London-Loughborough EPSRC CDT

Centre for Doctoral Training in Energy Demand

ANNUAL COLLOQUIUM 2017

Thursday 9 November 2017

The Building Centre, LONDON

About the Centre

The London–Loughborough EPSRC Centre for Doctoral Training in Energy Demand (LoLo) is the premier centre for energy demand research in the built environment in the UK. It was set up in 2009 with funding from EPSRC for 50 studentships over 5 years, with a renewal of funding in 2014 of 60 additional studentships over the next eight years.

LoLo currently has over 40 PhD and MRes students working on a range of topics of profound practical importance spanning energy technology and systems, policy, economics and human behaviour along with a growing community of over 20 alumni who have gone on to attain research positions and lectureships along with technical and professional roles in external organisations.

Both UCL and Loughborough are committed to cross-faculty collaboration in energy research, which enables the Centre to offer truly innovative, multi- disciplinary training. Our students experience a novel learning structure which enables them to make connections across academic disciplines.

Before embarking on their three-year PhD, students undertake a one-year MRes programme, which allows them time to absorb the context of energy demand studies and to pick up the rules, tools and methods that can support innovative, high impact research. For their PhD, students join large and active research groups that can support a wide range of research projects. Students work in partnership with a range of industrial stakeholders and collaborators and their work is disseminated both directly and through national and international networks.

We aim to create a unique, vibrant, student-focused environment with excellent support from stakeholders, a Centre that will train the energy leaders and pioneers of tomorrow who will take on senior roles in academia, industry, commerce, and policy formulation.

Prof Robert Lowe (Director UCL)   Prof Kevin Lomas (Director Loughborough)

UCL

Loughborough University

EPSRC
Engineering and Physical Sciences Research Council

Programme

13.00	*Registration – tea and coffee, light lunch available* Vincent Suite, Lower Ground Floor
14.00	**Opening address** Professor Robert Lowe, Director, LoLo CDT *(Director, UCL Energy Institute)*
14.15	**LoLo highlights from the year** Professor Kevin Lomas, Director, LoLo CDT *(Prof of Building Simulation Loughborough University)*
14.30-14.50	**Final year student presentations**
14.30	George Bennett UCL Energy Institute *Gas boilers & beyond: Dynamics of heating systems, understanding domestic heating system dynamics to improve performance of gas boilers and inform future heating system legislation and development.*
14.40	Tom Neeld UCL Energy Institute *Collaborating with Industry during the PhD (provisional title)*
14.50	*Coffee, networking*
15.20-15.40	**Final year student presentations**
15.20	Steven Watson, Loughborough University *Increased electricity demand from heat pumps, taking user behaviour into account*
15.30	Moira Nicolson UCL Energy Institute *Domestic consumer adoption of demand-side response; Using behavioural science to increase adoption of time of use tariffs*
15.40-17.00	**Poster Session** (Vincent Suite, Lower Ground Floor Foyer) Refer to list of projects
17.00	**Closing Remarks** Professor Robert Lowe, Director, LoLo CDT
17.10	End of main conference
17.20	**Keynote (**Vincent Suite, Lower Ground Floor)
18.20	**Winners of the Poster Competition** (Vincent Suite, Lower Ground Floor) Professors Kevin Lomas and Robert Lowe, Directors, LoLo CDT
18.30-19.30	**Drinks reception** (Ground Floor, Main Gallery)

Keynote session

Prof. Nick Eyre - Jackson Senior Research Fellow and Professor of Energy and Climate Policy- Oxford University

Energy Demand: What are the challenges now?

Mitigating climate change to deliver the goals of the Paris Agreement and UK carbon budgets requires an energy transformation by mid-century. Despite falling costs, renewable electricity generation options are not a panacea. Most international studies show that global reductions in energy intensity will need to reach 3% annually, perhaps more in service economies like the UK. This will involves going well past the traditional energy efficiency agenda, of incremental and cost effective improvements at modest cost, to include options that are not currently attractive to private investors.

The new challenge is also wider than demand reduction. Variable and inflexible electricity generation will put a premium on the flexibility of energy demand. This requires either that user practices are changed or that they are decoupled from the timing of energy supply. Published UK low-carbon scenarios rely heavily on increased electrification of heat and transport, and there are promising signs in transport, at least for light vehicles. However, electrification of space heating looks challenging even at the scale of some individual buildings. At the system level, large scale electrification implies either that major electricity system assets are unused in summer, or that inter-seasonal energy storage is deployed. All of these challenges raise new research questions: for technology, business models, social change and governance

Biography

Nick Eyre is Professor of Energy and Climate Policy, and a Jackson Senior Research Fellow in Energy at the ECI and Oriel College. He was recently appointed as Champion of new UK Centre for Research in Energy Demand (UKRED). In this role he is consulting with the UK energy research community to develop a consensus around a research agenda, to build an inter-disciplinary research consortium and plan a programme of research with a view to a new End Use Energy Demand Centre starting in April 2018.

Nick is a Co-Director of the Oxford Martin Programme on Integrating Renewable Energy, which is undertaking research on the combined, technical, economic, social and policy issues in moving to electricity systems with very high levels of variable renewables.

Nick has been Programme Leader for Energy in the ECI since 2007. From 2007 to 2017, he was a Co-Director of the multi-university collaboration, the UK Energy Research Centre, leading its research work on energy demand (2007-2014) and decision-making (2014-2017). He was a Co-Investigator within the Infrastructure Transitions Research Consortium from 2011-2017.

Nick worked at the Energy Saving Trust from 1999 to 2007, initially as Head of Policy and, from 2002, as Director of Strategy. He was responsible for the Trust's work on public policy issues, business development and long term business strategy. In 2001, he was seconded to the Cabinet Office, Performance and Innovation Unit, where he was a co-author of the Government's Review of Energy Policy. He led work streams on energy efficiency and long term energy scenarios.

Poster session

Name	Project Poster title
Charalampos Angelopoulos	Design and control of mixed-mode cooling and ventilation in low energy residential buildings
Kostas Chasapis	Modelling of Integrated Community Energy Systems (ICES)
Jessica Few	Measurement of Ventilation in an Occupied Case Study Dwelling
Duncan Grassie	Impact of data availability and model complexity on prediction of energy consumption in Camden schools
Matej Gustin	Forecasting summer overheating in dwellings with Time Series Analysis
Clare Hanmer	Flexibility in morning home heating times
Frances Hollick	Developing new methods to estimate whole building heat loss
Lisa Iszatt	Hygrothermal characterisation of brick walls and the impacts of internal wall insulation
Suneina Jangra	Investigating the in-situ thermal performance of loft insulation in cold-pitched roofs
Seb Junemann	Understanding overheating and poor indoor air quality impacts associated with UK energy efficiency retrofit
David Kenington	How can energy efficiency be improved in independent retail? The tale of the Butcher, the Fishmonger and the Cycle-shop.
Harry Kennard	Experienced temperature, fuel poverty and health
Matthew Li	Seasonal Variation in Electricity Demand: Analysis of Data from 58 English Homes
Anthony Marsh	Overheating in Student Accommodation
Murat Mustafa	Natural Ventilation, Mechanical Ventilation and Heat Recovery in Non-Domestic Passivhaus Building in the UK Climate Context
Giorgos Petrou	Does indoor overheating risk prediction depend on the choice of Building Simulation Software?
Ben Roberts	The effect of occupant behaviour on overheating
Zareen Sethna	Understanding the uptake of energy efficiency measures in the private rented sector
Salman Siddiqui	Management of Thermal Energy Storage in District Heating Networks
Zack Wang	Heat pumps in the UK's district heating: individual, district level, both or neither?
Stephen Watson	Increased Electricity Demand from Heat Pumps, taking User Behaviour into account
Catherine Willan	What can we learn about the origins of the performance gap from the processes and communications around energy targets in a construction team?
Daniel Wright	Occupant adaptive responses to overheating in bungalows and new build dwellings

PhD students

Charalampos Angelopoulos
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I hold a BSc in Mechanical Engineering from the Technological and Educational Institute of Piraeus, Athens, Greece in 2013, graduated with distinction. I continued my studies at Technical University of Denmark (DTU) where I obtained an MSc in Sustainable Energy. It was a 2-year program with a specialization in thermal energy. My MSc dissertation examined diverse energy storage technologies with a novel system of thermo-electric energy storage system. Afterwards, I continued my studies at LoLo CDT in Loughborough University where I obtained my MRes in Energy Demand with distinction. My research dissertation focused on the thermal performance of single-sided naturally ventilated classrooms. For the purpose of this analysis, I performed CFD simulations and the results were assessed against the updated draft version of BB101. For my PhD project, I work on the design and control field mixed mode ventilation residential buildings..

Design and control of mixed-mode cooling and ventilation in low energy residential buildings

The aims of this project are to develop control algorithms for mixed-mode buildings in hot climates. The sophisticated algorithm will optimally select between natural and mechanical ventilation in order to constantly maintain thermally comfortable internal environments as well as to minimise the energy consumption of the building. For the purpose of this research, dynamic thermal modelling simulations will be performed alongside with CFD simulations. The sophisticated control algorithms will be developed in Modelica which will be coupled with EnergyPlus to assess the performance of its control algorithm under a variety of scenarios

Kostas Chasapis
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Kostas is Electrical Engineer and holds an MSc degree in Renewable Energy Systems (2004) and an MRes in Energy Demand in Built Environment (2016), both from the Loughborough University. Kostas has working experience in the Energy sector and particularly in Renewable Energy projects and Electricity trading. Through his career he got involved in the design and installation of wind farms and PV projects. He got also involved with the analysis of the Electricity market and the day-ahead electricity trading. He has worked with small regional companies and international firms and has cooperated with several public authorities and organizations. He is currently studying at Loughborough University as a member of LoLo CDT and started the second year of his PhD.

Modelling of community energy system

The Integrated Community Energy Systems (ICES) are energy generation, distribution, storage and consumption systems involving local community ownership and participation. They promote the combination of locally owned production and consumption of energy. They can combine different energy technologies, comprising generation from intermittent sources, base loads and dispatchable sources. However, there is lack of methodological principles that lead from potential analysis to sustainable implementation strategies and to the planning of energy-efficient neighbourhoods.

This project will develop a tool to study and assess different community energy options to provide the neighbourhoods with the required energy. The tool will analyse the costs, emissions and energy balance of ICES and it will be used to study and compare the cases of ICES being formed in existing neighbourhoods on one hand and in new-built ones on the other.

George Bennett
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As a Mechanical Engineer I have had a relatively wide experience in industry since finishing my undergraduate studies a 'few' years ago. Including working as a development engineer on a wide range of Products, from stirling cycle cryocoolers to hydraulic control systems for aircraft.

For the last 10 years I have been working at Bosch Thermotechnology primarily working on the lifetime and robustness of gas boilers. If it can go wrong with a boiler or heating system, I have probably seen it! This has allowed me to live and work across Europe, through Germany, the Netherlands and to Turkey.

Comparison of the next generation of domestic heating solutions to identify the most appropriate solutions for real world conditions

European National Calculation Methods (NCM), such as the UK Standard Assessment Procedure (SAP), are used to make standardised and simplified assessments of building energy performance. These NCMs contain simplifications to aid ease of use and comparability of resulting Energy Performance Certificates (EPC). By comparing SAP with a modern, dynamic modelling system, and detailed field data this study quantifies internal temperatures and thereby heating energy consumption. Results show that thermal response, plant size ratio and controls play a significant role in the overall performance of the heating system. The inclusion of more realistic dynamics in building energy modelling for NCMs may provide a better basis for effective decision making with respect to a wide range of heating systems.

Performance gap in the sense of what legislators stipulate and expect compared to the realities of the application of heating systems in buildings with users is a topic not just limited to emerging technologies such as heat pumps but is an endemic problem being lived with in today's homes. The characterisation of the dynamic behaviour of gas boilers shows issues that can not only help improve the current building stock energy demand but also provide valuable lessons to be learned in the application of new technologies in the future.

Pamela Fennell
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After studying engineering at Cambridge University, and a Masters in the Management of Construction Enterprises at the ESTP, Paris, I worked for 14 years in the procurement of public private partnership projects. During this period, I led projects in a wide range of sectors, focusing in recent years on the education sector. Most recently, I spent 4 years leading a partnership between Southwark Council and Balfour Beatty which invested £250m in the refurbishment and rebuild of 13 schools. I obtained an MBA with distinction from Imperial College in 2007 and an MRes with distinction from UCL in 2014.

Energy Performance Contracting – is it time to check the small print?

In an Energy Performance Contract, the installer of an energy efficiency measure guarantees the expected savings which means EnPCs potentially have a key role to play in increasing levels of investment in energy efficiency.

Understanding the detail of how performance will be measured or "reading the small print" is essential if the parties are to understand their full risk exposure and their likely financial returns.

This study uses a stochastic modelling approach to investigate the effect of risk allocation on financial returns for clients and contractors and finds that the choice of measurement boundary for a lighting upgrade project has a significant effect on the level of protection that clients can expect from the guarantee. The effects vary depending on the client's underlying patterns of lighting use.

Jessica Few

PhD, UCL

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Jess graduated from Durham University in 2013 with a Physics degree. She then worked for three years as a research scientist in environmental monitoring, focusing on identification and quantification of atmospheric emissions from industrial processes. She joined the LoLo MRes programme in September 2016 and progressed to Mphil/PhD September this year.

The temporal and spatial variability of ventilation rate in newly built, occupied case-study dwellings with trickle vents and mechanical extract fans

In the UK, buildings have become increasingly airtight in recent decades to improve energy efficiency. Poor indoor air quality is associated with a host of poor health outcomes for occupants and low ventilation rates can contribute to this.

Despite the importance of ventilation for indoor air quality and building energy use there has been a lack of detailed studies on variability of ventilation rates in occupied homes in the past. This is a complex problem because of the combination of building characteristics, occupant behaviour and weather. This work will attempt to address this by conducting detailed monitoring of occupied case-study dwellings.

The project will involve developing the use of metabolic CO_2 as a tracer gas, and appropriate methods for analysing the data gathered.

Duncan Grassie

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Having spent the past decade as a petroleum engineering consultant modelling oilfield development scenarios on four continents, I have become aware of the decline in fossil fuel resources first hand and the impact this could have in a world of rising demand. Completing the Masters in Energy Demand Studies has provided background to the economical and behavioural barriers to transitioning from oil.

For my PhD I hope to use my experience of developing bespoke engineering workarounds to existing software to help incorporate occupant behaviour into a school stock model of all the schools in England and Wales.

Developing a crowdsourcing socio-technical school building stock model in the context of feedback and feedforward energy efficiency mechanisms

Within the non-domestic stock, a gap has been identified between potential and measured energy performance between similar buildings, framed as a complex feedback loop of both social and technical effects. To construct a national non-domestic stock model, datasets are required which not only to cover building fabric and construction but also differences in the utilisation of building services by occupants. The educational sub-sector presents a suitable starting point due to the similarity in energy services offered and the role of central government in maintaining comprehensive national construction datasets.

This research project will investigate the effectiveness of crowdsourcing methods in feeding forward new datasets for building simulation models of the entire UK school stock as well as influencing occupants' behaviour by offering tailored feedback on building performance to occupants from the conglomerated dataset. The incentive for policy makers to alter future occupant behaviour to meet national targets also requires further investigation..

Matej Gustin
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Matej studied at the University of Trieste in Italy. He got a Bachelor's Degree in Building Engineering in 2009 and a Master's Degree with honours in Civil Engineering in 2013. During the last year of university he worked as a part-time external collaborator in an architecture and engineering firm in Trieste. After his Master's Degree he worked for two years as a project engineer in the civil department of a multinational company in the field of steel and aluminium plant-making. He got a Master of Research in Energy Demand Studies in 2016.

Predicting overheating risk in UK homes

Overheating in the UK homes is a recognized existing problem for house builders, home owners, landlords and tenants. Climate change projections indicate that the UK is expected to experience more frequent and more intense heat wave periods over the coming decades. Thus, the problem will intensify as the climate warms and as homes become even better insulated, resulting in discomfort, health complaints and even mortality. For these reasons, predicting the overheating risks in UK homes is of utmost importance in order to identify the homes, locations and occupants that are most at risk.
The aim of this research is to develop and compare different statistical black-box models (e.g. Time Series Analysis and Artificial Neural Networks) to forecast the impending risk of overheating and the evolution of the internal air temperatures in the UK dwellings.

Clare Hanmer
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Clare worked for 10 years at the Carbon Trust, contributing to innovations support programmes and strategy development across a wide range of low carbon technologies. She managed a programme investigating the challenges and opportunities for low carbon refurbishment of non-domestic buildings and les the Carbon Trust input to a European strategy for wave and tidal energy deployment.

Clare has a degree in engineering from Cambridge University and worked initially in the industrial gases industry. She gained an MSc in Renewable Energy from the University of Reading in 2003 and an MSc in Energy and Society at the University of Durham in 2015.

Flexibility of morning heating demand in UK homes

Most future scenarios for decarbonizing the UK energy system include a high proportion of homes with electric heat pumps. If current heating demand patterns persist, this will lead to a peak in electricity demand in the morning. Demand management to reduce this peak can only be achieved if households are prepared to accept flexible running times for their central heating. The research investigates the factors that shape the patterns of home heating demand in the UK focusing on requirements in the early morning: the point at which preferences for cooler temperatures while sleeping changes to a requirement for warmer temperatures when getting up currently causes a morning peak in gas demand. The aim is to provide a picture of how people actually use their heating in the morning peak period and how flexible they are to accept changes in heating patterns.

A mix of qualitative and quantitative methods is being used, combining analysis of data from heating controllers in several hundred homes with qualitative interviews with case study households.

A theoretical framework, which draws on adaptive thermal comfort and social practice theories, has been developed to situate heating operation within the multiple practices taking place in the home and to consider the different options available to manage the internal environment. Recommendations will be made on the design of heating systems and controls to encourage flexibility. The findings about factors that restrict the potential for heating load management will be relevant to electricity network operators and organisations providing Demand Side Response services..

Frances Hollick
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During an undergraduate Physics degree at the University of Warwick I became interested in working to combat climate change; the LoLo CDT and the subjects of energy demand and building physics seemed to me one of the most constructive ways of addressing this issue.

Developing a dynamic model to estimate whole building heat loss which requires minimal input measurements

In order to meet emissions reductions targets for the domestic sector there must be a method of accurately assessing progress towards these. A dynamic method of determining whole house heat loss which utilises data from occupied houses is likely to accurately reflect the real energy performance. The optimum number of inputs will be determined to enable the method to be as easily and inexpensively applicable as is possible, and the uncertainty associated with excluding various parameters investigated.

Lisa Iszatt
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Lisa started her career in low energy Architecture practices, including Architype. She completed an MSc in Environmental and Energy studies then worked in various energy focussed roles in both commercial and public sectors, including London Borough of Merton. Her work at Parity Projects furthered an interest in the responsible retrofit of existing buildings and specifically the use of internal wall insulation on solid brick walls. Lisa also works part time with Cocreate Consulting on Passivhaus certifications and moisture monitoring of low energy retrofit projects.

Hygrothermal characterisation of brick walls in the UK, and the impacts of internal wall insulation

Applying internal wall insulation to solid brick walls may contribute significantly to stock wide carbon savings. However, unintended consequences include increased moisture in the existing structure, which may lead to structural failure and risks to human health from mould.

This research will include a detailed analysis of heat and moisture in a small number of similar brick walls for at least one year before and after insulation using high resolution surface and in-wall monitoring. Planned insulation works to the three walls are staggered, so comparisons between insulated and uninsulated walls in similar environmental conditions is also possible.

Heat and moisture processes in brick walls have so far mainly been explored through hygrothermal modelling, using laboratory derived material property data. High resolution in-situ monitoring of solid walls offers a unique opportunity to assess the outputs of these models, and potentially enables hygrothermal parameter estimation, using simplified models and inverse analysis.

Suneina Jangra
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Suneina is a doctoral candidate at the UCL Energy Institute. Her research focuses on the characterisation of heat flow through domestic roofs and aims to quantify the technical performance difference associated with loft insulation. The research trials a statistical-based dynamic method for the estimation of the thermophysical properties of building elements using in-situ measurements and aims to provide recommendations for minimising heat loss through roofs. Suneina holds an MRes in Energy Demand Studies from the UCL Energy Institute, an MScR in Civil Engineering, Architecture and Building from Coventry University, and an MEng in Civil Engineering from the University of Bristol.

Investigating the in-situ thermal performance of loft insulation in cold-pitched roofs

This project investigates the thermal performance of the insulation in cold-pitched roofs of standard construction using site surveys and in-situ monitoring. Measured heat flux and temperature data from a pilot study investigation have been used to estimate in-situ point U-values at a range of locations and the results are compared with estimated design U-values based on standard assumptions. Variability in the condition and coverage of the loft insulation is observed, particularly around storage and access installations however, the investigation found that the installed insulation has a better in-situ thermal performance than expected. This disparity between design and in-situ U-value estimates evidences a 'performance difference' where the predicted energy savings associated with installing loft insulation are not realised in practice. The results also suggest that the effects of solar gains and ventilation on the heat flow mechanism through the loft cavity are significant and could contribute to an overall performance difference across the wider UK residential stock.

Sebastian Junemann
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Previous to joining the LoLo programme, Seb worked in social research, having been part of the delivery of the ETI's Consumer Response and Behaviour Project and DECC's evaluation of the Renewable Heat Incentive. He has seven years' experience in the UK social housing sector and has specialised in qualitative and sociotechnical research.

Seb's primary interest is in understanding the relationship between people and the places where they live. Understanding the complex interactions between residents, homes and energy systems continues to drive his research surrounding ventilation and how occupant behaviour can make homes healthier, more comfortable places to live.

Occupant-driven Mitigation Strategies for Poor Indoor Air Quality in UK Homes

Poor indoor air quality in homes is a growing concern to the building research sector as evidence and modelling show that the internal environments in many UK homes can be detrimental to the health of their occupants. Furthermore, evidence suggests that improving the energy efficiency of homes can reduce the natural ventilation pathways and increase the need for new ventilation strategies.

This research builds on Masters-level research to work with occupants to co-create solutions to the myriad problems surrounding poor indoor air quality and identify the potential for behavioural strategies to mitigate these. The MRes work has highlighted a gap in the evidence base around behaviour-led solutions. An action research approach will be used to design interventions, test them and examine the efficacy and impacts using social and technical monitoring data.

As a result of this work, case studies will be developed to provide rich empirical data to give a stronger understanding of the potential for behavioural interventions to overcome poor indoor air quality, such that improved, targeted advice can be provided to occupants. While the work will not involve the installation of physical measures it will consider the way that physical factors provide constraints and enablers for behaviour to make recommendations for potential physical improvements to be made in homes in future.

David Kenington

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David has worked in research and evaluation in the energy sector for over 15 years, with roles at the Energy Saving Trust and Databuild Consulting Ltd, where he has research director for five years before joining UCL. David's has led or supported a range of research and evaluation projects for Government and other clients, covering domestic and non-domestic demand and supply wide policies. Examples include Renewable Heat Incentive, Smart Meter Roll-out, Public Sector Energy Efficiency Loans Scheme (Salix Finance), Carbon Reduction Commitment, GLA Fuel Poverty strategy and InnovateUK Retrofit for the Future pilots. David has a degree in Biology and MSc in Environmental Technology from Imperial College.

