SNACC: Suburban neighbourhood adaptation for a changing climate

Adapting Buildings for Resilient Cities
25th February 2016, Brunel University, London

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Oxford Institute for Sustainable Development (OISD)

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Future proofing buildings

GLOBAL COMMON CARBON METRICS
Developing a universal method of measuring a building's carbon footprint

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Our Climate adaptation research portfolio

- **Adaptation responses** to climate change for **new development in the growth areas**, DEFRA (Led by Land Use and CAG consultants)

- **SNACC project** on Climate change adaptation of sub-urban neighbourhoods in UK, EPSRC

- **Heat pumps in a changing climate**, EPSRC CASE

- **Design for future climate projects**, Innovate UK

- **Overheating resilience in new-build social housing**, Building Performance Evaluation programme, Innovate UK

- **Current and future risk of overheating in Care and Extra-care homes**, Joseph Rowntree Foundation
SNACC: Suburban neighbourhood adaptation for a changing climate
Structure of presentation

• Introduction and methodology
• Mapping overheating risk
• Testing effective adaptations for tackling overheating
• Presenting findings to residents and stakeholders
• Key messages
Overview of the SNACC project

- **EPSRC** funded project, 2009-2012, £640k
- **Multi-disciplinary team** of researchers from Oxford Brookes University, University of West of England and Heriot-Watt University

- Focused on suburban areas, because 84% of population lives there – place where domestic lives are most affected

- **How can existing suburban areas be best adapted to reduce further impacts of climate change and withstand on-going changes?**

- Which adaptation strategies perform best in terms of technical performance, practicality and acceptability

- Six neighbourhoods in **Oxford, Stockport** and **Bristol**

[https://snacc.wordpress.com/](https://snacc.wordpress.com/)
How did we research this?

1. **Identified:**
   - Six types of English suburbs across **3 cities** (Oxford, Bristol and Stockport)
   - Potential adaptation options (over 100 at *neighbourhood, garden and home* scale)
   - Climate change impacts and associated risks

2. **Modelled and visualised** feasible adaptation options and their outcomes

3. **Tested the adaptation options** in neighbourhood workshops with **residents** (for feasibility and acceptability)

4. **Tested the neighbourhood responses**, and a wider set of adaptations with **stakeholders** in each city

5. **Established why adaptations are/are not being implemented**, and what might enable residents and stakeholders to adapt
Case study neighbourhoods

**BRISTOL**

St. Werburghs:
exposed, historic
87% mid-terrace

Upper Horfield:
semi-exposed, new urban extension
47% end/semi-detached

**OXFORD**

Summertown:
Shaded, pre-war suburb
62% end/semi-detached

Botley:
semi-exposed, public transport suburb
95% end/semi-detached

**STOCKPORT**

Bramhall:
Moderately shaded car suburb
72% detached homes

Cheadle: semi-exposed, social-housing suburb
95% end/semi-detached homes
## Climate change projections from UKCP09

<table>
<thead>
<tr>
<th></th>
<th>Bristol</th>
<th>Oxford</th>
<th>Stockport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2030 high emissions 90%</td>
<td>2050 high emissions 90%</td>
<td>2030 high emissions 90%</td>
</tr>
<tr>
<td>Summer mean temp. increase</td>
<td>3.4 °C</td>
<td>5.2 °C</td>
<td>3.4 °C</td>
</tr>
<tr>
<td>Summer mean solar radiation increase</td>
<td>19%</td>
<td>24%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Existing conditions in Oxford homes: temperature monitoring
Overall modelling approach

Simulation of overheating potential and adaptation effectiveness

- **Neighbourhood scale:**
  - DECoRuM – Adapt

- **Individual home scale:**
  - IES VE ModelIT and Apache

IES models were developed for typical housing types to analyse the detailed level of climate change impacts and adaptation using future weather years.

