London-Loughborough EPSRC CDT
Centre for Doctoral Training in Energy Demand

Vision and leadership for a sustainable built environment

Energy demand pathways:

What does the future hold for the built environment?

LoLo Conference 2018 - 13th June 2018 at Nunn Hall (UCL), 20 Bedford Way, WC1H 0AL, London, UK

– Programme (12:00-20:00) –

12:00-13:00	**Registration -** Tea and coffee, light lunch available
13:00-13:10	**Opening address** Sebastian Junemann, Doctoral Researcher, LoLo CDT
13:10-14:30	**Oral presentations – Session 1**
13:10	Presentation No. 1: Rami El Geneidy, Loughborough University ***Review of techniques to enable community-scale demand response strategy design***
13:30	Presentation No. 2: Zhikun Wang, UCL ***Heat pumps with district heating for the UK's future domestic heating***
13:50	Presentation No. 3: Stephen Watson, Loughborough University ***Increased electricity demand from heat pumps, taking user behaviour into account***
14:10	Presentation No. 4: Nittalin Phunapai, De Montfort University ***A feasibility study for integrating the social, environmental and economic life cycle assessment of sustainable building projects***
14:30-15:30	**Poster Session** Tea and coffee
15:30 -16:50	**Oral presentations – Session 2**
15:30	Presentation No. 5: Daniel L. Wright, Loughborough University ***Assessing risk of overheating in UK homes: Impacts on health, energy and design***
15:50	Presentation No. 6: Ben Roberts, Loughborough University ***What can occupants do to reduce overheating?***
16:10	Presentation No. 7: Duncan Grassie, UCL ***An investigation of the feedback and feedforward mechanisms required for crowdsourcing occupant datasets for a UK school stock model***
16:30	Presentation No. 8: Joseph Levodo, London South Bank University ***Energy access cooperation in sub-Saharan Africa: Trade barriers between countries***
16:50 – 17:10	**Final break**
17:10 – 17:15	**Closing remarks and intro to keynote**
17:15-18:15	**Keynote** Dr Ruchi Choudhary, Reader in Architectural Engineering, University of Cambridge ***The role of Data in understanding demand: opportunities and risks***

UCL Loughborough University EPSRC Engineering and Physical Sciences Research Council

18:15 – 18:30 **Winners of the best oral and poster presentations**

18:30 – 20:00 **Drinks reception and finger buffet**

List of poster presentations

Presentation No. 9: Rima Alaaeddine, University of Huddersfield

An integrative machine learning methodology for occupants'behaviour prediction: An attempt to minimize the energy performance gap

Presentation No. 10: Diana Martinez-Trejo, Durham University

Holarchy architecture for P2P Energy trading

Presentation No. 11: Vinh Le, University of Huddersfield

Thermal acceptability of people in the hot humid climate of Vietnam and the potential of energy saving

Presentation No. 12: Hung Thanh Dang, University of Huddersfield

Studies on thermal environments, comfort perception and energy use in 'shophouse' dwellings in Ho Chi Minh City over warm season

Presentation No. 13: Yaman Aljaghbeer, Keele University

Investigate the connectivity between energy-related occupants' behaviour, facility management operations in the context of different spaces' functionalities at higher and further buildings

Presentation No. 14: Yesmeen Khalifa, Keele University

Integrated resources management for urban sustainability in the global south's megacities

Presentation No. 15: Karolis Petruskevicius, University of Manchester

Intelligent management of demand side heat storage in buildings

Presentation No. 16: Duncan Grassie, UCL

An investigation of the feedback and feedforward mechanisms required for crowdsourcing occupant datasets for a UK school stock model

Presentation No. 17: Rami El Geneidy, Loughborough University

Review of techniques to enable community-scale demand response strategy design

Presentation No. 18: Zhikun Wang, UCL

Heat pumps with district heating for the UK's future domestic heating

Presentation No. 19: Daniel L. Wright, Loughborough University

Assessing risk of overheating in UK homes: Impacts on health, energy and design

Presentation No. 20: Ben Roberts, Loughborough University

What can occupants do to reduce overheating?

