UKIEG 2014 Scientific Conference

Low Carbon Buildings: What About Health and Wellbeing?

Faculty of Engineering, University of Leeds
18th June 2014

Conference Programme

10:00-10.30	Registration & coffee	
10:30	Welcome & Chairman's introduction	Marcella Ucci University College London
	Morning session	Chair: Cath Noakes
10:40	INVITED SPEAKER Ventilation, indoor air quality and overheating: insights from POE studies of sustainable social housing	Prof Rajat Gupta Oxford Brookes University
11:10	Impact of climate change on indoor environment and health: a critical review	Dr Sani Dimitroulopoulou Public Health England
11:30	Urban pollution and indoor air quality, an undisputed relationship: OpenFoam modelling of pollutant ingress into a building with a single-sided opening	Dr Marco-Felipe. King PaCE Institute, University of Leeds
11:50	**Coffee**	
12:05	INVITED SPEAKER Modelling the invisible: energy and indoor air quality	Prof Malcolm Cook Loughborough University
12:35	Optimal strategies for healthy reduction of residential energy use in London and Milton Keynes	Dr Payel Das University College London
12:55	Poster 'quick fire session' (2 min presentations)	
13:15	***Lunch and Poster Viewing***	
13:45	***AGM***	Chair: Marcella Ucci
	Afternoon Session	Chair: Derrick Crump
14:15	INVITED SPEAKER Preventing Overheating - Investigating and reporting on overheating in England, including common causes and remediation techniques	Melissa Taylor Good Homes Alliance
14:45	The Impact of Household Energy Efficiency Measures on Health: A Meta-Analysis	Christopher Maidment University of Sheffield
15:05	Housing association and design team attitudes towards indoor air quality in social housing projects- A UK case study	Gráinne McGill Queen's University Belfast
15:25	Improving the Indoor Air Quality in a School Building by Using a Surface Emissions Trap	Prof Lennart Larsson Lund University, Sweden
15.45	The physics and health benefits claimed for "breathable" materials, a critical study	Tom Woolley Rachel Bevan Architects
	Discussion session and coffee	Chair: Paul Harrison
16:05	General discussion, closing remarks	
16.30	***Close of Meeting***	

*The UKIEG Conference Organizing Committee reserves the right to amend the program at short notice.

Confirmed Poster Presentations	
Indoor air quality and user perception of a renovated office building	Haruna Musa Manchester Metropolitan University
Improving internal air quality through paint materials	Hannah Maiden Keim Mineral Paints
100 unintended consequences of policies to create a low-carbon housing stock	Clive Shrubsole University College London
Low-carbon housing: How home occupants contribute to the quality of their indoor environment	Patricia Kermeci University of East Anglia
Thermal comfort and indoor air quality in teaching spaces	Robin Lowery University of Leedds
Occupant window opening behaviour	Adorkor Bruce-Konuah University of Sheffield
GPU based Real-time Simulation of Indoor Air Flow and Contaminant Transport	Amir Khan University of Leeds
Could Reducing Ventilation Rates to Meet Energy Requirements, Result in Changes in Infection Transmission?	Ann McDonagh University of Leeds
Monitoring and modelling exposure to emerging indoor air pollutants	Magdalena Kruza University of York
Population exposure assessment to consumer products	Sani Dimitroulopoulou Public Health England

UK IEG

Indoor Environments Group

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Abstracts

UKIEG 2014 Conference Booklet Contents

History of the UKIEG	3
UKIEG Committee 2014	4
Annual Conference 2014 Abstracts	
Invited Speakers	5
Oral Presentations	6
Poster Presentations	13
AGM Agenda	25
Pages for Notes	26

History of the UKIEG

The UK Indoor Environments Group (UKIEG) was launched in 2003, with the aim to co-ordinate and provide a focus for UK activity concerned with improving indoor environments for people.

The fact that people spend the vast majority of their time inside buildings – at home, at work, in vehicles, shops, etc. – is widely acknowledged, yet while the outdoor environment has received much attention, the importance of the quality of the indoor environment in relation to human health and wellbeing is often unrecognised and under-researched. Moreover, addressing problems relating to the indoor environment, which might include issues as diverse as indoor air quality, lighting, ventilation and thermal comfort, requires a highly multidisciplinary approach and involves numerous different stakeholders. Based on these considerations, our objectives are:

- To promote the health and well being of people in indoor environments
- To promote research and research collaboration in all aspects of the indoor environment
- To increase awareness of current activity and knowledge gaps in areas concerned with indoor environments and people
- To disseminate knowledge concerned with indoor environments and people
- To promote the effective and efficient design and operation of indoor environments
- To communicate, integrate and network activity concerned with indoor environments and people
- To communicate and liaise with other relevant groups within the UK and abroad
- To promote good practice

Our Members

We currently have nearly 230 registered members with a wide range of expertise from medics to toxicologists, architects, designers, appliance manufacturers, academics, regulators, researchers, chemists, modellers, engineers, building managers, environmental health professionals, social scientists - and others working in fields connected with the built environment. Our members can choose to receive regular updates on the Group's activities and relevant news and events.

