The UKIEG annual conference is a networking event for a multidisciplinary audience of academics, policy makers and industry experts with an interest in improving indoor environments for health and wellbeing. The indoor built environment can have a profound effect on the health, wellbeing and comfort of building occupants; particularly for more vulnerable groups such as children, the elderly and those with reduced mobility due to illness.

This conference brings together research and case studies to help shed light on this important topic. The conference will include invited speakers, presentations and discussion, a poster session and networking opportunities. The UKIEG AGM will take place during the lunch break.
<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Speaker/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>Registration, tea &amp; coffee</td>
<td></td>
</tr>
<tr>
<td>09:30</td>
<td>Welcome &amp; Chair introduction</td>
<td>Marcella Ucci, UCL; Tom Inns and Tim Sharpe, Glasgow School of Art</td>
</tr>
<tr>
<td></td>
<td><strong>Morning session</strong></td>
<td><strong>Chair: Prof Tim Sharpe</strong></td>
</tr>
<tr>
<td>10:00</td>
<td><em>Invited Presentation</em></td>
<td>Prof Jan Sundell, Tsinghua University Beijing</td>
</tr>
<tr>
<td></td>
<td>On the history of ventilation in homes</td>
<td></td>
</tr>
<tr>
<td>10:30</td>
<td>IEQ killer variable number 1 : Control</td>
<td>Dr Atze Boerstra, BBA &amp; Eindhoven University of Technology</td>
</tr>
<tr>
<td>10:50</td>
<td>Meta-study on assessing the relationship between IEQ and productivity in office buildings</td>
<td>Prof Rajat Gupta, Oxford Brookes University</td>
</tr>
<tr>
<td>11:10</td>
<td>Tea and Coffee</td>
<td></td>
</tr>
<tr>
<td>11:30</td>
<td>Guidance for designers on combined assessment of noise, ventilation and overheating in dwellings</td>
<td>Jack Harvie-Clark, Apex Acoustics &amp; ANC Noise, Vent &amp; Overheating Group</td>
</tr>
<tr>
<td>11:50</td>
<td>Improving indoor environmental quality &amp; supporting health &amp; wellbeing with indoor plants, green roofs &amp; green walls</td>
<td>Dr Lynette Robertson, MEARU, Glasgow School of Art</td>
</tr>
<tr>
<td>12:10</td>
<td>Poster ‘quick fire session’ (2 min presentations)</td>
<td>Chair: Prof Paul Harrison</td>
</tr>
<tr>
<td>12:35</td>
<td>Lunch and Poster Viewing</td>
<td></td>
</tr>
<tr>
<td>13:15</td>
<td>UKIEG AGM</td>
<td>Chair: Dr Marcella Ucci</td>
</tr>
<tr>
<td></td>
<td><strong>Afternoon Session</strong></td>
<td><strong>Chair: Dr Derrick Crump</strong></td>
</tr>
<tr>
<td>13:45</td>
<td>A struggle for 800 ppm</td>
<td>Prof Jelle Laverge, Ghent University</td>
</tr>
<tr>
<td>14:05</td>
<td>Evaluation of alternatives to common passive ventilation in home retrofit</td>
<td>Dr Oliver Kinnane, University College Dublin</td>
</tr>
<tr>
<td>14:25</td>
<td>A study of the implications for the Health &amp; Wellbeing of Energy-efficient House Occupants: A UK-based investigation of indoor climate and IAQ</td>
<td>Patricia Kermeci, University of East Anglia</td>
</tr>
<tr>
<td>14:45</td>
<td>Tea and coffee</td>
<td></td>
</tr>
<tr>
<td>15:05</td>
<td>Design decisions : how these might influence the performance characteristics of MVHR systems</td>
<td>Ian Mawditt, Fourwalls</td>
</tr>
<tr>
<td>15:25</td>
<td>Poor indoor air quality – A threat to human health</td>
<td>Leigh George, Allergy UK</td>
</tr>
<tr>
<td>15:35</td>
<td><strong>Discussion session</strong></td>
<td>Chair: Dr Marcella Ucci</td>
</tr>
<tr>
<td>16:00</td>
<td>Close of Meeting</td>
<td></td>
</tr>
</tbody>
</table>

* The UKIEG Conference Organizing Committee reserves the right to amend the program at short notice.
<table>
<thead>
<tr>
<th>Poster Presentations (12:10 – 12:35)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>2</strong></td>
</tr>
<tr>
<td><strong>3</strong></td>
</tr>
<tr>
<td><strong>4</strong></td>
</tr>
<tr>
<td><strong>5</strong></td>
</tr>
<tr>
<td><strong>6</strong></td>
</tr>
<tr>
<td><strong>7</strong></td>
</tr>
<tr>
<td><strong>8</strong></td>
</tr>
<tr>
<td><strong>9</strong></td>
</tr>
<tr>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

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

IEQ killer variable number 1: CONTROL!