Abstracts – Oral presentations

Presentation No. 1: Rami El Geneidy, Loughborough University

Review of techniques to enable community-scale demand response strategy design

Abstract: Community-scale modelling is important to understand how communities could participate in existing and future demand response (DR) schemes where parties like aggregators utilize collections of distributed energy assets to deliver DR. Model-predictive control (MPC) provides a framework to utilize energy flexibility of buildings for DR. However, designing MPC strategies for communities poses requirements on simulation and modelling methods which emerging Modelica-based tools aim to address better than traditional simulation tools, but their up-take is relatively low. The aim of this research is to contribute by developing recommendations for utilizing Modelica-based tools in designing MPC strategies for communities to deliver DR. To achieve this an integrative review was performed on research of MPC for DR along with reviewing relevant Modelica-based tools. The MPC literature was reviewed based on aspects including for example the general control approach, objective function in the MPC formulation, thermal response model in the MPC, amount and type of buildings considered, the type of DR, the control structure and the results obtained. Modelica building model libraries and related tools were reviewed to assess their suitability for community-scale simulations and MPC design. The results show that MPC studies focusing on participation of communities in CDR are very limited although novel modelling and simulation tools would provide the means to effectively design MPC strategies for this purpose and simulate their effects on communities. For designing these strategies is recommended that Modelica-based tools are used to demonstrate their effectiveness and increase their uptake within the modelling community.

Presentation No. 2: Zhikun Wang, UCL

Heat pumps with district heating for the UK's future domestic heating

Abstract: The UK has set ambitious targets to reduce carbon emissions, improve energy efficiency and affordability, encourage renewable energy generation, and reduce dependency on imported fossil fuels. Heating is the most important component of the UK's current residential energy consumption, and is mostly supplied through the direct burning of natural gas. With constantly changing market conditions and political regulatory frameworks, technology assessments and cost-effective planning strategies are critical for long-term energy and environmental policy designing. Electric heat pumps with decarbonised electricity are proposed as promising technologies that could replace gas heating and contribute to the UK's future low-carbon heat mix. District heating has been transforming over generations to meet heat demand. Both technologies have been well-developed, with abundant scientific research and industrial experiences in some European countries over the past few decades. However, the market shares of heat pumps and district heating networks are low in the UK, and there are technical, social, and economic challenges for their future deployment. This presentation aims to offer better understandings of heat demand in the UK's domestic buildings empirically, future alternatives to decarbonise the domestic heating sector, and the role of heat pumps and district heating by assessing their topological configurations for different types of dwellings on different scales. This study investigates heat pumps in individual households versus district heating networks through techno-economic models, to further explore their comparative advantages based on different aspects, including technical performance, carbon emissions, financial practicability, and policy uncertainties.

Presentation No. 3: Stephen Watson, Loughborough University

Increased electricity demand from heat pumps, taking user behaviour into account

Abstract: Most pathways for how the UK could meet its 2050 emissions targets envisage a significant proportion of domestic space and water heating being provided by electric heat pumps. This would result in a significant increase in electricity demand, especially during cold weather. Of primary concern is the peak electricity demand from heat pumps, the maximum ramp rate (rate of change) and the timing of the peak heat pump electricity demand compared to existing electricity demand. This new electricity demand could pose a challenge at a local and a national level, although this research focuses solely on the national picture. Monitored data from dwellings with gas heating and heat pumps has been analysed to investigate the existing heat demand, the range of ways in which heating systems are used and the factors affecting this. Based on this, the electricity demands resulting from a widespread use of heat pumps has been predicted under various possible scenarios. The approach used is empirical, being based on monitoring of real dwellings, rather than thermal simulations. Statistical methods such as clustering and regression are used. The results of this will prove useful in assessing the desirability of different domestic heating pathways, the necessity for thermal or electrical storage, and future electricity generation requirements.

Presentation No. 4: Nittalin Phunapai, De Montfort University

A feasibility study for integrating the social, environmental and economic life cycle assessment of sustainable building projects

Abstract: Environmental Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) tools are currently employed to evaluate the environmental and economic impacts of buildings throughout their life cycle. However, these tools often fail to take to adequately account for important social aspects of construction projects such as stakeholder involvement, neighbourhood impact, human health, quality of life, safety and equity. Recently, developments in Social Life Cycle Assessment (S-LCA) has attracted some attention and a number of assessment tools have been developed. The aim of this paper is to explore how existing standards and evaluation techniques for monitoring and anticipating the social, economic and environmental impacts of non-domestic buildings can be better integrated into improved and holistic decision making processes for new building projects. A critical review of exising assessment tools, building standards and potential modelling approaches that could be used to facilitate such integration are presented and used to generate a provisional methodological framework that will be trialled through an ongoing case study of a new development in a Higher Education Institution in Thailand. An important consideration for such a framework will be its ability to take account of cultural, climatic and construction differences in the assessment of a building's lifetime impact.

