Title	Author(s)	Abstract	Keywords
Thursday Evening Presentation: Chair Fergus Nicol			
Thermal Comfort and Productivity in Offices under Mandatory Electricity Savings after Great East Japan Earthquake	**Shin-Ichi Tanabe, Waseda University**	The great east Japan earthquake of March 11, 2011, wreaked enormous damage, forcing the Japanese government to mandate a 15% peak power reduction to address shortages in summer. Office workers were forced to be patient. The present paper reports the results of field studies conducted in Tokyo office buildings during summer to understand the relationship between indoor environment, productivity, and energy conservation measures under the mandated limits. Occupants generally expressed discomfort regarding the high temperature, but widely accepted the decrease in illumination from 750 to 300–500 lux. Increased awareness regarding power savings was found, with more than 90% of people accepting the poor indoor environment in light of the shortages that year. Clothing and raising set point temperature recommendations made by the Super Cool Biz campaign were followed in most offices. However, self-estimated productivity was 6.6% lower than last summer. Thus, strategies for electricity savings that do not affect productivity are necessary.	Indoor Environment, Energy Saving, Electricity, Earthquake, Productivity
Friday Session 1, Understanding the complexity of comfort - Chair Andreas Wagner			
Civilising Comfort: 1914-1945	Daniel J. Ryan University of Sydney,	Climate's influence on social behaviour was one of the core beliefs of early twentieth century science. Many of the engineers and physiologists involved in the nascent development of thermal comfort studies made frequent reference to the writings of the geographer Ellsworth Huntington. Huntington considered that civilisation was ultimately determined by changes in climate. Yet, while it is well known that early indices of thermal comfort between 1920 and 1950 came out of research that sought to determine set points for mechanical equipment, what has been overlooked are claims made at the time about the links between civilisation and comfort. This paper is a first attempt to investigate the beliefs concerning links between climate, comfort and productivity contained in a number of the key texts on thermal comfort during this period. It proposes that initial misunderstandings came out of a desire to legitimise a new field and the imperatives of colonialism at this time.	Climatic determinism, Productivity, Industrial hygiene
How does occupant perception on specific IEQ factors affect overall satisfaction?	Jungsoo Kim, Richard de Dear University of Sydney	This study aims to develop a better understanding of the relationship between the perceived performance of specific IEQ factors and occupants' overall satisfaction with their workspace, based on the hypothesis that the impact of an IEQ factor can differ depending on whether or not the occupants were satisfied with the IEQ factor in question. That is, a certain amount of increase or decrease in an IEQ factor's perceived performance does not necessarily translate into commensurate increment or decrement in occupants' overall satisfaction. Multiple regression analysis was conducted on the POE database from CBE (Center for the Built Environment) to estimate the impact of 15 different IEQ factors on overall satisfaction, depending on whether the performance on each IEQ factor was satisfactory or not. The results indicated that about half the IEQ factors had asymmetric effects on overall occupant satisfaction; these factors had a predominantly negative impact on overall satisfaction when occupants perceive that the building underperformed or was deficient in some way.	Indoor environmental quality, Occupant satisfaction, Office workspace, Post-Occupancy Evaluation
A Case Study about Comfort Level in Residential Space	Hatsuki Takahashi* and Keiko Takahashi** *Japan Minka Revival Association ** Aichi Konan College	Japanese traditional houses set on the basis of a comfortable life in summer in order to avoid the heat and humid climate. Those were designed with less wall space and large windows thus making it well-ventilated. However, Japanese modern houses have become westernized with smaller windows since Japan began importing foreign home construction materials and methods of construction. Therefore the modern houses have come to rely on air-conditioning to cool the home. Thus, it may be said that the modern Japanese houses may not be suitable for Japanese climate and environment. In this study, we considered the problems from different standpoints based on the research on comfort level and investigation of temperature-humidity in residential space and suggested our opinion about the matter.	House climate, Traditional house, Thermal Comfort, Humidity Comfort Comfort Level
Simplified calculation model for predicting overheating in early design phases.	Lieve Weytjens and Griet Verbeeck 1 PHL University College, Belgium 2 Hasselt University, Belgium	Early design support for summer comfort is increasingly important, considering the trend towards highly insulated buildings together with the importance of glass in contemporary architecture and the probability of higher outdoor temperatures due to climate change. From this perspective, this paper focuses on the integration of summer comfort evaluations of dwellings in early design phases. The reliability of a simple heat-balance based calculation model for an early indication of overheating was extensively tested in a comparative analysis with a multi-zone dynamic simulation in TRNSYS. A parametric study was conducted for both the simplified approach and TRNSYS, to evaluate the most important simplifications assumed in the model and to determine the impact of reduced data-input and complexity on the accuracy.	Summer comfort, early design phase, architects, simplified model, parametric study