Membership

Membership is free of charge. If you would like to join the Group or ask for further information, please contact our Secretary: Sani Dimitroulopoulou, email Sani.Dimitroulopoulou@phe.gov.uk

UKIEG Committee 2014

Dr Marcella Ucci (Chair)	Bartlett School of Graduate Studies, University College London	m.ucci@ucl.ac.uk
Dr Derrick Crump (Vice-Chair)	Director of the Institute of Environment and Health, Cranfield University	d.crump@cranfield.ac.uk
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Robert Greene	Head of Development, A2Dominion Group	
Prof Chuck Yu	President of the International Society of the Built Environment (ISBE), Editor-in-Chief of Indoor and Built Environment	
Clive Shrubsole	Research Associate, Complex Built Environment Systems Group (CBES), University College London	
Prof Paul Wilkinson	Department of Social and Environmental Health Research, London School of Hygiene and Tropical Medicine	paul.wilkinson@lshtm.ac.uk
Dr Cath Noakes	Director of Pathogen Control Engineering Institute, University of Leeds	c.j.noakes@leeds.ac.uk

Annual Conference 2014

Invited Speakers

Ventilation, indoor air quality and overheating: insights from POE studies of sustainable social housing

Professor Rajat Gupta, Professor of Sustainable Architecture and Climate Change, Director of the Oxford Institute for Sustainable Development (OISD), Director of OISD: Low Carbon Building Group, School of Architecture, Faculty of Technology, Design and Environment, Oxford Brookes University,

Modelling the invisible: energy and indoor air quality

Professor Malcolm Cook, Professor of Building Performance Analysis, Building Energy Research Group, School of Civil and Building Engineering, Loughborough University

Preventing Overheating - Investigating and reporting on overheating in England, including common causes and remediation techniques.

Melissa Taylor, Technical Associate, Good Homes Alliance

Oral Presentations

Health effects of climate change for the indoor domestic environment in the UK – a critical review

Sotiris Vardoulakis[1], Sani Dimitroulopoulou[1], John Thornes[1], Jonathan Taylor[2], Ka-Man Lai[3], Isabella Myers[4], Clare Heaviside[1]

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Keywords: Building overheating, Indoor air quality, Flooding damage, Indoor allergens

Abstract:

There is growing evidence that climate change, if unmitigated, is likely to have a significant impact on public health, primarily by amplifying existing risks related to heat exposure, flooding, and chemical and biological contamination in buildings. Identifying the health effects of climate change on the indoor environment, and opportunities and risks related to climate change adaptation and mitigation, can help optimise efforts to protect public health.

Climate change may exacerbate health risks and inequalities associated with building overheating, indoor air pollution, flooding damage, and water and biological contamination in the indoor environment, if adequate adaptation measures are not taken. Indoor environments can allow growth and propagation of pathogenic ecosystems; and overcrowding and poor ventilation may exacerbate airborne infectious disease transmission. Climate change mitigation and adaptation policies in the built environment can reduce greenhouse gas emissions and also bring ancillary public health benefits by reducing heat and cold-related mortality, indoor air pollution and mould growth. However, increased airtightness of dwellings could have negative effects on occupant health related to thermal stress, indoor air pollution ($PM_{2.5}$, CO and radon) and biological contamination, if mechanical ventilation is not provided. High risk groups include the elderly (especially those living on their own), individuals with pre-existing illnesses, people living in overcrowded accommodation, and the socioeconomically deprived.

We explored a range of health risks in the domestic indoor environment related to climate change, as well as the potential health benefits and unintended harmful effects of climate change adaptation policies in the UK building sector. We carried out a critical review of the scientific literature, focusing on the health effects of climate change in the domestic indoor environment in the UK. These have been grouped in the following categories: (i) building overheating and thermal comfort, (ii) indoor air quality, (iii) flood damage and water contamination, and (iv) indoor allergens and infections.

A better understanding of current and emerging building infrastructure (including construction materials, furnishings, household products, mechanical ventilation systems, energy microgeneration and building vegetation) and the potential associations with climate-sensitive health impacts in the indoor environment is needed in the UK and other high income countries. Long-term, energy efficient building design interventions, ensuring adequate ventilation in increasingly airtight buildings, need to be promoted.

