

**COMPLEX BUILT
ENVIRONMENT
SYSTEMS**

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



Mike Davies

INTRODUCTION AND CONTEXT



Agenda

- 09:45 **Welcome and overview of the Platform Grant and HEW Project**
- 10:40 **Introduction to the interactive simulation environment**
- 11:00 **Break**
- 11:20 **Trial-driven learning environment simulations**
- 13:00 **Lunch**
- 13:45 **Analysis-driven learning environment simulations**
- 15:15 **Exploring simulation-based scenarios**
- 16:00 **Break**
- 16:20 **Insights and future work**
- 17:30 **Closing remarks**
Drinks and nibbles



Welcome

Housekeeping





Welcome

- Complex Built Environment Systems group (CBES) at UCL
- EPSRC Platform Grant Funded Group – ‘Unintended Consequences of Decarbonising the Built Environment’
- HEW project is a pilot project – seed funded by the Platform Grant





Welcome

- Complex Built Environment Systems group (CBES) at UCL
 - UCL Institute for Environmental Design and Engineering
 - UCL Energy Institute, UCL Institute for Sustainable Resources, UCL Institute for Sustainable Heritage
 - Bartlett School of Environment, Energy and Resources (BSEER)



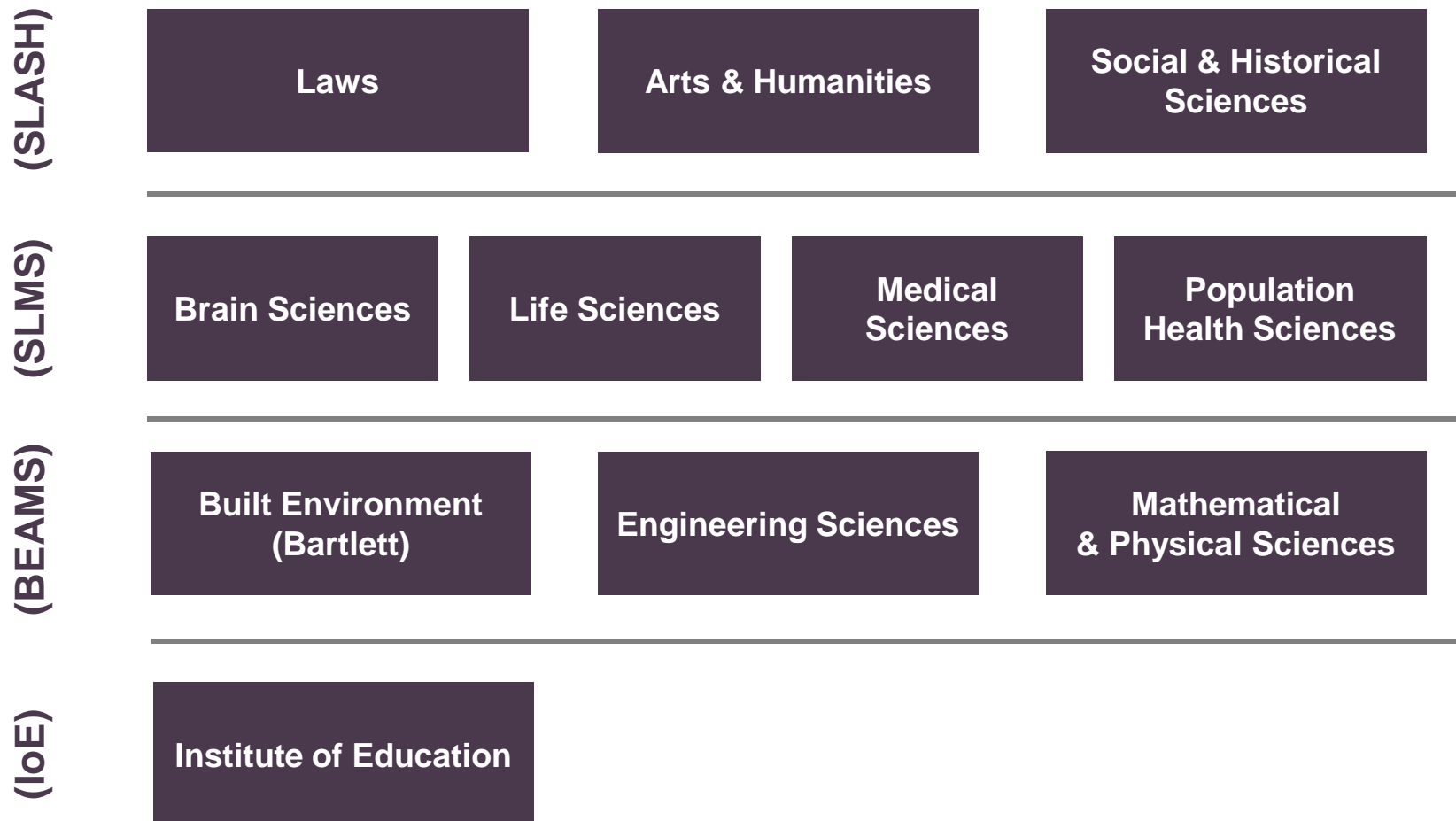
The Bartlett

We cover the full spectrum of built environment domains (and beyond):