Understanding retailer energy use: A behavioural perspective

Organisations use 16% of UK energy, and there are significant opportunities to reduce demand, saving money and reducing harmful emissions. Within the sector, retailers are high energy users, in particular food and mixed retailers, which use large amounts of energy for a variety of purposes including heating, cooling, cooking and other processes. Many new technologies, which improve energy efficiency have behavioural implications for retail staff and customers.

This work will focus on exploring behavioural implications of introducing such technologies (e.g. refrigeration) to help understand what works, in what circumstances and why. The outputs of the work will help to inform the sector and policy-makers to help improve the take up and performance of such technologies thereby reducing bills, emissions and security of supply.

Harry Kennard

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Harry is a Physics graduate and energy researcher from mid-Wales. Having completed an MPhil in Applied Mathematics he studied for an MA in Linguistics, in order to better understand social scientific research techniques.

Alongside academic research, he has worked in journalism as a consultant for Greenpeace's Energydesk and most recently with the Open University on the AHRC funded project 'Stories of Change' as a researcher for the BBC's Roger Harrabin.

Empirical measures of fuel poverty

The exact project focus is still being determined but it will likely seek to understand various empirical measures which occupants experience in domestic buildings, such as temperature, relative humidity and ventilation and determine how these compare between households experiencing fuel poverty and those with higher incomes. These measures will be related to government estimates of fuel poverty levels in order to determine both the prevalence of fuel poverty and aspects of domestic buildings which are associated with negative health outcomes for occupants.

Matthew Li
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Matt graduated from the MMath program at Oxford University in 2008, after which he spent five years teaching mathematics at Seoul Global High School in South Korea. Matt returned to the UK in 2016 to join the LoLo CDT, with the aim of applying mathematical and statistical methods to analysis of energy systems.

Matt's MRes thesis focused on factors influencing domestic electricity demand in English homes. It is hoped that the project's in-depth analysis of high-resolution monitored data may provide novel insight into monthly and intra-weekly variation in domestic electricity consumption patterns, with implications for future load profiling exercises.

Matt is currently working on data processing for Loughborough University's DEFACTO project while considering potential PhD topics.

Anthony Marsh
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In 2013 I graduated from the University of Leeds with a 1st class masters degree in Energy & Environmental Engineering.

Since then I have gained experience working as a technical consultant in the commercial solar industry, and as an energy consultant, primarily within the retail sector. My research examines the environmental performance of purpose built student accommodation in the UK.

Overheating in Student Accommodation

There is growing evidence of overheating incidences occurring in the UK building stock. New purpose built student accommodation (PBSA) contain a number of design characteristics that can make them particularly susceptible. This is investigated through post-occupancy monitoring of the environmental performance of four case study student accommodation buildings.

In the first case study building examined the majority of rooms were shown to have failed the most widely employed empirical tests for overheating. This raises serious concerns over whether overheating risk is being adequately assessed at the design stage in PBSA. It also has implications for how these residences are likely to perform in the years ahead as the UK climate continues to warm..

Murat Mustafa
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Murat has a first degree in electrical and electronics engineering from Eastern Mediterranean University. After graduating, he worked in construction industry as an electrical building services design engineer for ten years in Cyprus, Turkey and the UK. In 2016 he graduated from MSc program of "Low Energy Building Services Engineering" with distinction. His MSc dissertation project had been awarded as the best research in building energy theme in 2016 by Energy Institute of the UK. Consequently, he continued further study in London-Loughborough Research Centre as a fully funded student. Subsequently, he successfully finished his MRes program in energy demand in built environment and continued to his PhD study in LoLo Research Centre

Natural Ventilation, Mechanical Ventilation and Heat Recovery in Non-Domestic Passivhaus Building in the UK Climate Context

(continued)

This study has used CFD to model high internal heat gains and a low ceiling auditorium to investigate thermal comfort and IAQ provided by the MV with and without HR and NV systems in the UK climate context. The model was validated by using field measurements gathered over three days of occupation. Spatial temperature from CFD was compared to three thermal comfort standards. Results show that, for 84W/m2 of internal heat gains, MV provides thermally comfortable environment at outdoor temperature range of 17°C – 26°C, and 20°C – 29°C for NV. Furthermore, for 124W/m2, the outdoor operating temperature range is 14°C – 26°C for MV, and 17°C – 29°C for NV. Furthermore, NV provides less possibility of local thermal discomfort when expose to same outdoor temperatures due to reduced temperature stratification compared to MV. It was concluded that NV extends summer ventilation operating temperature range up to 6°C, whilst MVHR extends it 8°C for winter. However, neither MVHR nor NV is sufficient to provide thermally acceptable indoor environment. Thus, a mixed mode approach is necessary with additional means of active or passive cooling and heating.
Research Interests: CFD modelling of naturally ventilated spaces, ventilation effectiveness of natural ventilation and low energy cooling in non-domestic buildings.

Thomas Neeld
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After graduating with a first class master's degree in Physics I went on to spend two years working with IBM as a Technology Consultant in their Business Analytics unit, working closely with some of the biggest energy companies. After which I aimed to go back into university and pursue a PhD within the broad field of Energy in order to specialize. In my spare time I am a keen rower and row for London Rowing Club along the Embankment at Putney with the ultimate aim of winning at Henley.

George Papachristou
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George has a background in Civil Engineering after completing an MEng at Aristotle University of Thessaloniki. He continued his studies in the UK, where he obtained an MSc in Low Carbon Building Design and Modelling from Loughborough University with distinction. In his dissertation he used a bottom up model to explore the impact of different retrofit options on the energy use of the UK residential stock. For his performance he received the Energy Institute East Midlands MSc Student award. In his first year at the LoLo CDT, George completed the MRes in Energy Demand Studies with distinction, with his dissertation focusing on the control of natural ventilation in Central European plus energy houses. His current research looks at modelling approaches which are most able to utilise real-time data streams for identifying suitable models of the heat dynamics of existing dwellings

Reducing the Operation Performance Gap – improving building simulation tools through data-driven and real-time approaches

Digital innovations and technologies are growing and becoming integral to many sectors. For existing buildings this means that multiple sensors and controls will be recording a wealth of real-time time series measurements on all aspects of building performance. However, the current range of building performance models are not easily able to react to these measurements, as they were primarily developed for early stage design work.

The aim of the project is to develop new approaches to modelling the thermal characteristics of buildings, based on models which can integrate and react to real-time measurements arising from in-situ sensors. The overall goal is to develop new approaches to reducing the Operation Performance Gap. Among the expected outcomes are a set of model techniques that can include real-time performance data as part of their prediction algorithms, and which can update and calibrate in real time, to improve the thermal modelling of existing buildings.

Giorgos Petrou

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In 2016 I graduated with a Physics BSc degree from the University of Warwick. Following my graduation, I joined the LoLo CDT with the goal of having real world impact. Having a background in programming and an interest in modelling, my work has focused on the prediction of overheating risk through the use of building simulations. So far, my research has raised more questions to the general approach of predicting overheating risk and the implications of model selection than it has answered. This has led to a shift of my interest towards a holistic optimisation procedure of building design.

A holistic approach to building design optimization for whole year thermal comfort and indoor air quality in UK dwellings under multiple constraints and stochastic occupant behavior

Current efforts in optimising building design have mostly focused on winter thermal comfort through the increased levels of building air tightness and thermal insulation. However, the impacts of high indoor summer temperatures and poor indoor air quality (IAQ) are becoming more profound as the literature suggests. The current approach to mitigating the impacts of poor IAQ and overheating are interventions. However, what may be considered to be a better alternative is the multi-objective optimisation of building design with the goal of achieving whole-year thermal comfort and ensuring good IAQ. This process will be performed under multiple constrains, such as cost, noise levels and security. This will form an addition to the already existing stock models developed by UCL researchers.

Ben Roberts

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My interest in energy demand in the domestic sector began with an MSc. in Energy Policy at the University of Exeter where I conducted interviews and questionnaires around a policy analysis of the ill-fated Green Deal. Following this I was employed on a knowledge transfer partnership with Anglia Ruskin University and a Green Deal Provider to conduct research on consumer interaction with the early stages of the policy.

Due to the impending collapse of the Green Deal I left to begin an MRes. in Energy Demand Studies at Loughborough University in 2014 where my research focused on zonal heating controls.

I began a PhD in October 2015 investigating the effect of different window and blind opening strategies on the indoor thermal comfort during summertime.

The effect of occupant behaviour on overheating

Dangerous overheating can occur in UK homes during heatwaves and with a warming future climate, better insulated homes, an increasingly urbanised and ageing population a perfect storm is being created.

To avoid the future use of energy-intensive air-conditioning, this project is investigating the potential for simple mitigation strategies such as daytime shading and night ventilation to keep UK homes cool, healthy and comfortable and avoid dangerous summertime overheating. Utilising a matched pair of test houses various mitigation strategies are experimentally investigated.

Zareen Sethna
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Zareen studied Civil, Structural and Environmental Engineering at the University of Cambridge and graduated in 2008. After graduation Zareen joined the engineering consultancy Buro Happold, she worked briefly in their London office and subsequently joined their sustainability team in Berlin. She joined the LoLo CDT at UCL in 2013 and since then her interests have focused on energy consumption in homes and in particular the uptake of energy efficiency measures

Understanding the uptake of energy efficiency measures in the private rented sector

In order to achieve the UK Government's target of an 80% reduction in emissions by 2050 substantial improvements are needed in the energy efficiency of the existing housing stock. The private rented sector is the second largest tenure in the UK, accounting for 20% of households, and has the lowest levels of energy efficiency measures. The aim of this study is to improve our understanding of the uptake of energy efficiency measures in the private rented sector, using social practice theory as a guiding framework and using an explanatory sequential mixed methods research design. The quantitative phase will use data from the English Housing Survey to analyse the associations between rates of uptake of energy efficiency measures and dwelling, household, landlord and geographical characteristics within the private rented sector. The qualitative phase will explore landlords' practices and how these relate to the uptake of energy efficiency measures through interviews, walk-through interviews and focus groups with landlords and other stakeholders.

Salman Siddiqui
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Salman graduated in 2010 with a MEng in Mechanical Engineering from Imperial College. He then completed an MSc in Earth Science under scholarship from KAUST. After spending four years as an engineer and analyst in the Oil and Gas industry, his interests in sustainability and energy economics led him to join the LoLo CDT to work on the challenges of moving away from a fossil fuel based supply.

The operation and configuration of District Heating Networks in the UK transitioning to a decarbonised energy system

District heating networks and the electrification of heat have been identified as key technologies in facilitating the decarbonisation of heat supply in the UK. The decarbonisation is dependent on the growth of renewable power generation which is largely intermittent. To balance the grid, heat storage is a means of decoupling demand from supply and can be practically integrated into district heating networks. This work will focus on optimising district heating energy loads and supplies, as well as heat storage capacity for a for an economically effective transition from the current energy mix to a decarbonised system. To integrate a thermal grid with an electrical grid at various stages of decarbonisation, control algorithms and optimisation techniques will be developed to efficiently manage heat generation, distribution and storage and in doing so, uncover the economic value of heat storage and optimise the size of heat storage investment.

Zhikun Wang
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I am a PhD student at the UCL Bartlett School of Environment, Energy and Resources.I studied BSc Environmental Geoscience at the UCL Earth Sciences Department and graduated in 2013. After that, I had one year working experience in petrochemical industry in China. In 2015, I completed my MSc in Economics and Policy of Energy and the Environment at the UCL Energy Institute which focus on energy and environmental economics, policy assessments and energy modelling. My research interests include energy and environmental policies, business and sustainability, and low carbon technologies especially decarbonisation in power and heating sectors.

Heat pumps in the UK's district heating: individual, district level, both or neither?

Electric heat pumps together with decarbonised electricity are proposed as promising technologies that could replace gas heating. District heating networks have been transforming from fossil fuel based to renewable based over several generations to meet space heating and domestic hot water demand. 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 deployment.

The aim of this project is to better understand the role of heat pumps and district heating by assessing the topological configurations of heat pumps, district heating networks and thermal storage solutions for various types of buildings on different scales.

This study investigates heat pumps at individual households versus district heating networks through physical models, in order to further explore their comparative advantages from different aspects, including technical performances, carbon emissions, financial practicability and policy uncertainties.

Stephen Watson
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Stephen studied Engineering (MEng) at Durham University from 2009 to 2013. His final year specialisation was in New and Renewable Energy, which consisted mostly of Mechanical Engineering with some Electrical Engineering, and his final year project was on recovery of heat from domestic graywater. At Loughborough, his MRes project was about overheating of artifical sports pitches and the possibility of removing heat.

Stephen is interested in heat pumps and the role they might play in future UK heating, especially compared to other technologies such as district heating. Stephen worked for a year in the maintenance team at an outdoor centre.

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

In order to meet CO2 reduction targets, it is commonly envisaged that heat pumps will play a significant role in the UK's future domestic space and water heating. Most of the UK's space heating demand currently is met by the gas network, whereas meeting this demand from the electricity grid could prove challenging. However, electric heat pumps respond differently to gas boilers, having lower water temperatures and lower maximum heat output, thus possibly leading to different user behaviour.

In order to be able to make predictions about possible future national electricity demand under a widespread uptake of heat pumps, an empirical approach is being used, based on half-hourly demand data from real houses with heat pumps and gas boilers. These data are being analysed to investigate patterns of heating, the relationship to the type of house and occupants, and the degree of simultaneous usage, in order to obtain estimates of future national electricity consumption of heat pumps.

Catherine Willan
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Prior to joining UCL, Catherine worked for eight years in the low carbon sector. At the Carbon Trust, she worked in policy, strategy and business planning. Projects included: the development of PAS2050 and carbon labeling; research into global carbon trading mechanisms; greenhouse gas reporting; carbon-saving strategies for large corporates; and many other product and policy development areas, working with a wide cross-section of government and industry stakeholders. Subsequently, she joined the EOI business school in Madrid, where she taught and supervised international postgraduate students.

What can we learn about the origins of the performance gap from the practices and communications relating to energy targets in a construction team?

This PhD is working with a sponsoring construction company to help understand why energy expectations for the operational performance of non-domestic buildings may not always be met. The PhD has focused in detail on a case study non-domestic project. From this, a large amount of qualitative data has been collected, covering observation, interviews and documents. Three contrasting - but complementary - concepts from Science and Technology Studies are being employed to analyse the data. The aim is to explore the multiple ways in which people enact, communicate and share information on energy targets in construction, and to highlight the implications arising for building energy performance in operation.

Daniel Wright
PhD, Loughborough University
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Dan's background is in psychology and sustainability, and he worked as a projects officer for an international conservation charity before starting his studies with the LoLo Centre. His research interests include the consequences of overheating, the impacts of innovation and automation on energy demand, and the role of feedback/feedforward.

His LoLo MRes project focused on exploring the opportunities for, and barriers to, mitigating overheating in the home. He developed a survey tool, monitored the indoor temperatures of seventeen rooms across eight homes and carried out semi-structured interviews to develop an in-depth understanding of potential drivers of behaviour and the limiting factors that may make a home more susceptible to overheating. In his previous MSc with Birkbeck College (University of London), Dan researched into interactions with metering technologies and influence on reported behaviours, which is an area of research he hopes to explore further in his PhD. Dan is currently working as the cohort manager on Loughborough University's DEFACTO project.

MRes students

Susanna Ala-Kurikka

MRes Energy Demand Studies, UCL
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After graduating from the University of Glasgow with an MSc in European Politics, Susanna worked in EU policy roles in Brussels. She developed a keen interest in energy and climate policy while working as a journalist covering policy developments in the area. Following that, she gained experience in developing environmental and energy policies at the European Parliament and in the non-profit sector. For the past two years, Susanna was busy completing a Graduate Diploma in Economics at Birkbeck, University of London, while editing an environmental news publication. Susanna joined the LoLo CDT in 2017 with a view to pursuing research in the area of demand-side management.

Kinan Al-Zayat

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Kinan worked as a research assistant at University College London analysing aircraft operating cost and performance as part of the SAECA project. He built a model simulating the costs occurring for different airlines around the world. His thesis at City University London focused on evaluating the environmental impact caused by extra-atmospheric intercontinental travel. He recently graduated with an MSc in Aerospace Vehicle Design from Cranfield University. Prior to Cranfield, Kinan worked as a service engineer, providing support for pharmaceutical lab equipment.

Minnie Ashdown

MRes Energy Demand Studies, UCL
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Minnie graduated from Edinburgh University in 2010 with a degree in Astrophysics. After completing her undergraduate degree Minnie went on to complete an MSc in Climate Change Management, and has worked in the community sector setting up sustainable projects including a local food co-op, and with the local council and community to create entrepreneurial opportunities for local people. She is interested in improving quality of life through addressing fuel poverty, and improving the quality of the building stock. research in the area of demand-side management.

Rayan Azhari

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Rayan studied architecture (BSc) in Latakia-Syria from 2003 to 2008. He worked in Syria and Saudi Arabia before coming to the UK to do an MSc in Sustainable Buildings Performance and Design at Oxford Brookes University. After that Rayan carried out some research at Nottingham University on "Minimising Thermal Discomfort and Energy use in Houses". Then he worked for 3 years at Richard Morton Architects in London prior to joining the UCL as part of the LoLo CDT programme.

Ramy El Geneidy

MRes Energy Demand Studies, LU
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I completed both my bachelor and master degrees in Helsinki, under the wings of Aalto University School of Engineering in the Energy Technology programme. I dug deep into energy system studies, modelling and simulation. My master thesis was about studying potential of novel energy conservation methods in passenger ships, the work was published in The Journal of Marine Engineering and Technology. Before ending up in the CDT I worked for in the wind power industry in sales and market analysis. After a year in the renewable energy business it was time to shift into studying energy demand.

My main interest is in combining experimental methods with modelling and simulation but this might naturally shift during the course of the MRes. I am especially interested in finding areas and problems that span over different disciplines and have maximum impact. I hope my skills in engineering and business will be useful for solving these problems.

Lauren Ferguson

MRes Energy Demand Studies, UCL
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I did my Batchelor's in biology and since then I briefly worked as a bioinformatician at The Wolfson Institute of Preventive Medicine. I am interested in how the built environment relates to health, particularly focused on indoor air pollution and modelling these effects. My PhD commencing next year is in collaboration with Public Health England.

Josep Forde

MRes Energy Demand Studies, LU

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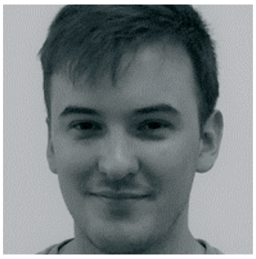

Following the successful completion of an MPhys Master's degree in Physics with Nanotechnology in 2015, Joseph spent two years working as an Energy Consultant working mostly on the domestic housing new build sector. An interest in the role of the construction industry in meeting future emission targets led Joseph to join the LoLo CDT in 2017.

Joseph's research interests include monitoring implementation of retrofit energy saving measures and the broad range of design measures to be taken to improve energy demand within the new build dwellings.

Daniel Franks

MRes Energy Demand Studies, LU

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I graduated from the University of Birmingham with an MSci in Mathematics in 2017, my dissertation was on modelling wave power devices. It was this that sparked my interest in energy demand, and motivated me to join the LoLo CDT.

Gabriele Gessani

MRes Energy Demand Studies, UCL

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Gabriele completed his undergraduate degree in Environmental Engineering and pursued an MSc in Engineering for Environmental Sustainability at the University of Modena and Reggio Emilia (Italy). He decided to join the UCL global community pursuing the MSc in Construction Economics and Management. In 2017 he decided to join LoLo CDT. With the passion towards urban development, and sustainability, he wants to initiate a change that would shape a better sustainable world.

Anneka Kang

MRes Energy Demand Studies, UCL

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I have a background in Mechanical Engineering and Sustainability, and have always been keen to pursue a career where I can contribute to improving sustainability for future generations. After graduating I worked globally with Unilever factories for 2 years as an Energy Consultant. Through Metering, Monitoring and Targeting projects, I helped them achieve utility reduction targets. For the past 2 years I have been a Mechanical Design Engineer, mainly working on the design of hybrid energy storage units. I created CAD models/ drawings, built prototypes, carried out stress analysis and heat/cooling flow simulations on products and saw them through to production. My research interests are currently in the field of renewable energy, domestic heating, simulation and design/optimisation.

Michael Lyons

MRes Energy Demand Studies, LU

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Michael has a background in transport and construction sectors including working in jobs as diverse as being a train driver and then an electrician he studied Civil Engineering at Northampton University.

Michael has previously owned a property renovation company and it was from this he developed an interest in the energy performance and comfort levels in older properties

Tomasz Mloduchowski

MRes Energy Demand Studies, UCL

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Tomasz Mloduchowski is a LoLo CDT MRes student at UCL where he researches the impact that blockchain and internet of things can provide to the realm of energy demand, energy trading and infrastructure design.

He's been involved in the Bitcoin and Blockchain space since late 2009, through his various commercial and social ventures. Tomasz studied physics at MIT where he focused on computational physics and supercomputing. At Harvard, he audited a number of lectures at the Berkmann Centre. He is an alumnus of the Clinton Global Initiative University programme, and founder of the Warsaw Hackerspace, where he explored the NGO and local governance segment.

Nathan Moriarty

MRes Energy Demand Studies, UCL

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After studying Mathematics BSc at UCL 2010-13, Nathan joined Fidessa - a financial services software company. He went on to complete an engineer training program at National Grid - GB System Operator - alongside a sponsored foundation degree in Electrical Power Engineering at Aston University. After a further year of experience at UKPN - Distribution Network Operator - within the innovation team, Nathan is now enrolled at the LoLo CDT in Energy Demand Studies.

Eleonora Ruffini

MRes Energy Demand Studies, UCL

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Eleonora holds a MSc in Energy and Nuclear Engineering from the Polytechnic University of Turin. As affiliate at the Lawrence Berkeley National Laboratory, she worked on the cost analysis of sustainable transportation technologies. Before starting the MRes, she worked as research intern at Joule Assets Europe, supporting the research in the context of two H2020 funded projects (FLEXICIENCY and SEAF). She also collaborates with Joule Smart, assessing potential energy savings from improved lighting, HVAC and building management systems in order to draw proposals for viable projects. Her interests range from demand response and demand side management to electric vehicles.

Alumni

Alexandros Adam (PhD, UCL)
Energy Analyst, National Technical University of Athens

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Alexandros received his undergraduate diploma in Mechanical Engineering from the National Technical University of Athens. He then came to London and obtained an MSc in Building Services Engineering with Sustainable Energy from Brunel University. He worked as a building services engineer for a consultancy in London.

In 2010 he joined the London – Loughborough EPSRC Centre for Doctoral Training in Energy Demand from which he obtained his MRes in Energy Demand Studies. In 2011 he joined the UCL Chemical Engineering department for a PhD degree in collaboration with the UCL Energy Institute. In 2015 Alexandros passed his PhD viva on the topic: "System Modelling and Optimisation Studies of Fuel Cell based micro-CHP for Residential Energy Demand Reduction". Alexandros is now working as an Energy Analyst at the National Technical University of Athens.

Joynal Abedin
PhD, Loughborough University

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Joynal is an Electronic Engineer by professional training and has substantial industrial Research & Development experience. He was awarded a prestigious industrial sponsorship by Thorn EMI Electronics Defence Group (now Thales) and studied MEng & BEng (Hons) degrees in Electronic and Electrical Engineering. He completed a two year IEE accredited post- graduate industrial training programme at Thales. Joynal has over eight years industrial R&D experience and held senior design engineer posts at Marconi Communications and Filtronic Comtek. Joynal has completed a Master of Research (MRes) degree in Energy Demand Studies at Loughborough University. Joynal's PhD research project title is 'Thermal Energy Storage in Domestic Buildings: A study of the benefits and impacts', and his research interests include short-term thermal energy storage technologies, building energy modelling & simulation, Demand side management and thermal energy storage materials.