Presentation No. 5: Daniel L. Wright, Loughborough University

Assessing risk of overheating in UK homes: Impacts on health, energy and design

Abstract: New-build homes and bungalows are at risk of overheating during hot UK summers. Bungalows are a dwelling type favoured by the elderly who are more vulnerable to the negative health impacts of overheating. Average temperatures and frequency of extreme weather events in the UK are predicted to rise, thus exacerbating any existing risk of overheating even further. A mixed-method survey tool, the Overheating Adaptive Opportunities, Actions and Barriers survey tool (OAST), was developed for to assess overheating incidence, adaptive opportunities, actions taken and barriers to action. The tool was deployed with a cohort of new-build (n = 4) and bungalow homes (n = 4) in Loughborough, central England. The survey highlighted potential indicators of elevated overheating risk, including post-occupancy retrofit (such as extensions and loft conversions). Occupants' reports provided context and were a key strength of the OAST. Expressed barriers to adaptive action included concerns about security, but there was an inherent lack of concern about overheating and the associated health risks. Recommendations are made for the further development of the OAST as a method of assessing overheating risk in households, supporting adaptation of homes as healthy spaces for all and mitigating further domestic energy demand via air conditioning units.

Presentation No. 6: Ben Roberts, Loughborough University

What can occupants do to reduce overheating?

Abstract: Overheating in summer is already occurring in UK homes. A warming climate, better insulated homes and an ageing, urbanised population is creating a perfect storm with implications for occupant health, comfort and wellbeing during hot weather and heatwaves. The aim of this work is to determine if simple occupant mitigations using windows, internal shading and internal doors can reduce the risk of overheating and avoid future use of air conditioning in UK homes. The matched pair of test houses at Loughborough University were used to conduct a unique set of full-scale, side-byside overheating experiments, under real weather conditions. Synthetically occupied with remote controlled actuated windows, motorised curtains and automated internal doors, the behaviour of real occupants was replicated and internal heat gains mimicked. Results are presented on overheating analysis, thermal comfort comparisons with advice on ideal occupant behaviours to reduce overheating risk.

Presentation No. 7: Duncan Grassie, UCL

An investigation of the feedback and feedforward mechanisms required for crowdsourcing occupant datasets for a UK school stock model

Abstract: Environmental Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) tools are currently employed to evaluate the environmental and economic impacts of buildings throughout their life cycle. However, these tools often fail to take to adequately account for important social aspects of construction projects such as stakeholder involvement, neighbourhood impact, human health, quality of life, safety and equity. Recently, developments in Social Life Cycle Assessment (S-LCA) has attracted some attention and a number of assessment tools have been developed. The aim of this paper is to explore how existing standards and evaluation techniques for monitoring and anticipating the social, economic and environmental impacts of non-domestic buildings can be better integrated into improved and holistic decision making processes for new building projects. A critical review of exising assessment tools, building standards and potential modelling approaches that could be used to facilitate such integration are presented and used to generate a provisional methodological framework that will be trialled through an ongoing case study of a new development in a Higher Education Institution in Thailand. An important consideration for such a framework will be its ability to take account of cultural, climatic and construction differences in the assessment of a building's lifetime impact.

Presentation No. 8: Joseph Levodo, London South Bank University

Energy access cooperation in sub-Saharan Africa: Trade barriers between countries

Abstract: Sub-Saharan African countries continue to suffer from energy shortages caused by lack of investment and challenges in providing energy access to the vast majority of the population. Building up energy access cooperation trade between different countries could make it easier for the region to benefit from a regional cooperation. Trade cooperation could significantly increase energy access, reliability, affordability and availability of domestic use; by leading economic growth with cost-effective and extending renewable energy base electricity in rural and urban areas. Expansion of renewable energy trade cooperation between different countries in Sub-Saharan Africa should address regional barriers of domestic energy base electricity use. Opening up bilateral renewable energy cooperation in medium and long term; especially creating projects as countries to countries could have confidence on energy trade with jobs creations, and possible advantages that this can offer. Renewable energy has not fully established in Africa because of various barriers to its diffusion. This paper identifies different barriers to renewable energy diffusion in Sub-Saharan Africa and proposed solutions to overcome them.