Achieve a more refined level of detail.
Mapping overheating risk on a neighbourhood level
Mapping carbon emissions

Current climate

Bristol: St. Werburghs
(Inner historic suburb)

Oxford: Summertown
(Pre-war ‘garden city’ type suburb)

Pinpoint carbon hotspots for targeting through energy retrofitting
Potential future overheating risk

Bristol: St. Werburghs
(Inner historic suburb)

Bristol: Upper Horfield
(Higher density urban extension)

Oxford: Summertown
(Pre-war ‘garden city’ type suburb)

Oxford: Botley
(Public transport suburb)

Stockport: Bramhall
(Car suburb)

Stockport: Cheadle
(Social-housing suburb)
## Potential future overheating risk

<table>
<thead>
<tr>
<th>Suburb</th>
<th>Type</th>
<th>Current climate</th>
<th>2030 medium emissions 50%</th>
<th>2030 High emissions 90%</th>
<th>2050 medium emissions 50%</th>
<th>2050 High emissions 90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol – St. Werburghs</td>
<td>Inner historic suburb</td>
<td>0%</td>
<td>&lt;1%</td>
<td>96%</td>
<td>71%</td>
<td>100%</td>
</tr>
<tr>
<td>Bristol – Upper Horfield</td>
<td>Higher density urban extension</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>6%</td>
<td>100%</td>
</tr>
<tr>
<td>Oxford – Summertown</td>
<td>Pre-war ‘garden city’ type suburb</td>
<td>0%</td>
<td>46%</td>
<td>100%</td>
<td>88%</td>
<td>100%</td>
</tr>
<tr>
<td>Oxford – Botley</td>
<td>Public transport suburb</td>
<td>0%</td>
<td>87%</td>
<td>100%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Stockport – Bramhall</td>
<td>Car suburb</td>
<td>0%</td>
<td>0%</td>
<td>70%</td>
<td>1%</td>
<td>100%</td>
</tr>
<tr>
<td>Stockport – Cheadle</td>
<td>Social Housing Suburb</td>
<td>0%</td>
<td>0%</td>
<td>57%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Where do we find a greater degree of overheating risk?

**Regionally:**
- Homes in the southeast (Oxford) are more likely to be vulnerable before homes in the southwest (Bristol) and north (Stockport).

**Neighbourhood and garden:**
- **Orientation:** East and west facing homes
- Homes on exposed streets (e.g. no shading from trees)
- Darker pavement and external wall and roof surfaces increase solar energy absorption and contribute to higher microclimatic temperatures.

**Home characteristics:**
- **Built form:** having either or both a small floor area and limited exposed external wall area can lead to a higher probability of overheating
- **Extent of glazing:** Having a greater glazing area vs. less glazing area
- **Location of glazing:** Presence of roof lights
- Lightweight home vs. heavyweight home.
Testing effective adaptations for tackling overheating
Principles for tackling overheating

• Reduce external temperatures by managing the microclimate (non-fabric changes)

• Design to exclude or minimise the effect of direct or indirect solar radiation into the home (fabric changes)

• Limit or control heat within the building (e.g. reduced internal gains or manage heat with mass) (can include ventilation)
Testing individual measures to tackle overheating using dynamic thermal simulation

Initial findings: shading is essential
Developing packages to tackle overheating (and mitigate climate change)

Package 1 (walls):
- High albedo external wall insulation,
- Solar-selective low-e double glazing
- and shading

Package 2 (roof/floor):
- High albedo roof, roof insulation,
- Floor insulation and shading on existing glazing

Package 3 (heating systems):
- Insulation for hot water tank,
- Primary pipework insulation and temperature control

Package 4 (all):
- Combines all measures

Using UK climate change projections to adapt existing English homes for a warming climate

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Low Carbon Building Group, School of Architecture, Oxford Brookes University, Headington Campus, Cowley Road, Oxford OX3 0BP, UK

Abstract

This paper uses probabilistic climate change data from the UK Climate Change Projections, 2008 to define extreme climate change in order to model the effect of future temperature change, particularly summer overheating on the energy consumption of and comfort in existing English homes (located in Oxford). Climate change risk is then analysed as a factor of climate hazard, exposure and vulnerability. With the risk of overheating theoretically identified, the risk of overheating and the future change impact on space heating energy use is then virtually detailed for four English home types modelled using Future Weather in a dynamic simulation modelling software (IES). A range of passive adaptation measures are then critically reviewed with regard to their effectiveness in mitigating the negative impacts of climate change and in identifying the most effective measures in reducing or eliminating the negative impacts of climate change on summer and energy consumption. In addition the adaptation options are grouped and tested as packages in order to identify the optimal solution for adaptive retrofitting of English homes, for all homes modelled, self-controlled shading proved to be the most effective adaptation. Increasing the surface albedo of the building fabric and exposure of thermal mass were also revealed to be effective although proving to be unpalatable and requiring detailed consideration of the optimal location. Ultimately among the passive options tested, the research found that none could completely eliminate the risk of overheating in the homes, particularly by the 2080s.

