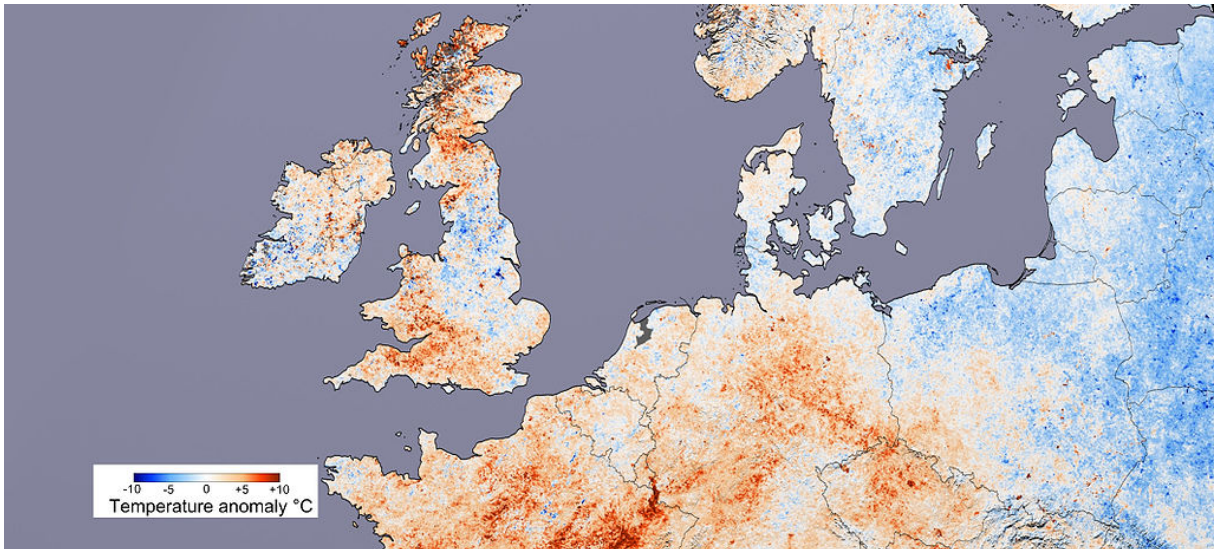
Effect of high temperatures on housing and adaptation options to increase resilience



Urban Areas as systems: adapting for the future

ARCC Network Assembly 2014, 11 June 2014, Birmingham

Professor Rajat Gupta and Matt Gregg

Oxford Institute for Sustainable Development | Oxford Brookes University

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Structure of presentation

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- Brief background
- Recent evidence of high temperatures (summertime overheating) in new-build and existing homes in current climate
- Modelling future overheating risk: SNACC climate change adaptation project
- Key findings
- Challenges in tackling overheating

Growing body of academic research on overheating

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Building and Environment 55 (2012) 1–7

Contents lists available at SciVerse ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

The implications of a changing clima

ABSTRACT

With a growing glob
predicted changes i
resulting in a fast-gr
a changing climate.
this subject. It discus
of knowledge on th
issue.

Keywords:
Climate change
Environmental effects
Impact on buildings and occupants
Performance prediction

1. Introduction

This special issue of *Building and Environment* deals with implications of a changing climate for buildings. Climate ch is considered to be one of the main challenges facing human in the 21th century, with serious and global consequences fo environment [1], human health [1,2], and the economy [3]. In i the built environment is a significant contributor to greenhous emissions. For typical developed nations like the OECD count about 25–40% of anthropogenic greenhouse emissions wil related to buildings; 40–95% of these emissions will be cause operational energy use with the remainder being caused

BRI Building Research & Information, 2013
Vol. 41, No. 3, 255–258, http://dx.doi.org/10.1080/09613218.2013.783528

Routledge
Taylor & Francis Group

EDITORIAL

Adaptive comfort in an unpredictable world

Fergus Nicol and F

The current global economic crisis which started in 2008 has changed the world for many people. The cost of living has gone up, and for many the standard of living is going down with a corresponding increase in fuel poverty. Even for larger companies the cost of energy is beginning to feature in boardroom discussions. How can comfortable working and living conditions be maintained for the majority in such a world, especially with the added uncertainty of climate change?

The answer must be by thinking differently. Unless thermal comfort research addresses such issues it risks becoming marginalized. Equally, the growing clamour for fixed global standards to achieve energy efficiency (such as the PassivHaus standard) does not recognize the contextual nature of thermal comfort. The research community must be part of the solution to global concerns. There are significant questions to be addressed:

- What are the appropriate ways to characterize a building that is truly 'fit for purpose' and which will remain so throughout its life?
- How can design goals be set that will ensure that

Structural Survey

Article Information: Adaptation of the built environment towards achieving improved resilience to climate change

To cite this article: Jessica Lamond, David Proverbs and Colin Booth, (2013) "Adaptation of the built environment towards achieving improved resilience to climate change", Structural Survey, Vol. 31 Iss: 4, pp. -

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Article Type: Guest editorial From: Structural Survey, Volume 31, Issue 4.

Changes to world climates are predicted to result in an array of challenges to both natural and man-made habitats, chiefly because they have evolved or been designed to operate under different climate conditions. The buildings we have now will still dominate most urban spaces in the future therefore adaptation of our existing built environment has become a key priority. Adaptive approaches need to be balanced against economic constraints, competing priorities, social norms and aesthetic tastes of people and society. Changes to perceptions and habits may need to be encouraged and perhaps accelerated by alterations to relevant legislation and guidance. However, within these challenges lie the seeds of an opportunity to transform our existing and new buildings for the better and to adopt new technologies and practices that improve the quality of the built environment for generations to come.

The papers submitted for this special issue reflect the theme of managing the transformation of the built environment for an uncertain future. Major challenges are expected to be seen in terms of increased levels of natural disasters, particularly flooding and heat waves. Long-term environmental change is also expected to result in sea level rise and increased storminess. However, the scale and timing of such changes are far from predictable and the responses chosen must be sensitive to this uncertainty as well as take into account the views of multiple stakeholders.

Two papers address the choices around adaptation for increased temperature based on climate predictions. As the global climate gets warmer, the issue of overheating in buildings becomes an increasing concern for building designers faced with designing new buildings and adapting existing buildings. This is a complex process with multiple factors to consider including the risks involved (such as threats to life and health), the probabilities associated with climate change projections and the myriad of building types, building forms and building technologies.