Carrie Behar (PhD, UCL)
Senior Sustainability Consultant, Useful Simple Projects

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I completed my PhD in spring 2016 and am currently working as a Senior Sustainability Consultant at Useful Simple Projects. We are a group of sustainability professionals providing strategic and technical consultancy services for the built environment. I enjoy the challenge of working across a broad set of environmental, social and economic themes on projects ranging from developing corporate sustainability strategies for well-known brands, to reviewing sustainable development opportunities for exciting new infrastructure and construction projects.

I also teach a module on Post Occupancy Evaluation for the MSc Environmental Design and Engineering course at UCL and am visiting sustainable design tutor on a number of university courses.

Francesco Babich
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Francesco is currently working as Senior Researcher at EURAC Research within the Energy Efficient Group (Renewable Energy Institute) and is about to complete his PhD at Loughborough University. During the last two years, he worked also as University Teacher at Loughborough University His field of interest is numerical modelling, including CFD, human thermal regulation and dynamic thermal modelling, and measurement techniques that are used to validated the models. Alongside his research activity, Francesco organized the second LoLo student-led conference, which had over 100 registered participants mainly from UK universities, is working as a University Teacher mainly in Investment Appraisal.

Previously, Francesco studied at the University of Trieste (Italy), where he obtained his Bachelor and Master Degree in Building Engineering. Having completed his Master, he was allowed to take the exam for the professional engineer license in July 2012 in Italy. He worked as an engineer and as a project manager for one year and half in Italy and Germany before joining LoLo in September 2013. He completed with distinction his MRes in September 2014.

Thermal comfort in non-uniform environments: real-time coupled CFD and human thermal-regulation modelling and validation

Mechanical systems such as built-in air conditioning consume a lot of energy because they cool down quite evenly the entire space. On the other hand, personalised systems such as air movement generated by a fan in warm environment improve occupants' thermal comfort while using less energy, but generate transient and asymmetrical environments. Traditional thermal comfort models (PMV-PPD, adaptive) have limited use for complex transient and asymmetrical conditions. A more advanced model, such as the IESD-Fiala model, may provide with better results. The IESD-Fiala model has been successfully and entirely coupled with a CFD code. This research aims to test and validate the coupled model.This research project includes field studies, computer based modelling and thermal chamber studies, and it is linked with a wider project that involves Loughborough University (UK), University of California Berkeley (USA), CEPT University Ahmedabad (India) and De Montfort University (UK), allowing for wider application of the developed models.

Arash Beizaee (PhD, Loughborough University)
Research Associate (DEFACTO Project), Loughborough University
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Arash graduated as a mechanical engineer in Iran and then continued his studies in the UK to obtain MSc in Building Services Engineering (with distinction) from Loughborough University. He joined LoLo CDT in 2011 and completed MRes in Energy Demand Studies (with distinction) before starting his PhD in 2012.

Arash is now working as a research associate on the DEFACTO research project at Loughborough University. DEFACTO is a 6 year interdisciplinary project started in 2012. The project examines the way that hundreds of households heat their homes and how the use of digital control enables reduction of energy use.

Nafsika Drosou
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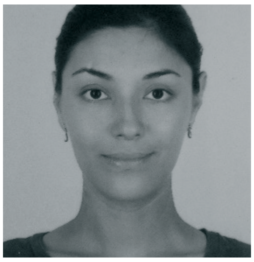

With a Civil Engineering background (University of the Philippines 2003, DMC Inc. scholarship) and diverse work experience, Nafsika completed an MSc in Low Carbon Building Design & Modelling at Loughborough University in 2010. Her dissertation employed simulation tools to examine the trade-off between visual and thermal comfort in a vernacular education building. She then joined Portsmouth University, School of Architecture, as a Research Assistant for SILCS (Strategies for Innovative Low Carbon Settlements) an EU Interreg IVC project. Returning to Loughborough University, she completed the MRes in Energy Demand Studies in 2013, with a dissertation project investigating IAQ compliance of refurbishment designs for a Victorian classroom, through CFD modelling.

Assessing actual daylighting performance of classrooms in use

Daylight is a non-depleting energy source with the potential to reduce lighting energy and contribute to the health and wellbeing of building occupants. The latest daylight design regulations for UK school buildings employed the new Climate Based Daylight Modelling (CBDM) metrics to specify daylight compliance, instead of using the traditionally and internationally used metric. However, knowledge that will allow assessing whether this move improves the daylighting performance of classroom designs is sparse. The project at hand addresses this gap by providing evidence of the visual needs, the user behaviour (electric light and blind use) and the subsequent operational daylighting performance from the day-to-day reality of four modern learning environments. A mixed method research approach associates the measured quantitative parameters with users' subjective views, revealing the underlying reasoning of observed behavioural responses and enabling an estimation of the potential held within daylight specifications and metrics to shape operational daylighting performance.

Özlem Duran
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After Özlem held her undergraduate degree in architecture, she worked in various design and construction companies in Istanbul, such as Arup. In 2007, she started MSc. in Istanbul Technical University (ITU), and completed her dissertation in the Applied Sciences University of Stuttgart (HFT) where she worked as a researcher later on. Currently, she is studying at Loughborough University as a member of LoLo CDT where she completed MRes in 2013 and writing up her PhD. She is also a part-time lecturer in Architectural Technologies at Nottingham Trent University.

Optimised retrofit strategies for post-war office buildings (continued)

Optimised retrofit strategies for post-war office buildings

The aim of the project is to optimize the retrofit process of post-war non-domestic modernist buildings focusing specifically on office buildings, by applying dynamic energy simulations to typical building model that represent this defined building stock.

Multiple combinations of energy saving refurbishment measures were applied to representative models of post-war office buildings. Based on energy consumption, thermal comfort and costs, a range of heating and cooling refurbishment features were evaluated under a parameter study. The initial evaluation shows that although retrofitted post-war offices with high insulation consume negligible amounts of heating energy, thermal comfort could only be provided by additional active cooling in future weather conditions as a result of over-heating which results in higher costs and lower greenhouse gas reductions.

Mike Fell (PhD, UCL)
Research Associate, Buildings (Domestic Energy & Behaviour), UCL Energy Institute

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Mike Fell researches the public acceptability of domestic demand-side response (DSR).

Prior to joining the London-Loughborough CDT Mike was the energy commissioning editor at Earthscan (a leading publisher of books and journals in sustainability). He graduated from the University of Southampton in 2004 with a BSc in Marine Science with French.

Mike has a keen interest in research/policy engagement, and regularly organize events bringing academics and policymakers together. From March to June 2013 he undertook a POST/EPSRC Fellowship in the House of Commons Library, briefing Members of Parliament on subjects in science and the environment.

Together with colleagues Mike also set up and coordinates the UCL-Energy Social Sciences Group which aims to bring together researchers across UCL with an interest in people and energy. After finishing his PhD Mike is now back at UCL Energy Institute, working as a research associate at the RCUK Centre for Energy Epidemiology. His focus is on behaviour and energy use in homes.

Louis Fifield (PhD, Loughborough University)

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Louis Fifield is a mechanical engineering graduate from the University of Manchester. He completed his final year project on hospital energy consumption and saw the CDT as way to further his interest in on the topic.

Being one of the first cohorts on the program he enjoyed completing an MSc in Low carbon building design and modeling where his research focused on monitoring Leicester city's urban heat island.

Louis has just passed his PhD viva with corrections, his project combined his interest in hospitals and monitoring to carry out an investigation of energy consumption in UK hospital buildings.

Stephanie Gauthier (PhD, UCL)
Lecturer in Energy and Buildings, University of Southampton

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Dr Stephanie Gauthier is Lecturer in Energy and Buildings within Engineering and the Environment at the University of Southampton.

Stephanie Gauthier is a lecturer in Energy and Buildings within the Faculty of Engineering and the Environment. Her degree and diploma were in Architecture followed by an MSc in Environmental Design and Engineering from UCL. Her PhD developed a new method to assess human thermal comfort using ubiquitous sensors, and introduced an extended model of behavioural responses to cold thermal discomfort.

Stephanie has over eight years of consultancy experience mostly focused in building and infrastructure, working at Arup, HOK, Atkins and ADPi. As an architect and project manager in multi-disciplinary design teams, she has collaborated on schemes in Abu Dhabi, UK, France and China; including the Oriental Art Center in Shanghai, the King Alfred Development in association with Gehry Partners, BSkyB broadcast center in London and Abu Dhabi National Stadium.

Virginia Gori
Research Associate, UCL

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Virginia is a Research Associate in the physical characterisation of buildings at the RCUK Centre for Energy Epidemiology (UCL Energy Institute) and part of the Physical Characterisation of Buildings group. Her PhD thesis, entitled "A novel method for the estimation of thermophysical properties of walls from short and seasonal-independent insitu surveys", combined Bayesian statistics, building physics and physical monitoring of insitu buildings to evaluate the thermophysical performance of building elements. The method developed showed the ability to provide robust estimates of the thermophysical properties of building elements using shorter monitoring campaigns than the incumbent method and collected at all times of the year.

Virginia has a keen interest in exploring the thermal performance of buildings by means of monitoring campaigns, building physics, modelling and data analysis. Virginia's research interests build on her engineering background, her MRes in energy demand studies, and previous research on the energy demand of urban neighbourhoods.

Sven Hallin (PhD, Loughborough University)

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I originally qualified with an Economics degree at Trinity College Dublin and on completion joined a UK multinational and was trained in the development and manufacture of a variety of surface coatings. After originally working in the UK, I then worked as an expatriate in Africa and the Far East before returning to the UK and starting my own manufacturing business specialising in the production of screen printing ink. This business was sold after eighteen years, and after a short period of retirement I undertook an MSc in Real Estate at Nottingham Trent University which was completed in 2010.

After completing a MRes in Energy Demand Studies in 2012, my PhD project entitled "Reducing residential sector dependence on fossil fuels: a study of motivating factors" was completed in 2015.

Currently, along with my supervisors, Professor Thomas Weyman-Jones and Dr Elizabeth Hooper, I have been working on a research paper entitled "Why the Green Deal failed: Case Study evidence and behavioural analysis." I'm also involved in some non-academic writing projects, specifically a second novel (which so far is around one third complete). I have also written a number of short stories. However, I am keen to have the opportunity at some time in the future to do some further academic research as a counterbalance to my interest in writing popular fiction.

Richard Jack (PhD, Loughborough University)
Energy Solutions Engineer, Willmott Dixon Energy Services Limited

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I completed my PhD in 2015, having had a (mostly) fun and enlightening time in Lolo. Completing a PhD is necessarily an introspective process at times, but being a part of the Lolo really helped me to keep an outward-looking perspective which helped to make my work more relevant to others and generally made life more interesting.

After completing my PhD I worked as a research associate at Loughborough University for a year, and then moved to Willmott Dixon Energy Services as an energy solutions engineer in March 2015. I specialise in performance measurement and assessment of buildings and building systems, and continue to apply the research that I completed during my time in Lolo.

Paula Morgenstern (PhD, UCL)
Building Performance Manager, BAM Construct UK
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I completed my PhD in summer 2016 and am now working as Building Performance Manager at BAM Construct UK. We are a company handling all aspects of the building lifecycle, i.e design, construction, FM and property development.

My role involves implementing a process for post occupancy evaluation within all our projects, so that experiences from past projects can be used to improve the performance of future buildings – for the occupants, the client and the environment.

Ashley Morton
PhD, Loughborough University
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Ashley has a background in Chemistry and Energy after completing a MChem (with industrial experience) and an MSc at Heriot Watt University. She joined the LoLo CDT in 2011.

For her Master's Ashley has undertaken dissertations in computational chemistry (MChem), fuel poverty (MSc) and temperature variation in homes (MRes). In 2012 she joined the EPSRC funded DEFACTO: Digital Energy Feedback and Control Technology Optimisation project to undertake her PhD. She submitted her thesis "Heating use in UK homes" for examination at the start of Oct 2016. Currently Ashley is working as the Cohort Interaction Research Associate on the DEFACTO project.

Heating use in UK homes

The aim was to examine household space heating use and to identify the reasons behind heating use in homes. Two main investigations were carried out to understand and identify the how, what and why with regards to heating use. The first investigation being a qualitative focused study on how people currently use their heating within their home and the reasons behind such heating practices. A new taxonomy of heating characters relating to heating use drivers was then developed. The second investigation was a small scale monitoring study of homes for ten months after new heating controls were installed. A mixed method approach was taken to uncover what people did with their heating, how they interacted with the controls, the reasons why they did what they did and the evolution of use through seasonal shifts. The benefits of adopting mixed method approaches within heating use research are also presented.

Moira Nicholson
PhD, UCL
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Moira has recently submitted her PhD thesis on consumer participation in demand-side response. She now works in the Behavioural Insights Unit at Ofgem.

Using behavioural science to increase consumer adoption of time of use electricity tariffs: evidence from survey and field experiments

A challenge for realising the benefits of smart meters, promoting energy security and decarbonising electricity is encouraging domestic consumers to switch from flat-rate electricity tariffs to a new generation of time of use (TOU) tariffs. In a marked departure from the existing literature, this thesis argues that opt-out enrolment (a type of 'nudge') is unlikely to be a suitable method of recruiting consumers onto TOU tariffs, even though it could achieve almost universal enrolment.

(Continued)

The first study shows that half of British energy consumers are unable to make informed choices about the cost-effective tariff for them, particularly those in low socio-economic grades. Consumers are therefore unlikely to opt-out of being switched onto a TOU tariff, even when unsuitable.
Results from three further studies covering a collective sample size of 16,000 participants, show that tailoring the marketing of TOU tariffs towards electric vehicle (EV) owners increases demand for TOUs amongst EV owners whilst reducing demand amongst non-EV owners, who pose less of a burden to the electricity network and are less likely to save money from switching. Unlike opt-out enrolment, tailored marketing is an 'effective and selective' nudge (Johnson, 2016). Unlike personalised defaults, tailored marketing can achieve informed consent.
The results have implications for multiple 'smart' energy programmes, from signing up to TOU tariffs or direct load control contracts to participating in vehicle-to-grid services. In each case, a decision will need to be made about whether consumers will be left to opt-in or opt-out of such services, and to what extent it matters that consent is informed.

Jenny Love (PhD, UCL)
Research Associate, Energy & Buildings, UCL Energy Institute

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Prior to her appointment as a Research Associate, Jenny worked for two years as a Consultant at Element Energy, a low carbon energy consultancy carrying out rigorous mathematical analysis to help provide a sound evidence base for clients to make decisions on low carbon strategy. Jenny was hired as a built environment specialist and carried out modelling and analysis for clients including DECC, the CCC, energy companies and charities. Example projects included: creation of a dynamic model of a micro-CHP system interacting with a house, zonal simulation of different heating systems in a historic palace to protect the building without a high energy penalty and technoeconomic modelling of the integration of heat pumps in district heating networks.

Jenny's training in the field of energy demand came from her PhD at the LoLo Centre for energy demand reduction in the built environment, where she studied how energy efficient building retrofit might change occupants' heating behaviour. Her work focussed on integrating technical evidence from sensors and social data from occupants to discern how increase in internal temperature comes about when homes are retrofitted. She was able to challenge the conventional physics-based and economic approaches to retrofit, proposing a socio-technical approach instead. Jenny holds an MSc in Environmental Design and Engineering at UCL and a Physics degree at the University of Oxford. Between these courses she spent a year volunteering with a Christian Organisation.

Argyris Oraiopoulos
PhD, Loughborough University

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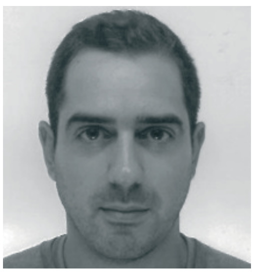

Argyris joined the LoLo CDT in 2012 where he completed his MRes on Energy Demand and his PhD on the development of an empirical model that is able to predict overheating in UK homes using descriptive time series analysis. He then worked as a Research Associate at Loughborough University looking at urban scale energy modelling. Currently he is employed as a Research Officer at the Association for the Conservation of Energy (ACE) working on energy policy.

Argyris' research interests include:

Overheating (criteria & predictions); Time Series Analysis & Empirical Modelling; Dynamic Thermal Simulation Modelling; Occupant Behaviour & Attitudes; Energy Policy; Public Engagement & Education (STEM & EWB Ambassador)

Sofie Pelsmakers (PhD, UCL)

Lecturer, University of Sheffield

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I am an architect and environmental designer with more than a decade of hands-on experience designing, building and teaching sustainable architecture, including at the University of East London where I lead a masters programme in sustainable design. I finished my doctoral research at the Bartlett, UCL's faculty of the Built Environment, where I also lead a low energy housing retrofit module. I now co-lead the MSc Sustainable Architecture Studies with Aidan Hoggard. My PhD was titled "Pre-1919 suspended timber ground floors in the UK: estimating in-situ U-values and heat loss reduction potential of interventions" and I currently undertake research and consultancy in this area.I am co-founder of Architecture for Change, a not-for-profit environmental building organisation and author of The Environmental Design Pocketbook. Alongside my research interests, I am interested in environmental context as a generator of architectural design.

Daniel Quiggin (PhD, Loughborough University)

Renewable energy analyst, Investec Asset Management

Daniel.Quiggin@Investecmail.com

My PhD covered supply-demand modelling of future energy scenarios and the quantification of household demand adaptations via demand side management. Energy demand research is difficult because its the interplay between economics, people, technology, social norms and buildings.

LoLo students benefit from the diverse research interests of the teach staff and PhD students alike.

My background is in Particle Physics, holding a Masters of Physics and moved into his current area of research via a Research Masters in Earth System Science.

Currently I model and analyse global supply – demand of renewable energy technologies for a Commodities and Resources team of an asset management group to inform the investment strategies of the groups funds.

Ella Quigley

(PhD, Loughborough University)

E.S.Quigley@lboro.ac.uk

I have a background in mechanical engineering but I have long been interested in building energy use and sustainability. This led me to join the LoLo CDT at Loughborough University, where I undertook an MSc in Low Carbon Building Design and Modelling, followed by a PhD concerning the energy and thermal performance of steel modular residential buildings in the UK.

I completed my PhD in August 2016; I am currently writing research papers about energy use and overheating in my case study buildings, and beginning to look for an interesting career in building performance and sustainability.

Ed Sharp (PhD, UCL)
Research Associate: Spatiotemporal Energy Modelling, UCL Energy Institute

ed.sharp@ucl.ac.uk

I am a geospatialist and energy modelller researching the spatio-temporal variation of renewable weather driven supply, domestic energy demand, non domestic stock models and air pollution in Great Britain. My overall aim is to improve aggregated scenario modelling by introducing spatial and temporal variation at a fine resolution using knowledge and methods from data science, GIScience and industry.

Examples of recent work I have done as part of my PhD and elsewhere can be seen on my blog at esenergyvis.wordpress.com.

Kate Simpson
PhD, Loughborough University

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Kate recently submitted her PhD thesis; a mixed methods study aiming to identify whether energy-efficiency refurbishment of UK owner-occupied homes were successful from the householders' perspective, and according to physical measurements. Following this study, Kate has been granted funding from the Association of Colleges to undertake a study titled 'Energy-efficiency refurbishment of UK homes: The installers' perspective, from which she hopes to gain industry reflections on the thesis results. These findings are intended to inform policy, training within Colleges and further research on post-occupancy evaluation following domestic refurbishment. In addition, Kate recently started a literature review on the health impacts of alternative construction materials for Smart Shelter Research. During the thesis write-up stage she undertook a 12 month internship with the research team at the Centre for Sustainable Energy where she worked on a number of valuable qualitative and quantitative projects. Kate's background is in Building Surveying, and 'traditional' building maintenance and refurbishment, which has informed her recent teaching on a HNC in Construction and the Built Environment, for part-time students working in industry (from whom she is learning a lot!), at the University Centre of North Lindsey College, Scunthorpe.

Sam Stamp (PhD, UCL)
Teaching Fellow in Building Performance, UCL Institute for Environmental Design & Engineering

samuel.stamp@ucl.ac.uk

Sam completed a four-year MSci in Physics at the University of Bristol in 2009, including a thesis exploring the potential for small-scale tidal stream technologies.

This work on small-scale energy generation led to a position at LIRE, the Lao Institute for Renewable Energy, in Southeast Asia. Work here focused on delivering a demonstration project to provide off-grid electricity, through pico-hydro generators, to remote villages in Laos.

Sam returned to the UK in 2010 to undertake a Masters in Energy Demand. Having submitted his PhD in September 2015, Sam has now started to work as a Teaching Fellow in Building Performance at the UCL Institute for Environmental Design and Engineering.

Vicki Tink
PhD, Loughborough University
v.tink2@lboro.ac.uk

Vicki is a researcher currently writing up her doctoral thesis. Prior to her doctorate she completed the Master of Research in Energy Demand Studies. Her background is as a technologist, graduating in 2011 from Loughborough University with a degree in Product Design Technology BSc. Vicki's research interests are centred around domestic buildings, in particular those in need of renovation to make them more energy efficient. She is also interested in the design and manufacture of building components; overheating in energy efficient dwellings; collection of measurements from dwellings; and the improvement of simple modelling techniques (e.g SAP) to inform decision making.

The effect of internal wall insulation in solid wall dwellings on energy demand, thermal comfort and overheating

Approximately 30% of the UK's housing stock is comprised of older, solid wall buildings. These buildings are expensive to heat, inefficient and can be uncomfortable for occupants throughout the winter. Solid wall buildings can be made more energy efficient and winter thermal comfort can be improved by the installation of internal wall insulation (IWI). However, there are concerns that IWI could lead to overheating in the summer.

Through the course of this doctoral research Vicki had sole access to a unique facility comprised of a matched pair of solid wall semi-detached houses. The houses were characterised (co-heating test, airtightness test, U-value measurements) and monitored (continuous measurement of thermal comfort parameters and energy consumption) both before and after the left house was retrofitted with IWI. The outcome of this research is empirical evidence into the debate over whether IWI is an appropriate retrofit technique to provide comfortable and energy efficient dwellings.

Faye Wade (PhD, UCL)
Career Development Fellow in Energy & Society, University of Edinburgh
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Faye Wade is a PhD researcher, adopting in-depth qualitative methods, including semi-structured interviews and observation, to explore the installation of domestic central heating systems. Aside from her PhD, Faye has gained experience in applying qualitative methods and social theories during short- term projects, including the use of focus groups and interviews to investigate residents' experiences of fuel poverty. Prior to the PhD, Faye completed a Master's degree in energy demand studies as part of the London-Loughborough EPSRC Centre for Doctoral Training, and a master's degree in chemistry at the University of York. Faye has just accepted a position at the University of Edinburgh as a Career Development Fellow in Energy and Society, in the Department of Science, Technology and Innovation Studies.

Peter Warren (PhD, UCL)
Senior Scientific Officer – Technical Energy Analysis, Department for Business, Energy & Industrial Strategy
Peter.Warren@beis.gov.uk

Peter completed his PhD on the mechanisms behind the success and failure of global energy efficiency and demand response policies. The PhD covered 30 countries, 36 sub-national states and 12 different types of demand-side policy. He worked at the IEA in the energy efficiency unit whilst finishing his PhD, and now works in the UK's Department of Energy and Climate Change.