Urban pollution and indoor air quality, an undisputed relationship: OpenFoam modelling of pollutant ingress into a building with a single-sided opening

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Keywords: urban canyon, pollutant ingress, openfoam, CFD

Abstract:
Current building design, driven by carbon reduction policies, strives to maintain equilibrium conditions indoors regardless of the changing urban microclimate outside. This energy-centric approach however may lead to short term sustainability gains but potential for opening a window “to get some air” may lead to long term health, energy and environment costs (Sundell et al., 2011)

This study investigates the ability for computational fluid dynamics (CFD) to simulate near-field pollutant dispersion and subsequent ingress into the building envelope within the same simulation. Open source software is attractive from a cost perspective, however usage and confidence of this in the wind engineering field is still tentative and there are still some requirements for validation. This study shows the the comparison of OpenFoam using Reynolds’ Averaged Navier-Stokes (RANS) coupled with a k-epsilon RNG turbulence model and a passive scalar transport equation against benchmarked street canyon data of pollutant dispersal published by Tominaga et al. (Tominaga & Stathopoulos, 2011). Full scale simulation represents an urban canyon on rough terrain with a building containing a single sided opening facing into the canyon. A passive scalar volume source is placed at pedestrian level at its base. Meshing is conducted in snappyHexMesh, is fully hexahedral and in the region of 2.5million cells. Concentration of pollutant is measured at the opening.

Results show an encouraging comparison with the experimental data. However noticeable differences between the CFD model does exist particularly within the locations of notoriously high vorticity at the building base. Quantity of pollutant ingress appears to be dependent on canyon/building ratio as well as prevailing wind direction and velocity. This benchmark comparison highlights the highly unsteady nature of flow between buildings, particularly at pedestrian level, a phenomenon which is still not fully understood and would benefit from further full-scale investigation.

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Optimal strategies for healthy reduction of residential energy use in London and Milton Keynes

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Keywords: Energy use, Indoor air quality, Optimization, Stock modelling

Abstract:

The global requirement to dramatically reduce greenhouse gas emissions places an increased emphasis on reducing residential energy demand, which is responsible for a quarter of current total UK CO2 emissions. Over half of these emissions are related specifically to space heating energy, and therefore improving heat transfer characteristics of dwellings is a principal target of abatement strategies. Where improved energy efficiency is in part achieved by tighter control of ventilation, there is potential for both positive and negative impacts on health from reduced air exchange in the indoor environment.

We use a multi-objective optimization algorithm to determine the energy-efficiency measures that most closely meet specified CO2 reduction targets, while minimizing adverse impacts on indoor air quality (as indicated by PM2.5, mould, radon, and environmental tobacco smoke) for two contrasting housing stocks: London, a long-established city and Milton Keynes, a growing new town. We use the in-house 'Strategies for Carbon Reduction in the Built Environment' (SCRIBE) tool, a UK housing stock modelling program developed from the 'Health Impact of Domestic Energy Efficiency Measures' (HIDEEM) tool for the PURGE* project. Scenarios are constructed for 2020, 2030, and 2050, covering a range of possible future heating energy carbon intensities and ambient PM2.5 levels.

The degree of decarbonisation of the heating energy source plays a major role in achieving overall policy success. The combination of reduced ambient PM2.5 concentrations and the provision of purpose-provided ventilation, results in reductions in indoor pollutant concentrations. Greater relative reductions in concentrations of all studied pollutants were predicted in London, due to its older housing stock, but both the initial and final concentrations were lower in Milton Keynes.

* Public health impacts in urban environments of greenhouse gas emissions reduction strategies. Funded by the European Union Seventh framework programme FP7/2007-2013 under grant agreement No 265325 S

The Impact of Household Energy Efficiency Measures on Health: A Meta-Analysis

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Keywords: Energy efficiency, Health, Wellbeing, Housing

Abstract:

It is widely accepted that interventions designed to promote household energy efficiency, like insulation, central heating and double glazing, can help to reduce cold-related illnesses and associated stress by making it easier for residents to keep their homes warm. However, these interventions may also have a detrimental effect on health. For example, the materials used or lower ventilation rates could result in poorer indoor air quality.

The present research sought to systematically quantify the impact of household energy efficiency measures on health and wellbeing. Thirty-six studies, involving more than 33,000 participants were meta-analysed. Effect sizes (d) ranged from -0.43 (a negative impact on health) to 1.41 (a substantial positive impact on health), with an overall sample-weighted average effect size (d+) of 0.08. On average, therefore, household energy efficiency interventions led to a small but significant improvement in the health of residents.

The findings are discussed in the context of the health improvements experienced by different groups of participants and the study design factors that influence health outcomes. The need for future studies to investigate the long term health benefits of interventions designed to promote household energy efficiency is identified.