Overheating metrics: still no consensus!

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Source	Assessment metric	Criterion
CIBSE Guide A	Percentage of occupied hours over operative temperature of 26/28^{0}C	No more than 1% of occupied hours
BS EN 15251	Percentage of occupied hours over category II adaptive comfort upper limit	No more than 3% or 5% of occupied hours

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Overheating in new-build dwellings: Insights from Building Performance Evaluation projects

Living room temperatures: Summer 2013

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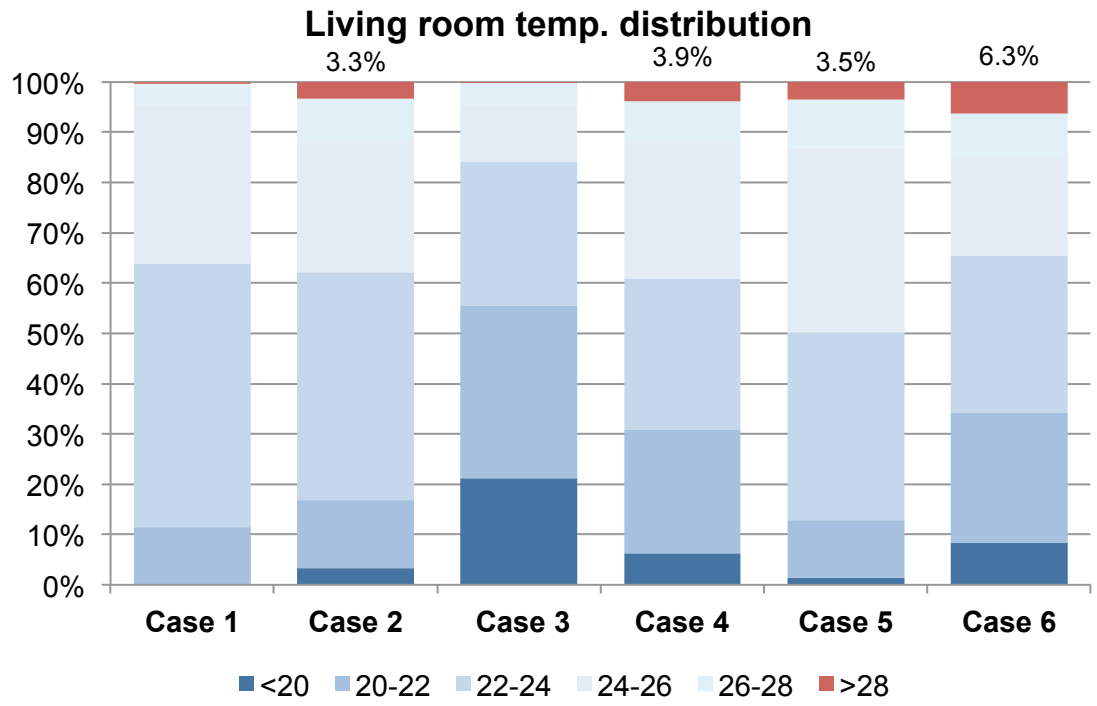
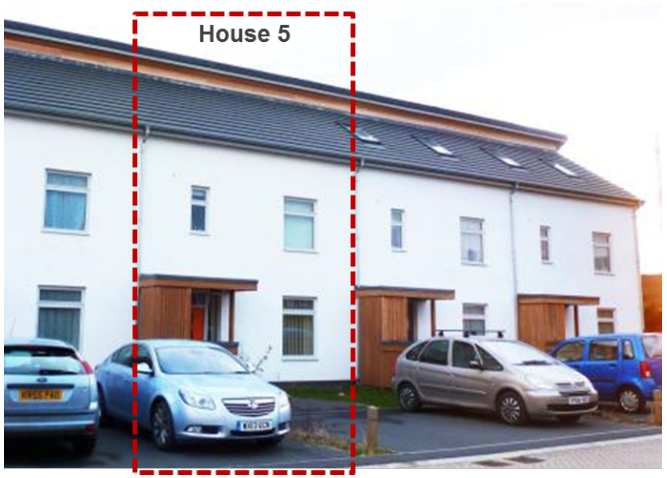


Case 1: Mid-terrace, north-facing

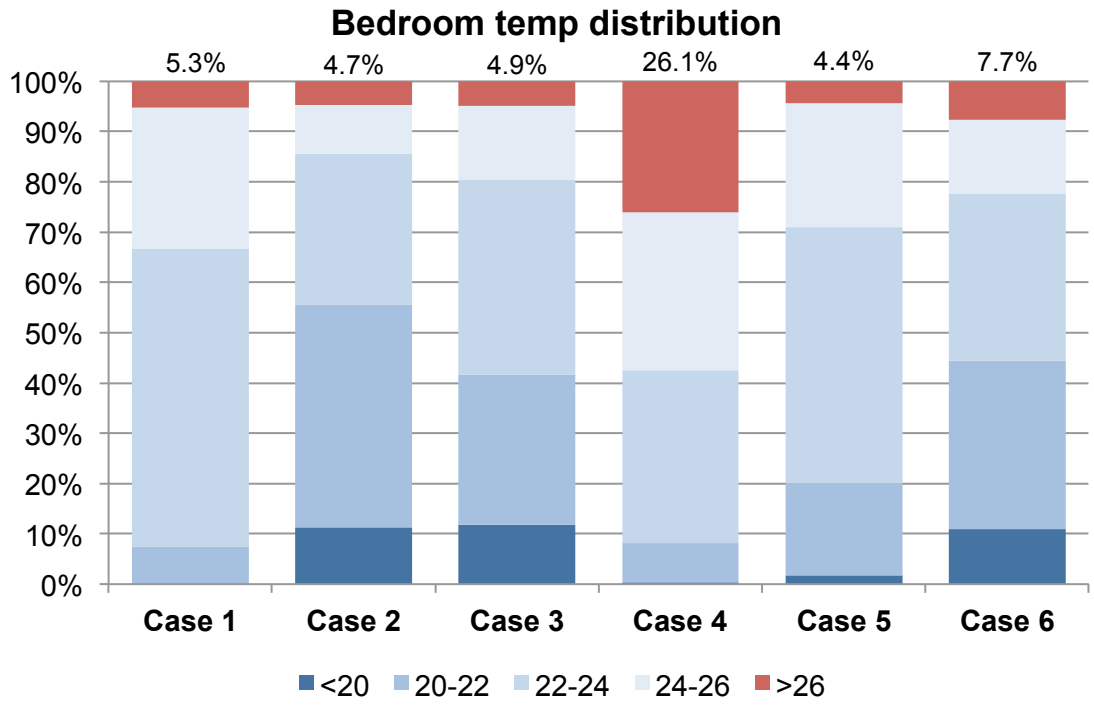


Case 2: Mid-terrace, south-facing

Case 3 (right): End-terrace, east-facing

Case 4 (left): Mid-terrace, east-facing

Living room temperatures: Summer 2013



Case 5: Mid-terrace, northeast-facing

Case 6: Semi-detached, southeast-facing

- Lack of measures to tackle the risk of overheating now and in the future.
- Risk of overheating exacerbated by internal gains especially in ‘air-tight’ buildings.