- Centre for Advanced Spatial Analysis
- School of Architecture
- School of Construction & Project Management
- Development Planning Unit
- School of Planning
- Space Syntax Laboratory
- UCL Institute for Global Prosperity
- **School of Environment, Energy and Resources (BSEER)**
 - **UCL Energy Institute**
 - **UCL Institute for Sustainable Resources**
 - **UCL Institute for Sustainable Heritage**
 - **UCL Institute for Environmental Design and Engineering**
- Institute for Digital Innovation in the Built Environment
- Real Estate Institute



UCL's Faculties



Our starting point for the Platform Grant work

- What will be the overall impact of policies aimed at reducing the energy demand and carbon emissions of dwellings?
- We know from history that single focus policies lead to ‘unintended’ effects



What can we learn from such examples?

- It is inevitable that policies such as the Green Deal will lead to ‘unintended consequences’
- Some will be positive and others negative



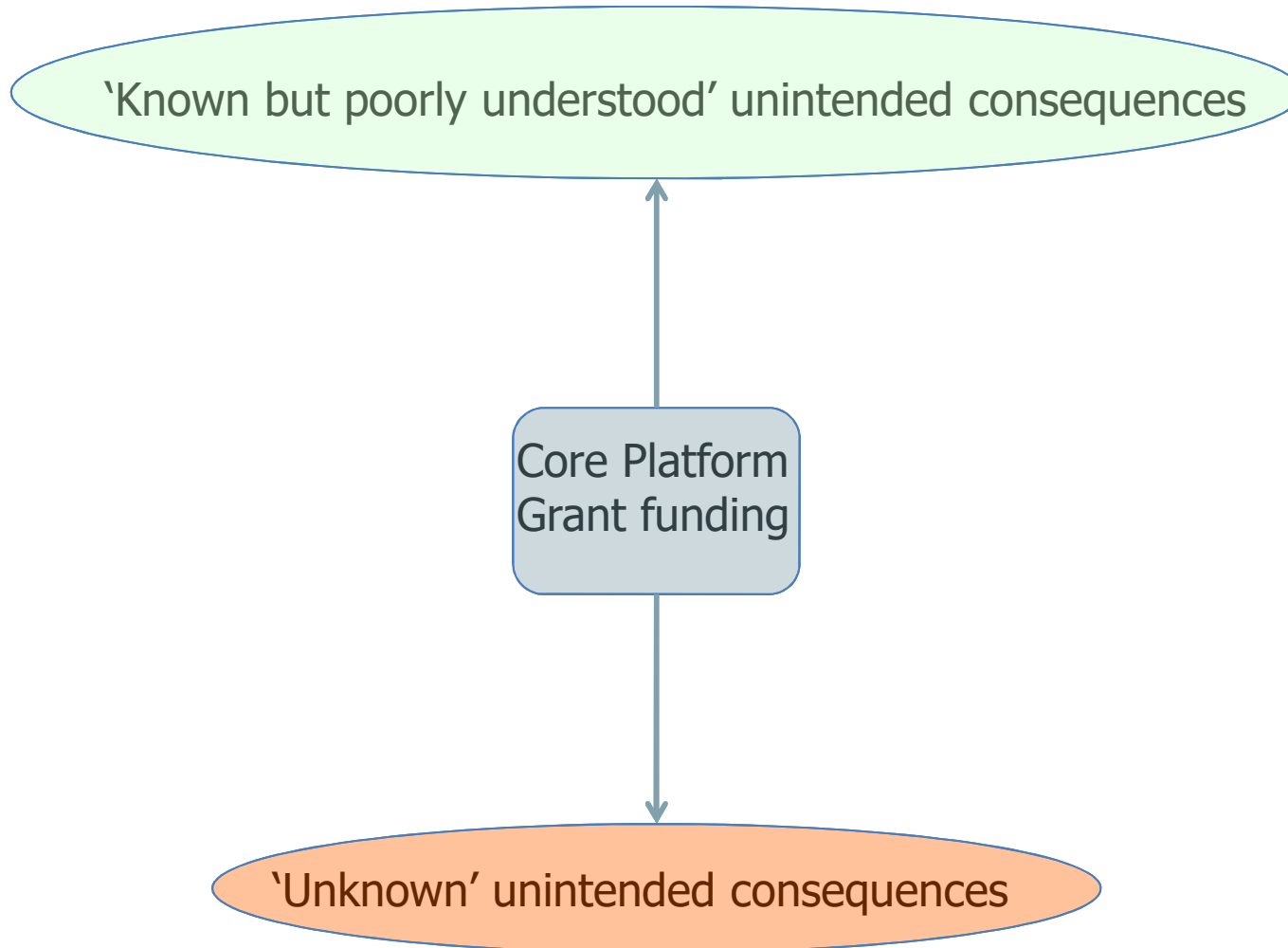
- Davies M and Oreszczyn T, (2012), The unintended consequences of decarbonising the built environment: A UK case study. *Energy and Buildings*, 46 pp 80–85.
- Shrubsole C, Macmillan A, Davies, M, May N, (2014), 100 unintended consequences of policies to improve the energy efficiency of the housing stock. *Indoor and Built Environment* 23 (3), 340-352.
- Macmillan A, Davies M, Shrubsole C, Luxford N, May N, Chiu LF, Trutnevyte E, Bobrova Y, Chalabi Z, (2016), Integrated decision-making about housing, energy and wellbeing: a qualitative system dynamics model, *Environmental Health*, 15(Suppl 1):37, 23-34, DOI 10.1186/s12940-016-0098-z.



