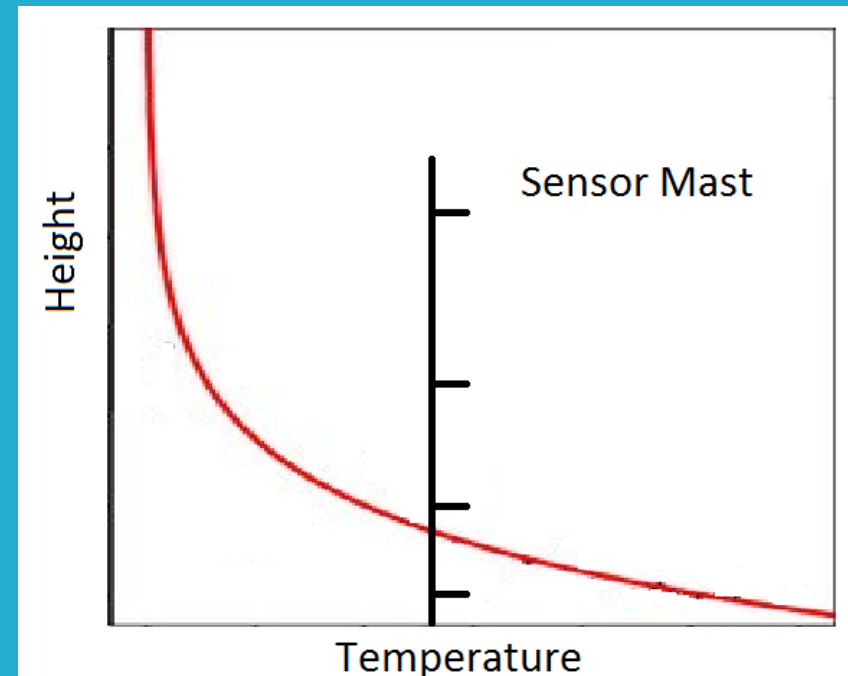
- The ACTUAL project has 2 observation stations in London – WCC rooftop (18m) and BT tower (190m).
- At each of these we have a weather station (vaisala WXT520), sonic anemometer (Gill R3), infrared hygrometer (Licor Li-7500) and a net radiometer (Kipp and Zonen CNR4).
- Experimental measurements of the surface energy balance on the rooftop can be compared to the resistance network model.



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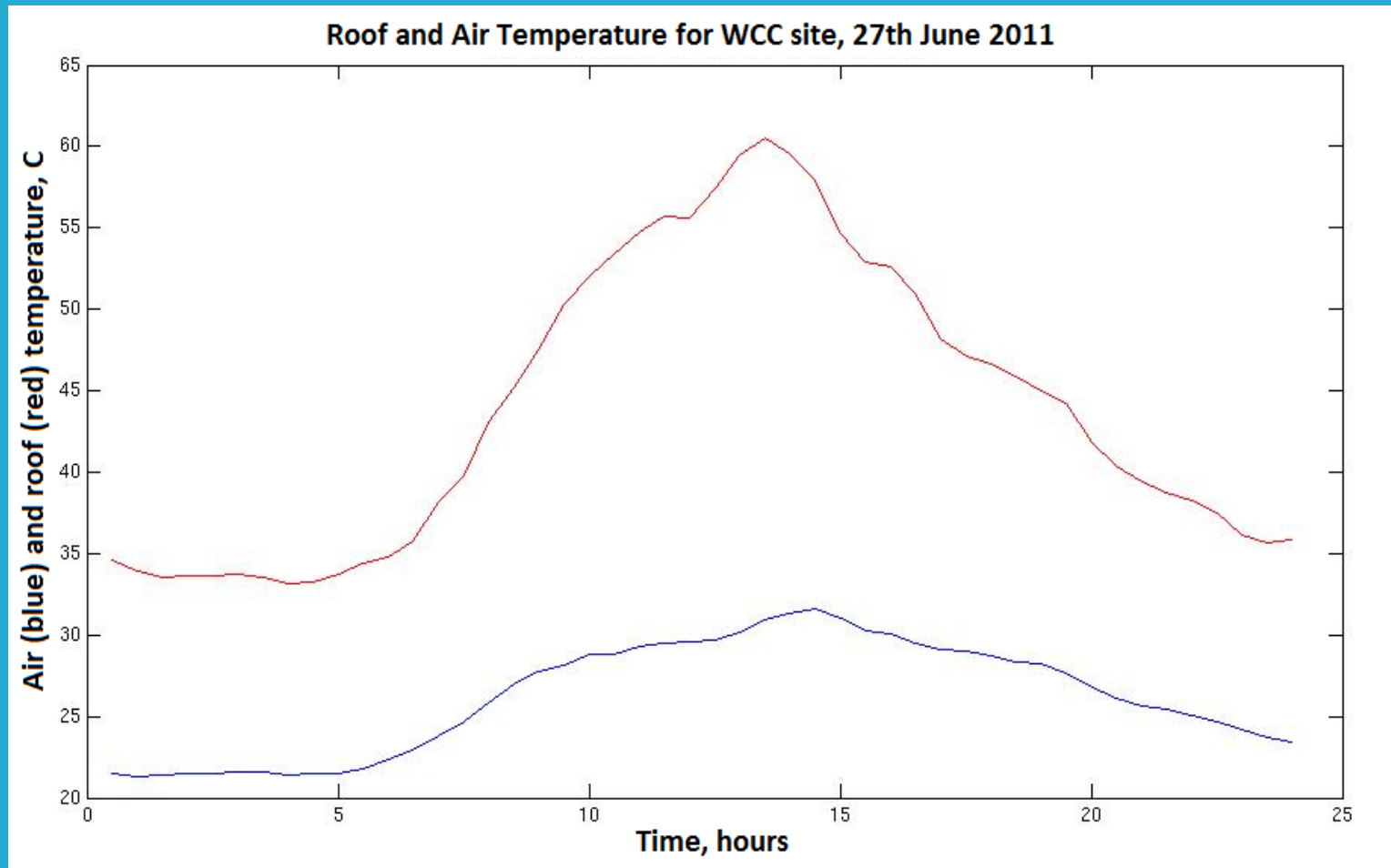
# Extensions to the rooftop experimental work.