Dr. Atze Boerstra
BBA Indoor Environmental Consultancy + Eindhoven University of Technology

Centralized indoor climate control seems to be a trend. Two-three decades ago most office workers still were able to directly influence the temperature and air freshness at their workstation e.g. by adjusting the thermostat on their radiator or by opening a window. But nowadays occupants in office buildings (esp. those in open plan offices) more often than not are deprived of control options and exposed to centrally controlled indoor climates designed with ‘average’ comfort needs in mind.

This is a problem. Extensive field and lab research has showed that building occupants are more comfortable, have less Sick Building symptoms and are more productive when they have adequate means to fine-tune their thermal environment and local air quality. Therefore class A climates should be defined (e.g. in programs of constraints for new buildings and their building service systems) in terms of optimal control options, not just in terms of temperature bandwidths and minimum air supply.

With reference to the outcomes of the PhD study of the author, and with reference to studies from the US, Scandinavia and the UK (e.g. Leaman & Bordass and Humphreys & Nicol), we will argue that (adequate) control (control over indoor climate) should be regarded as killer variable nr. 1. That is, when one wants to guarantee that the end-result is: a healthy, comfortable and the productivity-enhancing office environment.

A conceptual model will be presented that describes how available, exercised and perceived control acts as a moderator in the stimulus-response relation between environmental parameters (like air temperature or CO2 concentration) and occupant effects. And specific examples will be given of how not to offer control in office environments (think e.g. of overcomplicated interfaces) and of how to really boost perceived and actual control of building occupants (e.g. with microclimatisation systems).

---

Meta-study on assessing the relationship between IEQ and productivity in office buildings

Professor Rajat Gupta* and Dr Adorkor Bruce-Konuah
Low Carbon Building Group, Oxford Institute for Sustainable Development, School of Architecture, Oxford Brookes University, Oxford  *rgupta@brookes.ac.uk

Indoor environmental quality (IEQ) parameters in office buildings have been found to influence workers’ productivity. However majority of studies that have shown increased productivity from improved IEQ have focussed on individual IEQ elements, e.g. temperature or ventilation rates, which is not representative of a real office setting which experiences dynamic conditions where variables such as temperature, relative humidity (RH), ventilation rates, and air pollutants vary across the course of the day.

This paper describes meta-analysis of datasets on IEQ and occupant satisfaction surveys gathered through monitoring and Building User Survey (BUS) questionnaires from 21 low energy offices to investigate the influence of perceived indoor environment and control on productivity improvements of occupants in real office settings. The meta-study was conducted as part of Innovate UK’s national Building Performance Evaluation (BPE) programme which undertook case study investigations of 50 low carbon non-domestic buildings. The BPE programme focussed on the buildings’ fabric performance, energy use, environmental conditions and occupant satisfaction.

Results show that out of 21 offices, 12 reported an increase in perceived productivity. The maximum increase in productivity was 10% and average was 4.9%. Overall comfort accounted for 72% (r2=0.72) of the variation in perceived productivity, while satisfaction with noise levels was found to have a weak correlation with perceived productivity, explaining only 3% (r2=0.03) of the variation in productivity. Perceived productivity improvement decreased when air was perceived as stuffy and smelly, but surprisingly control over cooling and heating was negatively correlated with perceived productivity, implying that the effect of personal control may be dependent on the environment and the type of activities performed. When occupants were satisfied with temperature (mostly summer), noise, lighting and building features, perceived productivity increased. Insights from the analysis can help in improving (perceived) control of indoor environments as a means for improving productivity in workspaces.
Guidance for designers on combined assessment of noise, ventilation and overheating in dwellings

Jack Harvie-Clark and Nick Conlan

Apex Acoustics & ANC Noise, Vent & Overheating Group

The necessity to consider external noise ingress into dwellings typically arises as a Planning requirement. Ventilation is controlled under the Building Regulations, and there is no statutory requirement to consider overheating. However, the Planning system does not ensure that proposed buildings holistically consider insulation against external noise, ventilation and overheating. It is common for the façade sound insulation assessment to barely consider the effect of the ventilation strategy (for example the effect of the quantity of trickle vents required), and there is no general association between ventilation and noise level limits. Similarly, it is common for an overheating assessment, if undertaken, to assume open windows, at the same time that the façade sound insulation assessment assumes closed windows.