Overview: Approaches of Platform Grant

- We are using the Platform Grant funding, as planned, to:
 - Bridge members of staff between funded projects
 - Second key staff
 - Provide flexibility
 - Support feasibility work
 - Develop new areas of work
- There is no Gantt chart
- It is not a traditional ‘project’





Overview of Platform Grant

- Series of ongoing research projects (underpinned by the Platform Grant)
- Active programme of knowledge exchange



CBES research framework



CBES

- Update on examples of some research projects



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- The new EPSRC funded 'TOP' ('The 'Total Performance' of Low Carbon Buildings in China and the UK) project.



The 'Total Performance' of Low Carbon Buildings in China and the UK ('TOP')

- The 3-year project started in December 2016

Tsinghua University (China)

University College London (UK)



Integrated decision-making about Housing Energy and Wellbeing (HEW)
4th stakeholder workshop



The 'Total Performance' of Low Carbon Buildings in China and the UK ('TOP')

- Building Physics
 - Monitoring
 - Modelling
- System Dynamics



MERLIN 2

- The EPSRC funded ‘MERLIN 2 ‘project (led by Peter Raynham) is undertaking work to reduce the energy consumed by road lighting, whilst maintaining the visual benefits.
- This project is aimed at understanding the needs of pedestrians at night.
- In the first phase of work the team have been studying in detail exactly what pedestrians look at during the day and during the night.



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- The National Institute for Health Research Health Protection Research Unit in 'Environmental Change and Health' in which we are involved continues.
- <http://www.hpru-ech.nihr.ac.uk/>



Health Protection Research Unit in Environmental Change and Health

Search



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Heatwaves, Housing & Health

Climate change is likely to increase the frequency and intensity of heatwaves, which are known to have a range of impacts on health. Research is being undertaken on the effects of climate change on high indoor temperatures, an important indicator of health risk as people spend most of their time indoors. Dr Jonathon Taylor at UCL is mapping the risk of overheating in the UK.

HOME

Welcome to the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Environmental Change and Health.

CBES

- Our Wellcome Trust funded SHUE projects ('Sustainable Healthy Urban Environments' and 'Optihouse') continue.
- Wellcome Trust 'Our Planet, Our Health' priority area.
- <https://wellcome.ac.uk/what-we-do/our-work/our-planet-our-health>



Our planet, our health

We're committed to understanding and tackling the threat to our health posed by a dramatically changing world. We also want to ensure that any solutions protect, nurture and sustain our planet.

Our planet, our health has been a priority area for us since late 2015.

- [Why it's a priority for us](#)
- [What we're doing](#)
- [What we want to achieve](#)
- [Our advisory panel and funding committee](#)

Why it's a priority for us

Our health is closely linked to the environment we live in. But we're placing too many demands on our planet. Natural systems that we rely on – from clean air to fresh water, biodiversity to a stable climate – are under threat.

As researchers discover more links between our health and the environment, we become better equipped to come up with ways to reduce these threats. There are already opportunities for change, but more research and action is needed.

NEWS



CONTACT US

If you have any questions, contact the team:

OurPlanetOurHealth@wellcome.ac.uk



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- Update on some research projects
- The 'Optihouse' project involves Mexican, South African and Indian partners and we visited our Cape Town colleagues in May.