Window opening-Summer

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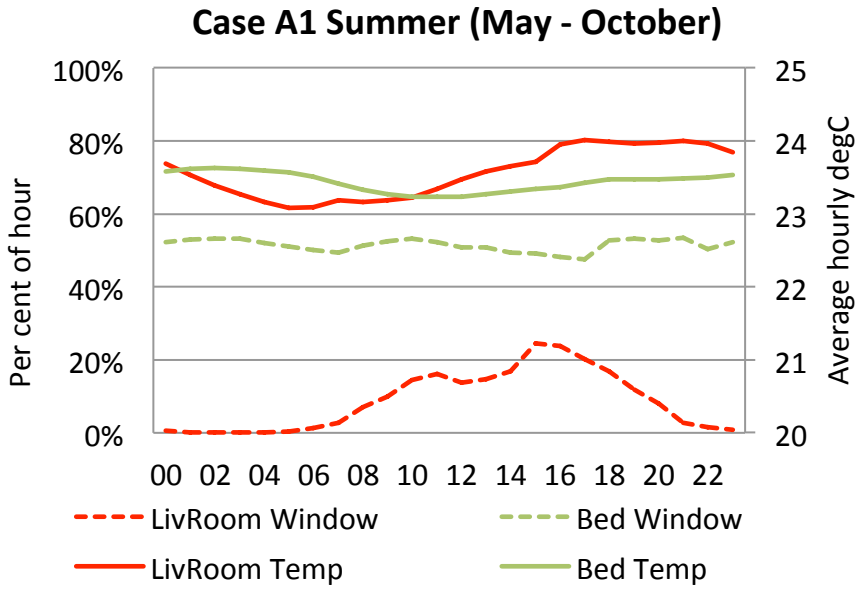