Housing association and design team attitudes towards indoor air quality in social housing projects- A UK case study

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Keywords: Indoor Air, Social Housing, Case Study, Interviews

Abstract:

The quality of indoor air in energy efficient buildings is a significantly important yet under-researched area, particularly in a social housing context. The implementation of air tight envelopes, reliance on mechanical ventilation systems, reduction of ventilation rates and the introduction of new building products, materials and/or techniques increases the risk of inadequate indoor air in energy efficient homes.

In this study, interviews with architects, consultants and housing associations of four recently completed UK energy efficient social housing projects were conducted in order to explore attitudes on indoor air quality and thermal comfort. This included perception on the importance of considering indoor air quality in the design process, knowledge of indoor air quality issues and drivers for the incorporation of indoor air quality strategies in the social housing projects.

Indoor air quality and thermal comfort strategies implemented during the case study projects were identified, including a reflection of their success. In particular, the degree of occupant training during the handover stages was discussed and feedback on the use of Mechanical Ventilation with Heat Recovery in a social housing context. Initial feedback from building occupants regarding indoor environmental quality was explored, including discussion of findings from previous field work conducted in the homes.

This work builds on the findings from recent investigations of indoor air quality and thermal comfort in the four case study projects, which consisted of physical indoor air quality measurements, building surveys and interviews with the building occupants. The identification of design team and client (housing association) attitudes is an important step in recognizing barriers and solutions to the effective adoption of indoor air quality strategies in social housing schemes.

Improving the Indoor Air Quality in a School Building by Using a Surface Emissions Trap

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Keywords: Indoor air purification, Volatile organic compounds, Building dampness, School environment

Abstract:

Introduction. Unsatisfactory indoor air quality can result from emissions of volatile organic compounds (VOCs) from the materials of a building. Here we studied the ability of a surface emissions trap (cTrap) to stop emissions in a water-damaged building and improve the indoor air quality.

Methods. A school built in the 1970:s with a long history of complaints on air quality was studied. 2-Ethyl-1-hexanol, a moisture-driven VOC originating from the degradation of components in the glue or/and PVC flooring, was used as a marker of dampness. A cTrap prototype (cTrap Ltd, Lund, Sweden), which is a laminate with one adsorption and one hydrophilic polymer layer, was attached on the existing PVC flooring. Over the cTrap was installed a laminate flooring. Air samples as well as samples of the cTrap cloth were taken from the floor at different time periods (up to 13 months) for measuring the amounts of 2-ethyl-1-hexanol in the air and adsorbed on the cTrap cloth, respectively.

Results. Already a few days after the cTrap had been installed a clear improvement in the perceived air quality was noticed. Air concentrations of 2-ethyl-1-hexanol decreased from 6-7 µg/m3 to 2 µg/m3; the concentrations of 2-ethyl-1-hexanol in the installed cTrap rose from 0 (unused cTrap) to 280.3 µg/g after 13 months of use.

Conclusions. Emissions of VOCs from a surface may be stopped efficiently by applying a cTrap cloth on the surface. At the same time the cTrap allows ready passage of water vapor. In the present study, attaching the cTrap on a PVC flooring in a school with air complaints led to a clear improvement in the perceived air quality as well as decreased 2-ethyl-1-hexanol air concentrations. The device may constitute an effective way of restoring the indoor air quality e.g. after water damage leading to unwanted emissions indoors.

The physics and health benefits claimed for "breathable" materials, a critical study

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Keywords: Breathability, Materials, natural, hygroscopic

Abstract:
Advocates of ecological and so-called healthy buildings frequently cite the advantages of breathable materials. These materials are mainly made from natural materials such as earth, lime, straw, wood, wool, hemp, flax and other cellulose materials. The term breathable is widely misunderstood but is related to the properties of materials being either vapour permeable and/or hygroscopic. The ability of materials, used on the inside of buildings, to handle moisture has potential benefits in terms of indoor air quality, whereas air-tight buildings that have been sealed up with plastic and synthetic materials may have greater risks in terms of IAQ. A further problem is related to the widespread use of so-called "breather" membranes that may not be as breathable as is assumed.

This paper investigates the literature about breathability, definitions of vapour permeability and hygroscopicity, and critically examines the benefits (or otherwise) to indoor air quality. Literature which discounts the benefits of bio-based and breathable materials is also discussed. This study is set within the context of growing concern about the health problems allegedly caused by higher standards of air tightness, ventilation problems and mechanical ventilation and heat recovery systems. Anecdotal evidence of growing problems of "dampness" and mould growth in new low energy houses and retrofitted dwellings is appearing. The dearth of scientific literature on the building physics of breathability, vapour permeability and humidity control is considered and suggestions are made about priorities for future research about the relationship between breathability and indoor air quality.