Thermal history and its influence on occupants' thermal acceptability and cooling preferences in warm-humid climates: a new desire for comfort?	Renata de Vecchi Christhina Cândido and Roberto Lamberts Federal University of Santa Catarina, Brazil University of Sydney, Australia	By the end of the 20th century it became extremely rare for commercial and educational buildings in South America to rely on anything other than air conditioning to create comfort indoors. Apart from the realization of the energy consumption and carbon footprint of such practice, is that occupants' expectations changed considerably. Air conditioning can be associated with a *new desire for comfort*. This project investigates the influence of prior exposure to air conditioning on occupants' thermal acceptability and cooling preferences in mixed-mode University buildings located in warm-humid climate zone in Brazil. Questionnaires were administered while indoor microclimatic measurements were carried out (air temperature, radiant air temperature, air speed and humidity). Results suggest significant differences in occupants' thermal acceptability and cooling preferences based on their thermal history. These findings also indicated that occupant's rising comfort expectations; resulting from constant air conditioning exposure, militate against the implementation of adaptive comfort principles in bioclimatic buildings..	*thermal history, thermal comfort, cooling preference, mixed mode buildings, energy conservation*
Facility Management Role in Thermal Adaptability Enhancement in Thai Universities	Darunee Mongkolsawat, Alexi Marmot, and Marcella Ucci University College London UK	This study examined the role of strategic and operational facility management in thermal adaptability enhancement in educational estates. Individual and organisational ability to adapt to non-air-conditioned environments were assessed using a questionnaire survey of university students and from interviews with facility managers. The aim of the study is to address the risks and opportunities in relation to thermal adaptability enhancement through facility management practice in non-residential buildings. In this study, adaptive thermal comfort theory and mixed-mode operational strategies were adopted in proposing a thermal adaptability assessment tool. The results show that an attempt to satisfy users by overprovision of air-conditioning and some minor building adaptations, e.g. space pre-cooling and removing fans, are the main barriers to enhancing thermal adaptability. The findings suggest that providing a greater diversity of thermal environments rather than fully air-conditioned surroundings would be more beneficial to thermal adaptability enhancement.	Thermal adaptation, facility management, mixed-mode, higher education sector, hot-humid climates
Friday Session 2 Schools and non-domestic buildings - Chair Michael Adebamowo			
Field study on thermal comfort in a UK primary school	Despoina Teli*, Mark. Jentsch, Patrick James, AbuBakr. Bahaj University of Southampton UK	This paper presents findings from a field survey in a naturally ventilated primary school building in Southampton, UK. The study included thermal comfort surveys and simultaneous measurements of indoor environmental variables. Approximately 230 pupils aged 7-11 in all 8 classrooms of the school were surveyed in repeated survey runs outside the heating season, from April to July 2011. In total 1314 responses were gathered. The survey involved questions on the thermal sensation and preference of the pupils. This paper investigates the children's thermal sensation trends, their perception of overall comfort and tiredness. Furthermore, it compares the survey results to predictions achieved with current adult-based comfort standards, namely ISO 7730 and EN 15251. The results suggest that children have a different thermal perception than adults. Possible explanations are discussed in relation to the particularities and specific character of school environments.	School buildings, Thermal comfort, Field survey, Comfort models, School children.
Links between occupant complaint handling and building performance	John Goins – University of California, Berkeley USA Mithra Moezzi– Portland State University	Building operations link the building, its performance, and end-users. When there is a mismatch between users' comfort provision expectations and operations processes, complaints can arise and building performance can suffer. Adopting optimized complaint handling processes can help diagnose performance problems, and thus support improved building performance. There is little discussion in academic literature about this path to improved performance. Using two US, Class A office buildings as cases, we describe the components that make up an enhanced complaint handling process, discuss the social dynamics of complaints in buildings and explain how the process potentially contributes to a type of "continuous commissioning."	building operations, energy use, indoor environmental quality, occupant satisfaction
Simple, timely and actionable feedback improves commercial office building performance	A. Craig Roussac and Richard de Dear University of Sydney, Australia	This paper presents findings from a program adopted in a portfolio of Australian commercial office buildings in which an 'action-reflection' approach was applied to foster collaboration around energy performance 'feedback'. An automated energy diagnostic and visualisation system was developed to present simple, timely and actionable information to building operators and their managers. Automated short messages were emailed each morning describing (and illustrating) each building's energy use for the previous day relative to peer buildings and the model's prediction. Variations between actual and predicted impacts (in particular, energy use) pointed to learning opportunities that helped building managers identify and replicate 'better than expected' energy performance, and more efficiently respond to 'worse than expected' performance. Small teams of building managers from the same neighbourhood and other participants, including the researchers, were assembled on a fortnightly (and *ad hoc*) basis to evaluate results and share insights, thus contributing to the program's ongoing success.	energy efficiency; commercial buildings; office buildings, building operators, energy performance data