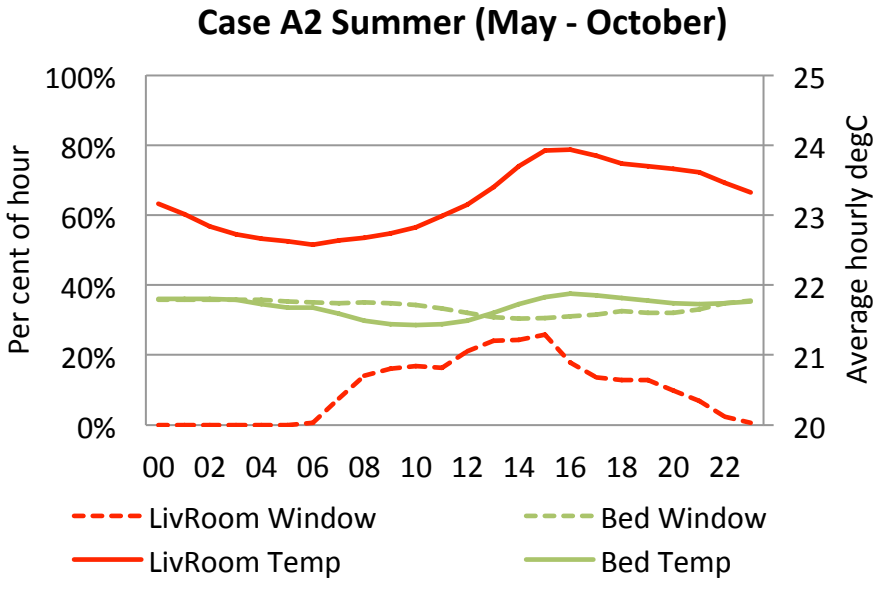

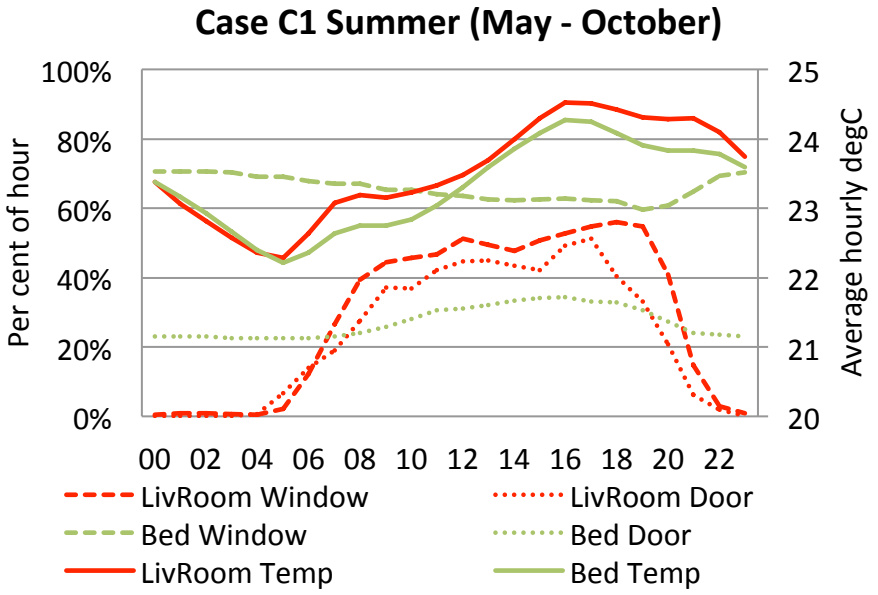

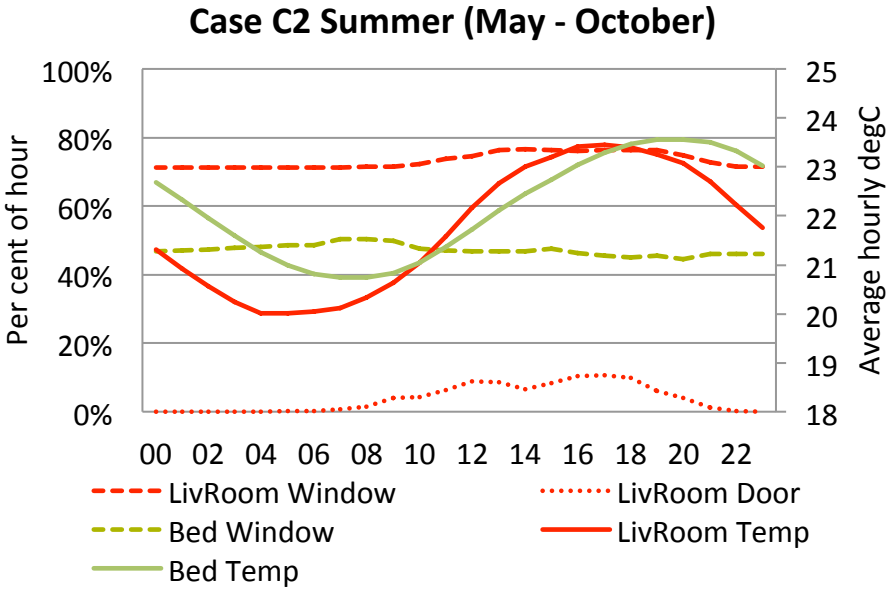

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Overheating in existing and refurbished dwellings:

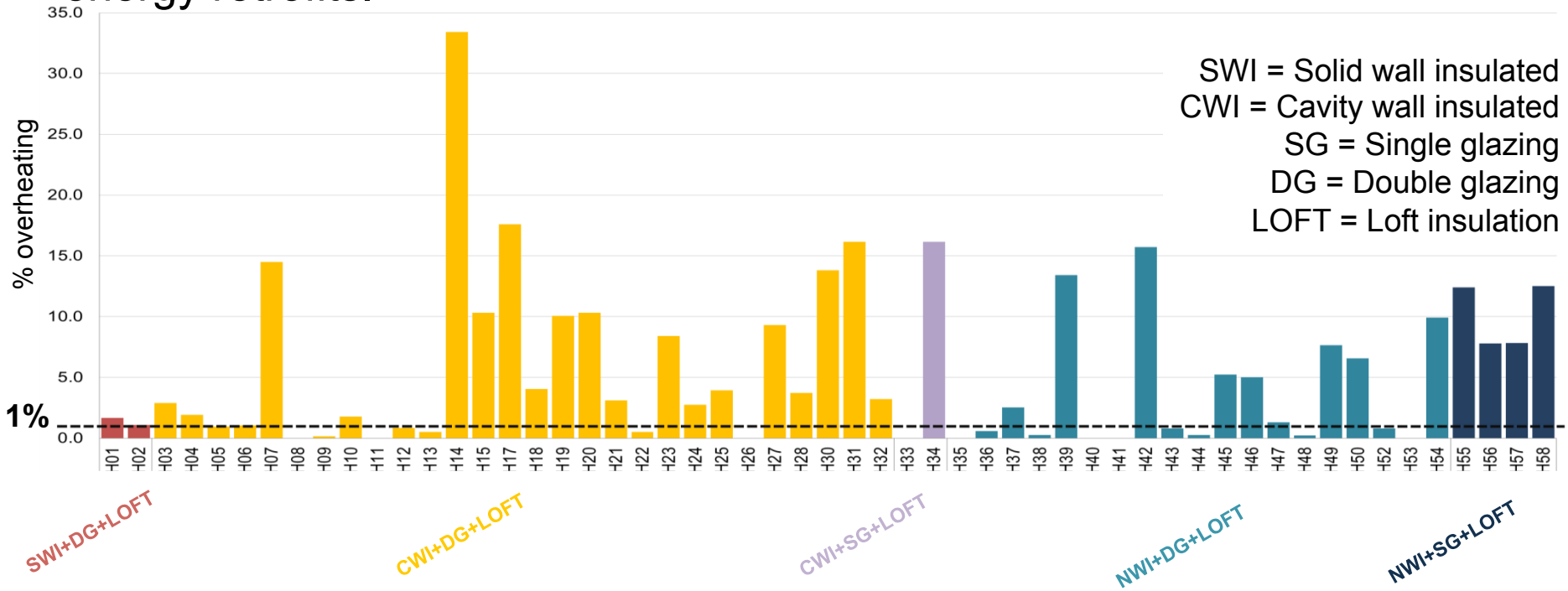
EVALOC low carbon communities project:
www.evaloc.org.uk

Overheating in bedrooms (July'13 – Aug'13)

OXFORD BROOKES UNIVERSITY

A sample group of **55 Houses:**

- **65%** of **bedrooms** reach temperatures greater than **26˚C** for **more** than **1%** of the occupied hours during summer
- Average percentage of occupied hours over **26˚C** in bedrooms is **5.5%,** with nearly **25%** overheating for more than **10%** of the occupied hours
- Lack of any interventions (socio-technical) for tackling overheating as part of energy retrofits.



Climate change projections from UKCP09

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	Bristol		Oxford		Stockport	
	2030 high emissions 90%	2050 high emissions 90%	2030 high emissions 90%	2050 high emissions 90%	2030 high emissions 90%	2050 high emissions 90%
Summer mean temperature increase	3.4 °C	5.2 °C	3.4 °C	5.3 °C	2.9 °C	4.5 °C
Summer mean solar radiation increase	19%	24%	16%	22%	15%	19%

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Suburban Neighbourhood Adaptation for a Changing Climate (SNACC) project

Overview of the SNACC project

- 3-Year (2009 - 2012) EPSRC funded project
- Multi-disciplinary team of researchers (three Universities)

Research questions

1. How can existing suburban areas be best adapted to reduce further impacts of climate change and withstand on-going changes?
2. Which adaptation strategies perform best for the stakeholders implementing them in terms of:
   - Technical performance
   - Practicality and
   - Acceptability

How did we research this?

