Institution: University College London

Unit of Assessment: 16 – Architecture, Built Environment and Planning

Title of case study:

Contributing to a healthy, low-carbon built environment

1. Summary of the impact

Research conducted by Davies et al within the UCL Bartlett's Complex Built Environment Systems (CBES) group on built environment choices and their implications – particularly for energy use and health – has contributed to a fundamental shift in global understanding of the possible health impacts of carbon mitigation measures, and has informed key policy formulation relating to this. At regional and national levels, research by CBES has informed London's Climate Change Adaptation Strategy, and led to changes in the Building Regulations for England and Wales, and produced a tool used by the UK Department of Energy and Climate Change to inform aspects of its Energy Efficiency Strategy. The international impacts of CBES arise both from its broad influence on policy-makers' awareness and understanding of the implications of energy efficiency policies, and from more specific contributions to the development of World Health Organisation guidance.

2. Underpinning research

The case for taking action to tackle climate change is now persuasive, and it is high-income countries that must reduce greenhouse gas emissions the most. For around a decade, this issue has been the focus of work conducted through a series of funded research projects in the Bartlett's EPSRC Platform-funded Complex Built Environment Systems (CBES) group now led by Professor Mike Davies (who joined UCL in 2004). That group aims particularly to improve understanding of the physical performance of built environment choices and their implications for energy use, health, conservation, productivity and climate change. CBES is primarily interested in developing solutions to the practical problems of designing, constructing, and managing appropriate environments within and around the built environment, and has been at the forefront of vital work associated with the decarbonisation of housing stock. It has demonstrated the potential for such large-scale programmes to produce unintended detriments to health, but also substantial co-benefits. The research outlined here is unified by its shared emphasis on establishing appropriate methods to recognise and minimise the former whilst maximising the latter to produce a simultaneously low-carbon and healthy built environment.

Work at CBES on the control of relative humidity in dwellings and the growth of mould through appropriate ventilation responds to tension between the need to *maximise* ventilation rates in order to reduce the risk of mould growth, and the desire to *minimise* such airflows in order to reduce energy use/carbon emissions. Work commissioned by the Department of Communities and Local Government (DCLG) in 2005 to address the issue of preventing damaging mould growth in dwellings via appropriate ventilation involved a combination of laboratory, modelling and fieldwork. The research demonstrated the need to amend ventilation guidance in the then current Building Regulations, which did not, for example, address the critical importance of the transient nature of mould growth in the most appropriate manner. These and other important research findings were published in outputs offering new recommendations to policy makers for the daily, weekly and monthly maximum average levels of relative humidity that should be permissible in dwellings **[a]**.

A second, related strand of CBES work has focussed on the health impacts of Urban Heat Islands (UHIs) and overheating in dwellings. Responding to the identification by the EPSRC of a key knowledge gap, the investigations by CBES have particularly focused since 2007 on UHIs within London. This work has produced new guidance on the measures that can be used to reduce negative aspects of UHIs (increased summer cooling energy demand and increased summer health risks due to overheating) whilst retaining their beneficial effects (decreased winter heating demand and decreased winter health risks due to reduced exposure to cold). This landmark body of research also studied factors influencing overheating in dwellings and provided guidance relating (amongst others) to: the relative importance of the location of a dwelling in the UHI versus its intrinsic thermal properties; and the impact of interventions on overheating in dwellings **[b, c]**.

Ground-breaking work conducted since 2009 expanded the remit of the CBES research to a wider treatment of the issue of projected climate change and the impact of energy efficiency interventions in dwellings on exposure to cold, heat and a range of pollutants such as radon, particulates and environmental tobacco smoke. The results were used in a collaborative team led by Professor Paul Wilkinson of the London School of Hygiene and Tropical Medicine (LSHTM) to extend the findings of CBES research to the effects of such exposure on health **[d]**. Further work has also dealt with a wider consideration of the possible unintended consequences of decarbonisation policies **[e]**. This pioneering holistic approach allowed the team to demonstrate both the dangers of inappropriate policy formulation and implementation, and also the very significant potential co-benefits.