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Poster Presentations

Indoor air quality and user perception of a renovated office building

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Keywords: Indoor air, Sick Building Syndrome , CO2, TVOC

Abstract:

The amount of time humans spends in enclosed environment especially in western countries is arguably estimated to be around 70-90% of one daily time. The deterioration of indoor air quality in any indoor environment can be attributed to the occurrence of a large number of pollutants present in the air. Renovation of buildings can adversely affect the building occupants by the release of biological contaminants, gases and particulates. The research aim is to monitor the air quality of a newly renovated Victorian building renovated to accommodate both staff and student using the facility on a daily basis. Considering that, materials and furniture fitted are made from various forms of materials that are known to release gas and particulates into the air especially during unpacking phase, while the removal of old building materials and furniture during the renovation phase could contribute to the release of biological contaminants.

A durational monitoring of the building after it becomes operational was done for the following environmental parameters; airborne microflora, total volatile organic compounds (TVOC), CO2, CO, Temperature and Relative humidity in the building. In addition, a structured questionnaire was sent to the users of the building after the first week of the building been occupied, to assess the users perception of the indoor environment. Preliminary results of the airborne flora monitored on MEA plate from three locations; selected office environment, corridor and outdoor (courtyard) the corridor result was the highest in both the morning (833 cfu/m^3) and afternoon (1213 cfu/m^3). Similar result was noticed on PCA plate during the morning period (731 cfu/m^3) and afternoon (1358 cfu/m^3). The result of the office space for the TVOC monitored over the first one week of the building being occupied showed the first two days of monitoring the reading peak at 10837 ppb and CO_2 highest reading recorded was 1163 ppm. The preliminary analysis of the questionnaire indicates majority of the staff that took part in the survey, experienced some form of healthy abnormality such as headache, shortness of breath, itchy eyes/ears, loose of concentration etc. especially in the first two days. The preliminary result showed that there is a relationship between high airborne mould count, TVOC and staff health perception of the building.

Improving internal air quality through paint materials

Hannah Maiden

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Keywords: Paint , Photocatalytic , VOCs

Abstract:

Conventional acrylic based paint systems which are commonly used throughout many internal areas contain harmful volatile organic compounds (VOC). As a result, products made which include these harmful VOC components release the gases into the air as they are used and for the life of the product.

Whilst measures can be taken to ventilate internal areas, it is also possible to use materials such as mineral paints which are made with only natural components. Mineral paints do not contain any petrochemicals or VOCs and are both environmentally friendly and sustainable. Mineral paints are odourless and since they do not off-gas any chemicals, rooms can be occupied very quickly.

Keim Ecosil-ME is a particularly beneficial paint as it is a photocatalytic high quality interior paint. Photocatalytic paints contain a catalyst, in this case titanium dioxide, which when activated by light, enables a reaction converting harmful air pollutants into harmless substances. The pollutants which Keim Ecosil-ME helps to reduce include formaldehyde and acetaldehyde, as well as other VOCs such as benzene and toluene. Nitrogen oxides and ammonia can also be reduced by the photocatalytic reaction.

The photocatalytic reaction also inhibits and kills bacteria. Independently tested it is proven to reduce living bacteria by 99% and dead cells completely. With regards to sanitation and health care the reduction and removal of dead and living biomass is very important to prevent infections. Dead cells can still have a toxic and allergic potential and Keim Ecosil-ME is proven to improve interior hygiene more effectively than a conventional film forming paint.

Keim Mineral Paints would be delighted to give a short presentation on photocatalytic paints, which we hope would allow attendees to think about paints and other materials which can make an active contribution to better air quality.

100 unintended consequences of policies to create a low-carbon housing stock

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Keywords: Housing Policy, Unitended consequences, Complexity, Wellbeing

Abstract:

Housing, as a major sector contributing to the UK's greenhouse gas (GHG) emissions is an important focus of Government policies to mitigate climate change. The current “single focus” policy approach (CO2 mitigation) will see the application of energy efficiency measures to a diverse building stock, with varying construction and design with differing occupant patterns and behaviour and will inevitably lead to a wide range of additional unseen and/or unintended consequences beyond those for which the original policy was intended. We have undertaken a scoping review identifying more than 100 unintended consequences impacting building fabric, population health and the wider environment, thus highlighting the urgent need for Government and society to reconsider its approach.

Many impacts are connected in complex relationships. Some are negative, others possibly co-benefits for other objectives. While there are likely to be unavoidable trade-offs between the different domains affected and the emissions reduction policy, a more integrated approach to decision making could ensure co-benefits are optimised, negative impacts reduced and trade-offs are dealt with explicitly.

Integrative methods can capture this complexity and support a dynamic understanding of the effects of policies over time, bringing together different kinds of knowledge in an improved decision-making process. We suggest that participatory systems dynamics (PSD) with multi/inter-disciplinary stakeholders is likely to offer a useful route forward, supporting cross-sectorial policy optimisation that places reducing housing GHG emissions alongside other housing policy goals.