Abstracts – Poster presentations

Presentation No. 9: Rima Alaaeddine, University of Huddersfield

An integrative machine learning methodology for occupants'behaviour prediction: An attempt to minimize the energy performance gap

Abstract: Building energy simulation models are imperative for the planning, optimization, and energy performance prediction of buildings. Due to the high level of complexity involved in the process and pervasiveness of large number of interdependent factors and constraints, achieving a truthful simulation of real-world building performance tends to be challenging. This challenge also lies in the limitation of present building energy simulation model to include occupant behaviors thoroughly. Most predictive models for building energy performance take occupants into account by prefixed values, deterministic scenarios, and predefined schedules. Consequently, Limitation in occupants' behavior prediction is partially responsible for the building energy performance gap present between predicted and actual building performance. For this reason, it is important, when estimating the building energy performance, to take into account occupant behavior. To address this challenge, this research proposes a novel methodology based on a probabilistic model built from knowledge derived from occupant behavior. By employing Machine learning techniques, which are capable of handling complex and non-linear problems, more accurate predictions on occupants' behavior can be obtained using prior knowledge of occupants to provide insights and defined relationships. Different machine learning algorithms are employed to predict different human actions. This allows the inclusion of the behavioral trends, patterns and impact on the energy consumption, which can be further employed as occupant behavior specific-inputs into constructing the proposed predictive model. The predictive model is then used for co-simulating to predict building energy performance. This eventually leads to more accurate predictions and minimizing energy performance gap.

Presentation No. 10: Diana Martinez-Trejo, Durham University

Holarchy architecture for P2P Energy trading

Abstract: One of the goals of the European Union's energy policy is expanding the share of renewable energy. Centralized schemes may not be able to fulfil it under the enlarged number of distributed generation units. Nowadays, with the integration of distributed energy resources in smart grids has opened new avenues for energy management system. Data calculation from smart meters is a major time-constraint, due to the available amount of data. A holarchy architecture is proposed to take control of the energy trading transactions between prosumers to reduce computational burden involved in communication and decision making. The proposed approach would also maintain global assessing, mainly ensured through electricity markets including energy providers and their customers. Applications in peer-to-peer protocols and real-world projects are discussed to present the utility of the proposed architecture.

Presentation No. 11: Vinh Le, University of Huddersfield

Thermal acceptability of people in the hot humid climate of Vietnam and the potential of energy saving

Abstract: Set-point temperatures in a building play an important role in energy saving, especially with the upper value in hot humid climates. This study aims to investigate the thermal acceptability of Vietnamese people in order to understand the suitable set-point temperatures for buildings in Vietnam. 8 experiments on 8 level of temperatures from 23°C to 30°C in a controlled room were carried out in both hot and cool season. In each experiment, subjects sedentarily exposed to a level of temperature in two hours and voted on ASHRAE thermal sensation scale every 30 minutes. A statistical analysis on 640 responses from 128 subjects shows that the lower and upper limit temperature of the acceptable range for a criterion of 80% thermal satisfaction are 23.7°C and 29.6°C respectively. This result is around 3.5 degrees higher than that of ISO 7730 2005 which the current Vietnam building code on thermal comfort is based on. This significant difference of thermal acceptability could result in a high potential of energy saving in Vietnamese buildings by setting a higher set-point temperature.

Presentation No. 12: Hung Thanh Dang, University of Huddersfield

Studies on thermal environments, comfort perception and energy use in 'shophouse' dwellings in Ho Chi Minh City over warm season

Abstract: This paper reports on an investigation into the thermal environment, comfort perceptions, and energy use in "shophouse" dwellings in Ho Chi Minh City (HCMC). Shophouses are narrow urban buildings used for business and accommodation. Typical dimensions range from 3-5m width, 10-100m length and 1-5 floors; when originally planned/built they provided scope for use of natural daylight and ventilation. However, since the 1980s, pressures on urban space and 32% of land area in HCMC fully covered by buildings have reduced natural light and ventilation options. This combined with urban heat island effects now causes significant difficulties for the internal environments of shophouses. Energy availability/cost means conditions in shophouses can reach/exceed the upper limits of acceptability and choices have to be made between energy-use and comfort. The work reviewed three main types of shophouses across the city. Automated data recording systems were set up for longitudinal investigations of physical variables in four dwellings coupled with occupant questionnaires/interviews and cross-sectional studies in additional buildings. Summaries of the extensive data are presented noting, over a warm season, the neutral temperature was 28.5°C and the upper limit of comfort range of 31.5°C. The average energy consumption over the year in 2017 for each shophouse was within 349kWh and 505kWh. Due to the nature of the dwellings, an important environmental factor was considered to be air movement and though there was a correlation between internal/external airspeed, indoor air movement rarely exceeded 0.2ms^{-1}. Design guidelines/suggestions for optimising comfort are made based on shophouse type.