Peter enjoyed his experience in the LoLo centre, particularly the multi-disciplinary nature of the course and regular access to energy experts from a range of disciplinary backgrounds.

In October 2015 Peter joined the Department of Energy and Climate Change (DECC) as a Senior Scientific Officer – Technical Energy Analysis, now the Department for Business, Energy and Industrial Strategy.

Selin Yilmaz
PhD, Loughborough University
S.Yilmaz@lboro.ac.uk

Selin's research aims to develop a high resolution residential electricity demand model to provide insights into the amount of flexible demand that can be available for shifting in the UK residential sector. She has MSc on Renewable Energy Science and Technology from Ecole Polytechnique in France where she worked on organic photovoltaics. She has graduated from the Chemical Engineering Department from Middle East Technical University in Turkey.

Household Appliance Usage model to quantify the demand response potential in the UK residential sector

My research develops a novel modelling framework of bottom-up stochastic model that is able to generate realistic electricity demand profiles for domestic appliance use that are based on measured data. The aim is to use the model to provide insights into the amount of flexible demand that can be available for shifting, when aggregated across a number of homes. The results of the model were analysed to address the key findings and challenges in modelling high-resolution electricity demand from measured data. It is shown that the model realistically reproduces electricity demand profiles for a large number of households. Finally, amount of flexible load available provided by different households types and appliance types are shown.

Appendix: Posters

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ANNUAL COLLOQUIUM 2017

Design and control of mixed-mode cooling and ventilation in low energy residential buildings

Charalampos Angelopoulos 2nd year PhD Student [C.Angelopoulos@lboro.ac.uk]
1st supervisor: **Professor Malcolm J Cook**, Loughborough University UK
2nd supervisor: **Dr. Eftychia Spentzou**, Loughborough University UK
3rd supervisor: **Dr. Yash Shukla ,** CEPT University India

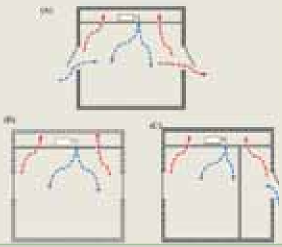
Introduction

Why this research now?

- Residential sector
  - 27% of total energy consumption in UK[1] and 50% in India[2]
  - Expected to increase x 8 by 2050 in India
- Exponential increase in floor space
  - Expected 500% increase by 2030[3] in India
- Higher comfort expectations
  - Economic growth
- Increased urbanization
  - x 3 current population in cities by 2030
- Future cooling strategies
  - Utilize natural ventilation/cooling to achieve long term sustainable growth

Mixed-mode buildings

- combine the benefits of natural ventilation with mechanical cooling[4]



Gaps in literature review

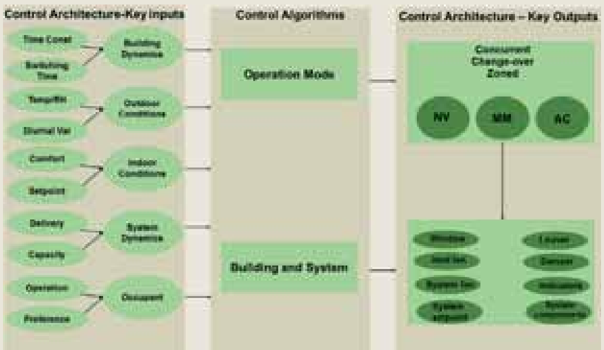
- Lack of knowledge on control of mixed-mode buildings
- Absence of studies focusing on residential mixed-mode buildings

Aim

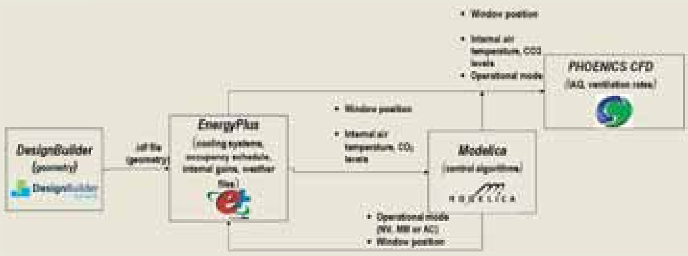
The aim of this research is to investigate the impact on thermal comfort and on energy savings of novel and sophisticated control algorithms in mixed-mode residential buildings in hot climates (i.e. India)

Methodology

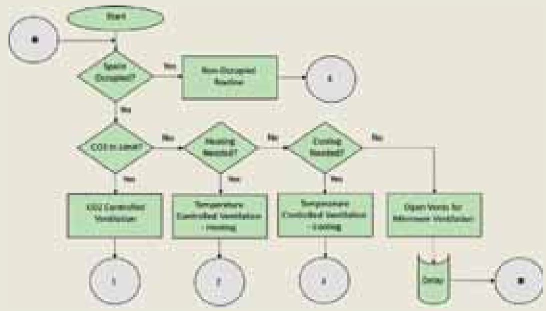
Control strategies for natural and mixed-mode ventilation



Simulation approach



Flexible control algorithms for low energy mixed mode buildings "Master Control Algorithm"

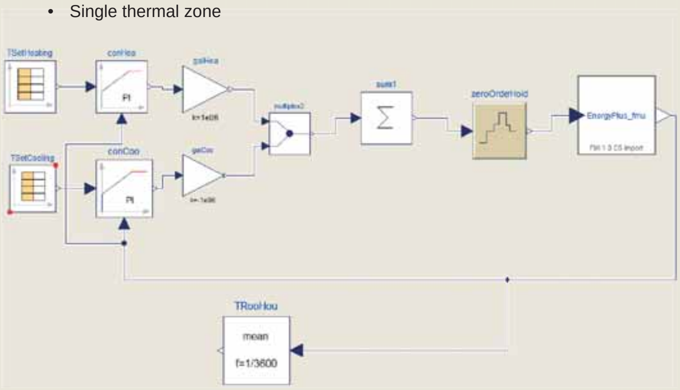


Demonstration case

- High rise residential apartment buildings
- Variety of climatic conditions
- Variety of low energy cooling technologies

Modelling

- Heating and cooling setpoints for HVAC system controlled by Modelica
- Single thermal zone



Anticipated Outcomes

The outcomes of this project will provide scientific evidence which will help to:

- Better understand the design and control of mixed-mode residential buildings
- Develop sophisticated control algorithms for mixed-mode residential buildings
- Quantify the energy saving potential of mixed-mode buildings by implementing the sophisticated control algorithms in predominately warm climates
- Validate the proposed control algorithms

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2. Kapoor, R., Deshmukh, A., & Lal, S. (2011). Strategy Roadmap for Net Zero Energy Building in India. USAID ECO-III Report. New Delhi, India: International Resource Group.
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4. Wouters, P., Heijmans, N., Delmotte, C. & Vandaele, L. (1999) Classification of hybrid ventilation concepts. In: The Second International Forum on Natural and Hybrid Ventilation, HybVent Forum. 1999 Sydney, Australia, The Second International Forum on Natural and Hybrid Ventilation, HybVent Forum. pp. 1–23

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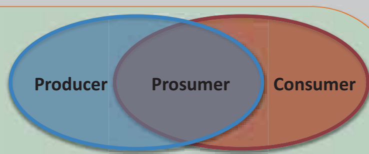
"Modelling of Integrated Community Energy Systems (ICES)"

Kostas Chasapis - 2nd Year PhD student
Supervisors: Prof. Kevin Lomas and Dr. David Allinson

Background:



Integrated Community Energy Systems (ICES) are:

- Multi-source local energy generation, distribution and storage system.
- Local community ownership and management.
- Governed by or for local people.
- Size: from a few households to an entire district.
- Participants are Prosumers instead of Consumers.

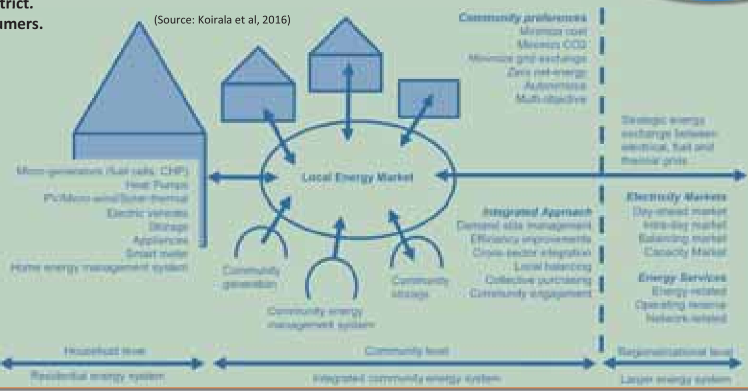
Purposes of ICES:

Create collective benefits for the Community:

- Reduced bills.
- Revenue generation.
- Investment opportunity.
- Community regeneration.

Advantages & Benefits of ICES:

- Energy efficiency.
- Use of local renewable energy.
- Improved energy security.
- Coordinated demand-side management.
- Initiation of green circular economy.
- Wealth retention within the community.
- Active engagement of people.



(Source: Koirala et al, 2016)

Aim:

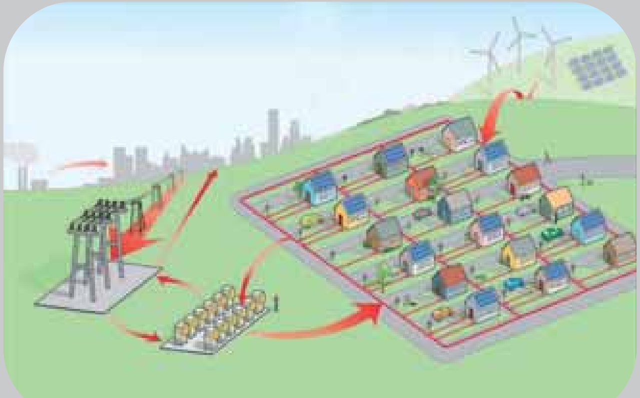
- Develop a modelling tool for the assessment of ICESs.
- Use the tool to compare new-build housing projects with existing neighbourhoods.

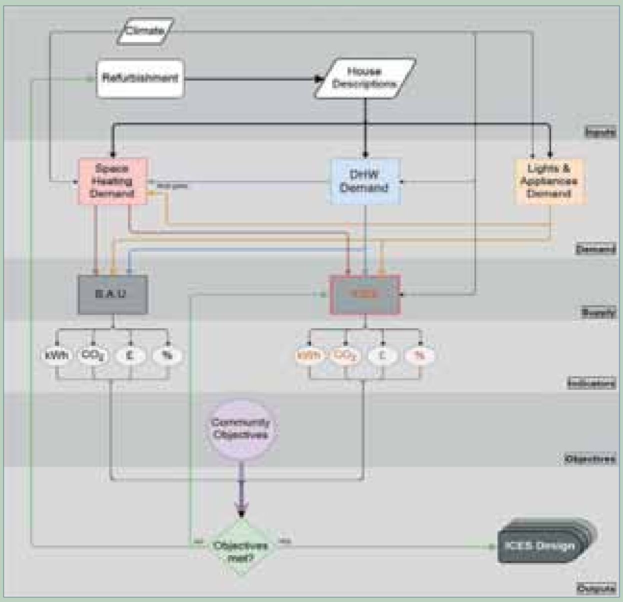
Research Question:

'Can ICESs be effectively modelled in a simple yet reliable way and the model be used to assess and compare the feasibility, performance and viability of new build developments against existing developments on the basis of achieving community objectives for energy, costs and emissions?'

Why this research?

- Increased need for methodological planning and analysis of ICES.
- Established analysis frameworks do not sufficiently capture the multi-domain value of ICES.
- To demonstrate quantitative evidence of the benefit of integrating energy systems.


(Source: sierraclub.org)



Methods:

- Literature review for ICES modeling approaches and assessment analyses.
- Modeling of ICES using the tool developed under this study.
- Verification of the tool's results.
- Application of the tool to existing and new-built neighbourhood case-studies.

Progress so far:

- Literature review.
- Development of a spreadsheet based on the Cambridge Housing Model as a scoping study.
- Calculation algorithms for heat and electricity demand estimation for the buildings within the community system.
- Assessment of energy demand reduction scenarios.
- Energy generation technologies. (under development)
- Cost estimation and cash flow analysis. (under development)

Anticipated Outcomes:

- Determine a set of key performance indicators that influence the ICES design.
- Find out how are the cases of existing neighbourhoods and new building developments differentiate the design of ICES.

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ANNUAL COLLOQUIUM 2017

Measurement of Ventilation in an Occupied Case Study Dwelling

Jessica Few MPhil Student
Supervisor: Dr. Cliff Elwell

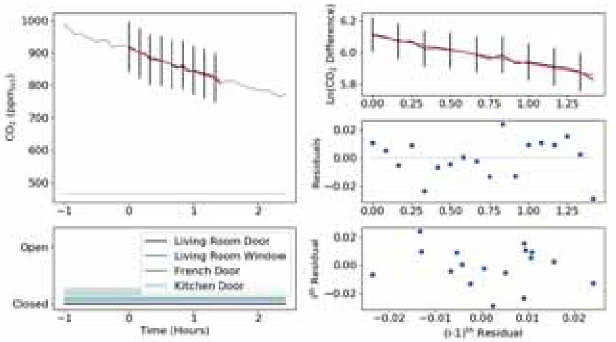
Reducing ventilation can reduce the energy use of a building, but ventilation is required for sufficient indoor air quality.

Regulatory Requirements

Part of the building regulations require adequate ventilation for the people present.
The simplest way to do this is to use trickle vents and mechanical extract fans.
The dwelling should have a ventilation rate of 0.5 Air Changes Per Hour (ACH).

Characterising Ventilation

1. Metabolically generated CO_2 was used as a tracer gas to estimate the ventilation rate.



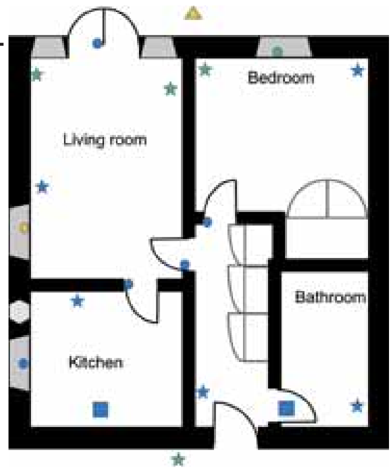
2. A 'rule of thumb' threshold of 1000 $ppm_{(V)}$ was used to indicate inadequate IAQ and inadequate ventilation.

3. A 'blower door' test was carried out to characterise the airtightness.

A Case Study Dwelling

An occupied ground-floor flat was monitored for two months.

The CO_2 concentration in each room was recorded, and open/closed sensors were placed on key windows and doors.



Dwelling floor plan.

Results

	Bedroom 	Living room 
Planned ventilation	None	Trickle vents, over required area
Overnight CO_2	> 4700 $ppm_{(V)}$	> 3000 $ppm_{(V)}$
Ventilation rate with doors and windows closed	0.09 ACH	0.23 ACH

- **Air permeability = 3.6 $m^3/hr.m^2$. This is fairly airtight in comparison to most dwellings of this type.**
- **76 different configurations of the doors and windows in the dwelling.**
- **Extremely low ventilation in a room with no planned ventilation in the configuration that the occupants sleep in.**
- **Clear differences between different rooms.**

Conclusions

Meeting the regulatory requirement in terms of the background ventilation provision does not guarantee adequate ventilation rates.

The estimated ventilation rates are observed different in different rooms. The distribution of sources of pollution and occupant time spent in different rooms means this is important to the exposure of the occupants.

Further work

Continued development of the CO_2 tracer gas decay method to estimate ventilation in occupied dwellings, recognizing the dynamic nature of ventilation and the influence the many influencing factors.

Greater appreciation of the role of the occupant in the ventilation realized in a dwelling.

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ANNUAL COLLOQUIUM 2017

Impact of data availability and model complexity on prediction of energy consumption in Camden schools

Duncan Grassie 1st year MPhil/PhD student, UCL
Supervisors: Prof. Dejan Mumovic, Dr. Ivan Korolija, Prof. Paul Ruyssevelt

Background

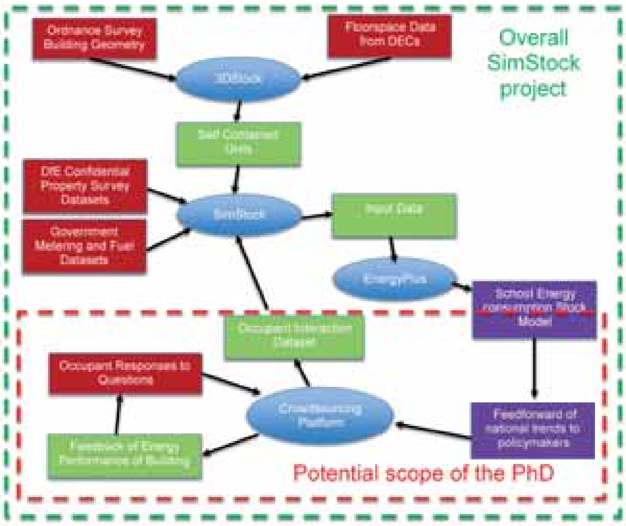
- Energy consumption in **non-domestic buildings** accounts for **18% of UK total emissions**
- **Schools** represent a sub-sector with **accessible datasets, similar energy end uses** with strong influence by government policy
- Previous methods used to model energy performance have been defined by two categories:
  - **Top-down** – **statistical analysis of large datasets** of measured energy consumption to determine correlation with other variables
  - **Bottom-up** – **building simulation** of energy **end-uses aggregated** based on detailed knowledge of building geometry, fabric and services
- **SimStock** - **National level energy simulation modelling** – recent development of automated functions to convert geometric and taxation data into models
- Previous studies have demonstrated a **gap between design and calculated energy performance** as well as **differences between similar buildings**
- **Aims** of this research project:
  - To identify **building simulation variables** essential for **predicting energy consumption on individual scale**
  - To develop **methods** which could be **scaled up** and **automated to build more than 22,000 school simulation models on a national scale**

Parameters of study

- **Three complex school campuses** selected in **Camden**
- **Display Energy Certificate (DEC)** data provide **annual measured electric and gas consumption**
- **Three cases** developed for each school increasing in complexity
- **Model** built in **EnergyPlus** based on:
  - **Geometry** generated using **SimStock/3DStock functions**
  - **Fabric** based on **archetypes** defined for **5 different eras**
  - **Occupant** variables based on government statistics

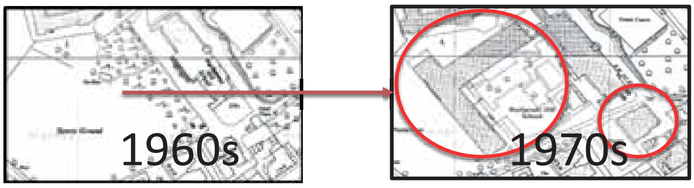
Future methods to be developed

- **Crowdsourcing** proposed for **feeding forward** of **individual occupancy** data on heating, lighting electrical appliance location, usage, setpoint, control
- **Feedback** of energy performance to occupants critical for achieving **buy-in**



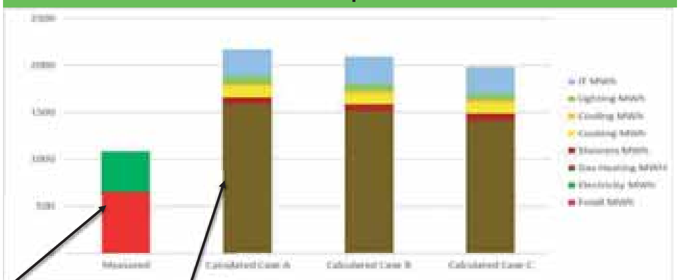
Automated methods used

Online map databases to define school building fabric by age using archetypes



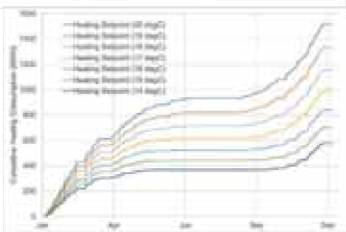
Glazing ratios calculated from images of individual school buildings

Essential variables required



Large discrepancy between **measured fossil fuel usage** and **calculated heating** in most cases.

Location as well as **heating setpoints and actual usage of controls by occupants** is essential for individual building detail



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Key Findings

Variables:

- The three cases demonstrated **discrepancies with floorspace recorded in DECs** and **differences between Lidar and actual building geometry**
- Archetypal approach is suitable for **pre-1995 buildings**, but **modern** buildings have a wide range of performances due to growth of **private financing**
- **Occupancy** data, particularly in **heating setpoints, locations and controls** are deemed to be more critical than corrections to **geometry** and **fabric**.

Methods:

- Methods which could be **automated** and **scaled up to construct simulation models for 20,000 UK schools** have been demonstrated.
- **Crowdsourcing** is proposed as a method for constructing **occupancy** datasets. **Feedback and feed forward** mechanisms will be investigated as a PhD.