CBES researchers involved in UCL research include: Hector Altamirano-Medina (Lecturer), Mark Barrett (Senior Lecturer), Phillip Biddulph (Senior Research Associate), Ben Croxford (Senior Lecturer), Payel Das (Research Associate), Mike Davies (Professor), Steve Evans (RA), Bob Lowe (Professor), Ian Hamilton (Lecturer), Alex Macmillan (SRA), Anna Mavrogianni (Lecturer), Dejan Mumovic (Senior Lecturer), Eleni Oikonomou (RA), Tadj Oreszczyn (Professor), Ian Ridley (Senior Lecturer), Clive Shrubsole (RA), Philip Steadman (Professor) and Marcella Ucci (Lecturer).

3. References to the research

[a] Altamirano-Medina, H., Mumovic, D., Davies, M., Ridley, I. & Oreszczyn, T., (2009) 'Guidelines to avoid mould growth in buildings', *Advanced Buildings Energy Research*, 3: 221–236. [DOI: http://doi.org/c4sn4n]

[b] Mavrogianni, A., Wilkinson, P., Davies, M., Biddulph, P. & Oikonomou, E., (2012) 'Building characteristics as determinants of propensity to high indoor summer temperatures in London dwellings], *Building and Environment*, 37: 583–597. [DOI: http://doi.org/crrsgv]

[c] Oikonomou, E., Davies, M., Mavrogianni, A., Biddulph, P., Wilkinson, P. & Kolokotroni, M., (2012) 'Modelling the relative importance of the urban heat island and the thermal quality of dwellings for overheating in London', *Building and Environment*, 57: 222–238. [DOI: http://doi.org/pnx]

[d] Wilkinson P., Smith K. R., Davies M., Adair H., Armstrong B., Barrett M., Bruce N., Chalabi Z., Haines A., Hamilton I., Oreszczyn T., Ridley I. and Tonne C., (2009) 'Public health benefits of strategies to reduce greenhouse-gas emissions: household energy', *The Lancet*, 374 (9705): 1917–1929. [DOI: http://doi.org/fj9xmp]

[e] Davies, M., & Oreszczyn, T. (2012) 'The unintended consequences of decarbonising the built environment: A UK case study#, Energy and Buildings, 46: 80–85 [DOI: http://doi.org/bmfv4j]

The quality of the underpinning research is shown by the fact it has been funded by various bodies including the EPSRC [e.g. grants numbered EP/I02929X/1, EP/E016375/1, EP/F007132/1 and EP/D506859/1], and DCLG [e.g. grants numbered BD2515 and BD2880], as well as DECC, NERC and the Wellcome Trust. Specific examples of these grants include:

- Davies, M. (PI), *Relative Humidity in Dwellings*, DCLG BD2515, 2005-07 (£200k). This grant led to output [a] above.
- Davies, M. (PI), *LUCID: The Development of a Local Urban Climate Model and its Application to the Intelligent Development of Cities*, ESPRC EP/E016375/1, 2007-10 (£600k). This grant let to output [c] above, and the combined funding portfolio for the overall LUCID work led by Davies was £1.0m.
- Davies, M. (PI), *Platform Grant - The Unintended Consequences of Decarbonisng the Built Environment*, EPSRC EP/I02929X/1, 2011–16 (£1.4m). This grant led to output [e] above.

4. Details of the impact

The health and wider aspects of low-carbon built environments now feature prominently on political agendas across the world, and the health and energy research by CBES as outlined above has made a major contribution to this state of affairs. It has had direct and significant impacts on the development and revision of guidance, regulation, and policy at regional, national and international levels. This influence has assured subsequent impacts from regional to global levels on the ways in which buildings are currently constructed or are likely to be refurbished, and, in turn, on improvements in human health and wellbeing across the UK and around the world.