Presentation No. 13: Yaman Aljaghbeer, Keele University

Investigate the connectivity between energy-related occupants' behaviour, facility management operations in the context of different spaces' functionalities at higher and further buildings

Abstract: Energy related occupants' behaviour in buildings has gained high interest in research to solve the problem of performance gap. The situation is less investigated in educational buildings although the reported performance gap is high in this sector. Educational buildings usually have wide range of space functionalities with different control responsibilities to the conditions of the indoor environment. The indoor environment conditions either centralized by the facility management or personalized by the occupants depending on the space type and facility management procedure. The aim of the research is to enhance the energy performance of building by realizing the main contributor for wasted energy in each space type through a case study at Keele University. This research explores the concept of energy occupants' behaviour in relation to space functionality and facility management. The methodology engages mixed method approach to investigate the main contributor of wasted energy in each space and the relation between occupants' behaviour and facility management operations. This is through i) quantifying primary data to correlate space functionalities with energy performance in campus buildings, ii) through quantitative and qualitative method to develop energy occupants' behaviour in each space and the driver of their behaviour, iii) through deep storytelling qualitative means to understand "why?" occupants behave in certain way, and "why?" facility management act in certain way.

Presentation No. 14: Yesmeen Khalifa, Keele University

Integrated resources management for urban sustainability in the global south's megacities

Abstract: To be successful, sustainable development requires tailored strategies to fit with the unique characteristics of individual cities, regions and countries in which they are being developed. The focus of research for this study is how to better understand complex issues in resources management in Cairo (Egypt), as an example of a rapidly urbanizing Global South megacity. The increasing demand of energy resources and the growth of solid waste present considerable challenges for sustainability in Cairo. The aim of this study is to outline the potential for measuring the flow of materials for the creation of robust urban sustainability strategies for a fast-growing megacity Cairo. The research considers cities both as consumers of primary (input) resources (for example, fossil fuels, renewable and non-renewable resources) and producers of secondary (output) resources (for example, waste and wastewater). With the growth of

urbanization, the demand of primary resources will increase and the production of secondary resources will continue to grow. Measuring, assessing and controlling these resources became crucial for improving the sustainability performance of developing countries. The proposed study will examine these resources by using an existing "multi-layered indicator set" tool (Kennedy et al., 2014). The research will utilize two principal data gathering methods: 1) a quantitative data collection to fill a multi-layered indicator set; and 2) qualitative interviews with representatives from public authorities to explore the drivers and barriers to resource management. The research is guided by a mixed methods research approach. Specifically, the research will involve collecting and analyzing existing published quantitative data and will use social science methods to collect qualitative data through semi-structured interviews. This will test the suitability and applicability of this existing tool to understand the unique characteristics of Cairo, drivers and barriers to sustainable resources management.

Presentation No. 15: Karolis Petruskevicius, University of Manchester

Intelligent management of demand side heat storage in buildings

Abstract: Electrification of heating, under present pricing rules, is expected to increase the total and peak demand of electricity. To provide for the peaks, power plants will need to be run part loaded, less efficiently, during the off-peak periods. Power network reinforcement and new generation capacity will also be required. Demand Side Response, utilising forward pricing, is one possible alternative solution. Monetary incentives encourage users to re-time their power consumption to lower price periods, this uses more physical electricity, but saves fuel costs by efficiently generating off-peak. In our proposed system, electric heaters in domestic houses are autonomously responding to forward electricity prices and weather forecasts. We evaluate the benefits of such a system by simulating a price driven electricity market, using Agent Based Modelling Techniques. Agents, houses and power plants, are individually optimised using dynamic optimization techniques. Power plants maximize their profits given forward electricity prices, subject to operational constraints. We use Balancing Mechanism Dynamic Data (Notice to Deviate from Zero, Ramp Rates) and part load efficiency curves to model the operational characteristics of the power plants. Buildings maximise their comfort given forward electricity prices, subject to flexibility restrictions supplied by the user. We use internal and external temperature from 823 houses in England to estimate representative thermal models and heating patterns. Assuming a 20 % electric heating penetration in GB, results provide evidence of lower energy costs for consumers, reduced peak demands and better utilization of more efficient power plants under forward pricing structure.