Where residential developments rely on opening windows to control overheating, there can be a compromise between allowing excessive noise ingress with windows open, or excessive temperatures with windows closed. This problem is exacerbated by the move towards better insulated, more airtight buildings and the need, particularly in urban areas, to consider residential development on noisier sites. A working group has been formed by the Association of Noise Consultants to provide guidance on acoustic conditions and design when considering both the provision of ventilation and prevention of overheating. The guidance produced by the group aims to clarify the conditions that should be considered together, and provide examples of acoustic design solutions.

This presentation describes the guide and presents practical methods available to provide ventilation which controls overheating and noise levels without the need to introduce comfort cooling systems. Case studies of projects include passive ventilation systems using attenuated façade vents and methods of using balconies to reduce noise levels incident on open windows.

Improving indoor environmental quality and supporting health and wellbeing with indoor plants, green roofs and green walls

Dr Lynette Robertson

Mackintosh Environmental Architecture Research Unit (MEARU), Mackintosh School of Architecture, Glasgow School of Art, Scotland, UK

Plants and vegetative green infrastructure such as green roofs and walls have significant potential for improving the quality of indoor environments and a growing body of research suggests a beneficial effect on the health, wellbeing and productivity of building occupants. This paper provides an overview of the evidence on the key pathways through which vegetation in the environment can help support or enhance human health and wellbeing, and highlights key evidence for: (i) indoor potted plants; (ii) green roofs; (iii) green walls.

Potential risks or negative impact on health and wellbeing are also discussed, and how these issues can be managed or overcome. Careful consideration of building characteristics, environmental context and occupant preference is essential in order to make best use of plants and green infrastructure to support human health and wellbeing. Further research is needed to ensure that green infrastructure technologies are sustainable in design and provide multiple environmental benefits.
A struggle for 800 ppm

Prof Jelle Laverge
Department of Architecture and Urban Planning, Ghent University

In the spring of 2016, the Belgian national government issued a new royal decree on the environmental conditions of work places. In it, the provisions for ventilation were substantially changed. The previous version of the decree mandated a minimum ventilation rate of 30 m3/h per worker in the space. Since measuring flow or even air exchange rates is not straightforward and therefore, the old decree was hardly ever enforced. Therefore, the new decree opted for a performance based approach, and includes a carbon dioxide concentration threshold value of 800 ppm, based on a best practice review of scientific and occupational health literature. Not only does this bring about a completely new framework for ventilation assessment in Belgium, it also catapults IAQ goals for the Belgian work place to one of the most ambitious set in Europe.

Since the introduction of the new decree, a number of very powerful lobby groups, mainly from the construction industry, are working hard to overturn or ‘soften’ the decree. Some of the arguments put forward have merit on principle while others are more opportunistic. These include issues around measuring protocol, issues with transition periods and economical feasibility.

In this paper, we will consider some of these arguments and frame them in a scientific and practical background and try to provide a perspective for the further development of this new decree.

Evaluation of alternatives to common passive ventilation in home retrofit

Oliver Kinnane¹, Will Turner², Derek Sinnott³
¹School of Architecture, University College Dublin
²Electricity Research Centre, University College Dublin
³Department of the Built Environment, Waterford Institute of Technology

Passively allowing air movement through the building envelope remains the most common strategy for ventilation provision in UK and Irish homes. Ingress and egress of fresh air through window trickle vents and/or wall vents, arranged to enable cross ventilation are proposed as first option in building regulations Part F. Previous studies have shown this system to have a number of drawbacks that may impact on the health of the building and its occupants and ultimately be at odds with the aims of achieving energy efficiency in the residential sector. Building Regulation developments towards NZEB and driving changes in ventilation design. This simulation study analyses alternative systems to passive ventilation: mechanical extract ventilation (MEV), demand-controlled ventilation (DCV), mechanical heat recovery ventilation (MHRV), and positive input ventilation (PIV). The systems are appraised for their efficacy from an indoor air quality (IAQ) and energy perspective; and assessed for their economic suitability to be included in nationwide residential retrofit schemes in the UK and Ireland.
A Study of the Implications for the Health and Wellbeing of Energy-Efficient House Occupants: A UK-based investigation of Indoor Climate and Indoor Air Quality