Monitoring and modelling exposure to emerging indoor air pollutants

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(2)Department of Chemistry, University of York

E-mail:

Keywords: Indoor air quality, indoor air pollutants, Secondary indoor air pollutants, Household products

Abstract:

Since the 1970s, increasing attention has been paid to indoor air quality, led in part by the emergence of building related symptoms such as headaches, allergy and eye irritation. Indoor environments are often more polluted than outdoors. Indoor air pollutants can be generated through different activities like cooking, cleaning or smoking. Moreover, they can be emitted from different sources like building materials, paints, carpets, furnishing or cleaning products. Finally, they can ingress from outdoors, which can be an issue near a busy road for instance.

We already have some knowledge about VOCs, microbial agents and dust. However, far less is known about secondary pollutants, even though there is increasing evidence that such pollutants may be responsible for some of the observed health effects indoors. Further, such secondary pollutants are a by-product of the use of cleaning agents and air fresheners commonly used as household products.

This paper will describe a new PhD project to detect, quantify and model emerging secondary indoor air pollutants, namely those formed through limonene oxidation. We will use novel measurement techniques and a detailed chemical model to understand the processes indoors that lead to high concentrations of potentially harmful species. Such work, will help us to understand potential health issues caused by the use of common household products.

Thermal comfort and indoor air quality in teaching spaces

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Keywords: Thermal comfort, Indoor air quality, Occupant work performance, Learning environments

Abstract:

There are many factors which affect thermal comfort and air quality in indoor environments. Some of these factors are influenced by the occupants themselves and others by the environments they occupy. Some ‘occupant’ influencing factors include: age, gender, physical activity and clothing, and some ‘environmental’ factors include ambient temperature, humidity and CO2 concentration. This study quantified the above-specified environmental factors using Telaire and Tinytag instruments, in three teaching spaces in the School of Civil Engineering at the University of Leeds. Furthermore, the occupants of these spaces were issued a questionnaire, to assess their perception of the thermal comfort and air quality in these spaces, as well as their own work performance.

From the measured data it was concluded that all three spaces provided poor thermal comfort and air quality to their users, with temperatures reaching as high as 27.68^{o}C, CO_2 concentrations reaching 3900ppm and humidity levels dropping as low as 27.05%. It was also found that occupants were unable to perceive fluctuations in humidity but were able to perceive variations in temperature and CO_2 concentration, with strong positive correlations being seen between the perceived and the actual conditions. Importantly it was found that increased temperature and CO2 concentrations can have negative affect on the perceived performance of occupants.

The questionnaire data indicates that a rise in temperature above 22^{o}C and a rise in CO_2 concentration above 2000ppm resulted in occupants perceiving their performance as worse than usual. As a result of these findings it was established that occupants of the spaces in the Civil Engineering department may be suffering from an 8% reduction in their work performance due to the poor environmental conditions, hence recommendations have been made to the university with regard to improving the thermal comfort levels and air quality in the teaching spaces examined in this study.

Occupant window opening behaviour

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Keywords: Window use, Carbon dioxide, indoor air quality, natural ventilation

Abstract:

There is current interest and drivers for reducing ventilation rates in an attempt to save building energy use and reduce carbon emissions. To address the trade-off between indoor environmental quality and energy/carbon reduction measures, it is important to understand what drives occupants to adapt their own indoor environment using openable windows. It is well known that indoor and outdoor air temperature drive window use and there are models available to evaluate this. However, there is reported evidence that levels of CO2 concentration above 600ppm have physiological effects on occupants (tiredness, headache, reduced concentration and performance). Even with these findings, we do not know if high levels of CO2 in thermally comfortable environments will prompt occupants in naturally ventilated spaces to open windows.

In this study, the influence of CO2 concentration and some non-environmental factors on window opening behaviour have been evaluated. In a series of tests, participants blinded to CO2 concentrations at background levels and at elevated levels evaluated their environment and they were free to open a window if desired. Results from the current study showed that CO2 concentration was not a driver for window opening. Participants perceived environment (thermal and indoor air quality) improved in lower temperature conditions and this was regardless of the CO2 concentration. Perceived thermal comfort and air quality had an influence on window opening as window opening occurred mostly when the environment had been perceived as thermally uncomfortable and/or stale air.

The study will have implications for the thermal comfort-IAQ-energy efficiency dilemma as it is important to provide adequate indoor air quality for occupants at the same time as maintaining thermally comfortable environments and reducing building energy use to meet legal requirements.