1. **Identified:**
   - Types of English suburbs
   - Potential adaptation options
   - Climate change impacts and associated risks
2. **Modelled and visualised** options and their outcomes in 6 case studies across 3 cities (Oxford, Bristol and Stockport)
3. **Tested adaptation options** in neighbourhood workshops with **residents** and **stakeholders**
4. **Established why adaptations are/are not being implemented**, and what might enable residents and stakeholders to adapt

SNACC case study neighbourhoods

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BRISTOL

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

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

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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

Potential future overheating risk at neighbourhood level

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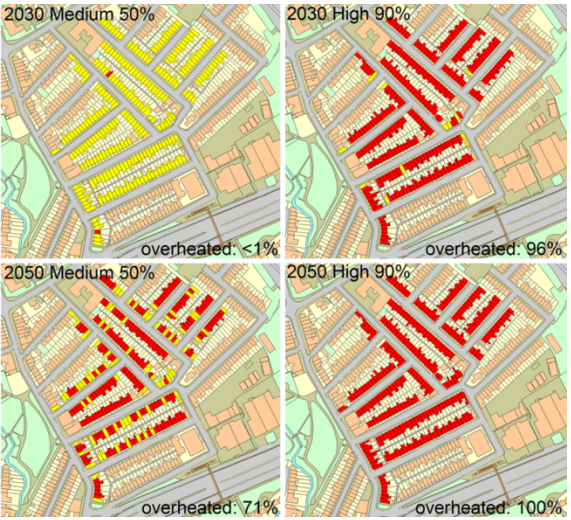
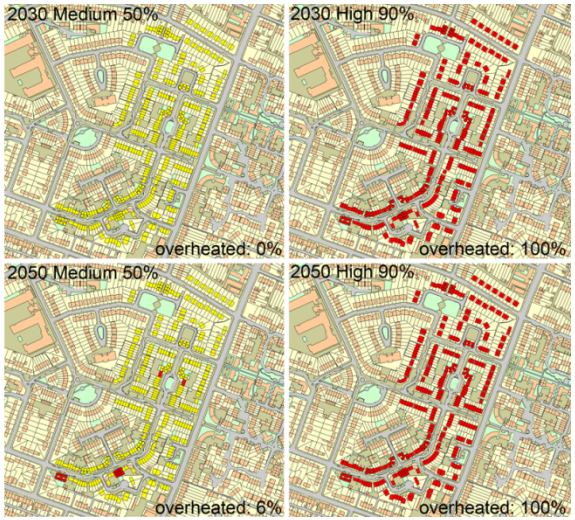
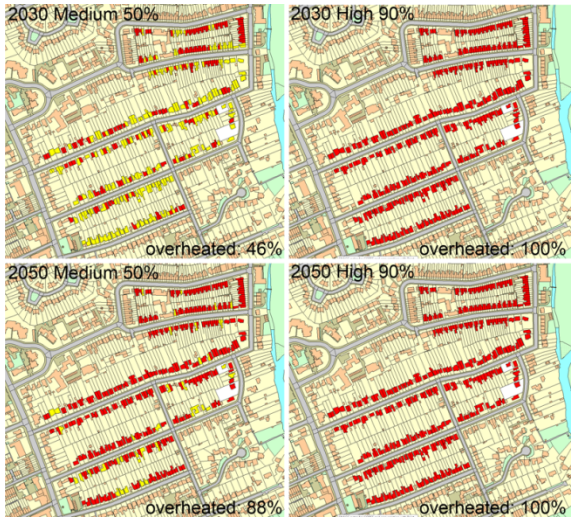
Bristol: St. Werburghs
(Inner historic suburb)



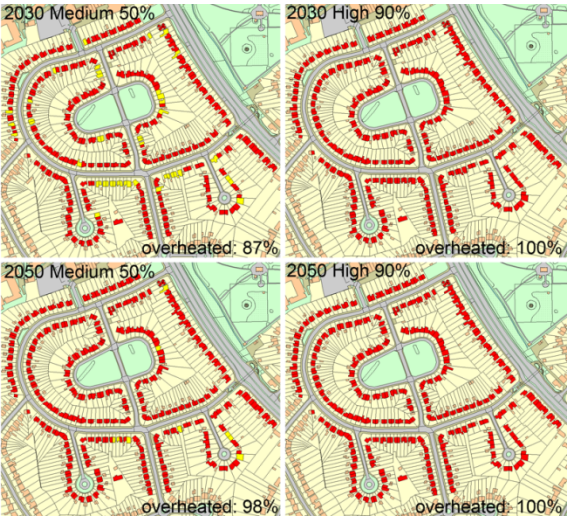
Bristol: Upper Horfield
(Higher density urban extension)



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

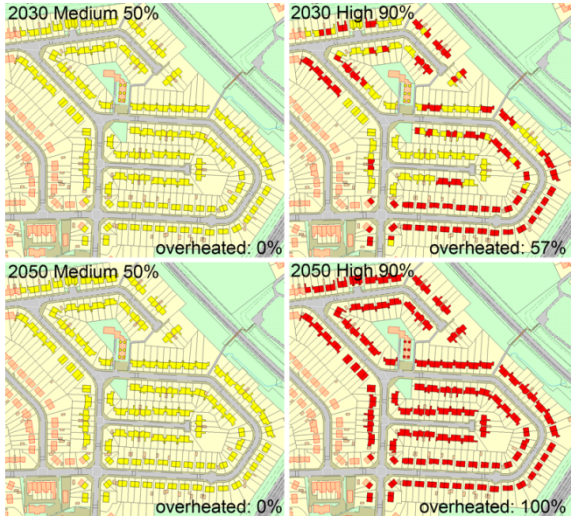


Oxford: Botley
(Public transport suburb)



Stockport: Bramhall
(Car suburb)

Stockport: Cheadle
(Social-housing suburb)



Assessing overheating risk: where do we find a greater degree of overheating risk?