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Centre for Doctoral Training in Energy Demand

ANNUAL COLLOQUIUM 2017

Forecasting summer overheating in dwellings with Time Series Analysis

Matej Gustin | 2nd year doctoral researcher, Loughborough University, email: M.Gustin@lboro.ac.uk

- **Aim of the forecasting model:**

  Short-term prediction of the impending risk of overheating and of the evolution of the internal air temperatures

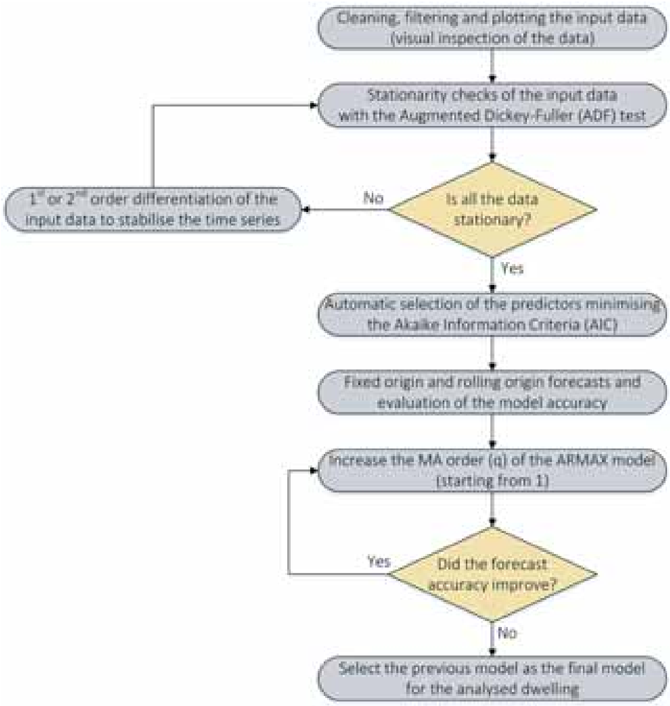
- **Required inputs for the forecasting Time Series Analysis model:**
  1. Observed past internal air temperatures
  2. Forecasted weather data (external air temperatures and solar radiation)
  3. Lag (no. of previous steps of data that are considered as predictors)
  4. Starting date and time of the training period (t_1)
  5. Ending/starting date and time of the training/validation period (t_2)
  6. Ending date and time of the validation period (t_3)

- **Order of the ARIMAX (p, d, q, e) model:**
  1. AutoRegressive order (p): no. of past observed values considered as predictors
  2. Integration order (d): adopted order of differentiation to make the series stationary
  3. Moving Average order (d): no. of past residuals considered as predictors
  4. eXogenous inputs (e): no. of external variables considered as predictors

- **Equation of the ARIMAX model:**

$T_{int}(t) = c +$	constant
$+ \phi_1 T_{int}(t-1) + \phi_2 T_{int}(t-2) + \dots + \phi_p T_{int}(t-p)$	AutoRegressive (AR) terms
$+ \alpha_1 T_{ext}(t-1) + \alpha_2 T_{ext}(t-2) + \dots + \alpha_i T_{ext}(t-i)$	eXogenous (X) terms
$+ \beta_1 SR(t-1) + \beta_2 SR(t-2) + \dots + \beta_i SR(t-i)$	eXogenous (X) terms
$+ \theta_1 e(t-1) + \theta_2 e(t-2) + \dots + \theta_q e(t-q)$	past residuals (MA) terms
$+ e(t)$	residual / error of the model

- **Model selection flowchart**

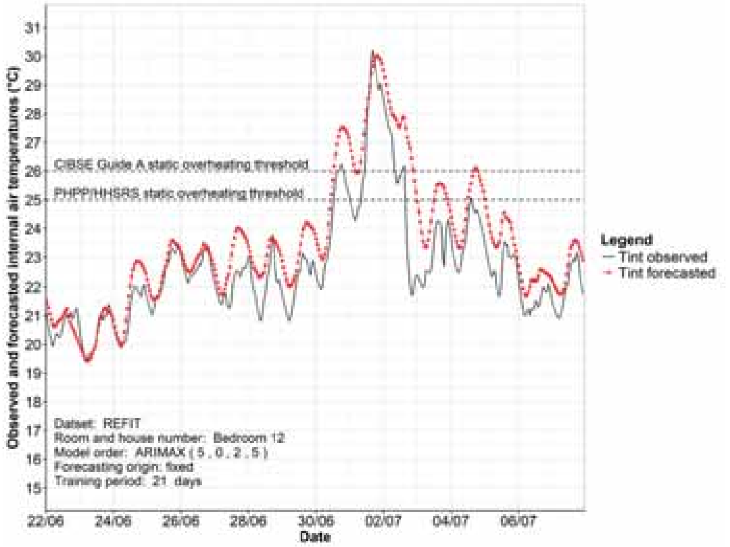


- **Evaluation of the accuracy of the model:**
  1. Scaled error metrics: MAE = 0.15-0.53°C, RMSE = 0.23-0.70°C
  2. Non-scaled error metrics: MAPE = 0.6-2.3%
  3. Error at the peak temperature: e_{Tmax}= +0.26°C (t+1) / -2.10°C (t+24) / -1.72 °C (t+72)
  4. Fit of the model: Adjusted R^2 = 85.0-98.8%
  5. Comparison of the observed and forecasted overheating hours:

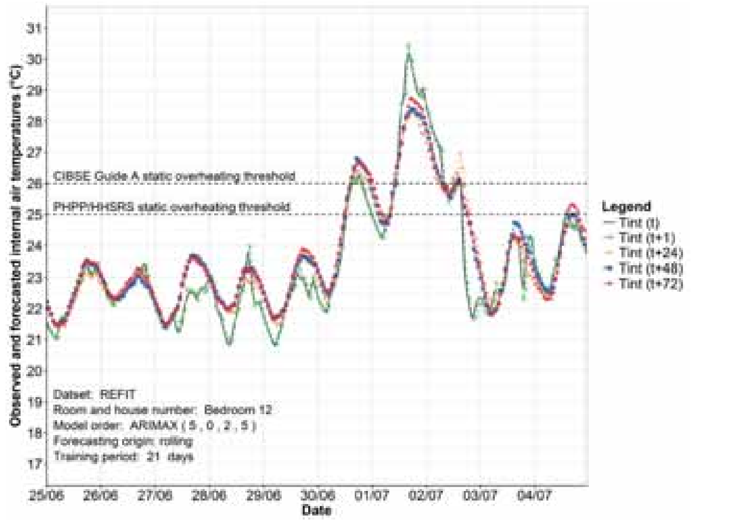
     a) PHPP/HHSRS (static threshold = 25 °C): observed = 43h / forecasted = 45-58h

     b) CIBSE Guide A (static threshold = 26 °C): observed = 27h / forecasted = 29-38h

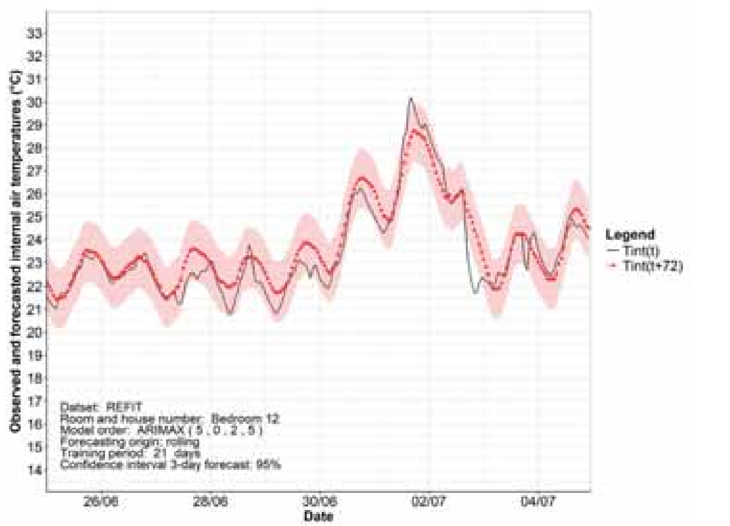
- **Fixed origin forecast – Heatwave 1 July 2015:**



- **Rolling origin forecast – Heatwave 1 July 2015 :**



- **95% confidence interval for the 3-day forecast – Heatwave 1 July 2015 :**



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ANNUAL COLLOQUIUM 2017

Flexibility in morning home heating times

Clare Hanmer Second year PhD clare.hanmer.15@ucl.ac.uk
Supervisors: Prof David Shipworth; Ms. Michelle Shipworth **Industrial Partner:** PassivSystems Ltd

Background

Understanding patterns of heating demand is important:

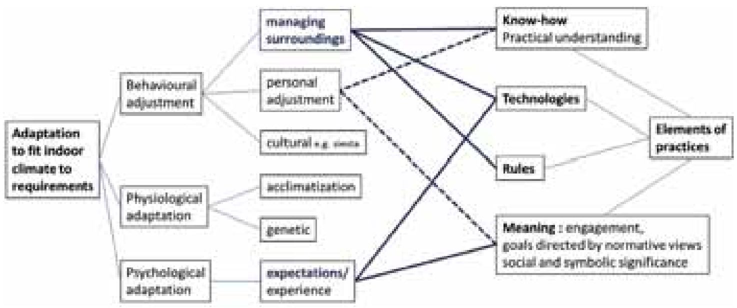
- What will the additional peak load on the electricity network be if electric heating (heat pumps) replaces gas boilers?
- Will low carbon heating be acceptable to users if operating patterns have to change (e.g. heat pumps run at night time)?
- How flexible is heating demand? Can it be used for Demand Side response?

Research question: What factors influence the degree of flexibility in home heating times?

Theoretical background

Drawing on two theoretical approaches

- **Adaptive thermal comfort**: what conditions do building occupants require, and what do they do to alter the thermal environment?
  - heating operation one of several adaptive options available
  - expectations shaped by physical context and constraints
- **Social practice theory**: energy as an element of multiple practices in the home
  - patterns of heating linked to wider social rhythms
  - how do practices change?
  - actions shaped by physical and social context



Conceptual framework linking two approaches

Research so far

Mixed methods investigation

- Data from heating controllers – what times is heating operated?
- Data from interviews – why it is operated at these times?

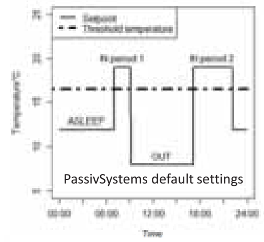
Pilot study

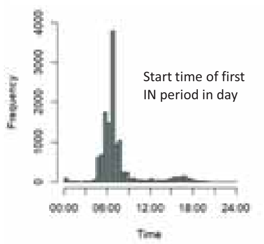
- Trial of new control algorithm with 12 households in PassivSystems Beta test group

Summary of findings

- Dislike of night-time boiler operation: overheating and noise
- Time settings linked to preferences of "sensitive" household member
- Many families choose to set a schedule which does not map exactly to occupancy patterns
- Some technically knowledgeable users running system close to lowest temperature household would tolerate.
- Shift working patterns affected heating settings in varying ways
- Most households had higher setpoint in evening than in morning
- In two homes residual heat from log burners used in evening affected central heating operation in morning

PassivSystems phone app





Future plans : FREEDOM case study

- Partnership of Wales and West Utilities, Western Power Distribution and PassivSystems Ltd aiming to investigate the network and consumer implications of the use of hybrid heat pumps. Funded under Ofgem's Network Innovation Allowance programme.
- Field trial of full sized combi boiler + air source heat pump in 75 homes in Bridgend, South Wales: mix of social and privately-owned housing.
- Running over 2017/18 heating season.
- Trials include running the system in a number of different modes.
- Change in heating system and operating modes provides opportunity to investigate flexibility and limits.
- Aiming to interview and follow through trial 15-20 households in total.
- Anonymised controller data for all participating homes.

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Developing new methods to estimate whole building heat loss

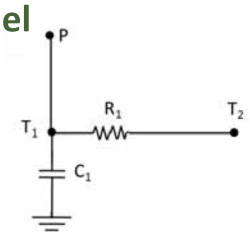
Frances Hollick UCL MPhil/PhD Student

Supervisors: Cliff Elwell & Bob Lowe

Sponsor: Fortem

- Knowledge of building heat loss is vital to assess progress towards efficiency and emissions reduction targets
- This work was part of a contribution to a common exercise of IEA EBC Annex 71
- Bayesian techniques are used for analysis
- The RC model here is very simple; models involving more parameters are being developed

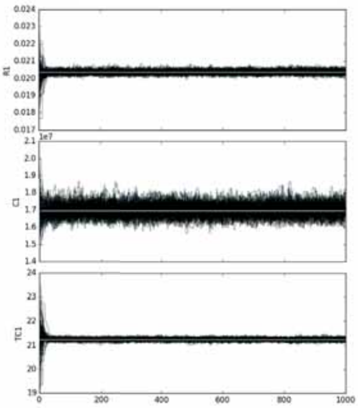
RC Model

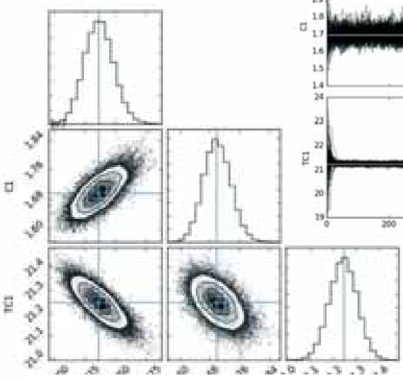


RC models are based on using the electrical analogy for heat transfer, with capacitances, C, representing effective thermal masses and resistances, R, thermal resistances.

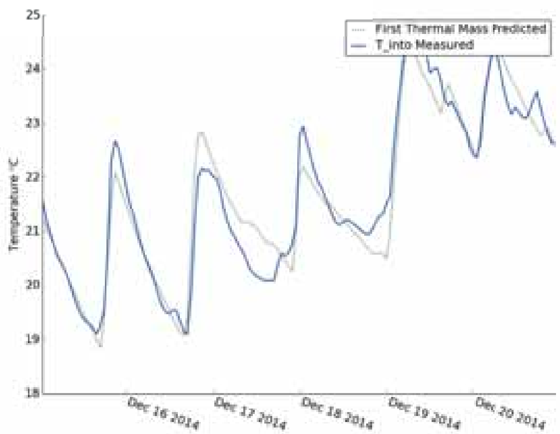
This analysis used an average internal temperature and the total electricity and gas use to estimate the R and C parameters using hourly data.

The HLC estimate obtained here is lower than that from the PTG method, which is to be expected as other sources of heat gains have not been accounted for in the analysis.





$$HLC = (44.7 \pm 1.2)\ WK^{-1}$$



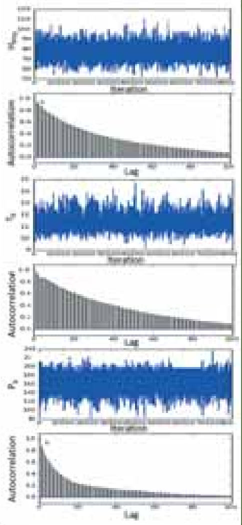
PTG Curve

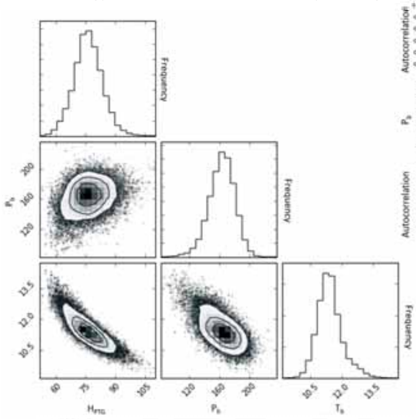
Power temperature gradient (PTG) curves are plots of power consumption against external temperature, which here have been fitted to the following equation:

$$P = \begin{cases} HLC(T_{bal} - T_{ext}) + P_{base} & for\ T_{ext} < T_{bal} \\ P_{base} & for\ T_{ext} \geq T_{bal} \end{cases}$$

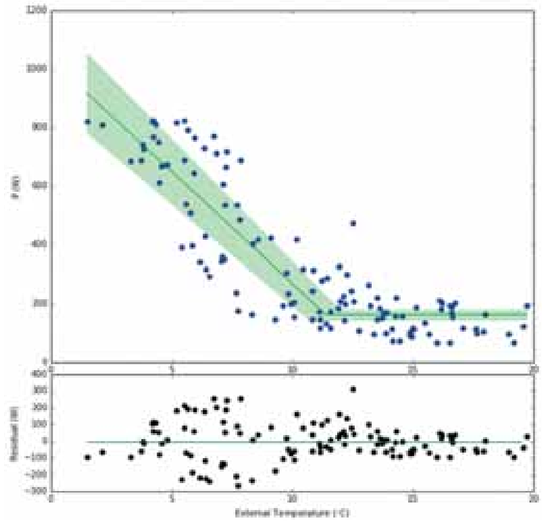
This analysis used weekly average gas use and external temperature to estimate the HLC (H_{PTG}), balance temperature (T_b) and baseline power use (P_b).

The value for the HLC is low, approximately passive house standard, which is what would be expected given the low energy construction of the case study building.





$$HLC = (71.1 \pm 7.0)\ WK^{-1}$$



Moving forward...

The aim of the PhD project is to develop a new method of assessing dwelling energy performance that has known uncertainties depending on the number of inputs. The RC model shown here will be expanded in order to achieve this.

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ANNUAL COLLOQUIUM 2017

Hygrothermal characterisation of brick walls and the impacts of internal wall insulation

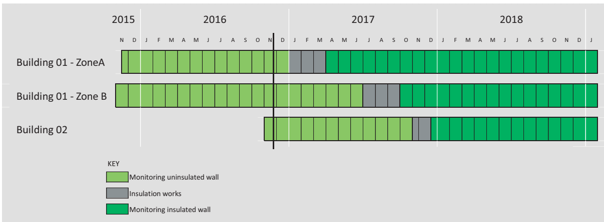
Lisa Iszatt 2nd Year PhD student (part time) **Supervisory team:** Cliff Elwell, Mike Davies, Neil May

Background

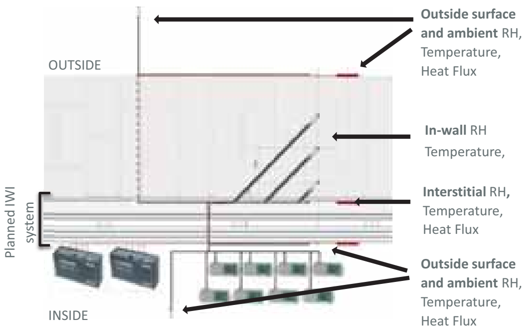
- Existing buildings account for approximately 40% of UK energy demand
- Internal wall insulation (IWI) may contribute significantly to reducing this demand
- IWI changes temperature and moisture profiles of walls → potential unintended consequences: structural damage & health risks due to mould
- High resolution in-situ monitoring of solid walls before and after IWI is rare, and there are opportunities for developing measurement and analysis techniques

Monitoring Campaigns

PROGRAMME OF MONITORING AND IWI INSTALLATION, 3 WALLS

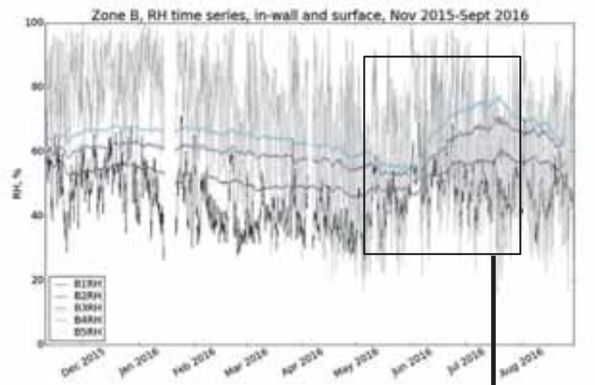


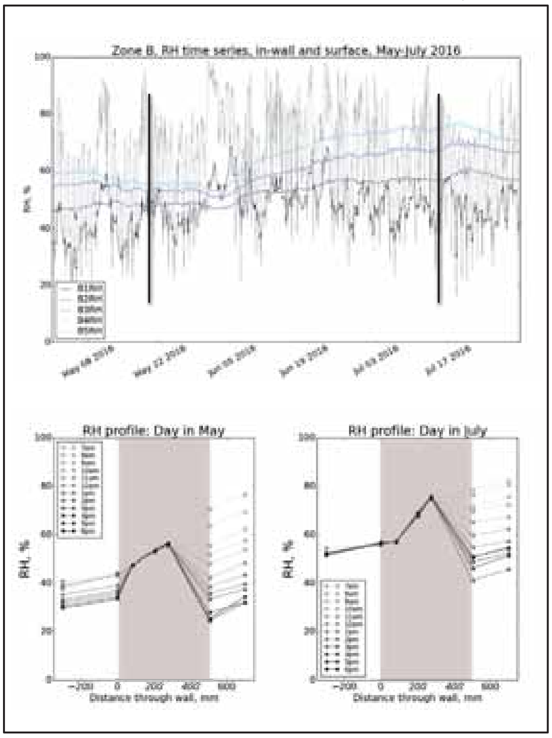
PLAN DIAGRAM



PHOTOS OF SET UP

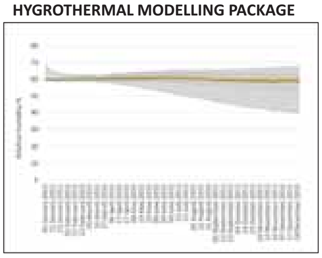
Initial results



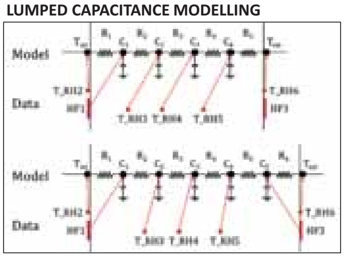


Future work

HYGROTHERMAL MODELLING PACKAGE



LUMPED CAPACITANCE MODELLING



ASSESSING MEASUREMENT TECHNIQUE

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Investigating the in-situ thermal performance of loft insulation in cold-pitched roofs

Suneina Jangra, 1st year PhD, UCL Energy Institute
Supervisory team: Dr Cliff Elwell & Prof Bob Lowe
suneina.jangra.16@ucl.ac.uk

HIGHLIGHTS

- The case-study roof has a **better than expected thermal resistance** (lower U-values) at each monitored location and across the whole loft area
- If additional insulation was installed in the case-study loft, **the payback period and potential carbon savings would be worse than expected** under standard assumptions
- Insulation defects caused by occupant intervention and installation issues result in cold spots and heat loss into the loft cavity

CONTEXT & MOTIVATION

- Loft insulation is one of the most common household energy efficiency upgrades but the expected energy and cost savings are not always realised in practice[1,2]
- Incorrect assumptions about the impact of energy efficiency upgrades can lead to misinformed energy demand policy
- Measured data is needed to improve the accuracy of thermal performance estimates and reduce uncertainty in models[3]
- There is little evidence to confirm that the in-situ thermal performance of loft insulation is in line with the expected performance under literature-based and design assumptions

RESEARCH QUESTIONS

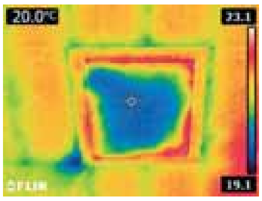
- How big is the **performance difference** between the actual and expected in-situ thermal performance of the loft insulation in the case study?
- How do workmanship and occupancy (storage and access) affect heat flow through and around the loft cavity in the case study?

METHODS & ANALYSIS

- In-situ U-value estimates using **measured heat flux and temperature data** (BS ISO 9869-1:2014) from a case-study dwelling
- Design U-value estimates based on standard assumptions about the thermal conductivity of building materials (BS EN ISO 6946:2007)

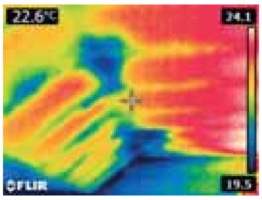
SITE SURVEY

INFRARED THERMOGRAPHIC SURVEY



Cold spots on uninsulated hatch i.e. **heat is lost into the loft cavity**

Cold spots around hatch caused by insulation gaps



Cold patches on sloping ceiling where insulation has dropped causing air gaps

VISUAL INSPECTION

Insulation gaps at the eaves as a result of poor installation around rafters

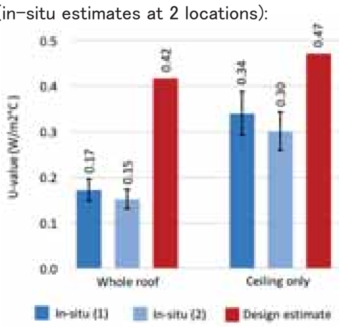
Further insulation gaps caused by installation of electrical wiring

RESULTS

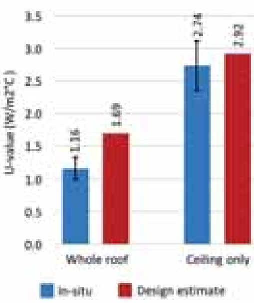
POINT U-VALUES

Estimated across the whole roof structure and across the ceiling/insulation layer alone at 8 locations.

Insulation as-installed and undisturbed (in-situ estimates at 2 locations):



Loft access hatch:



AREA-WEIGHTED U-VALUES

For the whole loft area calculated using point U-value estimates to represent different insulation conditions:

		Area weighted U-value ($Wm^{-2}K^{-1}$)
Design	Whole roof	0.42
	Ceiling only	0.48
In-situ	Whole roof	0.18
	Ceiling only	0.36

- **Design U-value estimates are consistently higher than in-situ estimates; design assumptions underestimate the thermal performance of the ceiling, insulation and roof structure**
- **In-situ U-value estimates across the ceiling/insulation layer alone are closer to design estimates suggesting that solar gains and ventilation have a significant effect on heat flow through the loft cavity**
- **Design vs in-situ performance difference: 57% for whole roof structure, 25% for ceiling/insulation layer alone**

ACKNOWLEDGMENTS

This research was made possible by support from the Engineering and Physical Sciences Research Council (EPSRC) Centre for Doctoral Training in Energy Demand (LoLo), grant numbers EP/L01517X/1 and EP/H009612/1.