Investigations of occupants' behavioural adaptation for improving thermal comfort in workplaces	Jing Liu, Runming Yao University of Reading, UK	The interaction of a building's occupants with the environment is complex because it is affected by many factors, such as local climate, economic and cultural background, habits, ambient thermal stimuli and room type. This paper presents the findings from year-long field investigations carried out in China and the UK, respectively. It reveals that subjects' adaptations are a dynamic process that is mainly driven by physical thermal stimuli. Comparisons between UK and Chinese respondents show significant diverse adaptive measures taken depending on seasons. The UK occupants use personal changes (e.g. clothing adjustment, having cold/hot drinks, etc.) more frequently if necessary during the day; while the Chinese occupants adjust their clothing according to the season and less frequently during the day. The existing thermal environmental conditions and systems, such as central or personally controlled systems, as well as occupants' habitat and economic and cultural background, greatly affect the choice of adaptation measures	Adaptation, dynamic response, thermal comfort, field study
"From Agent of Change to Global Citizen?" Dialogue, drawings, narratives and performances of secondary school children engaged with the design of a sustainable school.	Andrea Wheeler Loughborough University, UK	Why is comfort such a key term for engaging children in dialogue about their natural and designed surroundings? This paper discusses the findings of a 3 year RCUK post-doctoral research project with children in secondary schools describing the methods adopted and the conclusions of findings. I argue that comfort acts as a means to connect the personal to wider issues of climate change and to move children's understandings of themselves from agent of change to global citizen. This paper speculates on the future for the design of the 'sustainable' school. It also poses the following questions: are there new ways of thinking, living and being emerging from the younger generation, demanding support from adults; and does the 'sustainable' school and its design provide a testing ground for supporting changes in patterns of living? These questions are explored and illustrated through the dialogue, drawings, narratives and performances of secondary school children.	Sustainability, school, participation, philosophy, education
Light Penetration Factor – A new approach towards designing for comfort with direct sunlight	Peter Holzer; Renate Hammer, Danube University Krems, Austria,	Daylight is increasingly understood as an important aspect of indoor comfort. Recent research proves daylight being both a crucial contribution to visual comfort and a source of health and wellbeing. There are good reasons for integrating not only daylight but direct sunlight into the design of interiors: There's evidence for the photophysiological need for direct sunlight's levels of illumination, photometrical brightness and spectral range. Among others, direct sunlight's effects on delayed pigmentation, melatonin suppression and Vitamin D3 synthesis are of substantial importance. In a survey amongst 119 test persons the acceptance of direct sunlight in the interior and its impact on the subjective impression was investigated. The survey showed a preference of indoor situations with direct sunlight against ones illuminated by only diffuse daylight by a significance of 84%. The authors developed a new key figure to predict a room's interior daylight quality as regards its accessibility to direct sunlight. This new key figure, named Light Penetration Factor (LPF), indicates the proportion of a room's volume that potentially can be reached by direct sunlight within alternatively one day or one hour. The LPF allows designing for direct light from the very early design stage. The paper in hands explains the definition of the LPF, discusses its qualities and status of development and finally offers some preliminary applications.	Daylight, Interior Direct Sunlight, Photophysiology Light Penetration Factor

Workshop 1 Standards for the indoor environmental Quality – Facilitator: Bjarne Olesen

Workshop description: This workshop will deal with criteria for the indoor environmental quality, which can be found in international and national standards and rules. Three different papers will present the background to the following discussions and provide lead ideas that can be developed and discussed during the session.
This workshop will start with a paper by Baizhan Li of Chongqin University on " New Chinese standard for the indoor environment" followed by a paper by Runa Hellwig from Augsburg University of Applied Science titled "Developing a Revised Rule on Workplace Temperature Requirements" followed by a paper by Bjarne W. Olesen on "Revision of EN15251 standard related to criteria for the indoor environment" and finally a short orientation from Ken Parson on standards for the Ergonomics of the Physical environment.
The main focus of the workshop will be to discuss how existing standards and guidelines for the indoor environmental quality (thermal comfort, indoor air quality, lighting and acoustic) can be improved. Is it possible to make a standard that can be used worldwide for all types of buildings or do we need national standards?
The workshop shall give input to an upcoming revision of EN15251 with the aim to make an ISO-EN standard, which will provide indoor environmental criteria for design of buildings, calculation of energy performance of buildings and evaluation of the indoor environment.
Workshop format & program:This workshop will after a couple of background presentations lead into a general discussion and listing of ideas and issues to be dealt with in future revisions of standards.