Impacts on regional policy:

CBES work has informed key Greater London Authority (GLA) guidance relating to Urban Heat Islands (UHI), specifically as noted in terms of measures to minimise summer cooling energy demand and health risks, whilst retaining lower winter heating demands and decreased winter health risks due to reduced exposure to cold. In response, the GLA drew upon UCL's research to help produce its key policy document *Managing Risks and Increasing Resilience – The Mayor's Climate Change Adaptation Strategy* (2011), which details plans to tackle overheating in London **[1]**. The research has particularly supported the development by the GLA of better evidenced-based policies and programmes to optimise its mix of adaptation and mitigation measures, and to target limited funding as effectively as possible **[2]**.

Shaping national policy and practice:

CBES research into relative humidity and related growth of mould in dwellings has catalysed and informed important changes in the Building Regulations for England and Wales. In 2010, it resulted in amendments to the moisture criteria guidelines (ADF 2010) for the control of mould growth in dwellings **[3]**. Fundamental changes were made to the existing guidance, in line with CBES's own research recommendation for its amendment. Those changes included responses to more specific recommendations such as the need to recognise and respond appropriately to the transient nature of mould growth. The research provided policy makers with novel recommendations about the daily, weekly and monthly maximum average levels of relative humidity that should be permissible in dwellings. Changes to ADF 2010 have had a significant impacts on the UK construction industry and, thereby, on the UK population as a whole. Every dwelling constructed in England and Wales since 2010 has been subject to ADF 2010; from 2011 to 2012, this amounted to more than 230,000 households. Following the guidance improves the safety of dwellings and allows house builders to demonstrate the legal requirement for compliance with the Building Regulations.

Elsewhere, the research on UHIs (supplemented by further advice from the CBES team) is informing the development by the Chartered Institution of Building Services Engineers (CIBSE) of UHI guidance which will be included in the 8th edition of their Environmental Guide A **[4]**. This important guide, which is currently undergoing substantial revision and is due for release in 2014, will provide a primary reference source for the 19,000+ members of CIBSE.

CBES research has also been used to develop new evaluation tools informing further developments in policy and guidance. From 2011, modelling techniques developed over the years by CBES were used in collaboration with colleagues from LSHTM to develop the novel 'Health Impacts of Domestic Energy Efficiency Measures' (HIDEEM) tool for the UK Department of Energy and Climate Change (DECC). This included the construction of micro-environmental stock models to quantify indoor environmental conditions and monetise the health impact associated with energy efficiency changes in houses in Great Britain. These CBES methods employed, for example, empirically derived relationships between house temperatures and measures of energy efficiency, as well as physics based models of pollutant concentrations. HIDEEM informs analyses of the cost effectiveness of relevant policies by evaluating and monetising the health impacts of the large-scale implementation of low energy interventions within dwellings. Since its release in 2012, HIDEEM has been used by DECC's Energy Efficiency Deployment Office (EEDO) to generate health monetisation inputs to its 2012 Energy Efficiency Strategy. This, the first in a series of documents to support the delivery of DECC's energy efficiency policies, relates to and suggests ways to maximise energy efficiency potential across the UK economy. Here, the HIDEEM tool was used specifically to monetise the health impact of wall insulation measures: *'DECC modelling of the impact of the installation of solid wall insulation in all properties in England gives a total improvement in the health of those individuals in the properties of £3.5bn–£5.0bn over the lifetime of the measures'*. The report further notes the potentially significant benefits of such increases in energy efficiency to wellbeing: *'a higher disposable income, as a result of lower energy bills, can allow increased spending on other necessities. In addition, the health benefits from properly installed energy efficiency measures can be significant'* **[5]**. DECC has also used the tool to support its 2013 Fuel Poverty Framework. That document notes that modelling work carried out using HIDEEM suggests *"substantial health-related costs associated with cold homes"*. The influence of that work on the policies set out here is evident as the report continues: *'For this reason, we believe that we should continue to prioritise vulnerable fuel poor households for*

support. In addition, we will continue to build the evidence base on health impacts' **[6]**.