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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 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 individual measures to tackle overheating

nulation

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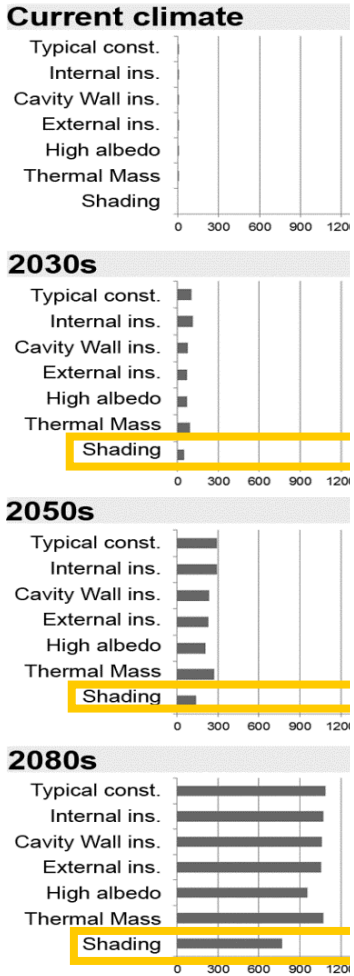

Initial finding

Building and Environment 55 (2012) 20–42

Contents lists available at SciVerse ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

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

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ARTICLE INFO

Article history:
Received 30 September 2011
Received in revised form
2 January 2012
Accepted 17 January 2012

Keywords:
Climate change
Overheating
Adaptation
Mitigation
Suburban housing

ABSTRACT

This paper uses probabilistic climate change data from the UK Climate Change Projections 2009 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 years in a dynamic simulation modelling software (IES). A range of passive adaptation measures are then critically reviewed with regard to their effectiveness in minimising the negative impacts of climate change and to identify the most effective measures in reducing or eliminating the negative impacts of climate change on comfort 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, user-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 complicated and requiring detailed consideration of the optimal locations. 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.

1. Introduction

Adaptation of the built environment to climate change is becoming increasingly as important as mitigation. Adaptation, a responsive adjustment to reduce or eliminate risk, will be critical given the earth is committed to at least 1.8 °C global average surface warming by the end of the century even in the most optimistic projection presented by the Intergovernmental Panel on Climate Change (IPCC) [1]. In the United Kingdom, it is very unlikely that the mean summer temperature change increase for the southeast of England will be below 1.4 °C by the 2080s [2].

The housing sector in particular is not only contributing to a significant proportion (27%) of the UK's CO_2 emissions as a result of energy consumed for heating, lighting, cooking and use of electrical appliances, but it is also recognised to be inadequate in capacity to adapt to future climate change or even variation in the current climate [3,4]. A warming climate is projected to change the comfort conditions and energy use patterns of existing UK homes to a considerable degree throughout this century. This is why emerging policy on climate change adaptation is overwhelmingly focused on tackling overheating in new and existing housing [5]. This policy focus needs to quickly link with the large scale deep retrofitting programmes, such as the Technology Strategy Board's Retrofit for Future programme, which are taking place now in response to the UK government's intent to reduce CO_2 emissions 80% below 1990 levels by 2050 [6]. Climate change mitigation can be both synergistic and opposable to adaptation so it is in our best interest to ensure that the retrofits do not lock-in overheating risk through measures that are not tested for future change in climate. It is also important that the potential to adapt in simple ways are not missed in the process of retrofitting the existing building stock. In order to most effectively reduce the risk to future generations it is essential that neither mitigation nor adaptation have negative consequences nor become contradictory [7].

Climate change adaptation has a clear role to play in mitigation oriented refurbishment approaches. One clear example is that a large majority of dwellings in the UK have no mechanical cooling. Modelling has shown that building performance in current 'heatwave conditions' can function as a performance benchmark for a typical hot summer in the 2050s [8]. Increase in summer

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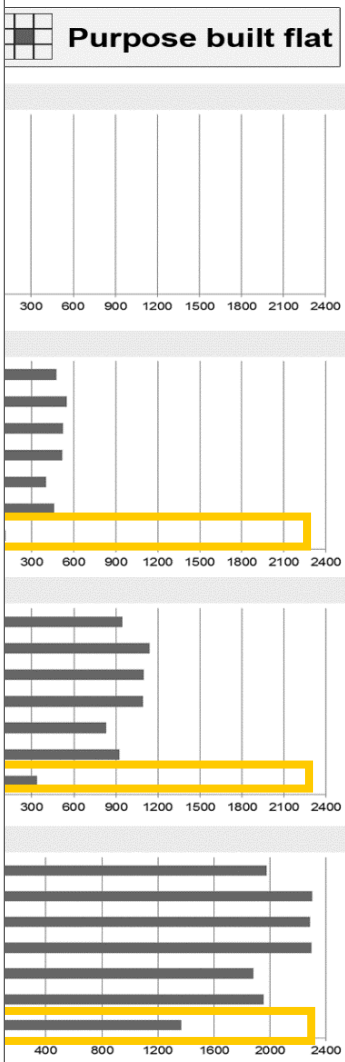
doi:10.1016/j.buildenv.2012.01.014



Developing packages to tackle overheating (and mitigation)

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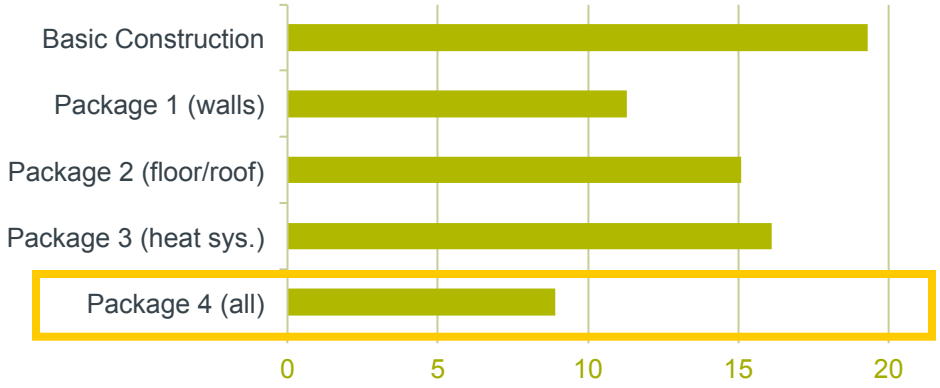
Package 1 (walls):
High albedo external wall insulation, solar-selective low-e double glazing and shading