Revision of EN15251 standard related to criteria for the indoor environment	Bjarne Olesen Technical University of Denmark	EN15251 specifies indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics. This standard has now been available for 5 years and must be revised. The paper presents several issues to be discussed in the planned revision. The presented issues are dealing with the thermal environment (when to use adaptive model and criteria for personalized systems), indoor air quality (ventilation effectiveness, air cleaning, adapted/non-adapted occupants, and personalized ventilation), acoustic (introduction of categories), lighting (introduction of categories, daylight factor) and finally occupant behaviour	Thermal comfort, indoor air quality, ventilation, illumination, acoustic, criteria

Developing a revised rule on workplace temperature requirements	Rune T Hellwig and Kersten Bux Augsberg University of Applied Sciences, German Federal Institue for occupational safety and Health, Germany	The German Ordinance on Workplaces calls for a room temperature range conducive to health. This requirement is specified in a revised version of the German rule for Workplaces ASR A3.5 'Room Temperature'. The former version of this rule laid down that the indoor air temperature shall not exceed 26°C *(79°F)*. During a hot summer period with outside temperatures above 26°C the indoor air temperature may be higher as an exception. In view of misinterpretation of this former version, the aim was to explain how to deal with a high room temperature during a hot summer period in Germany. In comparison to the former version of this rule the revised version defines the requirements for acceptable higher room temperatures in the case of high outside temperatures using a step model following the principle of the adaptive approach. This paper explains the need for the revision, the development of the revised version and the new rule in detail.	*Workplace, Office Buildings, risk assessment indoor temperatures, adaptation*
The Chinese Evaluation Standard for the Indoor Thermal Environment in Free-running Buildings	Baizhan Li, Runming Yao, Qinqing Wang, Yangang Pan，Wei Yu Chongqing University, China,University of Reading, UK, China Academy of Building Research, P. R. China	Designing for indoor thermal environmental conditions is one of the key elements in the energy efficient building design process. This paper overviews the investigation of thermal comfort conditions in China and relevant energy efficiency issues. A development of the Chinese evaluation standard for indoor thermal environments based on intensive field and laboratory studies has been introduced. Over 20,000 subjects participated in the field study for the different climate zones in China and over 500 subjects have been involved in laboratory studies. International standards such as the ASHRAE55, ISO7730, DIN EN Standards have been reviewed. The research findings reveal that there is a need for updating the Chinese thermal comfort standard based on local climates and people's habitats. This paper introduces in detail the requirements for the thermal environment for heated and cooled buildings and free-running buildings for different climate zones in China.	indoor thermal environment, adaptive thermal comfort, Chinese standard, Adaptive Predicted Mean Vote (aPMV) model , climate zones in China
ISO standards for ergonomics of the physical environment	Ken Parsons, Loughborough University, UK	Presentation only	

Workshop 2: Designing comfortable buildings – Facilitators: Sue Roaf and Fionn Stevenson

Workshop description: This workshop is about how people approach the challenge of designing buildings for comfort. Three different papers will inform the following discussions and provide lead ideas that can be developed and discussed during the session. After a century of handing over responsibility for the provision of comfort to models, machines and scientifically derived and assumption heavy formulae the challenge of re-empowering building designers to really understand how to provide low energy comfort in more passive buildings is a challenging one.

This workshop will start with a paper by de Dear and Candido discussing the fundamental question of An Adaptive Thermal Comfort Policy for a Geographically Dispersed Property Portfolio; Deciding When and Where to Air-Condition in a Warm Climate Zone. A core issue in this choice is when does natural convective cooling cease to be sufficient and the second paper by Indraganti is on the significance of air movement for thermal comfort in warm climates in the Indian context. Theoretical limits are all very well but what about the reality of designing for comfort in the context of real buildings. Stevenson, Carmona-Andreu and Handcock present a paper on comfort in the context of the usability barriers in low carbon housing in the UK.

The main focus of the workshop will be to try and map out key factors that designers can consider when designing for comfortable buildings – and this theme will be pursued throughout the hour and a half with a range of means. This is a very complex subject and its outputs should blend nicely into the more detailed discussion in the Saturday workshop on controls including the man-environment interactions through controls at room level or workstation level over thermal environment (heating, cooling) and indoor air quality (ventilation). Think: operable windows, clothing protocols, thermostats, ceiling fans, personal ventilation systems, and so forth.

The difference with this workshop will be that it deals with the building and micro, meso and macro-climate level considerations rather than the workstation level. The issues thrown up in the papers will provide a rich source of information on which to build an innovative discussion on the topic – What role does thermal history play in achieving comfort? How important is the ability to move in designing buildings? How can spatial planning be used to optimized the comfort experience over time? What are the larger issues around constraint and control in the comfort equations ? How do designers build in the very different comfort aspirations of people in different locations, societies and climates ? Is it better to heat and cool the person or the building ? etc.