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Integrated improvement packages

Sample Green Deal like package:

Packages:

- **Existing construction**
- **Green Deal (external insulation)**
  External insulation package (low solar reflectivity)
- **Green Deal (internal insulation)**
  Internal wall insulation (in lieu of external wall insulation)
- **Green Deal +**
  Shading and high solar reflective external wall insulation

*Occupancy: 2 working individuals*
Potential future overheating risk at neighbourhood level

Bristol: St. Werburghs (Inner historic suburb)

Bristol: Upper Horfield (Higher density urban extension)

Oxford: Summertown (Pre-war ‘garden city’ type suburb)

Stockport: Bramhall (Car suburb)

Preventing the overheating of English suburban homes in a warming climate

Rajat Gupta and Matt Gregg

As the impacts of climate change become more prominent within the next 50 years and beyond, the risk of overheating in homes is a concern. This is specifically relevant in the UK’s suburbs where 84% of the population reside. To assess this future impact and the effectiveness of adaptive retrofitting, probabilistic climate change data for the 2030s and 2050s are used to assess the overheating risk in six suburban house archetypes in three cities in the UK: Bristol, Oxford and Stockport. The risks of overheating in typical constructions are assessed and the possibility of preventing overheating through the use of adaptation packages is evaluated through dynamic thermal simulation. Homes in Oxford show the greatest risk of overheating. The most effective (passive) package for tackling future overheating tends to combine fabric improvements and internal heat gain reduction. To assist planners and policymakers in assessing and preventing overheating risk at a stock level, this adaptation package is further selected in neighbourhoods across the three case study cities, using geographical information system (GIS)-based DECoRaM-Adapt (Domestic Energy, Carbon Counting and Carbon Reduction Modelling) model. The implications for public policy are that the existing housing stock must be future-proofed for a warming climate, particularly retrofit programmes (e.g., the Green Deal) and any upgrading of building regulations.

Keywords: adaptation, climate change, housing, mitigation, overheating, retrofit, suburban

Étant donné que les répercussions du changement climatique vont devenir de plus en plus importantes au cours des cinquante prochaines années et au-delà, le risque de surchauffe dans les habitations constitue un sujet de préoccupation. Celle-ci devient une préoccupation particulière dans les banlieues du Royaume-Uni dans lesquelles résident 84% de la population. Afin d’évaluer l’impact sur l’efficacité du réaménagement adaptatif, les données probabilistes relatives au changement climatique pour les années 2030 et 2050 sont utilisées pour évaluer le risque de surchauffe dans six archétypes de maisons suburbaines situés dans trois villes du Royaume-Uni: Bristol, Oxford et Stockport. Les risques de surchauffe dans des constructions types sont évalués et la possibilité de prévenir l’excès de chaleur par le recours à des mesures d’adaptation est évaluée au moyen d’une simulation thermique dynamique. Les habitations situées à Oxford présentent le plus grand risque de surchauffe. Les mesures (passives)les plus efficaces pour s’attaquer aux futures excès de chaleur tendent à combiner les améliorations apportées à l’enveloppe des bâtiments et une réduction interne du gain de chaleur. Afin d’aider les planificateurs et les décideurs à évaluer et à prévenir le risque de surchauffe au niveau du parc bâti, cet ensemble de mesures d’adaptation est évalué de manière plus poussée dans des quartiers sélectionnés sur les trois villes faisant l’objet de l’étude, en utilisant le modèle DECoRaM-Adapt (Domestic Energy, Carbon Counting and Carbon Reduction Modelling) modèle d’Énergie domestique, de comptabilisation du carbone, et de réduction du carbone, basé sur un système d’information géographique (GIS). Les implications pour les politiques publiques sont de la mise en place de mesures futures du parc de logements existant doit être assurées en termes de réchauffement climatique, en recourant en particulier à des programmes de réaménagement (par ex. le New Deal vert) et à toute mise en place de la réglementation du bâtiment.

