Monitoring summer indoor overheating risk and ventilative cooling behaviour in London homes

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Overview

1 Background
2 The LUCID project: Overview
   Monitoring summer indoor overheating
   Exploring summer ventilation behaviour
3 The AWESOME project: Overview
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1 Background

Our climate is changing due to humanmade greenhouse gas emissions. Overheating in cities will be exacerbated due to the urban heat island effect.

Indoor overheating in homes
• Growing body of evidence
• Increased research interest
2 LUCID: Overview

Modelling the **local urban climate** and its impacts

**LSSAT**
- ANN model for 77 fixed temperature stations.
- Features:
  - Site specific hourly air temperature

**LondUM**
- Atmospheric model at 1km grid.
- Features:
  - 1.5m height surface temperatures

**Arup Outdoor Room**
- Urban canyon radiative exchange model.
- Linked to LondUM
- Features:
  - Air & surface temperature

**ADMS**
- Atmospheric dispersion model.
- Linked to LondUM
- Features:
  - Perturbations on temperature & humidity

2 LUCID: Monitoring summer indoor overheating

- **101 London dwellings** of varying morphology
- Convenience sample (UCL staff and students)
- Dry bulb **temperature** and relative **humidity** measured during summer 2009 (HOBO U12-012)
- 36 dwellings monitored during **hot spell** (29th June – 3rd July)
- **EPC survey**
- **Energy use and ventilation behaviour questionnaire** (80% response rate)
2 LUCID: Monitoring summer indoor overheating

Full sample (June-August):

- The analysis of the monitoring data indicated that London homes and, in particular, bedrooms are already at risk of indoor overheating during hot spells under the current climate.
- There is no strong correlation between temperature and distance from the centre.

Sub-sample (hot spell):

- Significant levels of night time overheating were recorded in the main bedrooms.
- Sleep impairment due to temperature rising above the 24 °C threshold might have been caused in 86% (31 out of 36) of the bedrooms.
2 LUCID: Exploring summer ventilation behaviour

Full sample (June-August):
- Around 70% of respondents open only one or no windows at night (mainly due to security reasons).
- Bedroom air temperatures were slightly higher in dwellings where the occupants tended to leave most or all windows open at night.

Sub-sample (hot spell):
- Daytime ‘rapid’ ventilation appears to increase the variability of living room temperatures.
- The effect of night time ventilation cannot be assessed with confidence due to the small sample of houses that left their windows open during the night (mainly due to security reasons).
3 AWESOME: Overview

1. Air pollution and meteorology
   • measurements
   • spatio-temporal models

Effect modification
2. Models of building performance
   (temperature, indoor pollutants)

Analyses
3. Time-space epidemiological models
4. Decision analysis
5. Health impact models

3 AWESOME: Modelling summer indoor overheating

Modelling of a 1960s mid-floor purpose-built flat (bedroom, Medium emissions, 50th percentile, 2050s):

- **Energy efficient retrofit** may increase summer overheating.
- Small temperature reductions in the bedroom as a result of **night cooling** and **internal shading**.
3 AWESOME: Modelling summer indoor overheating

Modelling of London dwelling archetypes (living rooms, current climate):
- Overheating rankings vary as a function of occupancy patterns, window opening and shading use.
- Daytime internal shading and night cooling can modify overheating risk but only to a certain extent.

3 AWESOME: Modelling summer indoor air quality

Modelling of a 1960s mid-floor purpose-built flat (bedroom, Medium emissions, 50th percentile, 2050s):
- There are trade-offs between thermal comfort and indoor air quality:
- Bedroom internal temperatures rise above the window opening threshold, which causes PM2.5 I/O ratios to approach 1.0 due to the ingress of outdoor air.
4 Conclusions

- London homes already experience hours with temperatures above the recommended thresholds, even during relatively mild summers.

- In the future, such risks are likely to be exacerbated due to climate change and certain retrofit measures (increased airtightness, internal wall insulation).

- No strong correlations between distance from the centre and overheating risk were observed, which may be an indication that building characteristics and occupant behaviour may be more important for overheating than the location within the urban heat island.

- Natural ventilation alone may not suffice to keep indoor thermal conditions within acceptable limits and its cooling potential may be further limited due to noise, security and outdoor air pollution concerns.

- Rankings of dwellings based on their propensity to overheat vary as a function of occupancy patterns, window opening and shading use behaviour.

4 Ongoing and suggested future research

- Carrying out a large-scale summer thermal monitoring study of statistically representative UK dwellings, potentially including thermal diaries and occupancy sensors, including information on window size and local wind speeds.

- Including a detailed comparison of the static vs. adaptive thermal comfort approach.

- Further exploring the complex interrelationships between the indoor thermal environment and airborne contaminant transport in heat vulnerable urban homes.

- Linking markers of exposure to indoor excess temperatures and pollutants with health markers (morbidity and mortality data) to assess the modifying effect of the indoor environment.
Publications

Journal papers


Conference papers

Thank you!

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Any questions?