Workshop format & program: This workshop will combine thought capture exercises with paper presentations and wide ranging discussions in which all will be expected to contribute.

An Adaptive Thermal Comfort Policy for a Geographically Dispersed Property Portfolio; Deciding When and Where to Air-Condition in a Warm Climate Zone	Richard de Dear and Christhina Candido, The University of Sydney, Australia	This paper describes a *Thermal Comfort Policy* recently developed for a client who owns a large portfolio of buildings in Australia. To date the client's decisions about where and when to install HVAC have been based on a static isotherm on the climate map of the region in which they operate, regardless of how well the building performs. The client's brief aims to shift air conditioning decisions onto a more rational footing, based on the climatic context, the building's thermal performance and occupants' thermal comfort. The solution we proposed was based on ASHRAE's 55-2010R adaptive model, with an exponentially-weighted running mean outdoor temperature for input. Of the three different metrics proposed for the diagnosis of systematic overheating, the simplest was finally selected by the client (>1 % of occupied hours annually during which indoor temperature exceeds the ASHRAE 55 upper limit (80% acceptability).	Adaptive comfort standards, compliance, exceedance, heat-wave

Designing for comfort – usability barriers in low carbon housing	Fionn Stevenson, Isabel Carmona-Andreu, Mary Hancock University of Sheffield, CA Sustainable Architecture, Oxford Brookes University, UK	Recent research into occupant behaviour in low carbon housing indicates that for the same type of house, energy and water use can vary by up to fourteen times between different households. This paper assesses the usability of 'touchpoint' controls in two contrasting building performance evaluation case studies. It situates the discussion within socio-technical theories of habit, practice, and emergent properties in products which facilitate easy and rewarding learning and thus durability. Key findings reveal poor design features and occupant lack of understanding including specific aspects of centralised mechanical heating and ventilation systems and some windows. Lessons learnt and recommendations are highlighted for design guidance and policy consideration, including a more user-centred approach to design and testing of products and key areas of focus in relation to delivering low carbon homes that are more controllable and therefore more comfortable.	low carbon housing usability controls
Significance of air movement for thermal comfort in warm climates: A discussion in Indian context	Madhavi Indraganti , Ryozo Ooka, Hom B Rijal The University of Tokyo,Tokyo City University, Japan	Thermal comfort research is yet to gain momentum in India. Indian designers follow verbatim the ASHRAE standard when designing the indoor environments. This only leads to over design/ energy wastage and in environments inappropriate to the local climates and customs. Our earlier study in 2008 highlighted the wide gulf between the actual comfort temperature recorded on field and that specified in the National Building Code- 2005. Therefore, comfort studies are exigent in India. Addressing this need, the authors are conducting a field study in warm-humid and composite climates of India from January 2012. The current paper highlights the significance of air movement for comfort at elevated temperatures as observed in our Hyderabad study. Subjects using fans had higher comfort temperature than those without. The occupants successfully achieved higher air velocities through the use of various personal environmental controls in order to comfortably offset the discomfort during the warm-humid months	Comfort temperature; Air movement; Humidity; Thermal Comfort research in India; Griffiths Method