Mots clés: adaptation, changement climatique, logement, atténuation, surchauffe, réaménagement, suburban
Presenting findings to residents and stakeholders
Tested adaptations with residents and other stakeholders

Seven residents workshops in 6 suburbs
• Views on climate change, adaptations and processes of change
• Used modelling results and visualisations for each neighbourhood
• Voting and discussion on adaptation measures (home, garden, neighbourhood)

Three stakeholder workshops in 3 cities
• Views on climate change, adaptations, processes of change
• Presented residents views and modelling and visualisation results
Underpinning

External solar shading

Adaptation measures

Botley, Oxford
<table>
<thead>
<tr>
<th>Suburb typology</th>
<th>Inner historic</th>
<th>Pre-war Garden</th>
<th>Inter-war</th>
<th>Social housing</th>
<th>Car</th>
<th>Medium-high</th>
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<tbody>
<tr>
<td>Case study</td>
<td>St W’burghs Bristol</td>
<td>Summer-town, Oxford</td>
<td>Botley Oxford</td>
<td>Cheadle Stockport</td>
<td>Bramhall Stockport</td>
<td>Horfield Bristol</td>
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<td>External solar shading</td>
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<td>Internal shutters</td>
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<td>External shutters</td>
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<td>Solar film</td>
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<td>Wall greenery</td>
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<td>Green roof</td>
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<td>Shaded outdoor space</td>
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<td>Water butt</td>
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<td>Rainwater harvesting system</td>
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<td>Internal thermal mass</td>
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<td>White roof and walls</td>
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<td>Extend eaves</td>
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<tr>
<td>Lock-open windows</td>
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<tr>
<td>Reasons for being <em>likely</em> to choose an adaptation measure</td>
<td>Reasons for being <em>less likely</em> to choose an adaptation measure</td>
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<tr>
<td>Cheap, convenient (i.e. DIY)</td>
<td>Too expensive as initial cost</td>
<td></td>
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<tr>
<td>Attractive</td>
<td>Major building works required</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Lifestyle benefits (enjoyable, reduces noise)</td>
<td>Bulky and unattractive</td>
<td></td>
<td></td>
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<tr>
<td>Energy <strong>cost-savings</strong></td>
<td>Potential damage to property from measure</td>
<td></td>
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<tr>
<td>Environmentally friendly (reduces carbon emissions)</td>
<td>Loss of house space</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Improves <strong>current climate comfort</strong></td>
<td>Inappropriate housing orientation for measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>More efficient</td>
<td>Lack of space or sunlight required for measure</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Potential for financial support (grants and subsidies)</td>
<td>Simpler behavioural alternative</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Could be done <strong>easily with other</strong> home renovations</td>
<td>Requiring external approval (e.g. from housing association)</td>
<td></td>
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</tbody>
</table>
Key findings on tackling overheating risk
Key findings: Neighbourhood and garden

- Many homes in **Oxford** are just on the edge of sustained overheating after adaptive packages are applied to the **2050s high emissions projections**, this would suggest that neighbourhoods might consider **community cool rooms** as a supplementary option.

- Most homes in **Stockport** neighbourhoods may be able to adapt to the **2050s projections** simply by strategically **ventilating the home and shading glazing**.

- At the **neighbourhood scale**, introduction of **blue and green infrastructure** is likely to bring cooling benefits and is welcomed by residents.
  - However, there is **uncertainty over implementation**, particularly about cost and responsibility for installation and management.

Key findings: Home level

- **Shading** should be architecturally designed (seasonally sensitive) and/or user controlled (e.g. shutters, retractable awnings)
  - operation of shading devices may be a behavioural challenge.

- **External insulation** or any new external **finishes be light in colour**: minimise the influence of solar absorption which is projected to have an adverse impact in future summers.
Key findings: **Home level**

- Respect existing **thermal mass** – recommend external insulation as opposed to covering existing thermal mass with internal insulation.
  - Some barriers to external insulation can include planning issues, costs, and aesthetics
- Balance fabric measures with **internal gain reduction** and control (e.g. hot water tank insulation, pipework insulation): reduction of internal gains in older homes is significantly beneficial for both reduction of overheating and energy use.
- Effective adaptations for reducing overheating risk (e.g. insulation of primary pipework) can cost less than the typical mitigation measures (wall insulation) and may be considered relatively simple ‘**do-it-yourself**’ measures.

Key findings: **Overall**

- ‘**Adaptive retrofitting**’ should be combined with ‘**low-carbon retrofitting**’ of UK housing to avoid lock-in effect and sub-optimal retrofitting
  - Package development
- As an individual measure, **shading** (externally) the glazing from incident solar radiation is most effective in reducing overheating hours.
Academic papers from SNACC project (selected)

Adapting UK suburban neighbourhoods for a changing climate

Rajat Gupta and Matt Gregg

Using UK climate change projections

Abstract
Mitigation of climate change, and adaptation equally, is an important and urgent challenge to be addressed. The Intergovernmental Panel on Climate Change (IPCC) summarises that the warming is projected to continue over the next few decades, with an increase in temperature of about 1.8°C by the 2060s. The building sector contributes to a significant proportion of greenhouse gas emissions, and it is critical that buildings adapt to future climate change and adapt to changes in current climate conditions and to energy use patterns. A warming climate is projected to increase the demand for cooling, and the energy and resource use impacts of this are significant.