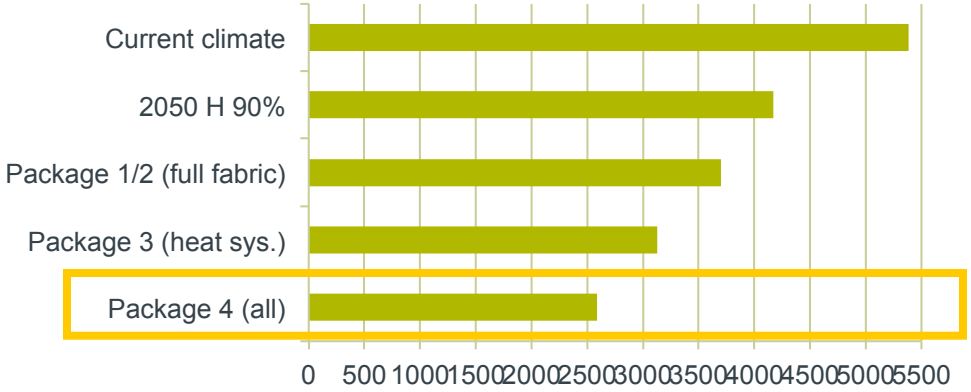
Package 2 (roof/floor):
High albedo roof, roof insulation, floor insulation and shading on existing glazing

Package 3 (heating systems):
Insulation for hot water tank, primary pipework insulation and temperature controls

Package 4 (all):
Combines all measures



Overheating potential (% hours)



Space heating requirements (kWh/yr)

Integrated improvement packages

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Sample Green Deal like package:

Packages:

- **Existing construction**
- **Green Deal (external insulation)**

External insulation package
(low solar reflectivity)

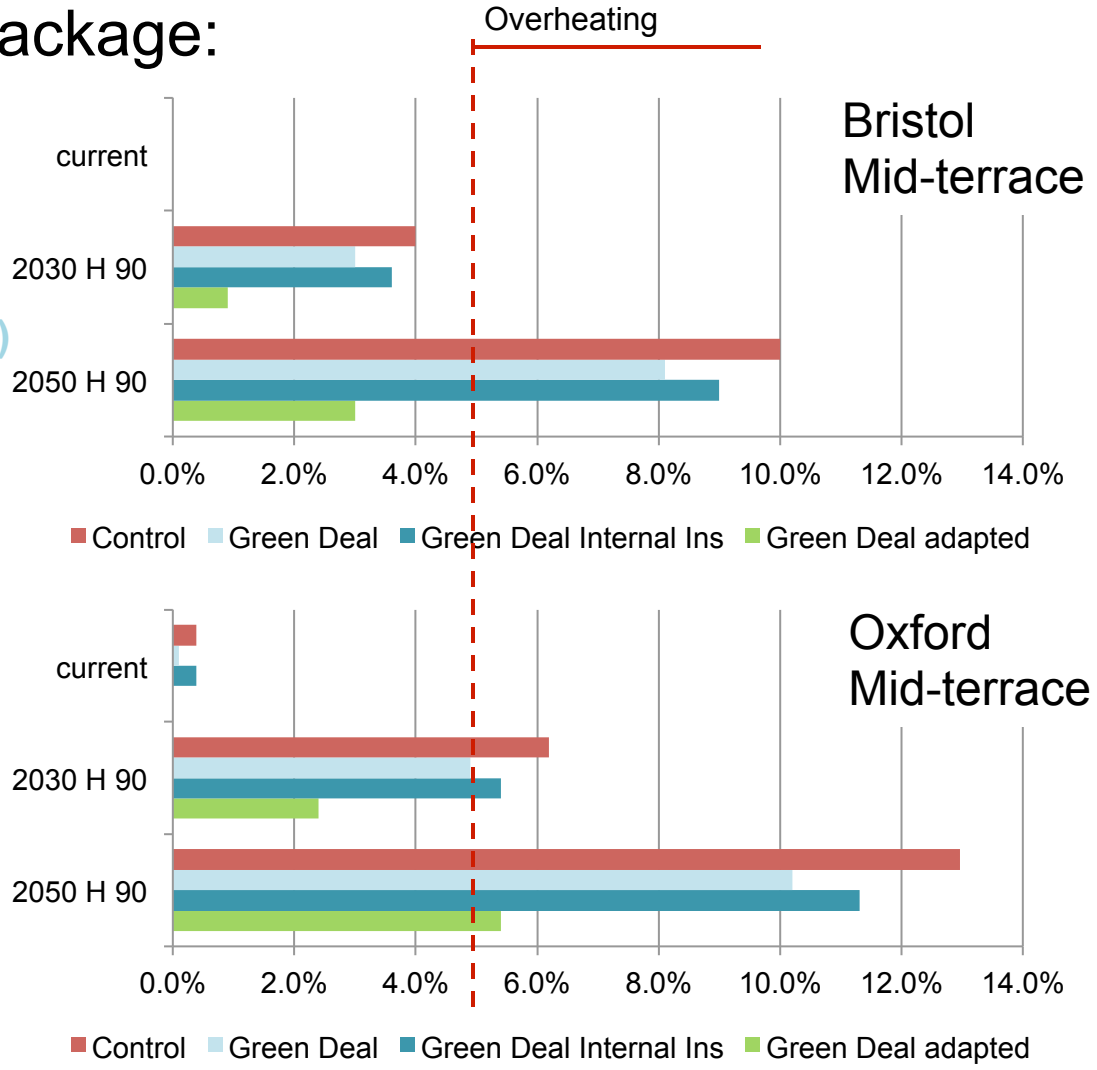
- **Green Deal (internal insulation)**

Internal wall insulation
(in lieu of external wall insulation)

- **Green Deal +**

Shading and high solar reflective external wall insulation

*Occupancy: 2 working individuals



Integrated improvement packages at neighbou

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ons 90%)

St. Werburghs

BRI Building Research & Information, 2013
Vol. 41, No. 3, 281–300, http://dx.doi.org/10.1080/09613218.2013.772043
Routledge
RESEARCH PAPER

Preventing the overheating of English suburban homes in a warming climate

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E-mails: rgupta@brookes.ac.uk and mgregg@brookes.ac.uk

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 policy-makers in assessing and preventing overheating risk at a stock level, this adaptation package is further evaluated in selected neighbourhoods across the three case study cities, using the geographical information system (GIS)-based DECoRuM-Adapt (Domestic Energy, Carbon Counting and Carbon Reduction Model) 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. Ceci revêt une pertinence particulière dans les banlieues du Royaume-Uni dans lesquelles réside 84 % de la population. Afin d'évaluer cet impact futur et 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 trains de 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 futurs 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 de cas, en utilisant le modèle DECoRuM-Adapt (Domestic Energy, Carbon Counting and Carbon Reduction Model – modèle d'énergie domestique, de comptabilisation du carbone, et de réduction du carbone), basé sur un système d'information géographique (SIG). Les implications pour les politiques publiques sont que la pérennité future du parc de logements existant doit être assurée en termes de réchauffement climatique, en recourant en particulier à des programmes de réaménagement (par ex. le New Deal vert) et à toute mise à jour de la réglementation du bâtiment.