Adapting REALL building design for comfort in a changing climate	Sue Roaf and Gary Clark Heriot Watt University, UK	It is virtually impossible to explore the issues around the provision of, and design for, comfortable housing / buildings with the now technology-heavy mix of complex building types, technologies and behaviours using the current range of fairly blunt simulation tools available. This is not least because models largely cannot, and do not, include issues of individual behaviours and expectations within them. At Heriot Watt University we will be building a world leading Living Laboratory to explore and test approaches to the provision of comfort in what we believe will provide a vital facility for the validation of approaches to comfort in buildings in current and future climates and the modelling of them.	
Friday Session3: Short papers with poster - joint Chairs: Peter Holzer and Luisa Brotas			
The use of sheds to promote the natural ventilation: the work of Brazilian architect João Filgueiras Lima, Lelé.	Marieli Azoia Lukiantchuki, Rosana Maria Caram, University of São Paulo, Brazil	Natural ventilation is an efficient design strategy that reduces the use of air conditioning significantly, especially in tropical countries like Brazil. Among the ventilation strategies, it highlight the sheds, openings in the coverage, which functions as air collector and extractor. The Brazilian architect João Filgueiras Lima, known as Lelé, uses these devices to improve natural ventilation in most of his buildings. Lelé has been designing sheds for almost fifty years and to improve the efficiency of these devices, these geometries have been modified. This paper analyses the Shed designs used in Lelé's buildings. The analysis is done in three stages. First, a data survey in the collection of the architect's projects was performed. Second, the architect and his design team were interviewed. Finally, a design analysis was performed. Results show the great potential of sheds for natural ventilation and Lelé's concern about improving the performance of these devices through the geometric changes.	Bioclimatic architecture; Sheds; geometry; natural ventilation; João Filgueiras Lima
Behavioral adjustment of Cool Chairs in Warm Offices	K. Washinosu, T. Nobe, and I. Suzuki Kogakuin University, Tokyo, Japan	This paper reports the specifications for a Cool Chair in subjective experiments in an office environment in Japan during summer. Thermal conditions affect a worker's comfort, clothes, physical condition and activity level. Therefore, it is beneficial to allow workers to individually adjust their thermal environment. Recently, as a solution to this problem, 'Personal Air-conditioning Systems' have been developed. In particular, a chair which has a mounted thermal airflow generator with an environment adjustment function was developed. In this chair, named as 'Cool Chair', air is blown from its movable armrests and the seat. The airflow and wind direction in the armrest can be easily adjusted. The airflow around the Cool Chair is isothermal with the indoor temperature. Subjective experiments were conducted with 20 adult participants to examine the cooling effect of the Cool Chair, and the effect of its thermal adjustability on the psychology of its users was examined.	Chair, Subjective experiment, Personal air conditioning system, Iso-thermal airflow, Thermal comfort
The comfort dimension when evaluating the discrepancy between predicted and actual energy performance in new school buildings	Andrea Wheeler, Masoud Malekzadeh and Dino Bouchlaghem, Loughborough University, UK	This paper presents results of work carried out with three case study UK secondary schools in the East and West Midlands and South Yorkshire respectively using post-occupancy assessment (POE) methods. These results form part of a project in Loughborough University Department of Civil and Building Engineering (PostOPE) investigating the extent and causes of discrepancies between computer-based predicted performance of buildings during design and their actual in-use performance, using a number of case study buildings. A post-occupancy evaluation and performance assessment approach was used for the case studies in the form of measurement-based performance monitoring, innovative user surveys and a review of the historical records of information from the design and construction phases of the projects. Alongside consumption monitoring studies, research also developed and tested an action-research based post-occupancy assessment (POE) approach for working with whole school communities in new school buildings.	Sustainability, comfort, performance-gap, schools, post-occupancy