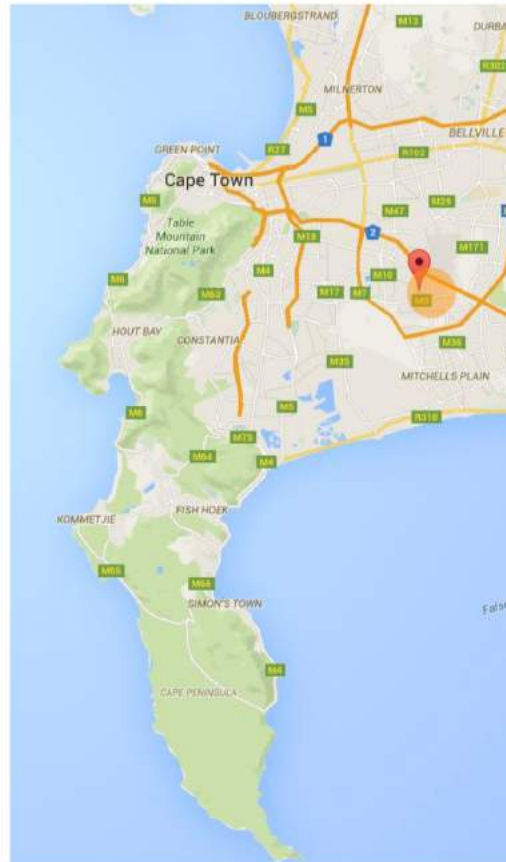


AERIAL VIEW OF RESEARCH FOCUS AREA – NYANGA

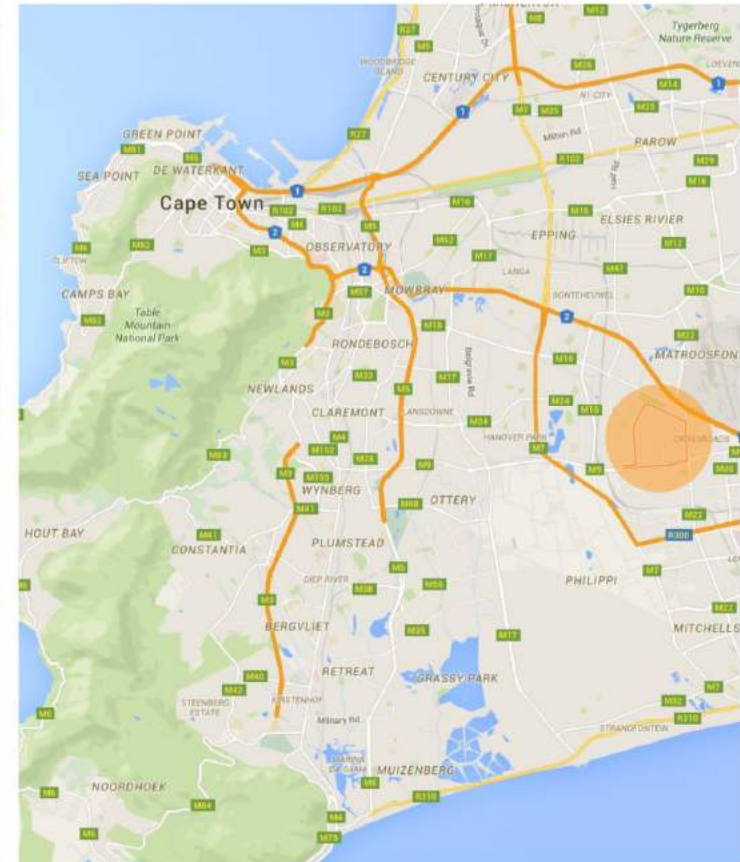


Google Map snapshot of South Africa locating Cape Town and the focus area

The main focus area is Nyanga. This is a township situated in Cape Town, South Africa. It was established as a result of the migrant labour system.



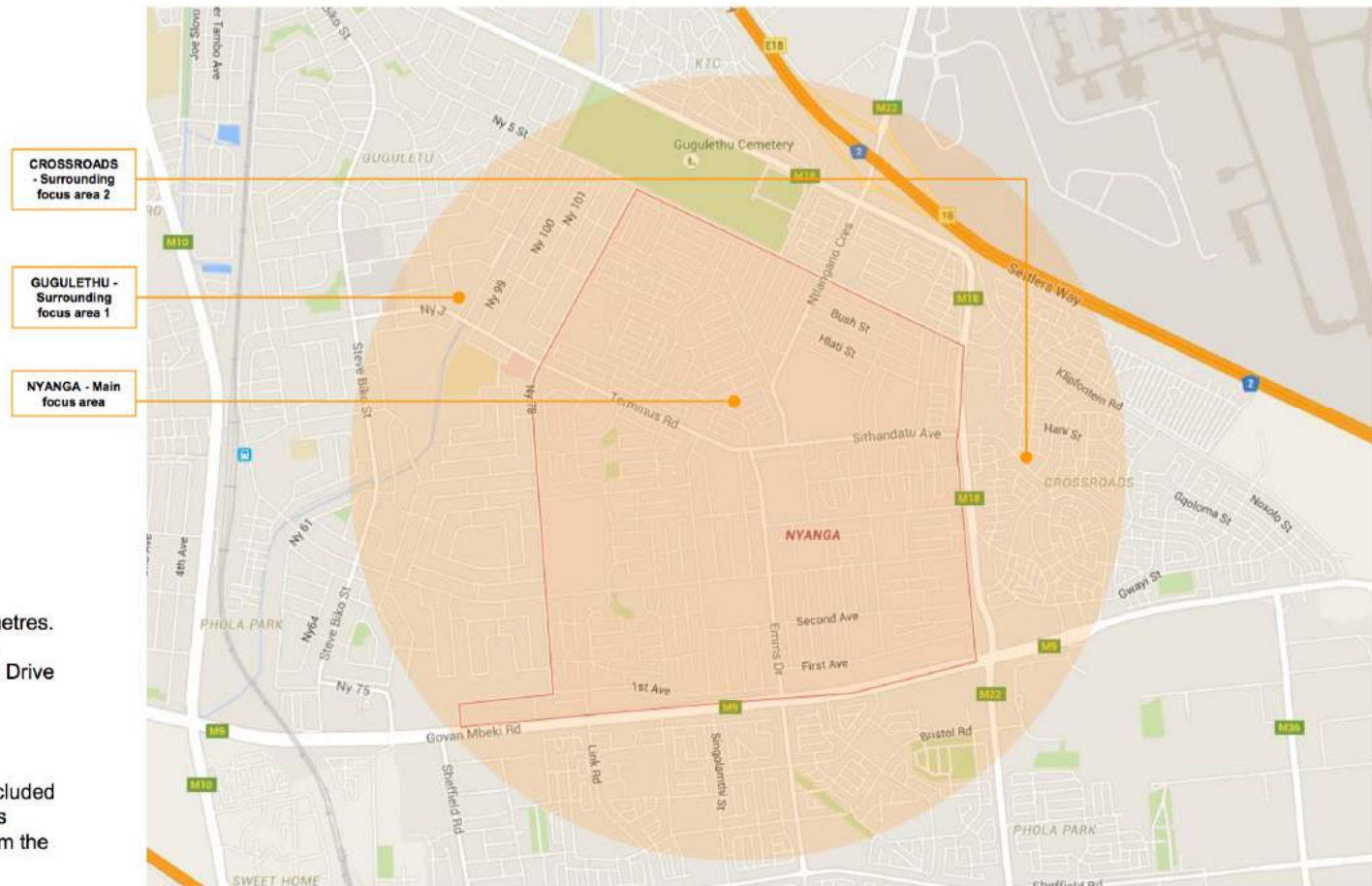
Zoom in locating the focus area and its context