Mots clés: adaptation, changement climatique, logement, atténuation, surchauffe, réaménagement, suburbain

eal+

Key findings on tackling overheating

Neighbourhood and garden

- Many homes in **Oxford** sustain overheating after adaptive packages are applied, so community cool rooms could be a supplementary option.
- 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.

Home

- **Shading** should accompany increased insulation and airtightness measures and be architecturally designed and/or user controlled
- **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 on tackling overheating

Home cont…

- Respect existing **thermal mass** – recommend external insulation as opposed to covering existing thermal mass with internal insulation.
- Balance fabric measures with **internal gain reduction** and control (e.g. hot water tank insulation, pipework insulation, temperature controls)
- Effective adaptations in reducing overheating risk (e.g. insulation of primary pipework) can reduce energy consumption and cost less than the typical mitigation measures - **'do-it-yourself' measures**.

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.

Challenges in tackling overheating

- **Convincing the residents that overheating is / will be an issue**
  - Some residents do not believe that overheating is a 'serious issue' for them (either because they don't believe the climate science or because they don't believe that their homes are at risk)
- **Occupant behaviour**
  - Learning when and how to operate shading devices (e.g. shutters, louvers)
- **Retrofitting**
  - Tendency to use internal insulation (aesthetics, cost, etc.)
  - Potential conflict between air-tightness and ventilation

SNACC findings: Guidance on overheating

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University of the West of England, BRISTOL

HERIOT WATT UNIVERSITY

Department for Communities and Local Government

Investigation into

Literature Review

The National Ad
Programme

Making the cour
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July 2013

HM Government

arcc cn

Synthesised advice on identifying and preventing overheating in homes under the Green Deal

April 2013

THE ARCC COORDINATION NETWORK

The performance of UK buildings and infrastructure is critical to our national well-being and economic stability. To ensure policy-makers and practitioners have the best available evidence on which to base decisions in these sectors, the EPSRC is investing heavily in research to improve resilience in the urban environment. This includes projects within the Adaptation and Resilience in a Changing Climate (ARCC) programme and the overarching Coordination Network (ARCC CN). By engaging research projects and a wide range of national, regional and local stakeholders, the ARCC CN maximises and accelerates the use of outputs from across the academic community to inform the development of a more sustainable built environment. Working with government provides a crucial channel for research to have a direct and timely input into the policy-making process.

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THE GREEN DEAL AND OVERHEATING

The Green Deal is a scheme, launched by the UK's Department of Energy and Climate Change (DECC), to enable householders and businesses to make energy-saving improvements without having to pay all the costs up front. Its focus is on retrofitting existing properties with an emphasis on actions such as insulation, draughtproofing and double glazing. It is an ambitious programme, aspiring to address the millions of properties that would benefit from energy efficiency measures. The Green Deal programme is expected to bring a large number of new players into the energy efficiency market, fulfilling the roles of authorised Green Deal assessors, installers and providers.

Three ARCC projects, CREW, LUCID, SNACC have produced findings that indicated that, in some cases, heavily insulated homes could increase their risk of overheating and poor indoor air quality. The projects all have evidence to suggest that Green Deal measures could create new problems in the future, with inappropriately-insulated properties experiencing poor indoor air quality and significant summer overheating. The latter is a particular risk, as latest climate change projections suggest that Britain will see warmer summers, with an increased likelihood of heatwaves. A review of overheating indicated that typically 2,000 deaths per year were brought forward due to heat, and that this could rise to 5,000 per year in the 2080s if action is not taken (DCLG, (2012)a).

Retrofit for Living: 1990s Terrace in London

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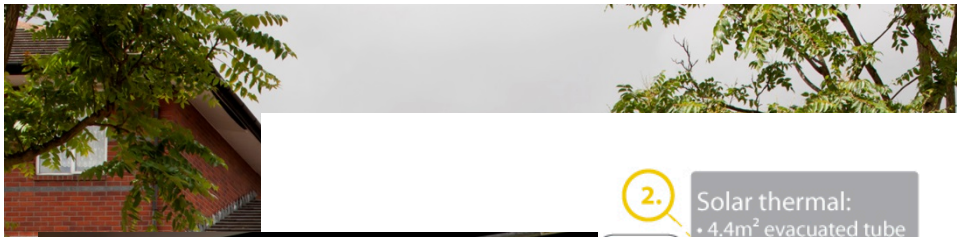

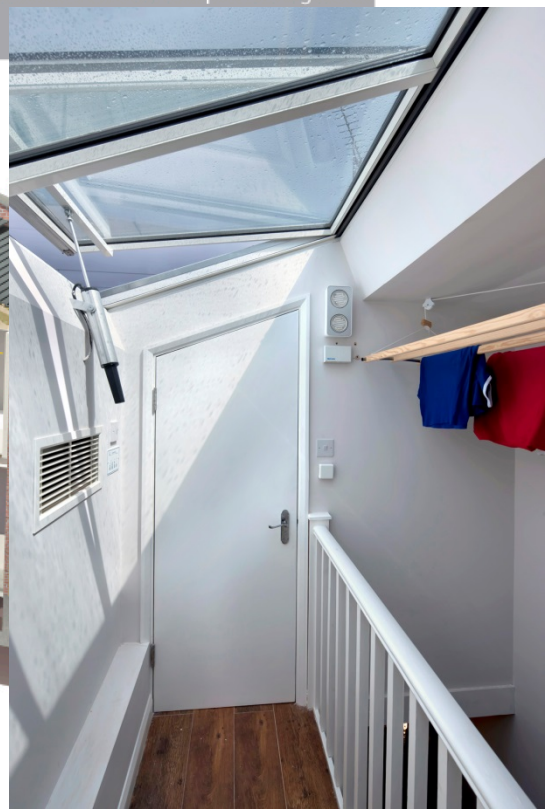

2. Solar thermal:
• 4.4m² evacuated tube

3. Solar chimney
• Rooflight with actuator and controller
• Lightwell with mezzanine level and space saving stairs
dryer

A+
• Tumble dryer
• Stand-by saver multiplugs

With Penoyre and Prasad Architects, London

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Thank you for your attention!

www.snacc-research.org

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