FUTURE WORK

- Test the validity of the lumped thermal mass method (Biddulph et al, 2014) for estimating ceiling and roof U-values
- Characterise and evaluate the effects of solar gains and ventilation in roofs
- Additional heat flux sensors to increase resolution of whole-element area-weighted U-values

[1] S.H. Hong, T. Oreszczyn, I. Ridley (2006) The impact of energy effiicient refrubishment on the space heating fuel consumption in English dwellings. Energy and Building 38 (10)
[2] C.A. Elwell (2017) The thermal characteristics of roofs: policy, installation and performance. Science Direct
[3] D. Crawley, J. Hand, M. Kummert, B. Griffith (2006) Contrasting the capabilities of building energy performance simulation programs. Building and Environment 43 (4)

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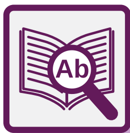
ANNUAL COLLOQUIUM 2017

Understanding overheating and poor indoor air quality impacts associated with UK energy efficiency retrofit

Seb Junemann 1st Year PhD Student

Energy Efficiency Retrofit is seen as one of the key priorities for the UK's journey towards a low carbon future. However, there is growing evidence that retrofit can lead to a wide range of negative unintended consequences including some associated with overheating and poor indoor air quality. Both of these issues can lead to occupant discomfort and, in some cases, potentially severe health impacts. This project aimed to inspect the evidence base to better understand these two ventilation-related issues and carry out a socio-technical case study of three retrofitted dwellings to see whether these issues were observed and experienced in real environments.



Step 1 Literature Search

A review of existing literature concluded that there is a **gap in the evidence base** surrounding empirical studies of overheating and poor indoor air quality in UK homes. Where studies exist, many of these are modelling studies which base many of their findings on a number of assumptions around factors like occupant behaviour patterns.

Step 2 In-home Monitoring

Loggers were selected to monitor three things in two locations in each dwelling:
- Air temperature
- Relative humidity
- Carbon dioxide concentrations

Loggers were set to fifteen minute intervals for a period of three months from 1st May - 31st July 2017.

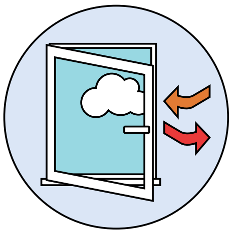
Step 3 Occupant Interviews

Brief qualitative interviews were conducted with the occupants of each dwelling at the point when data loggers were collected. These probed around the participants' experiences of temperature and air quality to provide a valuable comparison with the data collected by the monitoring devices over the previous three months.

KEY FINDINGS

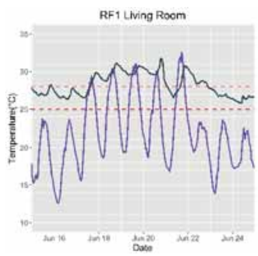
Occupants used "bad behaviour" with windows

All occupants reported leaving windows open during hot weather regardless of whether external temperatures exceeded internal temperatures. This is a significant finding as the opposite behaviour is assumed in many models that examine overheating in dwellings.



All three dwellings showed high temperatures

CIBSE thresholds for temperature in bedrooms and living rooms were exceeded in all dwellings for prolonged periods during the hottest part of the year. However, participants were generally satisfied with the environment in which they lived.



Occupants typically ignored MVHR system and controls

Despite having an MVHR system installed, occupants typically left the system on default settings and considered window opening to be the primary control method for addressing overheating or poor air quality

The study showed that issues of overheating and poor indoor air quality need further research to improve understanding. While the monitored homes showed typically good air quality, this only captured the summer experience. Capturing the winter experience, when ventilation rates may be reduced (due to less window opening) is critical. Forthcoming PhD work will focus on an action research approach to co-creating behavioural solutions to issues of poor indoor air quality in UK homes.

Vector image of flat by "sceneit" via "Vecteezy"
Vector characters by "freepik.com"

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ANNUAL COLLOQUIUM 2017

How can energy efficiency be improved in independent retail?
The tale of the Butcher, the Fishmonger and the Cycle-shop.

David Kenington

What did the research do? *Case-study mixed-methods research with three independent high-street retailers – a butcher, fishmonger and a cycle-shop in order to help better understand how energy efficiency could be improved.*

Objectives
1. To obtain a general understanding of how energy is managed, and to
2. Explore energy efficiency opportunities, in the context of energy management activities

Method*: In-depth face-to-face interviews and simple energy audits. Follow-up exploration of energy efficiency opportunities.*

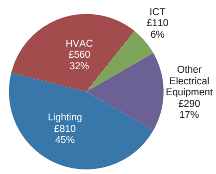
Findings: *For independent retail to take up energy efficiency requires the following factors:*

Concern + Conditions + Capacity + Commercial** influences **+** Conducive business **contexts.

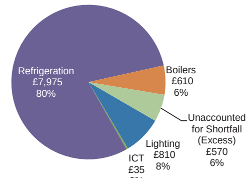
A framework for energy efficiency adoption for independent retail

What was energy used for?

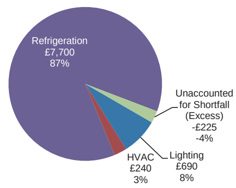
Cycle shop (bill estimate £1,770/a)



Fishmonger (bill estimate £10,000/a)



Butcher (bill estimate £8,400/a)



Operational costs were a driver and influenced by business contexts, reputational issues associated with high energy use less so.

Rationalising freezer room space: *"It's an interesting idea as it wouldn't cost much, and in normal business we never use all the space – that's only at Christmas time"…"It would also mean we have a back-up in place in case one of the motors breaks down"* Butcher.

Freezer room motors (Butcher)

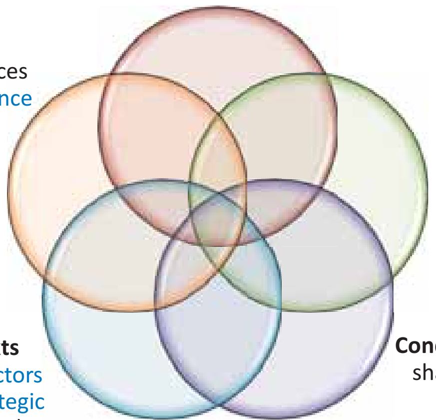
Commercial influences had utmost priority, so influenced equipment which were visible/interacted with customers. Placing physical barriers between products and customers was seen as a significant issue.

Exploring closing lids on refrigerated display units: *"On a Saturday, we go into that display maybe 700 times per day, so it would be open and shut, open and shut all the time, which would annoy the staff. Also, we'd get fish muck on the glass each time which would put customers off!"* Fishmonger.

Crushed ice fish displays (Fishmonger)

Concern (factors which shape attention to energy)
- operational costs

Commercial influences (factors which influence commercial performance)



Capacity (factors that moderate abilities to take energy actions)
- resources
- supply chain

Capacity in independent retail had a fluid meaning, and was influenced by concern and commercial influences.

Where equipment had strategic importance, there was willingness to invest: *I just spent ten grand [£10,000] upgrading these ones (pointing to the crushed-iced displays"* Fishmonger. Meanwhile, there was little appetite for upgrading back-room cold storage, which was older, used more and more inefficient

Crushed ice fish displays (Fishmonger)

Contexts, played a key role in the types of energy efficiency measures of interest and likelihood to act. The cycle-shop owner and fishmonger were 'mid-career', and were making 'strategic investments' in their businesses over time.
By contrast, the semi-retired butcher had not replaced any equipment for over a decade and was 'making-do' while planning to sell the business to a new owner.

Exploring appetite for energy efficiency: *"I'm semi-retired now, and I don't have the energy for such endeavours – I'll leave that to whoever takes over"* Butcher.

Business **contexts** (Organizational factors that influence strategic business activities)

Conditions (factors that shape where energy actions occur)
- Opportunities
- Triggers

Large, varied potential for energy efficiency was discovered across the sites

Retailer	Estimated energy bill (£/annum)	Estimated energy efficiency potential (£/annum)	Proportion of annual energy bills (%)
Fishmonger	£10,000	£1,380	14%
Butcher	£8,400	£4,800	57%
Cycle-shop	£1,770	£770	44%

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Experienced temperature, fuel poverty and health

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Harry Kennard 2nd year doctoral researcher in PACE research group

Supervisors: Prof. David Shipworth. Dr. Gesche Huebner

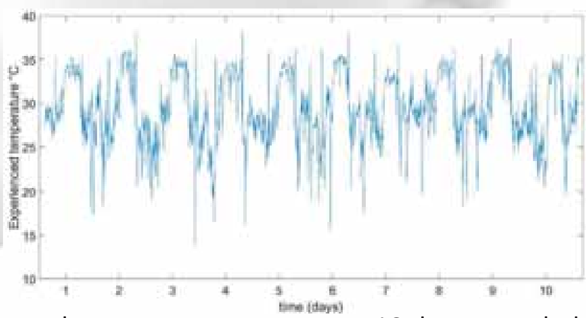
Motivation

- Fuel poverty is the condition of an occupant being unable to afford sufficient warmth for their home (Boardman, 1991).
- Fuel poverty is estimated to impact 4 million households in the UK (NEA, 2016).
- Improved understanding of the health impacts of fuel poverty has the potential to facilitate improved targeting and alleviation strategies.
- Knowledge of the variation of in experienced temperature is limited.

Overview

- The UK Biobank is national longitudinal health study of people aged 47-80 (in 2017).
- 100k participants wore a wristband which records activity and temperature for a week.
- The recorded temperature reflects participant's experienced ambient temperature and heat from the wrist.
- Investigations into associations between experienced temperature and health are ongoing.

Preliminary findings



An example temperature trace over 10 days, sampled at 5 second intervals. The trace is mixture of wrist temperature and the ambient temperature. Recorded night-time temperatures are higher for both metabolic and micro-environment reasons.

Next steps

- Down-sampling and processing of the data is currently under way.
- A regression analysis of the average temperature against health variables will be conducted.
- It is hypothesised that lower recorded temperatures will be associated with lower income, deprivation and fuel poverty.
- Seasonal variation in experienced temperature will be examined following repeat readings, which are currently being recorded.

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References

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Boardman, B. (1991). Fuel poverty: from cold homes to affordable warmth. London, United Kingdom: Belhaven Press.

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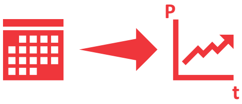
Seasonal Variation in Electricity Demand: Analysis of Data from 58 English Homes

Matthew Li (1st year PhD student) **Supervisors** Dr David Allinson, Dr Candy He
m.g.j.li@lboro.ac.uk

Research hypothesis



The shape of household electricity demand will vary significantly between months

Motivation

Literature gap: beyond total consumption, influence of seasonal variability on daily load profile shapes is sparsely reported.

Evolving UK electricity supply: Increasingly time-variable electricity supply expected in the coming decades as the UK transitions to intermittment renewable generation and inflexible nuclear power.

Materials & Methods

High-resolution household electricity data

Monitored load data (EFUS)

Drawn from DECC Energy Follow-Up Survey
58 English households
Household loads logged every 10 sec
July–December 2011

Synthetic load data (CREST)

Generated using a time-of-use-based stochastic load profile modelling tool[1]
58 synthetic households
Household loads simulated at 1 min intervals for July–December 2011

Electricity demand metrics (EDMs)

Per-household metrics used to describe 30-minute load profiles:
Mean daily electricity consumption (kWh)
Mean daily peak load (kW)
Mean daily load factor (%)
Mean daily peak load time (half hour)

Calculated for each month of data from each indivdiual household

Statistical tests

Significance of between-months differences in EDMs tested using one-way within-subjects analysis of variance (ANOVA)

Results

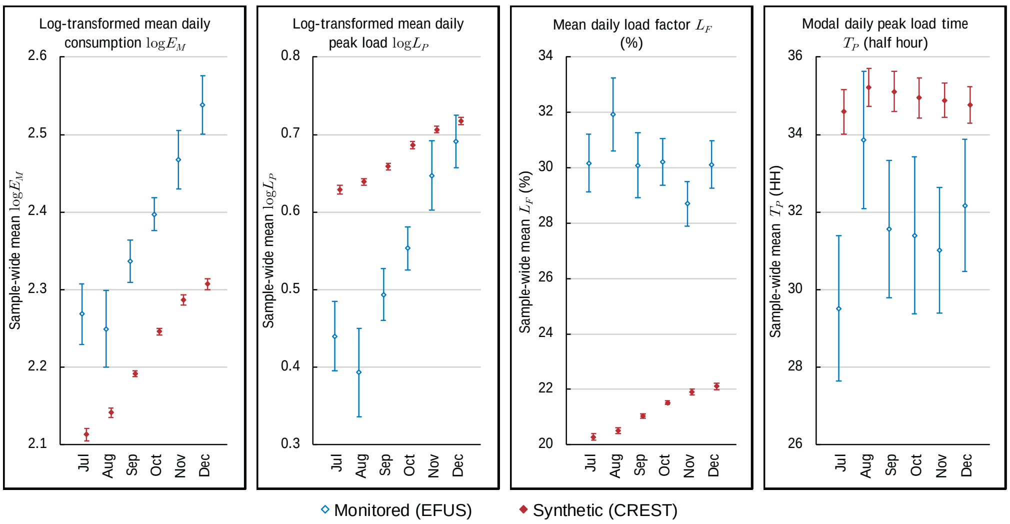


Fig 1. 95% within-subjects confidence intervals for electricity demand metrics from monitored and synthetic households, July-December 2011.

Within each dataset, values with non-coincident intervals were found to be significantly different ($p < 0.05$).

Differences between monitored and synthetic metrics may be partially explained by lack of between-months variation in occupancy and behaviour modelling.

(Lighting demand was the only seasonal component of synthetic load generation.)

Conclusions

- Significant between-months variability can occur in **daily consumption levels**, **daily load factors**, **daily peak loads** and timing of **daily peak loads**.
- The reported load profiling method **underestimated** the scale of between-months differences in **daily consumption** and **daily peak loads**.
- **Validation** of seasonal variability in load profile modelling **should consider the shapes of daily load profiles** in addition to overall electricity consumption.

[1] Richardson, I., Thomson, M., 2011. Integrated domestic electricity demand and PV micro-generation model. Loughborough University Institutional Repository.

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Anthony Marsh
2nd Year MPhil/PhD student, UCL Energy Institute
Supervisors – Prof. Paul Ruyssevelt & Dr Ivan Korolija

Overheating in Student Accommodation

Background

There is growing evidence of overheating incidences occurring in UK dwellings. This can affect the health and wellbeing of occupants, particularly if sleep is degraded. New student accommodation buildings contain a number of design characteristics that can make them particularly susceptible.

Methods

The temperature was monitored in a PBSA building in central London between May and August 2017. Overheating was assessed using the CIBSE Guide A (static) and the TM52 (adaptive) criteria. The analysis was completed assuming that the rooms were occupied at all times and under standard occupancy profiles - bedrooms (23:00 – 07:00) and Kitchen Living (KL) areas (08:00 – 22:00).

Summer 2017

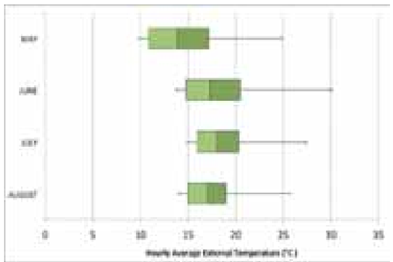

Figure 1: Monthly box plots for summer

Results

CIBSE Guide A Static Criteria

Figure 2: Bed lower threshold temp (24°C)

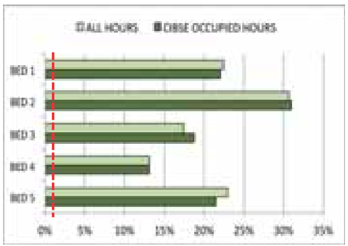

Figure 3: Bed upper threshold temp (26°C)

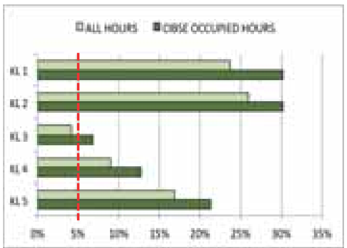

Figure 4: KL lower threshold temp (25°C)

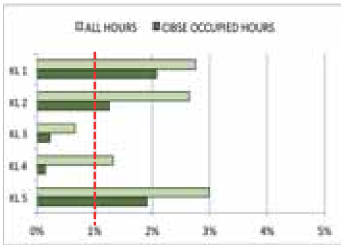

Figure 5: KL upper threshold temp (28°C)

TM52 Adaptive Criteria

Table 1: CIBSE TM52 results

	ALL HOURS	OCC. HOURS		ALL HOURS	OCC. HOURS
BED 1	FAIL	PASS	KL 1	PASS	PASS
BED 2	FAIL	FAIL	KL 2	FAIL	FAIL
BED 3	FAIL	PASS	KL 3	PASS	PASS
BED 4	PASS	PASS	KL 4	FAIL	FAIL
BED 5	FAIL	PASS	KL 5	FAIL	FAIL

Further Analysis

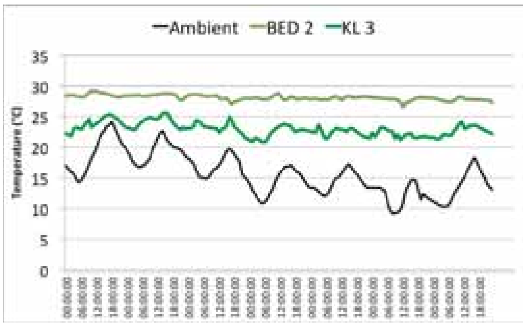

Figure 6: Temperature series plot (June 1st – 7th)

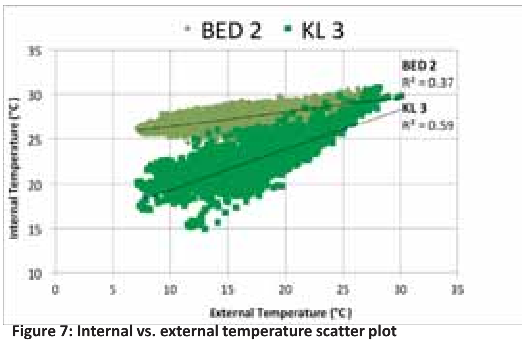

Figure 7: Internal vs. external temperature scatter plot

Discussion

The summer of 2017 [Figure 1] was slightly warmer than average, but this was largely due to a warm June, as from mid July onwards the weather was often cool. It therefore seems reasonable to suggest that the accommodation building should have been able to remain within comfortable temperature limits over this period.

However, all the bedrooms were found to exceed the annual 24°C and 26°C static temperature thresholds over the five-month monitoring period alone [Figures 2 & 3]. They failed whether they were assessed across the whole period or using standard occupancy profiles. Indeed, sustained periods of elevated temperatures were observed in bedrooms with minimal nighttime variation [Figure 6]. The bedroom TM52 results were shown to differ significantly depending on the assumed occupancy profile [Table 1].

Four of the kitchens living (KL) areas exceeded both the 25°C and 28°C static overheating thresholds for the year. The percentage of hours exceeding the thresholds increased under standard occupancy profiles. Three of the kitchens also failed the adaptive overheating tests, however, the temperature within the KL areas was shown to be more responsive to ambient temperatures [Figure 7].

Conclusions

These findings raise concerns over whether overheating risk is being adequately assessed at the design stage in new student accommodation buildings. It also has implications for how these residences are likely to perform in the years ahead as the UK climate continues to warm.

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Natural Ventilation, Mechanical Ventilation and Heat Recovery in Non-Domestic Passivhaus Building in the UK Climate Context

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Background:

Anthropogenic climate change (cuased by humans) is now widely accepted and thus many countries have taken measures to reduce GHG from buildings (Feist et al., (2005); Liu and Linden (2006)). Two promising concepts, Passivhaus and natural ventilation (NV) are emerging to combat these effects. Research about mechanical ventilation with heat recovery (MVHR) and NV in domestic Passivhaus buildings had been implied that MVHR is not the best solution for every climate but research lacks to advance that knowledge in non-domestic building context especially in the UK.

Aims:

1. Answer the question of ***"What is the performance limits of NV and MVHR in non-domestic Passivhaus in the UK climate?"***

2. Providing guidelines for MV and NV for non-domestic Passivhaus certified buildings for the UK climate context

Objectives:

1. Creating CFD model of case study validated by robust field measurements.

2. Modelling different MV and NV ventilation scenarios and benchmarking the results by using national and international thermal comfort performance standards (ASHRAE Standard 55 (2010) -1-, Building Bulletin 101 (2006) -2-, CIBSE Guide A (2016) -3-) to assess the performance limits of MV and NV.

3. UK climate analysis and comparison of CFD results to the UK climate.

Case Study Building:

Leicester University, Medical School Building, Low ceiling High Internal Heat Gains Auditorium

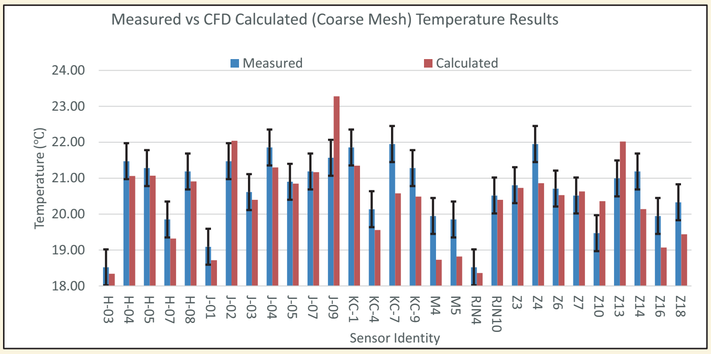
Summary of the Results:

1. NV extends summer outdoor operating temperatures up to 6ºC and MVHR extends winter outdoor operating temperatures up to 8ºC. However, neither NV nor MV is sufficient alone to provide thermally comfortable environment during all times of the year in the UK climate for that building context. Thus, mixed-mode ventilation approach is necessary with additional active or passive heating and cooling systems.

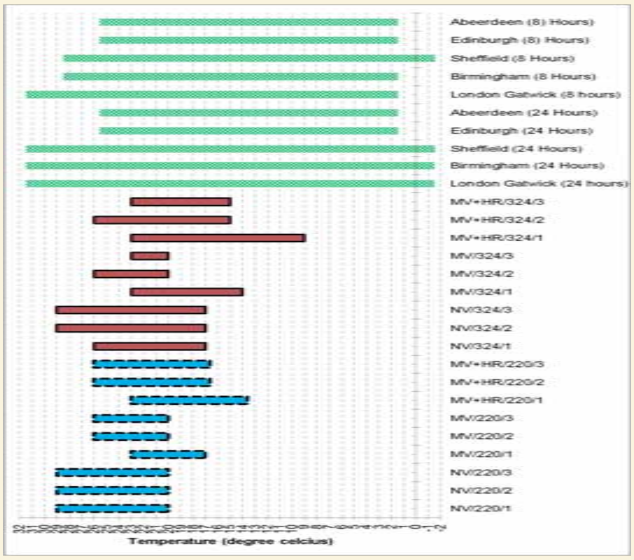
2. When exposed to same outdoor temperatures, NV provides better thermal environment due to less temperature stratification within the domain.

3. For MV, variable flow rate air handling unit, and for NV, adjustable in size and location (E.g. roller shutter systems) openings are recommended for best thermal performance.