Zoom in locating the focus area



AERIAL VIEW OF RESEARCH FOCUS AREA – NYANGA



The focus area, Nyanga, spans about 1,6 kilometres. It is centred on the three-way junction at which Terminus Road, Sithandalu Avenue and Emms Drive (formerly Amsterdam Avenue) converge. The geographical coordinates of this junction is:

-33.992277, 18.582217

The surrounding focus areas (parts of) to be included in the study are, Gugulethu and Old Crossroads which span approximately 800 metres each from the main focus area.



RDP HOUSE 1



LOCATION

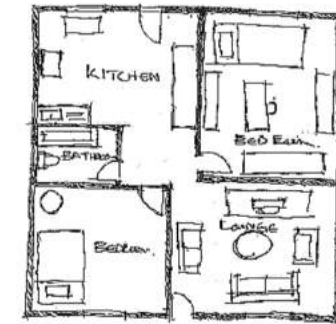
- Nyanga, 11th section (1130 Bayana Street, New Cross Roads) (within New Cross Roads)
- New Cross roads began as a negotiated settlement between the government and those that lived within the settlement in 1979.

DRAWINGS



ROOF PLAN

Source: emap.capetown.gov.za/egisviewer



GROUND FLOOR LAYOUT

USE/PROGRAM

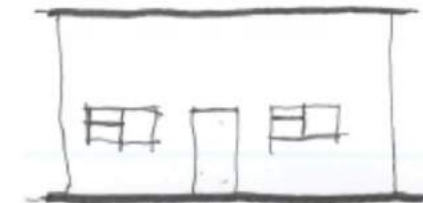
- Subsidy/RDP type house built within the 80s – built within a section of New Cross roads that was prohibited from registering their homes to get formal ownership or title deeds.
- Single storey two-bedroomed house with a lounge area, kitchen as well as a toilet. In addition to this, the house has its own waterline as well as prepaid electricity.

CONSTRUCTION/MATERIALS

- Built using low-cost material mainly tiled roofing, concrete blocks, steel framed windows and doors as well as wooden doors.



SECTION



ELEVATION



CBES

Some examples of knowledge exchange

We produce a wide variety of academic papers..