Patricia Kermeci*

Final year PhD researcher for the University of East Anglia, School of Environmental Sciences, Norwich, UK
*patriciakermeci@gmail.com

Policies related to the reduction of both carbon dioxide and energy consumption within the residential sector have contributed towards a growing number of energy-efficient houses being built in several countries. Many of these energy-efficient houses rely on the construction of very well insulated and highly airtight structures, ventilated mechanically. Although energy-efficient houses are indeed more energy efficient than conventional houses, concerns have been raised over the quality of their indoor air and, consequently, the possible adverse health and wellbeing effects for their occupants. Using a longitudinal study design over three different weather seasons (winter, spring and summer), this study has investigated the indoor climate and indoor air quality of different rooms (bedroom, living room and kitchen) in five energy-efficient houses and four conventional houses in the UK. Occupants have kept diaries of their activities during the studied periods and interviews have been conducted to investigate possible behavioural explanations for the findings. Data has been compared with reviews of epidemiological, toxicological and other health related published literature to reveals three main findings. First, it shows that the indoor environment quality of energy-efficient houses cannot be treated as a holistic entity as different rooms presented dissimilar indoor climate and indoor air quality. Thus, such differences might contribute to the health and wellbeing of occupants in different ways. Second, the results show that the indoor environment quality of energy-efficient houses can vary following changes in weather season, leaving occupants at a lower or higher risk of adverse health and wellbeing effects during different weather seasons. Third, one cannot assume that even identical energy-efficient houses provide a similar indoor environment quality. Fourth, the findings reveal that the practices and behaviours of the occupants of energy-efficient houses likely determines whether they enjoy a healthier indoor environment when compared with their control houses. In conclusion, it has been considered vital to understand occupants’ practices and behaviours in order to explain the ways they might contribute to the indoor climate and indoor air quality in energy-efficient houses.

Design decisions: how these might influence the performance characteristics of MVHR systems

Ian Mawditt

Fourwalls, UK

This paper further explores the findings published in a meta-study1 that reviewed the in-use performance of whole-house mechanical ventilation heat recovery systems (MVHR) installed in 54 low energy dwellings in UK, as part of a national research programme. MVHR systems have been successfully adopted in low energy standards such as Passivhaus. However, MVHR technology is frequently included as a strategy for demonstrating lower CO2 emission rates for meeting regulatory targets. The study reviewed the original design and commissioning data, and the measurement data recorded by the funded projects. Design team interviews were also conducted to ascertain the reasons for selecting MVHR as a ventilation strategy. Cross-analysis of this quantitative and qualitative data helped to identify the key aspects of MVHR systems with respect to quality of design, installation, and commissioning procedures.

The study identifies that adopting MVHR as a way of meeting regulatory targets can often be independent of building characteristics (e.g. degree of airtightness and practicalities for plant and duct accommodation), and needs or expectations of the building occupants. The study also highlights the potential consequences of this approach: the prevalence of sub-optimal systems, and the possible implications on both energy efficiency and indoor air quality. A further consequence being the potential for systems to be turned off where there may be no provision for background ventilation.

Recommendations from the study include better understanding of the design issues to ensure correct airflow; avoid installation problems associated with ductwork; designing for maintenance; ensuring good communication of the design details with installers and commissioners in conjunction with better quality control onsite; along with improved handover processes and occupant guidance.

1 Sharpe T; McGill G, Gupta R; Gregg M; Mawditt I: Characteristics and performance of MVHR systems: a meta study of MVHR systems used in the Innovate UK Building Performance Evaluation Programme. 2016
Poor indoor air quality – A threat to human health

Leigh George

Allergy UK

Poor ventilation, temperature, humidity and inefficient air exchange are major contributors to mould and house dust mite – both factors which can have a significant and detrimental impact on the health of adults and children in their own homes. In 2016 the Allergy UK Helpline received over 10 calls a week from people whose allergic symptoms suggested the cause was house dust mite or mould and the number of callers with eczema and perennial rhinitis, both exacerbated by poor indoor air quality, increased.