GPU based Real-time Simulation of Indoor Air Flow and Contaminant Transport

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Keywords: Lattice Boltzmann, GPU, Indoor environment quality, Contaminant transport

Abstract:

Computational fluid dynamics (CFD) has been playing an increasingly important role in the assessment of building design. The information provided by CFD has been extensively applied to all aspects and stages of building design. CFD can provide detailed information about the indoor environment quality (IEQ), such as air velocity, temperature and contaminant concentrations. Although CFD can predict the dynamic nature of contaminant transport and distribution in great detail and accuracy but the computational time is prohibitive for its usage as a management or control tool. Hence the aim of our work is to present an investigation into the development and implementation of a novel graphics processing unit (GPU) based simulation tool, to predict air flow and contaminant transport, in real-time and thereby transforming the traditional CFD based IEQ analysis into a viable tool for indoor environment management and control.

In this work we use a non-traditional CFD method to simulate interactively in real-time the behaviour of indoor air flow and contaminant transport. In order to achieve both real-time compute and visualisation capabilities while maintaining good physical accuracy, lattice Boltzmann method (LBM) was chosen. It is a microscopically inspired method designed to solve macroscopic fluid dynamics problems. It places itself at the interface between the microscopic (molecular) and macroscopic (continuum) worlds, hopefully capturing the best of both. LBM has several advantages over the traditional CFD, such as its numerical stability and accuracy, the capacity to efficiently handle complex geometries and the data-parallel nature of its algorithm.

Our results of the 3D LBM simulation running on a GPU are in good agreement with the benchmark results found in the literature. Furthermore good agreement between LBM and traditional CFD based method are obtained for turbulent air flow in a 32m3 bio-chamber. The simulated room is based on a real Class II bio-aerosol chamber built in the School of Civil Engineering at the University of Leeds.

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Could Reducing Ventilation Rates to Meet Energy Requirements, Result in Changes in Infection Transmission?

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Keywords: Mechanical Ventilation, Infection Transmission, Bioaerosols, Spatial distribution.

Abstract:

The fate (whether airborne or surface residing) and spatial distribution of hazardous aerosols in an indoor environment, are strongly dependant on the airflow within that environment. Many indoor environments are mechanically ventilated; therefore it is the ventilation rate and regime which primarily determine the room's airflow patterns and hence the transport of aerosols. Many high risk indoor environments such as hospital rooms are looking to reduce ventilation rates in an attempt to reduce energy use. This study experimentally examined the effect of reducing ventilation rates, on the size, concentration and spatial distribution of aerosolised bioaerosols. It is essential to further our understanding of the relationship between ventilation and the fate of hazardous aerosols, in order to mitigate the risk of exposure for building occupants.

Experiments were carried out in a 32m^3 class 2 aerobiological test chamber. The temperature, humidity, ventilation rate and ventilation regime within the chamber were externally controlled. A known concentration of *Bacillus Subitilis* was continually introduced into the chamber via a six-jet Collision Nebuliser. A Geo-α particle counter and a 6-stage Andersen Impactor were constantly sampling at the ventilation exhaust. The concentration and spatial distribution of the airborne bioaerosols were determined using both an Aerodynamic Particle Sizer (APS, also determines size distribution) and an All Glass Impinger (AGI), by sampling through tubing located in the breathing zone at three pre-defined locations. TSA agar plates were placed on the chamber floor directly beneath the air sampling tubing, to assess the concentration and spatial distribution of deposited bioaerosols.

Comprehensive analysis of the data is currently underway and thus no absolute conclusions can be determined at the present time. However, initial analysis indicates that there are significant differences in the concentration of bioaerosols at the different locations and there appears to be no correlation in the concentration of bioaerosols in the air and deposited to the ground, at each location examined.

Population Exposure Assessment to Consumer Products

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Consumer products have been identified as indoor sources in the domestic environment, which may emit key and emerging pollutants of known or suspected adverse health effects.The impact of using these products on human health depends on the frequency of product use and the duration of exposure to the emitting pollutants. The recently finished EPHECT project, funded by DG Sanco, focused on the emissions from 15 consumer products (all-purpose cleaners, kitchen cleaners, floor cleaners, glass and window cleaners, bathroom cleaners, furniture polish, floor polish, combustible air fresheners, air fresheners–sprays, electric air fresheners, passive units-air fresheners, coating products for leather and textiles, hairsprays, spray deodorants, perfumes), in order to assess the inhalation exposure to formaldehyde, d-limonene, acrolein, α-pinene and naphthalene.

Methodology:

Scenarios for the use of 15 consumer products by two population groups (Housewives, Retired) in 4 geographical areas of Europe (North, West, South, East), were constructed based on the analysis of the IPSOS household questionnaire survey (4335 people interviewed in 10 EU countries). The exposure assessment followed the “most representative worst-case scenario” strategy: scenarios reflecting the worst-cases for the use of each product, under realistic conditions.