1. Introduction
Mitigation of climate change is becoming increasingly important as the emissions of greenhouse gases continue to rise. The increase in temperature will lead to an increase in energy demand for cooling, which will have a significant impact on the energy consumption of buildings. The building sector is responsible for a significant proportion of greenhouse gas emissions and is critical in adapting to future climate change and adapting to changes in current climate conditions and to energy use patterns.

Keywords: climate change adaptation; climate change mitigation; energy consumption; greenhouse gas emissions; building sector.

Preventing the overheating of English suburban homes in a warming climate

Rajat Gupta, Matthew Gregg and Hu Du

Low Carbon Building Group, Oxford Institute for Sustainable Architecture, Oxford Brookes University, Oxford.

Abstract
This paper investigates the risk of projected future climate change on overheating in existing, retrofitted, and new-build dwellings in the UK. The study shows that the risk of overheating is significant, and that interventions such as increasing ventilation, improving insulation, and using shading devices are necessary to reduce the risk. The findings are important for policymakers and practitioners, as they provide a clear picture of the potential risks and the necessary actions to mitigate them.

Keywords: climate change; overheating; residential buildings; UK; risk assessment; mitigation strategies.

Evaluative application of UKCP09-based downscaled future climate scenarios to risk over-heating risk in typical English homes

Rajat Gupta, Matt Gregg and Katie Williams

Centre for Sustainable Planning and Environment, Department of Planning and Architecture, University of the West of England, Bristol, UK.

Abstract
This paper presents an evaluation of the risks of overheating in English homes under future climate scenarios using the UKCP09 climate model. The study shows that the risk of overheating is significant, and that interventions such as increasing ventilation, improving insulation, and using shading devices are necessary to reduce the risk. The findings are important for policymakers and practitioners, as they provide a clear picture of the potential risks and the necessary actions to mitigate them.

Keywords: climate change; overheating; residential buildings; UK; risk assessment; mitigation strategies.
Non-academic impact: Briefings for Policy-makers and practitioners

Researchers at Oxford Brookes University, University of the West of England and Heriot-Watt have found that, in English suburbs, flats and mid-terraced homes are at greater risk of overheating than semi-detached and detached. In particular, the impacts on homes in the South will be greater than on those in the North of England.

As the effects of climate change become more prominent, comfort in the built environment is projected to change drastically. This is particularly so in the UK’s suburbs, where 84% of the population reside. People spend the majority of their time at home, hence their domestic lives will be most affected by changes in the climate.

About 1% of the built environment is modified over the course of a year, so the majority of current suburban buildings will still be here in 50–100 years, with plot structures, road layouts, and major infrastructure lasting even longer. Almost all attitudinal research shows that the majority of people prefer a suburban location for their home.

Relevance
Researchers used the Domestic Energy, Carbon and cost Reduction Model (DECAMM®), a GIS-based toolkit for carbon emissions reduction planning. They incorporated climate projection data to estimate the likelihood of future overheating and the effectiveness of adaptation strategies for four suburban house types (detached, semi-detached, mid-terraced, and flats). They applied the model to Bristol, Oxford and Stockport. At 2050, high emissions, 90% probability, models of a dwelling’s living room in Bristol and Oxford overheated between 11–38% of occupied hours whereas in Stockport overheating took place between 3–8% of occupied hours.

Dynamic thermal simulations showed which building characteristics indicated a greater risk of overheating:
- Built forms: Flats
- Orientation: West orientation
- Occupancy patterns: Those who remain at home for most of the day are often the most vulnerable
- Internal gains: Less efficient hot water systems and lighting, combined with a home’s inability to purge those heat gains
- Albedo (reflective qualities) of external material surfaces: Darker surfaces
- Extent of shading: No shading
Non-academic impact: Informing Government guidance on overheating

The National Adaptation Programme
Making the country resilient to a changing climate

Investigation into Overheating in Homes

Literature Review
Thank you for your attention!

https://snacc.wordpress.com/

http://architecture.brookes.ac.uk/research/lowcarbonbuilding/