For the last two years, following the Report by the University of Reading on the future of indoor air quality and its impact on human health, Allergy UK has been working with other relevant organisations on the development of the case for improved building design and the specification of appropriate and sustainable building products to address poor indoor air quality. While energy efficiency remains a priority for the building industry the issue of indoor air quality is beginning to become more widely recognised.

Allergy UK remains the only national patient organisation that is able to support all aspects of allergic disease and its key objective is to help improve the lives of the millions of people who live with allergy. We are presenting our latest data on the impact of poor indoor air quality; describing the work we are doing to create better awareness of its impact on human health and demonstrating our commitment to improving and extending the robust research data we need to support our cause. At the same time we are showing how our endorsement scheme, through which people living with allergy can choose products that will help them manage their allergy symptoms in their daily lives, supports the work that we do.
Dedicated indoor drying spaces- A step towards improving indoor air quality

Rosalie Menon and Colin Porteous

Mackintosh Environmental Architecture Research Unit (MEARU), Mackintosh School of Architecture, Glasgow School of Art, Scotland, UK

In 2010 as an outcome of MEARU’s 3 year EPSRC funded project titled ‘The Environmental Impact of domestic laundering’ a design guide was produced. This A4 published guide was distributed to Housing Associations across Scotland by the SFHA Scottish Federation of Housing Associations (SFHA) and to housing designers by the Royal Incorporation of Architects (Scotland) RIAS. The project also gained significant expose in the UK media outlets including BBC news.

The design guide is still in use as a best practice guide to ensuring new homes have a provision to remove humidity caused by drying clothes by passive methods. This poster highlights key recommendations from the report and illustrates methods by which housing designers have subsequently integrated these into their new home layouts. The guide aims to improve indoor air quality in dwellings by providing dedicated drying cupboards which are independently heated and ventilated to remove moisture from living spaces (a frequently used location for drying clothes on radiators). In addition to moisture removal a dedicated drying space allows potential VOC’s from laundry detergents and fabric softeners to be isolated from the home too. Options to integrate ventilation in these spaces with new MVHR systems in new air tight homes is also investigated.

UK winter temperatures and the health of the ageing population

Caroline Hughes

University of Bath

Modern lifestyles result in people spending 90% of their time indoors. With a growing body of evidence linking buildings to human health, the importance of ensuring the population lives in healthy and comfortable homes is becoming increasingly significant. In the winter of 2014/15 there were 43,900 excess winter deaths (EWD’s), with cold homes causing approximately 30% of these deaths. The majority of EWDs are in older people, with an ageing population residing at home for longer, ensuring that older people live in warm homes is increasingly significant.

The current UK housing stock is not conducive to achieving warm homes. Inefficient buildings, increasing fuel prices and incomes rising lower than inflation result in a growing number of people unable to afford sufficient heating. Older people, who tend to require longer heating periods whilst also being on low incomes, suffer most. This could result in a paradoxical situation where the desire to live at home for longer could result in health risks.

This study measures the internal temperature and humidity in 42 households, all with occupants aged 60 and above. Simultaneously, questionnaires track occupant health and well-being. Results show that a significant proportion of the participants were not achieving the World Health Organisation’s recommended internal temperatures. This is worrying given that a large proportion also had health complaints that are worsened by sub-optimal temperatures. It is also apparent that reasons for not attaining optimal temperatures vary, including (i) an inability to meet the cost of heating, (ii) leaky buildings with high heat losses and (iii) personal attitude towards heating. This is the first of three phases of temperature monitoring planned for this project, and it is anticipated that this will be the starting point for a larger scale project.
A Computational Evaluation Assessing the Impact Changes in Building Guidelines and Energy Retrofit Scenarios on Indoor Radon Concentrations

Dr James McGrath
School of Physics, National University of Ireland, Galway

Radon is classified as a level one carcinogen by the World Health Organization, and in many countries recognised as the second highest leading cause of lung cancer. In an OECD survey of 29 countries, Ireland was found to have the eighth-highest average indoor radon concentration. Radon accounts for over 56% of the Irish population’s radiation exposure, resulting in up to 250 cases of lung cancer each year.