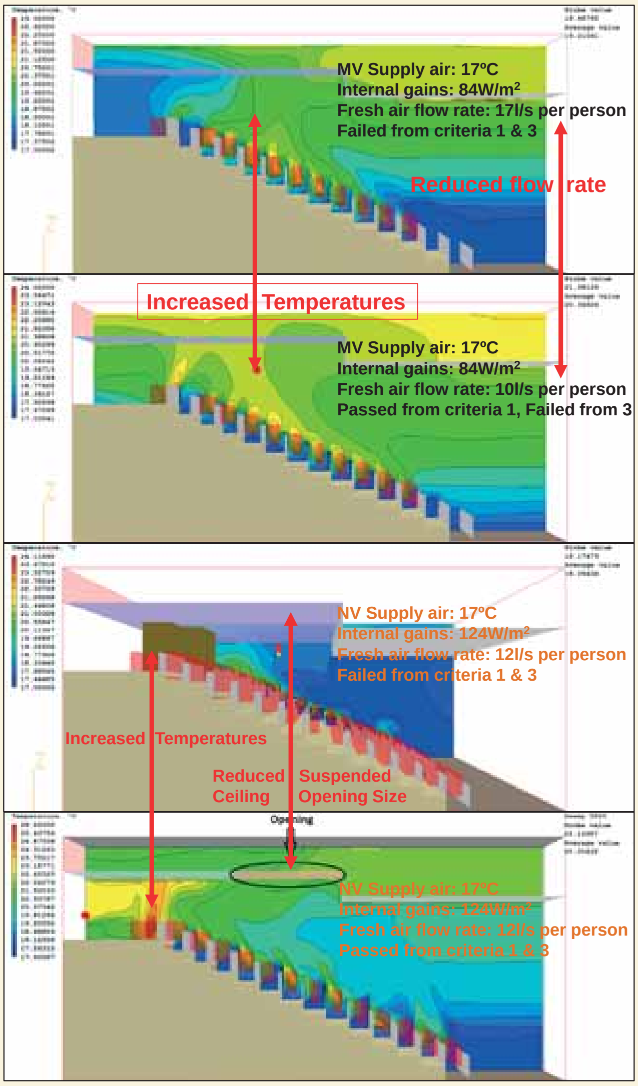
Objective 1:



Objective 2, 3 and Aim 1:



Aim 2:



References:

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Liu, Q.A. and Linden, P.F., 2006. The fluid dynamics of an underfloor air distribution system. Journal of Fluid Mechanics, 554, pp.323-341

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Does indoor overheating risk prediction depend on the choice of Building Simulation Software?

Giorgos Petrou **UCL Energy Institute MPhil Student,**
Dr. Anna Mavrogianni and Dr. Phil Symonds **UCL IEDE Academic Supervisors**
Anastasia Mylona **CIBSE Industrial Supervisor**, Gurdane Virk **Atkins Industrial Supervisor**
Dr. Rokia Raslan and Prof. Michael Davies **UCL IEDE Academic Contributors**

Key Points

1. **The choice of building simulation software impacts the predicted overheating risk.**
2. **Wind-driven natural ventilation significantly influences the observed differences.**
3. **Empirical validation of simulated indoor temperatures in naturally ventilated dwellings is required.**

Introduction

- **Domestic overheating** is a growing concern due to the projected increase in frequency of extreme heat episodes along with the progressively higher levels of building thermal insulation and air-tightness [1].
- Through the Technical Memorandum 59 (TM59), CIBSE aims at providing a common procedure for predicting the overheating risk, using Building Performance Simulations (BPS) tools [2].

Research Questions:

- Does the prediction of overheating risk differ significantly between two commonly used BPS tools?
- What algorithmic differences are responsible for the discrepancies, if any, in the predictions?

Methods

- A base-case model, chosen to be representative of a typical London flat [3], was modelled in *EnergyPlus 8.6* and *IES VE 2016,* following TM59. Eight further iterations were developed which assessed factors identified by literature as being influential towards the risk of overheating (table 1).
- Within each software, the default algorithmic options were used. Natural ventilation was modelled by the *Airflow Network* in EnergyPlus and *MacroFlo* in IES VE.
- Overheating risk was compared through an inter-model comparison.

Table 1: Key physical characteristics of the nine models.

Code	Description
BC	Floor level: 11.2 m, orientation: south facing, single aspect, top level flat, Lightweight construction: Timber frame, external brick layer and internal plasterboard. U-values: Wall – 0.17 W/m²K, window – 1.28 W/m²K, floor – 0.18 W/m²K, roof – 0.13 W/m²K. Window Solar Heat Gain Coefficient = 0.5
G	Ground-level flat, floor level: 0 m, flat of similar temperature above
M	Mid-level flat, floor level: 5.6 m, flats of similar temperature above and below
W	West-facing flat
N	North-facing flat
E	East-facing flat
HW	Heavyweight construction: Concrete blocks, int. dense plaster and carpet
SH	Shading: Overhang external shading, length of 2.2 m and width of 0.5 m
DA	Dual aspect model with a second window included in the bedroom

Results

- Indoor temperatures in EnergyPlus models were higher than IES VE with a mean temperature difference of 0.64℃ and a greater inter-quartile range suggesting greater fluctuations (figure 1a).
- EnergyPlus predicted a high overheating risk in seven out of the nine models, while IES VE did not predict a high risk in any case (figures 1b, 1c)

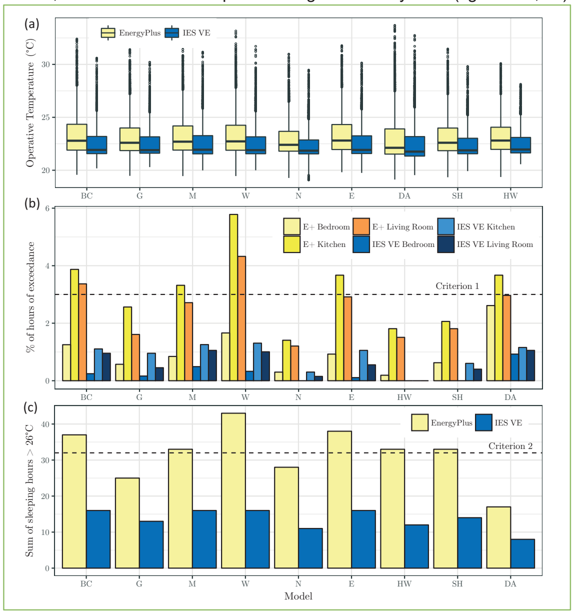

Figure 1: Part (a) is a box plot of temperature distributions for each model during the period of interest. Parts (b) and (c) display the results of criterion 1 and 2 for all models, respectively .

- Comparison of the heat mechanisms revealed that **external (natural) ventilation** dominated the differences in half of the cases**.**
- As shown in figure 2a, on a typical day the window flow rate predicted by IES VE exceeded the EnergyPlus equivalent by up to 135%.
- By setting the wind velocity to zero (figure 2b), the flow rates were in close agreement, suggesting that wind-driven ventilation is responsible for the observed differences.
- This result could relate to each software's method of estimating wind-pressure coefficients and wind turbulence.

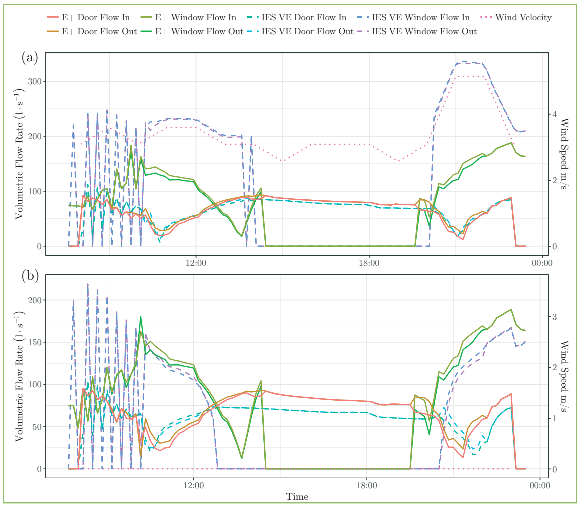

Figure 2: Line graphs of the predicted volumetric flow rate for the bedroom door and window in either software on the 15th of July. Part 2a is the comparison with the suggested weather file. In part 2b the wind velocity was set to zero.

Discussion & Conclusions

- The choice of BPS tool influences the predicted overheating risk
- Further research and empirical validation are needed to reveal which software may be considered more appropriate.
- TM59 may be improved through specifying the software and algorithms to be used.

Acknowledgements

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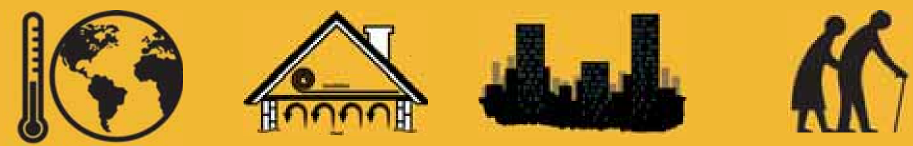
THE EFFECT OF OCCUPANT BEHAVIOUR ON OVERHEATING

BEN ROBERTS, DR. DAVID ALLINSON AND PROF. KEVIN LOMAS

OVERHEATING: A PERFECT STORM

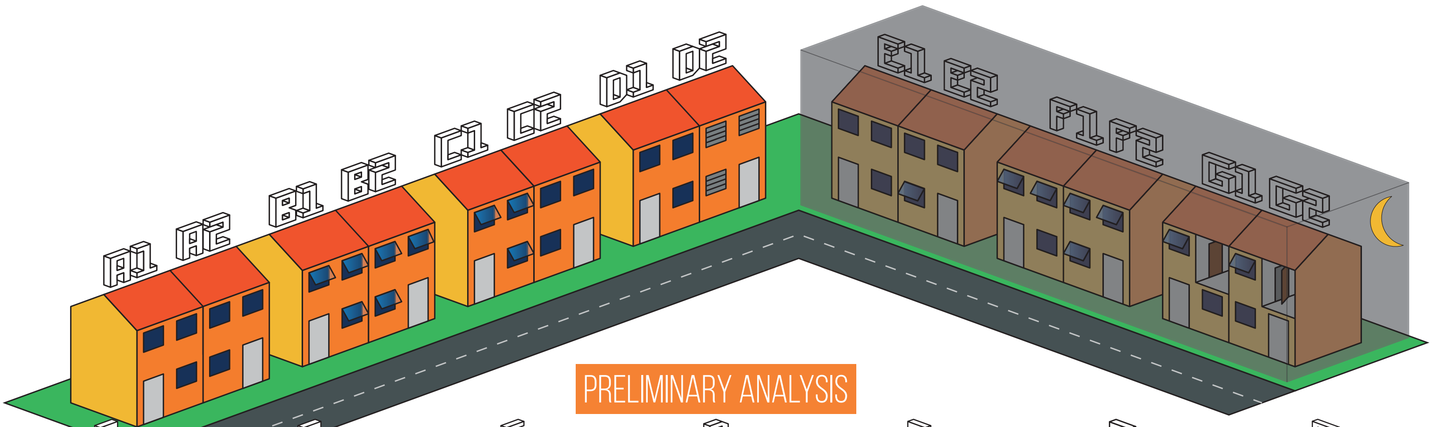


AIM

To determine if simple mitigation strategies can keep UK homes comfortable and healthy during summer and heatwaves.

METHOD

- A matched pair of synthetically-occupied test houses were utilised to replicate the behaviours of occupants: window opening, blind use and internal door use.
- Automated behaviours allow the following mitigation strategies: window opening in response to indoor temperature; night ventilation; daytime shading; and cross-/stack-ventilation.
- Different mitigation strategies were enacted in each of the matched pair of houses, under the same weather conditions, with identical internal heat gains, and the indoor temperatures, thermal comfort and air change rates compared.



PRELIMINARY ANALYSIS

TEST A: MATCHED PAIR WINDOWS CLOSED

House 1: Windows always closed, blinds closed at night, internal doors closed at night.
House 2: Same as house 1.
Test length: 17 days
Average external temperature: 16.6°C

Living Room — 1: Max: 27°C, Mean: 23.4°C, Min: 17.3°C; 2: Max: 27.3°C, Mean: 23.5°C, Min: 17.4°C

Bedroom — 1: Max: 29.7°C, Mean: 25.8°C, Min: 18.8°C; 2: Max: 29.5°C, Mean: 25.6°C, Min: 18.4°C

TEST B: MATCHED PAIR WINDOWS OPEN

House 1: Windows open if $T_{in} \geq 22°C$ and room occupied, blinds closed at night, internal doors closed at night.
House 2: Same as house 1.
Test length: 8 days
Average external temperature: 16.7°C

Living Room — 1: Max: 25°C, Mean: 21.8°C, Min: 20.2°C; 2: Max: 25.2°C, Mean: 21.8°C, Min: 20.1°C

Bedroom — 1: Max: 25.4°C, Mean: 22.7°C, Min: 21°C; 2: Max: 25.4°C, Mean: 22.1°C, Min: 20°C

TEST C: COMPARISON, WINDOWS OPEN IN HOUSE 1 ONLY

House 1: Same as test B, house 1.
House 2: Same as house 1, except windows always closed.
Test length: 21 days
Average external temperature: 18.2°C

Living Room — 1: Max: 28.6°C, Mean: 23.1°C, Min: 19.4°C; 2: Max: 29°C, Mean: 24.3°C, Min: 19.7°C

Bedroom — 1: Max: 31°C, Mean: 24.3°C, Min: 21.2°C; 2: Max: 32°C, Mean: 26.4°C, Min: 21.6°C

Paired t-test: Living Room 0.8-1.4°C COOLER in house 1; Bedroom 1.6-2.6°C COOLER in house 1

TEST D: COMPARISON, BLINDS CLOSED IN HOUSE 2 ONLY

House 1: Same as test B, house 1.
House 2: Same as house 1, except blinds always closed.
Test length: 21 days
Average external temperature: 16.8°C

Living Room — 1: Max: 26.5°C, Mean: 22.2°C, Min: 20.1°C; 2: Max: 25.5°C, Mean: 21.9°C, Min: 19°C

Bedroom — 1: Max: 26.7°C, Mean: 22.5°C, Min: 18.5°C; 2: Max: 26.8°C, Mean: 22.5°C, Min: 18.5°C

Paired t-test: Living Room 0.1-0.2°C COOLER in house 2; Bedroom No sig. difference

TEST E: COMPARISON, NIGHT VENTING UNOCCUPIED ROOMS

House 1: Same as test D, house 2, except internal doors open at night.
House 2: Same as house 1, except additional ground floor window open at night, regardless of internal temperature.
Test length: 15 days
Average external temperature: 16°C

Living Room — 1: Max: 24.1°C, Mean: 21.4°C, Min: 19.1°C; 2: Max: 23.5°C, Mean: 20.8°C, Min: 17.5°C

Bedroom — 1: Max: 24.2°C, Mean: 22.3°C, Min: 20.6°C; 2: Max: 23.8°C, Mean: 21.8°C, Min: 19.4°C

Paired t-test: Living Room 0.5-0.8°C COOLER in house 2; Bedroom 0.4-0.6°C COOLER in house 2

TEST F: COMPARISON, NIGHT VENTING BEDROOMS

House 1: As test E, but bedroom windows open at night regardless of internal temperature.
House 2: Same as house 1, but one addtional ground floor window open.
Test length: 18 days
Average external temperature: 15.7°C

Living Room — 1: Max: 25.6°C, Mean: 21.4°C, Min: 18.1°C; 2: Max: 25.4°C, Mean: 20.6°C, Min: 16.1°C

Bedroom — 1: Max: 26.4°C, Mean: 22.2°C, Min: 21.2°C; 2: Max: 26.1°C, Mean: 21.7°C, Min: 16°C

Paired t-test: Living Room 0.5-1°C COOLER in house 2; Bedroom 0.3-0.5°C COOLER in house 2

TEST G: COMPARISON, NIGHT VENTING INTERNAL DOOR USE

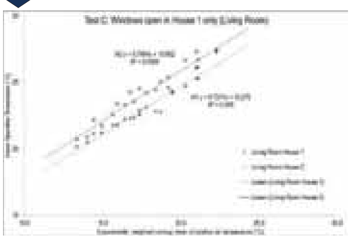
House 1: Bedroom windows and one ground floor window only open when sleeping, blinds closed when night, internal doors closed at night.
House 2: Same as house 1, except internal doors open at night.
Test length: 15 days
Average external temperature: 13.7°C

Living Room — 1: Max: 23.6°C, Mean: 19.4°C, Min: 15.6°C; 2: Max: 23.3°C, Mean: 19.1°C, Min: 14.5°C

Bedroom — 1: Max: 24.4°C, Mean: 20.6°C, Min: 17°C; 2: Max: 23.5°C, Mean: 19.8°C, Min: 15°C

Paired t-test: Living Room 0.1-0.4°C COOLER in house 2; Bedroom 0.7-1°C COOLER in house 2

Regression analysis
using exponentially weighted running mean of outdoor temperature
(allows for comparison between different testing phases)



NEXT STEPS...

- Comparison of operative temperatures in other rooms and different time periods e.g. sleeping hours or occupied hours only. Paired t-tests and descriptive statistics.
- Overheating analysis and comfort thresholds.
- Regression analysis comparing between testing phases.
- Development and calibration of dynamic thermal models.

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ANNUAL COLLOQUIUM 2017

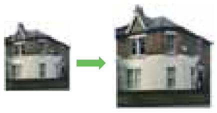
Understanding the uptake of energy efficiency measures in the private rented sector

Zareen Sethna 3rd Year PhD (part time) zareen.sethna.13@ucl.ac.uk
Supervisors: Dr. Lai Fong Chiu & Dr. Ian Hamilton

CONT EXT

29% of UK energy consumption comes from homes. [1]

87% of existing homes will still be in use in 2050. [2]



Private rented sector (PRS) has doubled in size since 1990 and is the 2nd largest tenure in the UK. [3]

The private rented sector has lower levels of energy efficiency measures than other tenures. [4]

CHALLE NGES

SPLIT INCENTIVE

The main benefits of energy efficiency improvements accrue to the tenant rather than the landlord.

1.4 million landlords

Landlords are a large, diverse and fragmented population making them challenging for policy makers to reach. [5,6]

The proportion of flats in the PRS is 4 times greater than in owner occupied dwellings [7], the retrofit of flats is often more challenging due to common property issues.

AIM

To improve our understanding of the uptake of energy efficiency measures in the private rented sector.

RESEAR CH DESIGN

Phase 1: Quantitative secondary data analysis

Research question 1:
How do rates of uptake of energy efficiency measures relate to dwelling, household, landlord and geographical characteristics within the PRS?

Data sources:
English Housing Survey
Private Landlords Survey

Data analysis:
Multivariate logistic regression

Phase 2: Qualitative data collection & analysis

Research question 2:
What are landlords' practices and how do these relate to the uptake of energy efficiency measures?

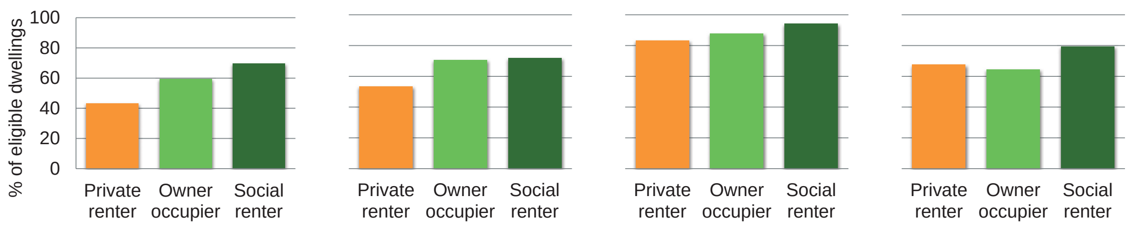
Data collection:
In-depth interviews, focus groups and walk-through interviews with landlords, tenants, housing officers and estate agents.

Sampling:
Quota sampling used to select approx. 30 small (<5 properties), part-time landlords.

Phase 3: Synthesis and interpretation

Research question 3:
How does the qualitative data on landlords' practices help to explain the patterns of uptake of energy efficiency measures found in the quantitative analysis?

INITIAL RESULT S



Graphs showing presence of energy efficiency measures in each tenure, based one English Housing Survey data from 2015.[8]

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ANNUAL COLLOQUIUM 2017

Management of Thermal Energy Storage in District Heating Networks

MRes Dissertation

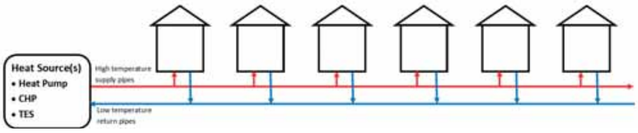
Salman Siddiqui 1st Year MPhil/PhD Student

HIGHLIGHTS

- Disaggregated climate and wind generation data is used to create and link power supply and heat load profiles
- A fully decarbonised electricity generation scenario based on wind and nuclear power is assumed
- Domestic heat load is simulated using distributions of physical properties and a stochastic occupancy model
- A district heating network is simulated incorporating thermal energy storage and heat pumps
- Benefits of thermal energy storage were found to diminish logarithmically with increasing capacity

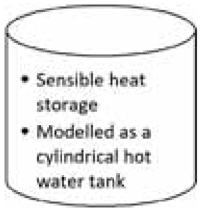
INTRODUCTION

- District heating Networks (DHN) can enable the efficient distribution of electrified heat and are able to practically incorporate large capacities of Thermal Energy Storage (TES)
- The impact of TES in district heating networks and a renewable based electricity supply was investigated
- An analysis was conducted into the effect of TES capacity on balancing renewable electricity supply and heating loads



RENEWABLE THERMAL ENERGY STORAGE (TES)

- A stable electricity grid requires balancing of supply and demand
- Wind power dominated system will have a highly fluctuating supply
- TES can be used to decouple supply from demand and store electrified heat during surplus generation periods



BUILDING HEAT LOAD

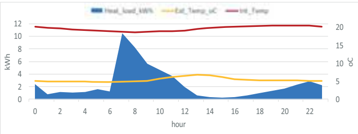
- Randomly generated set of dwellings to estimate Specific Heat Loss (SHL), Thermal Mass (MTh), and Hot water
- Dynamic hourly simulation of heat losses and gains from disaggregated population weighted mean conditions
- Stochastic occupancy model to simulate hourly consumption

$Q_{EXT} = SHL\ (T_{INT} - T_{EXT})$

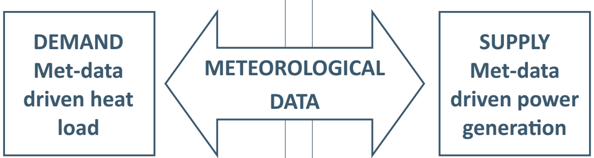
$Q_{TOT} = Q_{GAINS} - Q_{EXT}$

$\Delta T_{INT} = Q_{TOT} / MTh$

$Q_{DEMAND} = MTh\ (T_{SET} - T_{INT})$

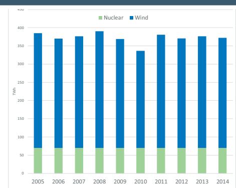


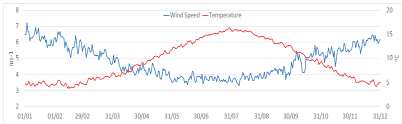
December average daily heat profile



POWER GENERATION SCENARIO

- Fully decarbonised power supply
- Total wind power capacity of 75 GW and retained current nuclear capacity of 8 GW
- Average annual power generation similar to current levels - 350 TWh
- Hourly wind generation data



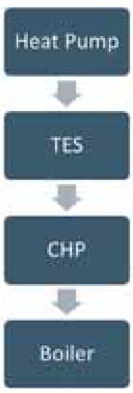


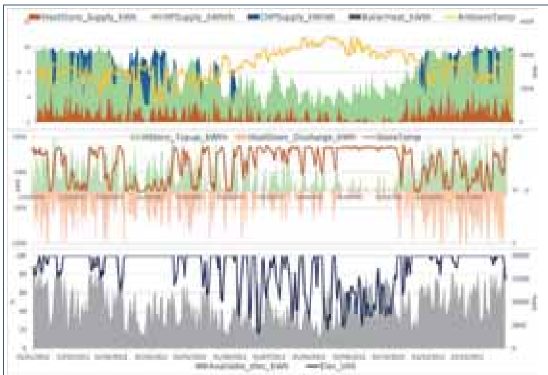
Average meteorological data (1985-2015)

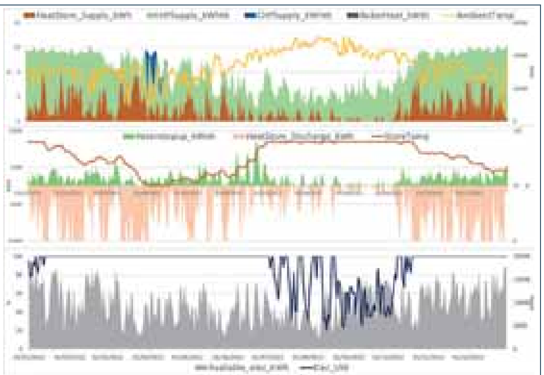
SYSTEM SIMULATION

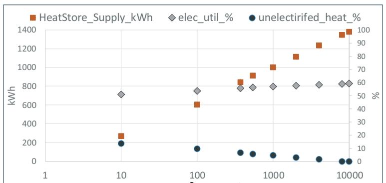
- Hourly simulation of heat load, power supply and DHN operation
- Power supply scaled down to the fraction of the dwelling stock simulated
- TES varied to increase electricity utilisation: The fraction of zero carbon electricity providing heat

Criteria	Value	TES Size
Peak hourly heat supplied	2,772 kWh	31 m^3
Peak daily heat supplied	46,968 kWh	538 m^3
1% annual heat supply	927,412 kWh	10,631 m^3




1% annual heat supply - 538 m^3 TES simulation profile


Peak daily heat supply - 10,631 m^3 TES simulation profile



TES Size m^3 Logarithmic

CONCLUSIONS AND FURTHER WORK

- Electricity utilisation increases with extra TES capacity and unelectrified heat is eliminated at large TES
- Increasing TES capacity results in diminishing returns for direct TES heat and utilisation - log-linear
- Demand was restricted to residential buildings and other demands should be included in future work
- A more comprehensive range of power scenarios and sources such as solar generation will be analysed
- A cost model will be added for economic optimisation of the heat dispatch from the DHN power plant

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ANNUAL COLLOQUIUM 2017

Heat pumps in the UK's district heating: individual, district level, both or neither?

