The Development of a Local Urban Climate Model and its Application to the Intelligent Development of Cities (LUCID) and The Unintended Consequences of Decarbonising the Built Environment

Complex Built Environment Systems group The Bartlett School of Graduate Studies, UCL
TODAY

LUCID
• Background and overview
• Urban climate models
• Impact assessment models
• Key messages
• Ongoing work

Unintended consequences
• Background and overview
• Collaborative mapping
• System dynamics
• Ongoing work
Future projections

Our climate is changing due to humanmade greenhouse gas emissions.

Overheating in cities will be exacerbated due to the urban heat island effect.

Source: LUCID project

Source: UKCP09
## LUCID OVERVIEW

<table>
<thead>
<tr>
<th><strong>Project title</strong></th>
<th>The development of a Local Urban Climate model for the Intelligent Development of cities (LUCID)</th>
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<tbody>
<tr>
<td><strong>Timescale</strong></td>
<td>2007-2010</td>
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<td><strong>Focus</strong></td>
<td>London</td>
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</table>
| **Scales**        | City  
                      Neighbourhood  
                      Street  
                      Building |
| **Team**          | UCL  
                      University of Reading  
                      MetOffice  
                      Brunel University  
                      LSHTM  
                      CERC  
                      Arup  
                      GLA |
LUCID  LOCAL URBAN CLIMATE MODELS

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

Source: LUCID project
Characteristics of the London heat island

- London experiences a significant heat island. Temperatures may vary considerably (3-4 °C) over relatively short distances due to the different thermal properties of the land use types, as well as the varying morphology.
- **Building form** has the potential to change the urban heat island up to 1 °C when altered at the city-scale.
- The **current greening** in London reduces night-time temperatures by up to 2-3 °C.
- **Anthropogenic heat** emissions appear to increase the magnitude of the urban heat island at the city scale - up to 2 °C at night.
- The most intense heat island is observed on calm nights with clear skies. **Advection** of cool rural air changes the urban heat island pattern on windier days and distributes heat within London.
LUCID IMPACT ASSESSMENT MODELS

Urban heat island impact on energy use and thermal comfort

• The urban heat island was found to decrease domestic space heating loads by 14% in the urban areas compared to a rural reference site.
• This energy balance will depend critically on future uptake of air conditioning.
• The thermal quality of dwellings seems more important than the location in the urban heat island in terms of influencing internal temperatures.

Source: Mavrogianni et al. 2009
Local urban climate modelling at the neighbourhood scale

- A **cool roof** was most effective at reducing air temperature during the day, when solar energy is greatest, whereas a **green roof** reduced air temperatures mostly during the evening.
- Dried-out roof plants provide less cooling than **irrigated** ones, which may be a disadvantage in possible drier summers of the future.

Source: Virk et al. 2014
UNINTENDED CONSEQUENCES  OVERVIEW

The facts
- 80% UK legally binding decarbonisation target by 2050
- 27% of UK energy consumed in dwellings
- 85% of existing dwellings will still be standing in the 2050s
- only 1% of which have adequate thermal performance

The challenge

- eradication of fuel poverty
- smart meters in all UK homes, ‘whole house’ retrofit package to 7 million houses
- implementation of all cost effective measures
- 1+ home fully retrofitted every minute for the next 10 years!
### UNINTENDED CONSEQUENCES OVERVIEW

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<tr>
<th>Project title</th>
<th>Partners</th>
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<tr>
<td>Platform Grant Renewal Bid: The Unintended Consequences of Decarbonising the Built Environment</td>
<td>Anne Thorne Architects Partnership</td>
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<td>2011-2016</td>
<td>Ceravision Ltd</td>
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<td>Max Fordham LL</td>
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UNINTENDED CONSEQUENCES MAPPING

Integrated decision-making about Housing, Energy and Wellbeing (HEW)

• Systems thinking
• Cognitive maps from interviews
• Collaborative mapping for stakeholders
• Causal maps, reinforcing and balancing loops
UNINTENDED CONSEQUENCES  SYSTEM DYNAMICS

Source: Macmillan et al. 2014
UNINTENDED CONSEQUENCES  SYSTEM DYNAMICS

Source: Macmillan et al. 2014
UNINTENDED CONSEQUENCES  SYSTEM DYNAMICS

Source: Shrubsole et al. 2014
REFERENCES

LUCID project

REFERENCES

HEW project

- Macmillan A., Davies M., Bobrova Y. 2013. Integrated decision-making about housing, energy and wellbeing (HEW), Report on the mapping work for stakeholders. Complex Built Environment Systems, The Bartlett School of Graduate Studies, UCL.
- Shrubsole S., Macmillan A., Davies M., May N. 100 Unintended consequences of policies to improve the energy efficiency of the UK housing stock. Indoor and Built Environment. 2014; In press.
Thank you!
Any questions?

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