Selection of papers published / accepted since January 2016

1. Taylor J, Mavrogianni A, Davies M, Wilkinson, P, Shrubsole C, Hamilton I, Oikonomou E, Biddulph P. Housing as a modifier of air contaminant and temperature exposure in Great Britain: A modelling framework Indoor Air 2016, Ghent, Belgium, 03 Jul 2016 - 08 Jul 2016. 03 Jul 2016.
2. Symonds P, Taylor J, Chalabi Z, Mavrogianni A, Davies M, Hamilton I, Vardoulakis S, Heaviside C, Macintyre H. Development of an England-wide indoor overheating and air pollution model using artificial neural networks Journal of Building Performance Simulation 1-14 02 Apr 2016
3. Taylor J, Davies M, Mavrogianni A, Shrubsole C, Hamilton I, Das P, Jones B, Oikonomou E, Biddulph P. Mapping indoor overheating and air pollution risk modification across Great Britain: A modelling study Building and Environment 99:1-12 01 Apr 2016
4. Macmillan A, Davies M, Shrubsole C, Luxford N, May N, Chiu LF, Trutnevte E, Bobrova Y, Chalabi Z. Integrated decision-making about housing, energy and wellbeing: a qualitative system dynamics model ENVIRONMENTAL HEALTH 15 Article number ARTN 37 08 Mar 2016
5. Shrubsole, C., Taylor, J., Das, P., Hamilton, I. G., Oikonomou, E., & Davies, M. (2016). Impacts of energy efficiency retrofitting measures on indoor PM2.5 concentrations across different income groups in England: a modelling study. *Advances in Building Energy Research*, 10 (1), 69-83. doi:10.1080/17512549.2015.1014844
6. Impact of the new Chilean air-tightness regulation on indoor air pollution in dwellings with inefficient heating sources Findings from a Field Study. Narvaez, R., Shrubsole, C., Altamirano-Medina, Indoor Air Conference 2016 Ghent, Belgium
7. Estimating Current and Future Indoor Air Pollution and Temperatures in England. Taylor, J., Symonds, P., Mavrogianni, A., Davies, M., Shrubsole, C., Hamilton, I., Chalabi, Z. and Wilkinson, P. Indoor Air Conference 2016 Ghent, Belgium
8. Makantasi A.-M., Mavrogianni A. Adaptation of London's social housing to climate change through retrofit: a holistic evaluation approach. *Advances in Building Energy Research*. 2016; 10:1, 99-124.
9. Loucari C., Taylor J., Raslan R., Oikonomou E., Mavrogianni A. Retrofit solutions for solid wall dwellings in England: The impact of uncertainty upon the energy performance gap. *Building Services Engineering Research and Technology*. 2016; Available online.
10. Taylor J., Symonds P., Mavrogianni A., Davies M., Shrubsole C., Hamilton I., Chalabi Z., Wilkinson P. Modelling population exposure to high indoor temperatures under changing climates, housing conditions, and urban environments in England. In: *International Conference on Urban Risks (ICUR)*; 30 June - 2 July 2016; Lisbon, Portugal.
11. Hsu S.-C., Hamilton I., Mavrogianni A. Comparing spatial interpolation techniques of local urban temperature for heat-related health risk estimation in a sub-tropical city. In: *Urban Transitions Global Summit 2016 - Towards A Better Urban future in An Interconnected Age*; 5-9 September 2016; Shanghai, China.
12. Eker, Sibel; Zimmermann, Nici: Understanding the Mechanisms behind Fragmentation in the Housing Construction and Retrofit, 34th International Conference of the System Dynamics Society, 17–21 July 2016.
13. Taylor J., Picetti R., Symonds P., Heaviside C., MacIntyre H., Wilkinson P., Davies M., Mavrogianni A. Estimating changes in heat-related mortality following built environment adaptations in the West Midlands, UK. In: *Public Health England (PHE) Annual Conference 2016*; 13-14 September 2016; London, UK.
14. Joshi R., Mavrogianni A. A holistic modelling framework for retrofitting hard-to-treat homes in London: Energy, comfort, cost and value propositions. In: *International Building Performance Simulation Association (IBPSA) Conference - Building Simulation and Optimisation (BSO) 2016*; 16-17 September 2016; Newcastle, UK.
15. Taylor J., Symonds P., Mavrogianni A., Davies M., Shrubsole C., Hamilton I., Chalabi Z., Wilkinson P. Estimating current and future indoor air pollution and temperatures in England. In: *Indoor Air 2016*; 3-8 July 2016; Ghent, Belgium.
16. Schneider dos Santos R., Taylor J., Davies M., Mavrogianni A., Symonds P. Modelling and monitoring tools to evaluate the urban heat island's contribution to the risk of indoor overheating. In: International Building Performance Simulation Association (IBPSA) Conference - Building Simulation and Optimisation (BSO) 2016; 16-17 September 2016; Newcastle.
17. Stave, Krystyna; Zimmermann, Nici; Kim, Hyunjung: What are System Dynamics Insights? 34th International Conference of the System Dynamics Society, 17–21 July 2016.
18. Yates, T. A., Khan, P. Y., Knight, G. M., Taylor, J. G., McHugh, T. D., Lipman, M., . . . Abubakar, I. (2016). The transmission of Mycobacterium tuberculosis in high burden settings. *The Lancet Infectious Diseases*, 16 (2), 227-238. doi:10.1016/S1473-3099(15)00499-5
19. Taylor, J., Yates, T., Mthethwa, M., Tanser, F., Abubakar, I., and Altamirano, H. (2016). Measuring ventilation and modelling M. tuberculosis transmission in indoor congregate settings, rural KwaZulu-Natal. *International Journal of Tuberculosis and Lung Disease*, doi:10.5588/ijtld.116.0085.
20. Milner, J., Taylor, J., Hamilton, I., Barreto, M., Davies, M., Haines, A., Sehgal, M., Wilkinson, P. (2016). Climate change-related temperature increases and associated health risks for cities in the SHUE database. In: International Society of Environmental Epidemiologists (ISEE) Conference - 2016; 1-4 September 2016; Rome, Italy.
21. Picetti, R., Taylor, J., Symonds, P., Macintyre, H., Heaviside, C., Davies, M., Wilkinson, P. (2016). Estimating the health impact of housing adaptations on heat-related risks in the West Midlands region (UK). In: International Society of Environmental Epidemiologists (ISEE) Conference - 2016; 1-4 September 2016; Rome, Italy.
22. Li, Y., Lalor, M., Taylor, J., Altamirano-Medina, H. (2016). Assessing the role of UK buildings on the transmission of tuberculosis. In: *Indoor Air 2016*; 3-8 July 2016; Ghent, Belgium.
23. Zimmermann, Nici; Chiu, Lai Fong; Bobrova, Yekatherina; Chalabi, Zaid: Endogenous transformation of exogenous effects in a system dynamics model of heating, ventilation and rebound, 34th International Conference of the System Dynamics Society, 17–21 July 2016.



