Domestic Overheating – an integrated approach from designer to occupant

William Wright
Building Research Establishment, Watford
william.wright@bre.co.uk
Introduction

- Need for guidance for designers, landlords and occupants
- Decisions early in the design process can have significant impact
  - Early communication between stakeholders to help avoid overheating problems later
- Window of opportunity to reduce overheating propensity at minimum cost
  - Otherwise, may lead to higher cost measures later or use of mechanical cooling
- Occupants are part of the solution
Integrated approach

– Mitigating overheating as a process from design, construction, to operation
  – **Benefits** occupant comfort, reduced risk, energy demand and carbon emissions

– Can consider overheating in the following ways:
  – **Designers** Features to design in, reducing gains, rejection passively, what behaviour to assume of the building occupants and key questions to ask
  – **Landlords** How operation and maintenance is undertaken, consider long term issues and changes to building and surroundings
  – **Occupants** How actions affect thermal environment, understanding of the building as a dynamic thing responding to environment and usage
Defining ‘overheating’

- Experience of overheating can be different for different occupants
  - Several metrics and precise definitions of criteria derived from statistics on people’s experience of overheating
- Any unwanted heat within a building affecting thermal comfort
  - Long lasting low level
  - Short high temperature events, heat waves
  - Night time – repercussions on health and mortality rates
- Most definitions describe risk of thermal discomfort in terms of indoor temperatures being too high – long term effects on health also important
Modelling overheating

- Building energy simulation models and thermal comfort based criteria
  - Accurate but time consuming, costly
  - Subject to judgement of the modeller – to be undertaken by experienced and qualified person
- SAP Appendix P
  - More general (whole building) definition derived from the domestic context
  - Risk levels - ‘Not significant’, ‘Slight’, ‘Medium’, and ‘High’
- Approach in this study
  - Modification of SAP Appendix P model to consider the problem in the round
  - Shorthand to reflect key decisions in design, management and operation processes
  - Not meant to catch every occurrence of overheating in every context
  - Considers broader features outside traditional boundaries of building energy models
Considerations around overheating

- Technical issues
  - Relatively well known
  - Admission and expulsion of heat from the building

- Practical issues
  - Less well appreciated
  - Only now becoming apparent

- Practical issues down to judgement of the energy modeller
  - May be reflected in the model or not
  - Not a reflection upon any one modelling technique or tool

- Focus given here to the highest risk buildings
  - Urban apartments and issues that affect them most

- Most other dwelling types have lower likelihood of overheating
  - *So long as basic elements of shading and natural ventilation are available*
Effect of local environment

- Local environment
  - Urban versus rural
  - Generally not under control of the developer, but can affect the ambient temperature significantly
  - Regional weather files reflect part of urban temperature uplift
- Localised UHI effect
  - General uplift for any city, localised effects depending on the specific layout of a city and proximity to green space
- Heat build-up in urban environment
  - Proportion of concrete to green space governs how heat builds up and is retained
  - Local albedo
Heat gains and losses

**Gains**
- Readily controlled in some cases
  - May be difficult on an operational level
- Solar gains
  - Shading to counteract solar gain increasingly well understood
  - External or internal blinds.
- Internal gains
  - Many sources, some obvious, some obscure
  - Particular experience in recent years is unexpected heat build-up related to communal heating systems

**Losses**
- Ventilation
  - Rate of heat expulsion must be enough to offset the rate of heat gains
  - Should be controllable by the occupant
- Free cooling
  - Cooling via natural ventilation determined by ability to achieve high air flow
  - Window sizing and placement, potential for use of stack effect, cross ventilation
- Barriers to natural ventilation
  - Noise, pollution, and security
  - May mean occupants cannot be expected to open windows for ventilation
System design and maintenance

– Initial design (effectiveness) of systems and how performance is preserved later in the lifecycle
– Mechanical ventilation
  – Air change rates higher than required for air quality reasons
  – MV systems sized to provide sustained high purge ventilation rates
  – Likely to require larger duct sizing than normal
  – Ventilation inlets shaded and in position where inlet air is not locally warmed
– Maintenance
  – Mechanical systems need to be maintained – filters, operation
The occupant