Presentation No. 16: Duncan Grassie, UCL

An investigation of the feedback and feedforward mechanisms required for crowdsourcing occupant datasets for a UK school stock model

Abstract: Environmental Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) tools are currently employed to evaluate the environmental and economic impacts of buildings throughout their life cycle. However, these tools often fail to take to adequately account for important social aspects of construction projects such as stakeholder involvement, neighbourhood impact, human health, quality of life, safety and equity. Recently, developments in Social Life Cycle Assessment (S-LCA) has attracted some attention and a number of assessment tools have been developed. The aim of this paper is to explore how existing standards and evaluation techniques for monitoring and anticipating the social, economic and environmental impacts of non-domestic buildings can be better integrated into improved and holistic decision making processes for new building projects. A critical review of exising assessment tools, building standards and potential modelling approaches that could be used to facilitate such integration are presented and used to generate a provisional methodological framework that will be trialled through an ongoing case study of a new development in a Higher Education Institution in Thailand. An important consideration for such a framework will be its ability to take account of cultural, climatic and construction differences in the assessment of a building's lifetime impact.

Presentation No. 17: Rami El Geneidy, Loughborough University

Review of techniques to enable community-scale demand response strategy design

Abstract: Community-scale modelling is important to understand how communities could participate in existing and future demand response (DR) schemes where parties like aggregators utilize collections of distributed energy assets to deliver DR. Model-predictive control (MPC) provides a framework to utilize energy flexibility of buildings for DR. However, designing MPC strategies for communities poses requirements on simulation and modelling methods which emerging Modelica-based tools aim to address better than traditional simulation tools, but their up-take is relatively low. The aim of this research is to contribute by developing recommendations for utilizing Modelica-based tools in designing MPC strategies for communities to deliver DR. To achieve this an integrative review was performed on research of MPC for DR along with reviewing relevant Modelica-based tools. The MPC literature was reviewed based on aspects including for example the general control approach, objective function in the MPC formulation, thermal response model in the MPC, amount and type of buildings considered, the type of DR, the control structure and the results obtained. Modelica building model libraries and related tools were reviewed to assess their suitability for community-scale simulations and MPC design. The results show that MPC studies focusing on participation of communities in CDR are very limited although novel modelling and simulation tools would provide the means to effectively design MPC strategies for this purpose and simulate their effects on communities. For designing these strategies is recommended that Modelica-based tools are used to demonstrate their effectiveness and increase their uptake within the modelling community.

Presentation No. 18: Zhikun Wang, UCL

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Presentation No. 19: Daniel L. Wright, Loughborough University

Assessing risk of overheating in UK homes: Impacts on health, energy and design

Abstract: New-build homes and bungalows are at risk of overheating during hot UK summers. Bungalows are a dwelling type favoured by the elderly who are more vulnerable to the negative health impacts of overheating. Average temperatures and frequency of extreme weather events in the UK are predicted to rise, thus exacerbating any existing risk of overheating even further. A mixed-method survey tool, the Overheating Adaptive Opportunities, Actions and Barriers survey tool (OAST), was developed for to assess overheating incidence, adaptive opportunities, actions taken and barriers to action. The tool was deployed with a cohort of new-build (n = 4) and bungalow homes (n = 4) in Loughborough, central England. The survey highlighted potential indicators of elevated overheating risk, including post-occupancy retrofit (such as extensions and loft conversions). Occupants' reports provided context and were a key strength of the OAST. Expressed barriers to adaptive action included concerns about security, but there was an inherent lack of concern about overheating and the associated health risks. Recommendations are made for the further development of the OAST as a method of assessing overheating risk in households, supporting adaptation of homes as healthy spaces for all and mitigating further domestic energy demand via air conditioning units.

Presentation No. 20: Ben Roberts, Loughborough University

What can occupants do to reduce overheating?

Abstract: Overheating in summer is already occurring in UK homes. A warming climate, better insulated homes and an ageing, urbanised population is creating a perfect storm with implications for occupant health, comfort and wellbeing during hot weather and heatwaves. The aim of this work is to determine if simple occupant mitigations using windows, internal shading and internal doors can reduce the risk of overheating and avoid future use of air conditioning in UK homes. The matched pair of test houses at Loughborough University were used to conduct a unique set of full-scale, side-byside overheating experiments, under real weather conditions. Synthetically occupied with remote controlled actuated windows, motorised curtains and automated internal doors, the behaviour of real occupants was replicated and internal heat gains mimicked. Results are presented on overheating analysis, thermal comfort comparisons with advice on ideal occupant behaviours to reduce overheating risk.