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We have just been notified that Jonathon Taylor's paper:

Taylor J, Mavrogianni A, Davies M, Das P, Shrubsole C, Biddulph P, Oikonomou E. (2015) Understanding and mitigating overheating and indoor PM2.5 risks using coupled temperature and indoor air quality models, Building Services Engineering Research and Technology 36(2):275-289.

has won the 'CIBSE Napier Shaw Bronze Medal' this year, which is awarded for the most highly rated paper published in BSER&T relating to research.



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To also note the 2015 award for Clive Shrubsole's paper:

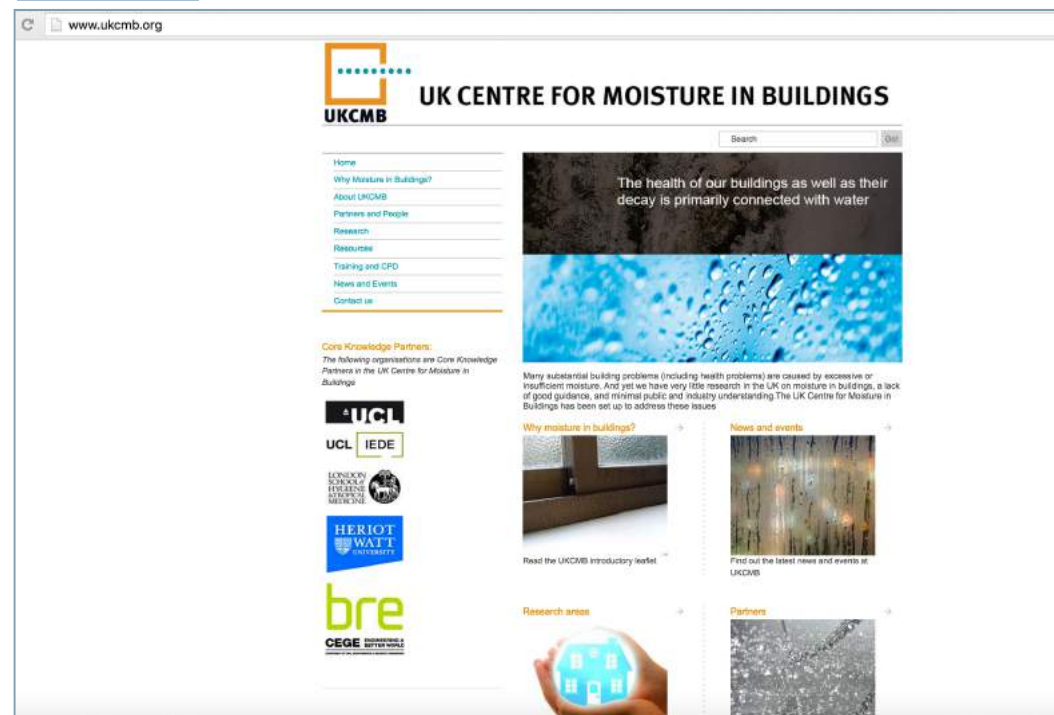
Shrubsole C, Macmillan A, Davies M, May N. (2014) 100 Unintended consequences of policies to improve the energy efficiency of the UK housing stock, Indoor and Built Environment 23(3):340-352.

which Indoor and Built Environment, the Journal of the International Society of the Built Environment recognised as outstanding and awarded it 'Best paper 2014'.



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- Neil May led the large kick-off meeting for the UK Centre for Moisture in Buildings (UKCMB) in May with approximately 100 attendees. The UKCMB has a [website](http://www.ukcmb.org).