Zikun Wang PhD student
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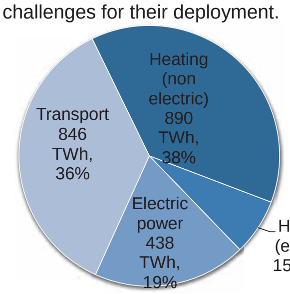
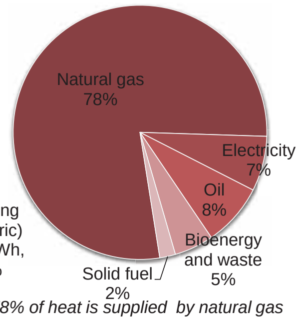
Background and research aims

Electric **heat pumps** together with decarbonised electricity are proposed as promising technologies that could replace gas heating and contribute to the future low-carbon heat mix. **District heating networks** have been transforming from fossil fuel based to renewable based over several generations. Both technologies have been well developed with abundant scientific research and industrial experiences 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 deployment.



45% of final energy demand is consumed to supply heat



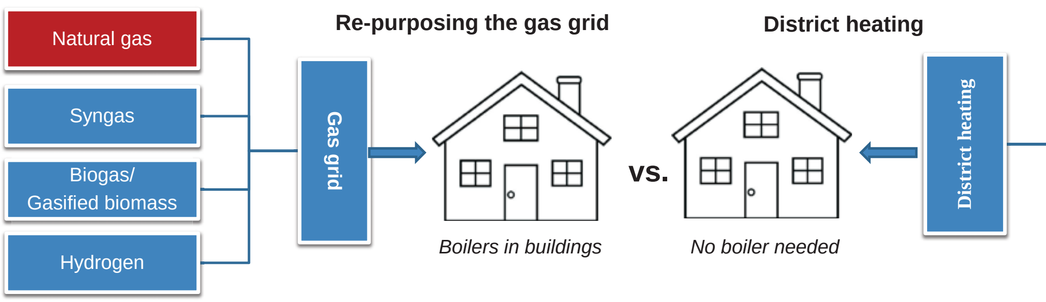
78% of heat is supplied by natural gas

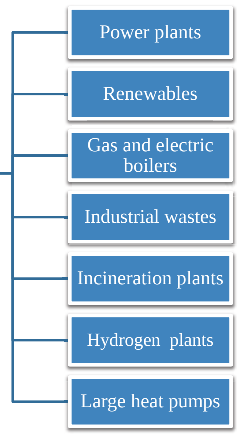
The **aim** of this project is to analyse role of heat pumps and district heating in the UK's buildings by assessing the topological configurations of heat pumps, district heating networks and thermal storage solutions for a range types of buildings on different scales.

Research questions:

Heat demand -- How much heat demand could be met by individual heat pumps or district heating networks on different scales?
Individual heat pumps versus district heating -- What are the economic and environmental advantages of deploying heat pumps based different topologies?
Competitiveness -- How competitive are heat pumps and district heating compared to other heating measures?

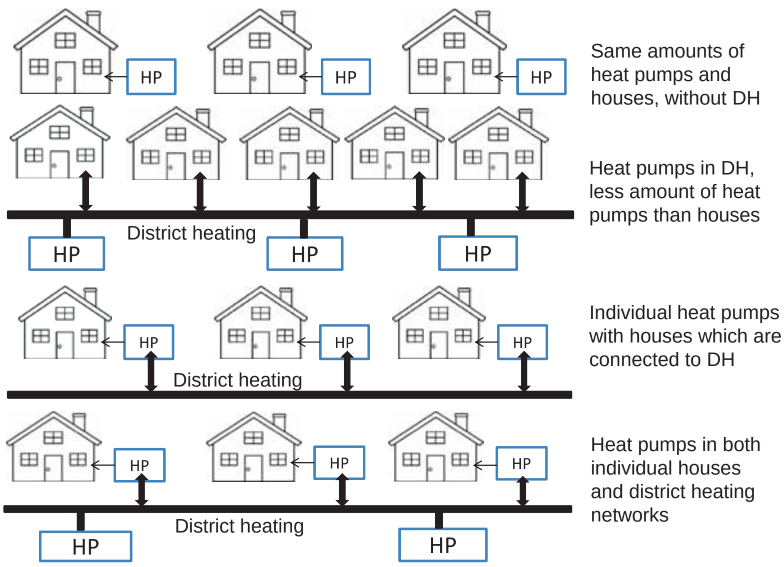
Decarbonising the heating sector





The cheaper approach is re-purposing the gas grid through **substitution of natural gas** to biogas or syngas. The second one is to develop district heating networks, which could offer higher flexibility and efficiency. Unlike the gas grid that uses high-quality energy resources for a low-quality demand, district heating could **utilise different types of sources** including fossil fuels, renewable resources, and waste energy.

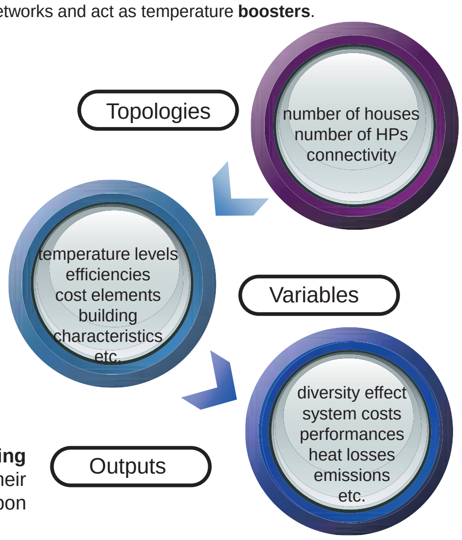
Individual heat pumps vs. heat pumps in DH



Topological configurations of buildings, heat pumps and district heating networks

Heat pumps can be utilised in district heating schemes based on three main approaches:

1. to integrate heat pumps into **existing networks** (normally with flow temperature above 70°C) as additional **heat generator** or together with combined heat and power (CHP) plants for **heat recovery**.
2. to develop new district heating with **large heat pumps** with **low flow temperatures.**
3. to use **decentralised heat pumps** in very low temperature networks and act as temperature **boosters**.



My PhD study investigates heat pumps at **individual households versus district heating networks** based on **different topologies**, through physical models, in order to further explore their comparative advantages from different aspects, including technical performances, carbon emissions, financial practicability and policy uncertainties.

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ANNUAL COLLOQUIUM 2017

Occupant adaptive responses to overheating in bungalows and new build dwellings

Dan Wright 1st Year PhD Student | Loughborough University
Supervised by Prof Kevin J Lomas and Dr Victoria J Haines

INTRODUCTION

Retrofit energy efficiency measures such as loft insulation, draft-proofing and improved glazing have had unintended consequences [1, 2]. There are concerns that as average temperatures increase due to climate change [3], an increasing number of homes will suffer from uncomfortably high indoor temperatures, termed overheating. The elderly are recognised to be most at risk from the negative health impacts of overheating. There is still limited understanding of how people interact with their homes during warm periods and what the underlying drivers for actions may be [4], particularly in dwellings recognised to be susceptible to overheating (new build and bungalow homes).

OBJECTIVES

1 2 3 4

1. Assess opportunities and barriers using a methodical survey tool.
2. *Explore* how occupants utilise available opportunities to cool their home.
3. *Investigate* perceived barriers that may prevent utilisation of cooling.
4. *Present* initial recommendations for engaging and advising occupants.

METHODOLOGY

A → B → C

The mixed-methods experimental procedure involved surveys (👁), interviews (💬), diary-keeping (📓) and indoor temperature monitoring (📶).

New build (n = 4) and **bungalow** homes (n = 4) from Loughborough, central England participated in the research. Phases involved:

A. Assessment using the Overheating Adaptive Opportunities and Barriers (OAOB) Survey Tool, the first semi-structured interview and deployment of Onset HOBO temperature sensors.

B. Temperature sensors monitored indoor temperatures in the month between visits and occupants were asked to keep notes in action diaries.

C. Collection of temperature sensors and final semi-structured interview.

OAOB SURVEY TOOL

- Innovative method of assessing risk of overheating.
- Items compiled from the Energy Use Follow-Up Survey [5], the English Housing Survey [6], and others.

INCIDENCE OF OVERHEATING

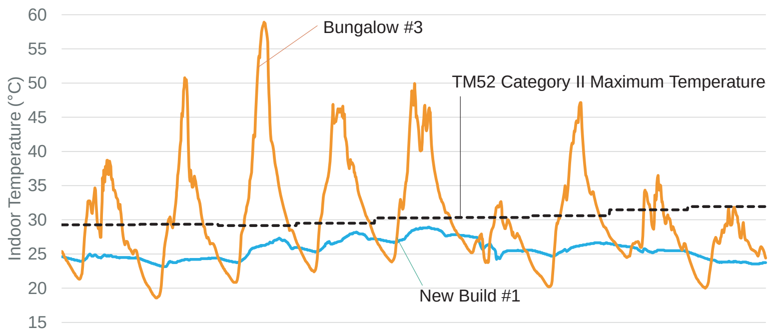

Figure 3. Monitored indoor temperatures comparing incidence of overheating in functional living rooms between Bungalow #3 and New Build #1 between 15 and 23 June 2017.

- Seventeen rooms monitored in total.
- UK Met Office heatwave thresholds not met during monitoring period.
- However, very warm period between 15 and 23 June 2017.

FINDINGS
All monitored main bedrooms and living rooms exceeded 24°C (potentially unhealthy) for 50-100% of hours over very warm period.

DRIVERS OF ACTIONS

“...open everything you can…
- Female, 62

- Opening **as many windows and doors as possible** in warm weather a common response.
- **Lack of feedback** from natural ventilation may make occupants more likely to utilise mechanical ventilation.

BARRIERS TO ACTIONS

“...I’m reluctant to leave a window open… *- Male, 70*

- All occupants expressed **security concerns** as one of the main barriers to using windows for natural ventilation.
- Both bungalow and new build occupants were concerned about **openings on lower levels**.
- Many expressed **lack of concern** about overheating as an issue that may affect them.

RECOMMENDATIONS

Occupants were asked whether they would be interested in receiving **advice about mitigating overheating** in their home.

Initial recommendations for developing advice programmes included:

1) Advice needs to be **household specific** rather than general.
2) Occupants may engage more if there is an **economic**, or significant **comfort**, advantage.
3) Advice needs to come from a **specialist**.

RESULTS AND APPLICATIONS

- The OAOB survey provides a foundation for a **methodical means of assessing dwelling susceptibility to overheating**.
- Post-occupancy structural additions (conservatories) and modifications (loft conversions) potential indicators of overheating risk in bungalows. **Installers of such extensions have a greater role** to play in reducing risk
- Insights into the drivers for adaptive actions taken to reduce indoor temperatures help to inform **better modelling simulations** for dwellings.
- Improved understanding of possible barriers to utilising natural ventilation could be a basis for **improved, user-centred design** of windows.
- Recommendations to **support future government overheating awareness initiatives**.

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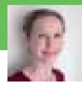
ANNUAL COLLOQUIUM 2017

What can we learn about the origins of the performance gap from the processes and communications around energy targets in a construction team?

Catherine Willan, 3rd year Doctoral Researcher, UCL



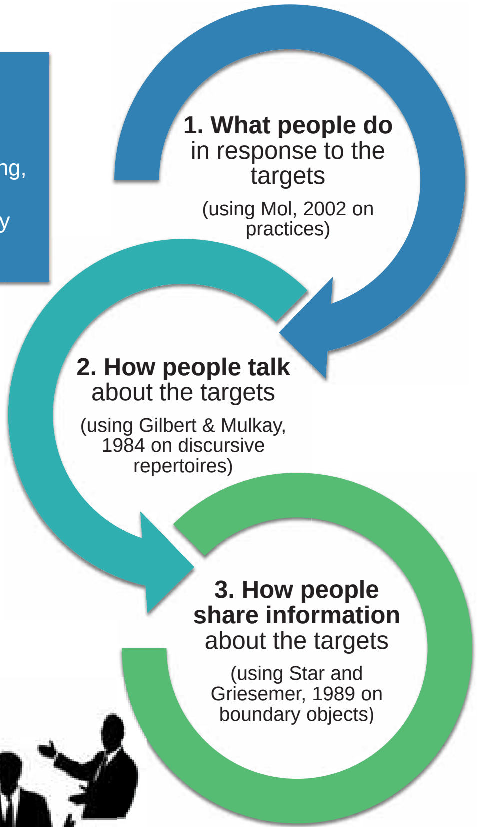
Overview: A case study of how energy and carbon performance targets are managed by the construction contractor in a large, non-domestic building project. Targets for buildings in operation could be one means to address the performance gap (UKGBC, 2016).

Concept: If there are "***different ways of knowing energy***" (Shove, 1997), what impact might **multiple versions** of energy performance targets have in large, complex construction projects, where communication and coordination are already difficult (Zero Carbon Hub, 2014)? Three analytical lenses are being used ***to follow the energy targets through the case study project***:

Approach: In-depth, qualitative, data from interviews, documents and observation, working in partnership with a large, UK construction company.

Challenges of data collection:

- Sampling from so many actors, locations, and events
- Construction time frame vs PhD time frame
- Defining project boundaries
- Working with real world people and data requires thinking on your feet



To what extent are people's practices separated or coordinated?

"they've got insight into what they are designing, which I am not part of "
"what you do is very, very specialist and very technical…"

Does discussion of energy performance vary by context?

"An effective metering strategy will be paramount in controlling energy consumption" [formal]
"A lot of the time you go back on to these sort of big projects and meters aren't set up properly, haven't been installed ..." [informal]

Do systems foster collaboration between professions?

"It's easier to ring them, explain the problem, rather than go through the official route…"
"You can't re-run a building model every time you do a variation"

Are incentives keeping these multiple versions of the targets apart?

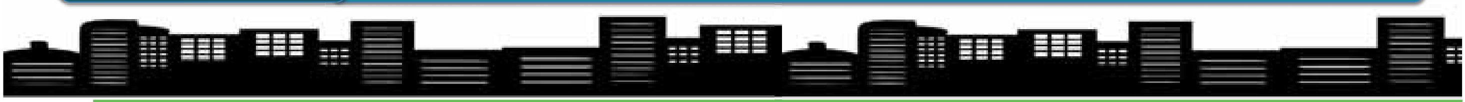
The energy targets operate within the construction project's complex system of relationships, loyalties, risks, rewards, and commercial pressures

Emphasis on design compliance — "That's what I found in Part L calculations actually, it's so limited …it just doesn't reflect the reality"

Perverse incentives — "So that sort of stimulates you to put in massive atriums, which are inefficient – but using the volumetric measure, highly efficient"

Divergent incentives — "Every company's got its own vested interest to get done, get off site and maximise their profits"

Competing incentives — "Often clients give us briefs which have conflicting requirements"



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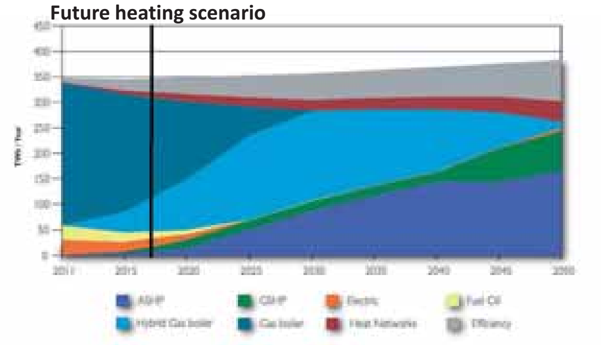
ANNUAL COLLOQUIUM 2017

Increased Electricity Demand from Heat Pumps, taking User Behaviour into account

Stephen Watson PhD Student (Loughborough University)
Supervised by **Dr Richard Buswell** and **Prof Kevin Lomas**

Background:

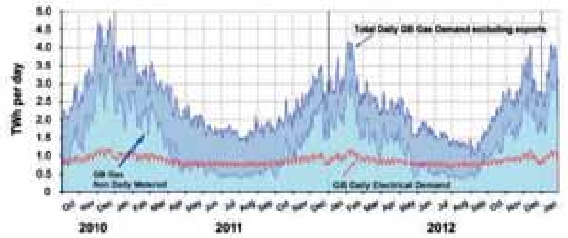
Future heating scenario



Heat pumps are expected to play a significant role in domestic heating by 2050. (Source: DECC (2013))

- Heat pumps are expected to play a role significant role in domestic heating in most future heating scenarios.
- The number of houses heated by heat pumps varies between scenarios.
- A widespread introduction of heat pumps would introduce a significant new demand for electricity.
- This increased demand for electricity, especially during cold weather, is considered to be one of the main challenges associated with a widespread use of heat pumps.

Gas and electricity demand



There is a large variation in the demand for heat over a year. Peak heat demand is considerably greater than current peak electricity demand. (Source: Wilson et al (2013))

Aim:

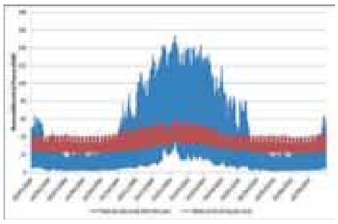
To quantify the additional electricity demand resulting from a widespread introduction of heat pumps for space and water heating in UK homes, and to determine the implications for future UK energy policy.

Objectives:

1. Obtain monitored data from heat pumps and gas boilers.
2. Analyse proportions of users using heating systems in particular ways and factors affecting this.
3. Produce estimates of national heat/electricity demand under various future heating scenarios
4. Investigate consequences of these new demands and value of heat storage.

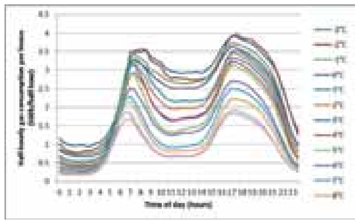
Results:

Current national domestic heat demand



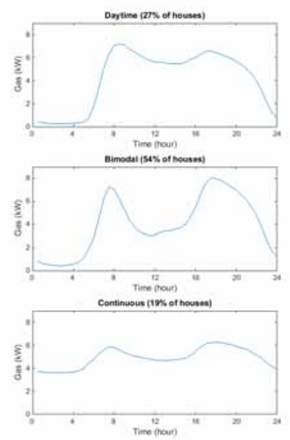
This is based on monitored data and shows lower peaks than previous estimates

Changes with outdoor temperature



Shape of heat demand varies with outdoor temperature. Predictions of heat demand need to take this into account

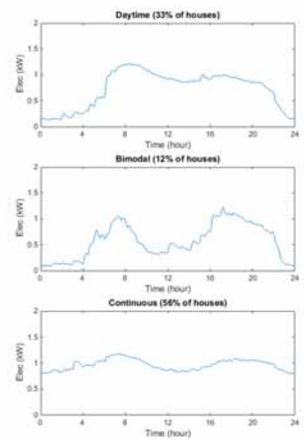
User types: Gas boilers



Effect of behaviour:

- Peak demand would be 12% lower than at present if all users were continuous.
- Annual demand would be 21% higher than at present if all users were continuous

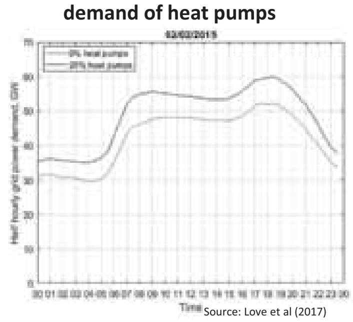
User types: Heat pumps



Factors affecting behaviour:

- Outdoor temperature
- Socio-demographics
- Heat pump type
- Emitter type

Effect on national electricity demand of heat pumps



Source: Love et al (2017)

Effect of heat pumps

- If 20% of houses have heat pumps, peak national electricity demand is increase by 14%.
- There is little effect on ramp rate

Further work:

Produce national electricity demand estimates for heat pumps, using knowledge of range of behaviour types and factors affecting behaviour. Give implications of this new demand.

Outputs:

- Contribution to Love et al (2017) – paper on addition of heat pump electricity load profiles to GB electricity demand
- Draft paper on current heat load

References:

DECC, 2013. *The Future of Heating : Meeting the challenge*,
Love, J. et al., 2017. The addition of heat pump electricity load profiles to GB electricity demand : Evidence from a heat pump field trial. *Applied Energy*, 204, pp.332–342. Available at: http://dx.doi.org/10.1016/j.apenergy.2017.07.026.
Wilson, I.A.G. et al., 2013. Historical daily gas and electrical energy flows through Great Britain's transmission networks and the decarbonisation of domestic heat. *Energy Policy*, 61, pp.301–305. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0301421513004655.

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