Recent research has shown that energy retrofitting of dwellings may lead to greater airtightness, and there is a possibility of increased radon concentrations. The Irish National Energy Retrofit Programme aims to upgrade one million residential, public and commercial buildings by 2020. While buildings built on or after the 1st of July 1998 require a fully sealed membrane (radon barrier), this only applies to dwellings in high radon areas (> 200 Bq/m³). However, the majority of dwellings undergoing energy retrofit were built between 1979 and 2008, there is public concern surrounding further increases in indoor radon concentration due to increased building airtightness. In addition, during this period, there have been considerable revisions to the building regulations. The first Irish Technical Guidance Document Part F - Ventilation were only introduced in 1991 with revisions in 1997, 2002 and 2009.

The current work examines the various changes in the building guidelines in relation to dwellings undergoing energy-retrofit. Simulations will contribute to knowledge gaps by carrying out a sensitivity analysis on the impact that both indoor temperature and a buildings’ airtightness have on the pressure differentials, and subsequently radon entry rates into dwellings. Through simulation radon concentrations in retrofitted buildings, incorporating a range of initial radon concentration scenarios and retrofit strategies, are estimated and situations are identified where radon levels exceed 200 Bq m⁻³.

Health benefit and economic cost of upgrading ventilation system to reduce indoor exposure to outdoor pollution in Beijing China

Zhiwen Luo¹, Ye Yuan², Jing Liu²

¹School of the Built Environment, University of Reading, UK
²School of Municipal Environmental and Engineering, Harbin Institute of Technology, China

Beijing has been suffering severe ambient air pollution nowadays. As people spend the majority of time indoors, the indoor air pollution being transferred from outdoors has more effect on health. It is therefore important to understand what is the best economic ventilation approach to reduce indoor exposure to outdoor pollution. In this study, we consider 15 ventilation scenarios by combining air tightness levels (ATLs) of building external envelopes and different PM2.5 filtration efficiencies (PFEs) of mechanical ventilation system. The hourly indoor PM2.5 concentrations and corresponding monetary effects of mortality case change and energy consumption cost are analyzed.

Results show that in urban Beijing, the indoor exposure to PM2.5 will increase with ATL< 5 while PFE<70%. The annual average indoor PM2.5 concentration will be smaller than 10μg/m³ (the threshold concentration set by the World Health Organization) only with ATL > 7 conjunction with PFE>90%. The total monetary effect combining health and energy shows that 3 scenarios with combination of high ATL and PFE (ATL=7 and PFE=90%, ATL=5 and PFE=99%, and ATL=7 and PFE=99%) can achieve obvious economic benefits, while adopting mechanical ventilation system with PFE below 70% will lead to an increase of total monetary cost.

We also apply the same approach into four other typical mega cities in China (Shenyang, Shanghai, Chengdu, and Guangzhou). It shows that the economic benefits become less sensitive to ATL from north to south, while cities without central heating are more sensitive to PFE, among which Chengdu and Guangzhou can hardly achieve economic benefits with mechanical ventilation.
Pollutant Ingress into Residential Buildings and the Influence of Street Canyon Design

Marco-Felipe. King¹,⁎ and Catherine J. Noakes¹

¹ Institute for Public Health and Environmental Engineering, School of Civil Engineering, University of Leeds, Leeds, UK. ⁎Corresponding email: m.f.king@leeds.ac.uk

Natural ventilation is advocated in the UK as a means of reducing building energy consumption and promoting human health in buildings. However there is a trade-off in polluted environments, where the ventilation may result in pollution ingress into the building.

Computational fluid dynamics (CFD) is used in this study to evaluate the effect of building and street canyon shape on pollutant ingress from street traffic (NOx). This study considers air exchange between outdoor and indoor environments in the context of terraced residential buildings with single-sided natural ventilation. Two street-canyon aspect ratios were investigated (Height/Width=0.5 and 1) with roof angles of zero and 26.6º. An open window was located on the on the leeward side connecting to an interior room. Ansys Fluent 16 was used with the k-ω SST SAS turbulence model on hexahedral meshes to model airflows while a species transport equation was used to solve for NO2.

Results showed that increasing canyon width reduced the residence time of the outdoor pollutant in the street and reduces ingress. Flat roofs for both ratios drew the pollutant to the leeward side of the building due to negative pressures. However, pitched roofs created more complex systems that reduced contaminant in the canyon due to unsteady vortices.