The Missing Link – Next Generation IEQ LAB with Ultimate Flexibility	Ashak Nathwani, Richard de Dear and Christhina Cândido University of Sydney, Australia.	In responding to the challenge of greenhouse emission reductions, intense international attention has turned to energy efficiency in the way we design and operate built environments. However, the risk of compromising Indoor Environmental Quality (IEQ) for building occupants with indiscriminate efficiency measures is high. It is not surprising that there is an intensification of IEQ related research activity; driven mainly by the simple fact that indoor comfort, particularly through air conditioning, typically accounts for more than half of a commercial building" s operational energy. In response to these fundamental drivers, a next generation of *Indoor Environment Quality Laboratory*, with ultimate flexibility, is under construction at the University of Sydney"s Faculty of Architecture, Design and Planning. For the first time, Australia"s research community and the broader building sector can examine how multiple IEQ factors combine to affect human comfort, productivity and health outcomes for occupants in built environments.	*indoor environmental quality, thermal comfort, climate chamber, flexibility*
Energy efficiency versus overheating in a temperate climate for residential buildings	Eleonora Alders, Stanley Kurvers, Eric van den Ham, Delft University of Technology, The Netherlands	This paper shifts the focus of energy conservation to flexible measures that both conserve energy as well as prevent overheating. It proposes efficient possibilities to discard excess heat at appropriate time and place, flexible to the dynamics of weather shifts and occupation. Strategies are described to partly control the building characteristics of a dwelling, to influence the thermal behaviour of the room, discarding or conserving heat at the appropriate moment. Proposed solutions are: Ventilation according to occupancy and temperature; Advanced solar shading; Thermal shutters during the night; Season dependent values for U-value and thermal mass The results show that standard measures, if applied flexibly, can diminish heating demand significantly and that the problem of verheating can be successfully tackled by the new flexible solutions proposed, if operated properly. These measures may create opportunities to develop new techniques for adaptive climate systems in the near future.	
The concept of thermal comfort in the built environment given the current global economic crisis – a case study of Lagos, Nigeria	Toks Sangowawa, Michael Adebamowo KOA Consultants Ltd, University of Lagos, Nigeria	The global economic crisis that has gripped the world over the past years is not abating even as we go into 2012. The cost of energy has now gone up even in Nigeria that happens to be an oil producing nation. By virtue of the warm and humid climate in Lagos, the use of mechanical cooling to attain desired thermal comfort is common place. However air-conditioning uses energy and energy costs money. How then can we maintain comfortable working and living conditions for the majority in the face of dwindling wealth? This paper discusses the concept of thermal comfort in the warm and humid climate of Lagos with a focus on the psychology of thermal comfort. Given the number of quantitative studies already carried out in similar environments, the study relied more on the qualitative aspect. A review of relevant literature is presented. The paper proffers suggestions as to how to ensure that people live comfortably and affordably. .	Thermal comfort, psychology, low-energy
Assessing the ability of PMV model in predicting thermal sensation in naturally ventilated buildings in UK	Arash Beizaee, Steven K. Firth, Keyur Vadodaria, Dennis Loveday Loughborough University, UK	A study was conducted to investigate the accuracy of the PMV model for predicting thermal comfort sensations in naturally ventilated residential and office buildings in the UK. Sixteen participants participated in identical thermal comfort studies at both their homes and their offices. Environmental variables affecting thermal comfort were recorded while the participants voted their thermal sensation in both locations. The comparison of reported thermal sensation and those predicted using ISO 7730 showed that in general PMV under predicts the thermal sensation of occupants in both environments. The neutral temperatures found in homes and offices were 23.4ºC and 23.2ºC which were respectively 3ºC and 2.5ºC lower than those predicted using ISO 7730. Together with 0.2ºC difference found between reported neutral temperatures at homes and offices, this suggests that there could be a context influence affecting occupants' thermal sensations in home and office environments.	Thermal comfort, PMV, Thermal sensation, Context effect
Adaptive Effect to Thermal Comfort of Cool Chair in ZEB Office	Ikuno Suzuki, Kazuhiro Washinosu and Tatsuo Nobe Kogakuin University, Tokyo, Japan	This paper reports the operational status of the Cool Chair in the ZEB renewal office building during the autumn to the winter of 2010. Each worker has his or her own preferences for thermal environmental conditions and personal thermal comfort. Therefore, not every worker's preferences can be met by the conditions in the office building, and for many workers, their individual preferences of thermal comfort are not satisfied. To solve this problem, this study investigated the operational status of the Cool Chair, which has been developed since 2003. The airflow is blown from the armrests and the seat of the chair. The armrests are movable, and the flow, direction of the air from the armrests can be easily adjusted. Thirty-three chairs were introduced into office space on the third floor of the building, and the authors investigated the thermal environment conditions and use of the chairs.	Chair, Environmental preference, Personal air-conditioning system, Isothermal airflow, Thermal comfort.
Planning barriers to the Government agreements for reducing carbon emission in existing houses	Renata Barreto and Luisa Brotas London Metropolitan University, UK	The UK government has agreed to decrease its greenhouse gas emissions at least by 80% below base year 1990 levels by 2050. The residential sector is one of the major contributors to the greenhouse effect and the Department for Environment, Food and Rural Affairs predicted that 70% of the house stock of 2050 is likely to have already been built. This study analyses the revision to Part L of the Building Regulations regarding strategies to deliver carbon emissions reductions in the existing house stock. Data collection using a questionnaire directed at architects involved in house retrofitting has identified that strategies adopted to reduce CO_2 emissions are likely to be refused by Planning Departments on the grounds of appearance. This constitutes a major barrier for upgrades in existing houses. A case study exposes the necessity to accept new technologies and eventual changes to the character of Victorian and Georgian Houses, if the proposed environmental commitments are to be achieved.	Planning Barriers, Part L, refurbishment, Renewable Eneergy