- Role of the occupant is significant
  - Modelling specific to the occupier yields the most accurate result
  - But occupants or their habits may change
  - Most useful to assess building performance given typical occupant behaviour
  - Determines building subject to reasonable consideration of overheating risk
- Accounting for occupant behaviour
  - Installing and using curtains or blinds
  - Can be encouraged but not assumed
- Iterating through multiple scenarios reporting 75th percentile result
  - Not an alternative to occupant education!
Occupant education

– Education about operation of occupants’ dwelling can improve experience of thermal comfort
– Difficult for occupant to make instinctive connection between closing blinds, opening windows and overheating
  – May be time lag in the effects
  – Different strategies needed at different times
– Passivhaus and CfSH certifications require ‘user guide’ for the house
  – Also recommended by CIBSE Guide A
– Designing for the worst case (no positive occupier action)
  – Potential drift towards use of air conditioning as quick fix
  – Could encourage occupier apathy, rebound effect
## Stages in the dwelling lifecycle

<table>
<thead>
<tr>
<th>Stage</th>
<th>Details</th>
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<tbody>
<tr>
<td>Preplanning</td>
<td>• Urban or rural location&lt;br&gt;• Consider local environment</td>
</tr>
<tr>
<td>Master planning</td>
<td>• Canyon effect&lt;br&gt;• Urban Heat Island</td>
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<tr>
<td>Local Planning</td>
<td>• Green spaces in masterplan&lt;br&gt;• Communal systems&lt;br&gt;• Noise, pollution or security issues</td>
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<tr>
<td>Dwelling level planning</td>
<td>• Natural / mechanical ventilation&lt;br&gt;• Window sizing, type of opening light, placement, cross ventilation&lt;br&gt;• Hot air extracted high level to prevent build-up of heat&lt;br&gt;• South west façade of high rise apartments with low-albedo surroundings</td>
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<tr>
<td>Building Systems</td>
<td>• Inlet shaded from the sun&lt;br&gt;• Flow rate for purge ventilation calculated and fully attained&lt;br&gt;• Maintenance requirements communicated with landlord/owner&lt;br&gt;• Communal heating network design</td>
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<tr>
<td>Occupancy</td>
<td>• Blinds or curtains during warm weather, and able to open windows at the same time for natural ventilation&lt;br&gt;• Noise, pollution or security issues may change over the lifetime of the building</td>
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Decision tree approach

- Typical measures available to developers, designers and occupiers
  - From project conception through to occupancy
  - Measures presented in order of applicability
- ~3,000 permutations identified for all inputs
  - Only those with greatest effect upon final overheating risk shown
  - Average result of other permutations, with aim of offering high level advice
  - Approach could be extended to cover greater detail or for specific property
- Example
  - Indicative decision tree generated relevant to the highest risk of property types
  - Modelled top floor apartment to building regulations
  - Apartment 60m$^2$ TFA, windows sized to 25% of treated floor area, East-West
  - Thames region for urban case
Decision Tree

Urban low albedo asphalt and concrete
- Secure ventilation through dedicated louvers if necessary
- Security, noise, air pollution
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- Green space, Increase in local albedo
- Green planting

Urban
- Natural ventilation
- Security, noise, air pollution
- Secure ventilation through dedicated louvers if necessary
- Mechanical Ventilation - maintain purge flow rate and maintenance schedule
- Mechanical Ventilation to ADF background rate only
- Windows open and Blinds closed
- Windows closed
- High
- Not significant
- Medium
- Not significant
- Not significant

Rural
- Natural ventilation
- Security, noise, air pollution
- Secure ventilation through dedicated louvers if necessary
- Mechanical Ventilation - maintain purge flow rate and maintenance schedule
- Mechanical Ventilation to ADF background rate only
- Windows open and Blinds closed
- Windows closed
- High
- Not significant
- Medium
- Not significant
- Not significant
Application/Conclusions

- Presented for use as a shorthand
  - To illustrate impact of timely collaboration and intervention
- Key items to consider
  - Outside bounds of traditional simulations
- Not a substitute for building energy simulation
  - Whole house, simplified
- Further investigation and uses
  - Applicability to specific dwellings
  - Items to consider in modelling
  - Use with DSM for reporting