CBES

- We continue our work to establish an undergraduate course in 'Engineering and Architectural Design' - a course that will train students to think and act systemically.
- The course has now been formally approved by UCL.
- <http://www.bartlett.ucl.ac.uk/architecture/programmes/undergraduate/eng-engineering-and-architectural-design>



CBES

- Our new MSc in ‘Health, Wellbeing and Sustainable Buildings’ has now been formally approved by UCL.
- <http://www.bartlett.ucl.ac.uk/iede/programmes/postgraduate/msc-health-wellbeing-sustainable-buildings>



CBES

- In February we held an event to celebrate the 50th anniversary of Environmental Design and Engineering at The Bartlett. It was a joint event with the Zero Carbon Hub on the theme of ‘Building Performance Evaluation – Understanding the Performance Gap’. The very successful event had approximately 250 attendees.
- <http://www.bartlett.ucl.ac.uk/iede/iede-news/Twitter-review-BBB-EDE50>



CBES

- We now have a series of ‘so-what?’ reports published on the ARCC network
- <http://www.arcc-network.org.uk/so-what/>



www.arcc-network.org.uk/so-what/#.V3QLX5MrJ0s

So what?
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 Design for future climate
 Early career researchers
 OpenARCC

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- Health & wellbeing
- Infrastructure & interdependencies
- Smart adapting cities
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- ARCC theme
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- Building type
- Select building type
- Location
- Select location
- Research theme
- Select research theme

So what?

Ever wondered how built environment & infrastructure research is relevant to you? Have a look at our 'So what' guides...

Deal or no Green Deal: time to make smarter policies

To help avoid making decisions in isolation that can lead to unintended detrimental consequences, researchers at UCL devised a decision-making model to aid UK housing policy decisions.

09, Apr 2016 | Category: Health & wellbeing, Residential, So what? |

Can we predict the location of overheating-related deaths?

Researchers combined maps of data for 2.6 million London addresses to predict the location at greatest risk of heat-related mortality.

01, Feb 2016 | Category: Extremes, London, Overheating research, Residential, So what? |

Do you have research you would like to share? Download and complete our So what? templates, send them back to us and we'll do the rest.

So what? template (ppt, 1 MB)

So what? Twitter campaign template (ppt, 40 KB)

SO WHAT? ARCHIVE

Deal or no Green Deal: time to make smarter policies

Can we predict the location of overheating-related deaths?

Energy efficiency retrofit is more effective & has health benefits if combined with grid decarbonisation & enhanced ventilation

Building type & construction have a significant effect on post-flood drying time

High levels of CCS could lead to energy sector demand for water exceeding supply

Over 70s are more likely to dangerously



Policies about housing, energy and wellbeing – like other policies – can have a broad range of impacts that may not be immediately apparent and can ultimately result in policy failure.

so what?

Researchers at UCL suggest we can greatly improve the effectiveness of housing policy decisions by making the review process more dynamic, enabling testing of the causal linkages between housing, energy efficiency, health and wellbeing.

The UK government has an ambitious goal to reduce carbon emissions from housing through energy efficiency improvements. This narrow-focus policy provides a strong driver for change. However, the implementation has resulted in both positive and negative unintended consequences across a broad range of outcomes for health, equity and environmental sustainability. Now these complex inter-linkages have been identified, researchers are working to help policymakers test draft policies against this continually evolving evidence base, in order to clarify the potential repercussions of implementing new housing policy.

Relevance

The process

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- We are contributing to the [UK Climate Change Risk Assessment \(CCRA\) Evidence Report](#).
- Chapter 5: People and the Built Environment
- To be launched mid July
- Led by the CCC's [Adaptation Sub-Committee](#), the report is the result of three years of extensive research, consultation and analysis. Its findings will help to inform the UK Government's second Climate Change Risk Assessment due to be published in early 2017.



CBES

- We are the UK representatives for the International Energy Agency (IEA) Annex 68



Energy in Buildings and
Communities Programme**Factsheet**

Design and Operational Strategies for High IAQ in Low Energy Buildings

ANNEX 68

To achieve nearly net zero energy use, all buildings in future will need to be more efficient and optimized. As new buildings are already well insulated in certain industrialised countries, the focus is shifting to limiting space heating energy consumption by reducing ventilation demand. Low energy buildings need to be airtight and energy demand for ventilation is often reduced by lowering the ventilation rate to the minimum necessary. Each of these can have adverse impacts on indoor air quality (IAQ). This project is therefore investigating how to ensure that future low energy buildings are able both to improve their energy performance and to provide comfortable and healthy indoor environments.

PROJECT OBJECTIVES

- 1** provide a scientific basis for the design and operational strategies of buildings that have minimal energy consumption, and at the same time maintain very high standards regarding indoor environmental quality based on the control of sources, sinks and flows of heat, air, moisture, and pollutants under in-use conditions
- 2** collect and provide data about properties for transport, retention and emission of chemical substances in new and recycled materials under the influence of heat and moisture transfer



CBES

Funding – bids submitted and funding won

- We have been fortunate to win funding for a series of new research projects and we are also bidding for a number of others.
- We were invited by EPSRC to submit an application for renewal of the CBES Platform Grant. We submitted an outline proposal following which we have been invited to submit a full bid by September with the interview to be held in January.



Integrated decision-making about housing, energy and wellbeing (HEW)



So, how to proceed?

- How to explore the possible future states of such complex systems?
- A different approach
- One that will provide insights regarding decarbonisation
- But, vitally, moving beyond this ‘single issue’ to also allow insights regarding integrated decision making about the wider system of housing, energy and ‘wellbeing’.
- HEW: Integrated decision-making about Housing, Energy and Wellbeing
- Nici