Microenvironmental modelling (using ‘CONC_CPM’ model) was carried out to simulate indoor air pollutant concentrations in dwellings, resulting from the use of the above 15 consumer products, based on: i) quantified emission rates derived from chamber testing, according to the above constructed scenarios; ii) ventilation rates from literature review [1] as well as ventilation ‘zero’ (0.1 ach), in order to be proactive in the case of future building regulations; iii) room volumes derived from data across EU countries [2].

Results:

The 24h mean exposures to the above pollutants are well below the exposure limits, even in the case that very a low ventilation rate is assumed. The max 30min exposures are also below the exposure limits, however, in the case of formaldehyde, they may represent a significant fraction of the exposure limit, under low ventilation conditions.

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Using PM2.5 collected from smokers' homes to determine how long second-hand smoke (SHS) remains in air

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Keywords: Second-hand smoke, PM2.5, smoker's home, indoor air quality

Abstract:

Introduction: Over 85% of second-hand smoke (SHS) is invisible1 and smokers are often unaware of the amount of SHS produced during smoking. There is also little information about how long SHS particles linger in the air within a home setting.

Methods: This project gathered data from a series of studies where fine Particulate Matter (PM2.5) concentrations were measured every minute in homes. The PM2.5 peak produced by SHS from the last cigarette smoked of the day was identified. The time taken for this peak to reduce by 50% was calculated, as was the time between the peak and a return to the World Health Organisation's (WHO) 24-hour guidance value for PM2.5 of 25 mg/m3.

Results: From over 230 days of 1-minute resolved PM2.5 data from 103 smoking households, 140 suitable peaks were identified. The median (Inter quartile range (IQR)) for the time for the SHS peak to decay by 50% was 55 (23-116) minutes and the median (IQR) for the peak to reduce to the WHO guidance value for PM2.5 was 160 (90-313) minutes.

Conclusions: SHS remains suspended in the air in homes for a considerable period of time after a cigarette is smoked. This information will be useful in designing public health campaigns and in interventions to encourage smokers towards smoke-free homes.

Low-carbon housing: How home occupants contribute to the quality of their indoor environment

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Keywords: low-carbon housing, indoor air quality, occupants' behaviour, mechanical ventilation system with heat recovery

Abstract

The UK government have set a highly ambitious target to reduce greenhouse gas emissions by at least 80% by 2050 (UK Govt, 2008). With greenhouse gas emissions from homes contributing to one quarter of the total current emissions, domestic carbon emission reduction has been the centre of much interest and embedded within key government plans and strategies. A fundamental part of this strategy aims to move the construction industry towards building more sustainable, highly energy-efficient homes. For instance, from 2016, zero-carbon homes are expected to become a legal requirement through the Building Regulation (Zero Carbon Hub, NHBC, 2013). To be able to achieve zero-carbon home standards, buildings must not only have energy efficient heating and cooling systems, but they also need to be highly airtight. Since concentrations of many air pollutants are often higher indoors than outdoors (Adgate et al. 2004; Jurvelin et al. 2001) the required increased airtightness generates immediate concerns over the quality of indoor air and its effects on human health.

Many epidemiological studies have explored the health effects of poor indoor air quality (Franklin, 2007; Foster & Kumar, 2011; Jones, 1999). In order to provide an exchange of outdoor and indoor air, airtight homes are often reliant on the use of MVHR (mechanical ventilation with heat recovery). In actual fact, the health of the zero-carbon home occupants will greatly depend not only on the ability of the MVHR system to provide good indoor air quality, but also on the occupants' behaviour regarding the operation and maintenance of the ventilation system.

Several studies (Dimitroulopoulou, 2012; Aizlewood & Dimitroulopoulou, 2006 & Leech, et al. 2004) show that home occupants lack understanding and awareness of the ventilation system in their own home. Bone et al. (2010) concluded that there is insufficient public awareness of the importance of achieving appropriate indoor ventilation rates and further research should be carried out to attain a better understanding of occupants' knowledge, behaviour and attitude regarding ventilation.

As a result, this research project aims to explore knowledge and perceptions of home occupants relating to their indoor environment in highly airtight, energy efficient homes and also to analyse how home occupants' behaviours affect the quality of their indoor environment.

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UK INDOOR ENVIRONMENTS GROUP

ANNUAL GENERAL MEETING, London, 18th June 2014

<u>AGENDA</u>

1. Welcome and Chairman’s Report
2. Status of Committee Membership
3. Future ideas for UKIEG:
    i. Membership
    ii. More events
    iii. International Links
    iv. Others
4. Topics and Venue for the next UKIEG annual conference
5. Ambassadors and LinkedIn
6. AOB: Motions/Comments from the floor

Notes

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