- a) H/W=1, Flat
- b) H/W=1, 26.6º
- c) H/W=1/2, Flat
- d) H/W=1/2, 26.6º

Figure 1. Velocity vectors in the four canyon shapes
On the dependence of cross-ventilation turbulent flows on the wind direction of the approaching flow

Christos H. Halios 1,*, Hannah L. Gough 1, Janet F. Barlow 1, Marco-Felipe King 2, Catherine J. Noakes 2, Roger Hoxey 3, Adam Robertson 3, Andrew Quinn 3 *c.halios@reading.ac.uk

1 Department of Meteorology, University of Reading, United Kingdom
2 Institute for Public Health and Environmental Engineering, University of Leeds, United Kingdom
3 School of Civil Engineering, University of Birmingham, United Kingdom

Natural ventilation, one of the main controls of occupant's comfort, primarily depends upon the characteristics of the approaching flow (e.g. wind direction, turbulence) and the building's openings (e.g. number, position, geometry). In cross ventilation, when the ventilation openings are placed in opposite walls and under winds perpendicular to the openings, a jet penetrates the indoor environment. On the other hand when the flow is parallel to the openings, an unsteady flow develops and fluctuations become the main source of momentum for air exchange. Features of this kind of flows are by far less well understood. This study aims to examine the less understood turbulent aspects of the incoming flows for varying angles of the incident flow, namely when the flow is perpendicular, diagonal and parallel to the openings, under cross ventilation scenarios.

Measurements obtained at the Silsoe experimental cube during a 10 month field campaign and CFD simulations facilitated the understanding of the flow field around and inside the cube. Results show that for flows perpendicular, diagonal and parallel to the openings, velocity power spectra indoors appear flattened, implying an enhancement of the importance of small eddies indoors. When the flow is parallel to the openings, unsteady phenomena are dominant and pulsation flows develop. Spectral analysis highlighted the significance of the small scale fluctuations indoors. Our results reveal the dependence of the fine structure of the indoor flows from the wind direction of the approaching flow under cross ventilation scenarios.
Housing for old age through the platform of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA)

1Evangelia Chrysikou, 2Eleftheria Savvopoulou, 3Primaly Paranagamage

1 University College London Coordinator in D4 Action Group and Coordinator for all commitments of the Innovation Collaboration Plan D4, The Bartlett School of Architecture
2 SynThesis Architects
3 School of Architecture and Design, University of Lincoln

The global ageing phenomenon is affecting individuals, investors and policy makers. An environment incorporating, in its’ design principles and spatial characteristics, the knowledge on human physiology and psychological effect of the built environment and especially the physiology and perception of people across the lifespan, is beneficial for all and acts as their multiplier.

This project bears a multi-disciplinary, innovative, participatory, user-inclusive approach created as part of the call of Commitment Actions of the D4 Action Group, EIP on AHA, EU. Main objective is to include accommodation and housing as main priorities in Europe and provide inclusive environments for older people allowing them to live an independent life and being able to contribute to the silver economy. This project targets synergies between European Regions to identify areas of research in generating practical scalable solutions applicable to reference sites and new or existing buildings to improve the quality and comfort of housing for people across the lifespan.

It identifies new design paradigms, informed of end-users’ opinion on the care and treatment of ageing population so as to sustain healthy societies free of sources of structural stigma. This includes transfer of knowledge, upscaling for frailty and fall-prevention through design technologies and Evidence Based Design for policy initiatives for people across the lifespan.

Partners include academia, central government, local authorities, regulatory bodies, start-ups, end-users, user-representatives and SMEs from architecture, planning, IT technologies, transportation, healthcare, psychiatry, art-therapy, business administration, medical tourism and service provision. They collaborate in creating informal networks of partnerships on advancing the state of the art through experimental and interpretative frameworks, advancing the potential for investment in successful solutions for improving indoor environments through suitable quality tools and collect & disseminate promising practices to contribute to the silver economy. First findings from a D4 commitment plus the latest policy-making activities of the D4 action group will be presented.