International impacts: The reach of these research impacts on construction and human health has been very considerably extended by the further influence of the relative humidity research on international guidelines. In 2008, CBES was invited to provide expert advice to the World Health Organisation (WHO) on best practice in, and the international regulatory framework for, humidity and mould growth. CBES drew on its research work to supply that advice via contributions to two expert meeting reports. These resulted in the publication in 2010 of important new WHO mould guidance documents. This guidance *'provides policy-related recommendations and identifies potential ways for international, national and local authorities to prevent, reduce or mitigate exposure to dampness and mould'* – all in order to *'enable policy-makers to identify appropriate measures to support and advocate in the field of public health protection and … provide them with relevant examples and guidance for policy and regulatory measures'* **[7]**.

More broadly, CBES work has contributed to a fundamental shift in the awareness and understanding among international policy-makers of the possible co-impacts of carbon mitigation measures. Its research elucidating the health impacts of housing energy efficiency interventions **[d]** has particularly profoundly influenced international awareness of and engagement with the issues it raised. The significance and reach of that influence was demonstrated in statements of support made by the UN Secretary-General Ban Ki-Moon, WHO Director Margaret Chan, and US Department of Health and Human Services Secretary Kathleen Sebelius, all of whom acknowledged the global significance of the research project to which CBES **[d]** made a substantial contribution at the launch of its findings in December 2009 **[8].**

The expert knowledge of CBES researchers of the specific health impacts of carbon mitigation measures is now being combined with their wider expertise about the impacts of decarbonisation on factors other than health **[e]**. This combined expertise led, in 2013, to an invitation by the International Energy Agency (IEA) to deliver expert input (alongside DECC) to its 'Capturing the Multiple Benefits of Energy Efficiency' initiative. That key input from CBES, which related both specifically to the HIDEEM tool and to wider aspects of the unintended consequences of decarbonisation, has now supported the development of a key IEA Handbook **[9]**.

5. Sources to corroborate the impact

[1] For reference to CBES research and to the Mayor of London's intention to *'work with the LUCID and AWESOME research teams* [both UCL] *to map overheating risk'*, see Greater London Authority (2011), *Managing Risks and Increasing Resilience* [http://bit.ly/H1BKIH, p. 75, n. 74–76]

[2] The contribution made by the UCL research to the development of GLA policy can be corroborated by that organisation's Senior Policy and Programme Officer (Environment).

[3] For the incorporation of recommendations arising from CBES research, see HM Government (2010), *Approved Document F – Means of Ventilation* [http://bit.ly/15QSz1Z, pp. 43–46]

[4] The use of the UCL research to inform the development of UHI guidance by CIBSE can be corroborated by the Environmental Data Coordinator at CIBSE.

[5] For the use of the HIDEEM tool, see DECC (2012), *The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK* [http://bit.ly/1aVDDPS, p. 12]

[6] For the use of HIDEEM to inform the UK government's Fuel Poverty action framework see DECC (2013), *Fuel Poverty: A Framework for Future Action* [http://bit.ly/12o6Gun, p. 21, and the analytical annex to that document, http://bit.ly/1g6LVdN, pp. 80–82]

[7] World Health Organisation (2010), *Technical and policy recommendations to reduce health risks due to dampness and mould* [http://bit.ly/H7mA4S, with Davies being named on pp. 7, 42]

[8] See, for acknowledgement of the significance of CBES research: (i) UN Secretary-General Ban Ki-Moon [http://bit.ly/16923po]; (ii) World Health Organisation Director Margaret Chan [http://bit.ly/1i4s37z]; (iii) US DHHS Services Secretary Kathleen Sebelius [http://bit.ly/1a1ro62]

[9] The contribution made by CBES to the development of the International Energy Authority's Handbook can be corroborated by a member of their Energy Efficiency and Environment Division.