Hukseflux Heat Flux plates measure the heat flux through a surface.



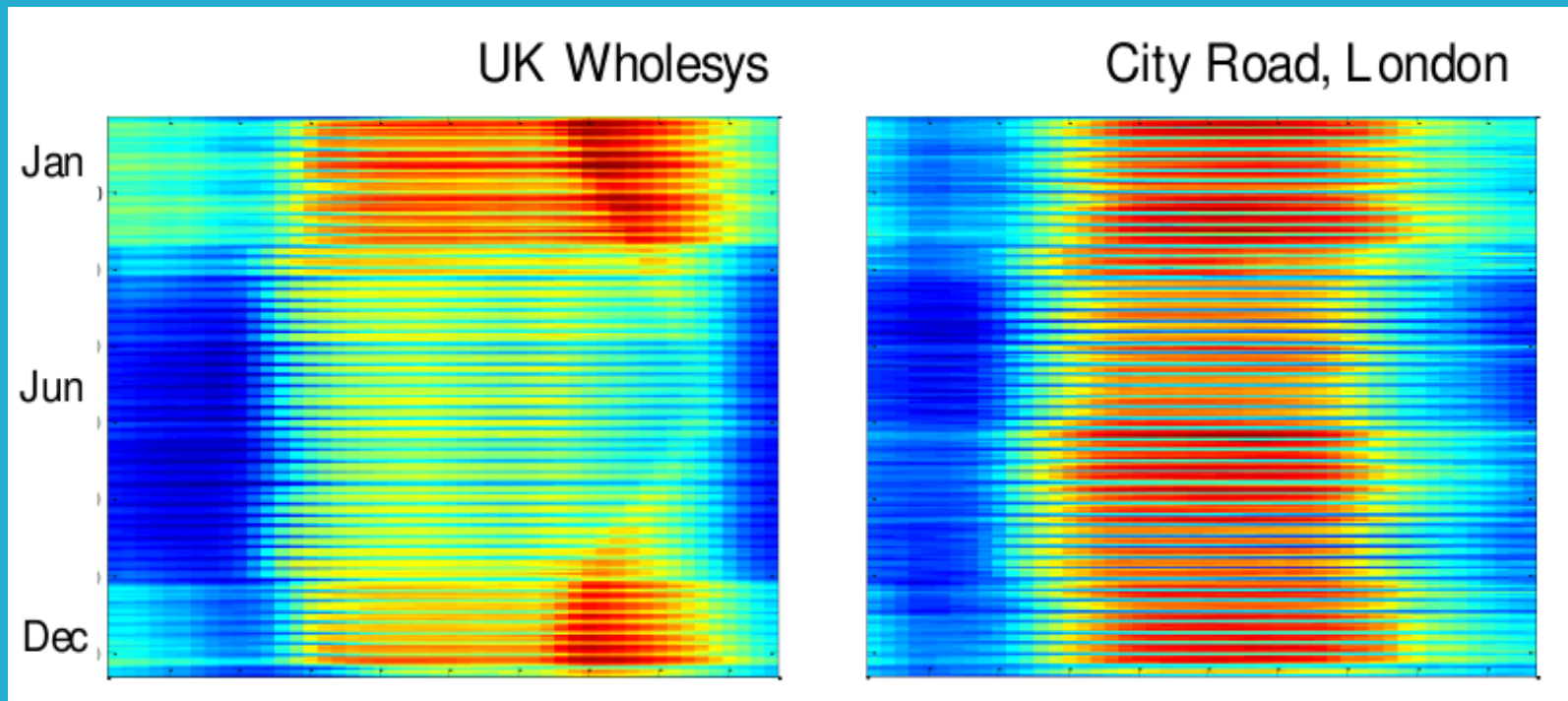
A mast of temperature sensors would allow mapping of the buildings boundary layer.

On a sunny day the rooftop becomes much hotter than the air above.



# How do high temperatures impact on energy use?

For the whole UK system electricity demand in winter is much higher than summer but in London this divide is less clear.



# Summary of key points.

- The ACTUAL project urban laboratory can be used to test the resistance network model.
- Ways in which this model could be improved have been identified.
- Through the right collaborations it is hoped that we can get energy use data for central London.



Thank you for listening!