Passive ventilation methods, occupant interaction and IAQ - A Simulation Based Study

Muhammad Zaeem
University of Strathclyde

Thermal comfort, air quality and energy usage – these three entities really need to be balanced in order to maintain healthy living environment. By using survey and experimental data and with the help of simulation techniques, a good set of recommendations can be made for occupants. Current trickle vent positioning and size is said to be ineffective to maintain required ventilation rate by an occupant. Moreover, for better air quality if windows are opened more often, thermal comfort is compromised. Hence in an extensive simulation study it is intended to establish an understanding and possible techniques in order to obtain best possible air quality standards. Building user interaction with passive ventilators is very important; it has been concluded that majority of them simply don’t use as they are not aware of their effectiveness. In this study it will be concluded that how the use of passive ventilators can be effective in houses/accommodations where no centralised ventilation system is installed and how user interaction can be helpful in obtaining best possible IAQ with least energy requirement. Occupancy of a room has great influence on IAQ. Simulation study will elaborate relationship between occupants’ metabolic rates and their effect on IAQ and how at different activity levels passive ventilators should be used. A good comparison can be made from various simulation setups and comparison of results with real life case studies would be interesting.
Using a low-cost particle sensor to distinguish smoking and smoke-free homes

Ruaraidh Dobson
University of Aberdeen

Second-hand smoke (SHS) continues to be one of the most serious sources of poor indoor air quality with 40% of children regularly exposed worldwide. Particulate matter (PM) is widely used as a proxy for the presence of SHS but other household sources such as cooking fume and spray aerosols can also increase PM concentrations.

The Dylos DC1700, a low-cost laser particle counter previously validated for the detection of SHS, provides channels for both fine (<2.5um) and coarse (>2.5um) particles. As SHS has a distinctive particle size distribution peaking in the ultrafine range, it may be possible to use this monitor to differentiate between emissions from SHS and non-SHS PM. This work aimed to develop a rule-based approach to classify homes as smoking/smoke-free.

Using a pre-existing dataset of data from 116 smoking homes and a newly gathered dataset of records in 25 smoke-free homes, an algorithm was developed to identify non-SHS PM from Dylos measurement logs. Statistical methods were used to identify a threshold for the percentage of coarse particles that was associated with SHS and then select a cut-off value representing the percentage of records remaining, above which a smoking home was indicated.

The algorithm correctly identified 96% of cases when a threshold value of 1.8% large particles and a cut-off value of 1.4% records remaining were used. Homes where SHS was present had significantly higher mean concentrations of PM2.5 than smoke-free homes, but the algorithm-derived data was better at classifying homes than the use of mean concentration.

It is possible to use a low-cost sensor to identify the likelihood that smoking occurs in a given home with a high degree of accuracy. This may be valuable in air quality feedback interventions designed to promote smoke-free homes.

Exploring classroom comfort with youth researchers

Kimberley O’Sullivan*, Helen Viggers*, Philippa Howden-Chapman*, Daniel Hutchinson, and Waiopehu College Social Action Research Team 2016

*He Kainga Oranga/Housing and Health Research Programme, University of Otago, Wellington. All other authors are affiliated to Waiopehu College, Levin. *kimberley.osullivan@otago.ac.nz

Cold indoor environmental conditions present a range of physiological and psychosocial health risks. Scant available evidence highlights poor building quality and thermal comfort in NZ classrooms. This study investigated indoor temperature in classrooms and the experience of thermal comfort among children in schools in a semi-rural town in the lower North Island, using mixed methods and participatory research approaches. A collaborative data collection process was developed, and a class of students aged 15-16 years were involved by installing data-loggers in their own high school as well as four local primary schools during spring 2016. The findings confirmed the anecdotal reports of cold temperatures. Of the 27 classrooms monitored, all but two were less than 15°C for at least some of the school hours (weekdays between 9am and 3pm). The exposure to these very cold temperatures varied strongly by school - one school had five out of the nine measured rooms colder than 15oC for approximately one hour per day of school. All of the rooms monitored were colder than 18oC for some school hours; and half were colder than 18oC for a quarter of the school-time. There was some issue with overheating at this time of year with five rooms reporting temperatures over 25oC, but only for very short periods. Overall, all monitored rooms were outside the 18oC-20oC guidelines from the Ministry of Education for at least an hour per day, while a typical room experienced about 3 ¼ hours per day outside the guidelines, and the worst 4 ½ hours. At each of these schools, the Year 11’s facilitated a classroom workshop with the goal of obtaining qualitative data from children about how they felt their classroom environments affected their learning and health. We present these findings and discuss policy implications of this participatory action research.