Energy efficient living - INTEWON: From measuring to modelling to managing .	Boris Kingma, Christel Jacquot, Ad van der Aa, Linda Steg, Arjan Frijns, Frans de Haas and Wouter van Marken Lichtenbelt' Maastricht University Medical Center The Netherlands	In 2011, a Dutch multidisciplinary project was launched entitled "Individual-oriented information technology for energy efficient living" (INTEWON). It is a four-year study aimed at gaining more insight into the factors that determine the actual energy consumption of a household. It is a co-operation between the Maastricht University (physiology and knowledge engineering), Groningen University (human energy saving behaviour), Cauberg-Huygen engineering agency (energy calculations), and the University of Technology Eindhoven (energy technology and build environment). The purpose of the study is to obtain insight into the interaction between the individual comfort, the resulting behaviour and the techniques that enable energy efficient behaviour. It is a study in which technical, physiological and social research work together. The experiments are currently being conducted and here we report pilot data on the interaction between thermal physiology and thermal behaviour. In part I, experiments are described that are carried out in a specially designed indoor climate facilities at Maastricht University. In the laboratory the environmental conditions can be accurately prescribed whilst continuously monitoring behaviour and physiological parameters such as energy expenditure and skin temperature. In part II a novel numerical model for prediction of thermal behaviour using a Bayesian approach is described.	Thermal sensation, Physiology, Mathematical modelling, Thermal Behaviour, Thermal Comfort
Friday After dinner talk: Chair Susan Roaf			
Andy Ford, President of the Chartered Institution of Building Services Engineers (CIBSE)		**A view from the Coal Face of practice: how the changing circumstances around us are affecting the ways we way we design buildings**	
Saturday Session 4 Thermal comfort and domestic buildings (Chair Tri Harso Karyono			
Summertime temperatures in 282 UK homes: thermal comfort and overheating risk	Lomas KJ and Kane T, Loughborough University, UK	Summertime temperatures in UK homes are a matter of increasing concern, particularly because of global warming and an increased incidence of heat waves. Refurbishment adds to uncertainty about the resilience of UK homes to climate change. This paper examines internal summertime temperatures in the living and bedrooms of 282 homes in the UK city of Leicester. This is a statistically representative sample of the city's housing stock. The generally cool monitoring period included a short period of hot weather. Occupant behaviour had a significant impact on internal temperature, 13% of the homes were actively heated even during the spell of hot weather. In the 230 unheated homes, 28% of the living rooms and 88% of bedrooms were classed as severely overheated, as judged by the static, CIBSE, criteria. In contrast, 64% of the living rooms and 71% of the bedrooms were judged uncomfortably cool as defined by the BSEN15251 Cat II adaptive thermal comfort standard.	Comfort, houses, UK, measurement, summer
Thermal experience in an era of low exergy domestic heating systems	Christopher Tweed and Dylan Dixon Cardiff University, UK	Existing theories of thermal comfort are largely blind to the way heat is delivered to spaces. Field studies, however, show that people create and enjoy thermal conditions that lie outside conventional definitions of comfort—the thermal experience itself is valued—some of which are tied to particular ways of delivering heat. The concept "exergy" can be used to describe the quality of heat energy and its ability to provide warmth. A shift from fossil fuels towards renewable sources heralds a new era of space heating consisting mainly of low exergy sources, such as heat pumps. This marks a major turning point in the history of domestic heating. This paper begins by discussing variations in domestic thermal environments before considering new forms of low carbon heating. Later sections analyse the way in which these systems deliver heat within people's homes and consider the implications for thermal experience, comfort and energy consumption	Thermal experience, heating systems, alliesthesia, low energy design
Identifying a suitable method for studying thermal comfort in people's homes	Vireen Limbachiya, Keyur Vadodaria, Dennis Loveday, Victoria Haines Loughborough University, UK	In the UK, domestic buildings are responsible for a significant amount of overall carbon emissions from buildings. Together with improving the energy efficiency of the existing domestic stock, an in-depth understanding of thermal comfort in homes is necessary to ensure that acceptable levels of thermal comfort are maintained whilst energy use is being reduced. Currently, there is limited knowledge on domestic thermal comfort in the UK as, compared to non-domestic buildings, conducting thermal comfort studies in homes is challenging. Detailed thermal comfort studies are usually considered to be intrusive in domestic environments. Is it therefore possible to conduct thermal comfort studies that are less intrusive and yet scientifically rigorous? With a view to address this question, the study presented in this paper undertook a comparison of two data collection methods. Data collected using a less-intrusive method, referred to as the 'Silver standard' was compared with the data collected using the ASHRAE/ISO recommended method (referred to as the 'Gold standard'). A strong correlation was observed between PMV values obtained using the Silver Standard method and those obtained using the Gold Standard method. The findings suggest that the less-intrusive method devised and tested in this study provides reliable data for thermal comfort evaluations in homes. The findings also suggest that further work is necessary, particularly in winter conditions to comprehensively validate this non-intrusive method.	
Investigation of comfort temperature and the adaptive model in Japanese houses	Miho Honjo, Hom B Rijal, Ryouta Kobayashi and Takashi Nakaya Tokyo City University, Japan	We have conducted the thermal measurement in the living rooms and a thermal comfort survey of residents for a year in Japan. The residents are highly satisfied with the thermal environment of their houses. Seasonal difference was found in the comfort temperature. The results showed that the comfort temperature changes with changes the indoor and outdoor climate. By using the relationship between indoors and outdoors, the adaptive model was proposed to predict and control the indoor comfort temperature.	House; Living; Adaptive model; Thermal comfort survey; Comfort temperature

Investigation of window opening behaviour in Japanese houses	Hom B Rijal and Takashi Nakaya Tokyo City University, Japan	We have investigated the window opening behaviour and thermal environment in Japanese houses for one year. The proportion of '*open window*' in the naturally ventilated mode is significantly higher than that of the air conditioned mode. The window opening is related to the indoor or outdoor air temperature. The window opening behaviour predicted by the logistic regression analysis is in agreement with the measured data. The deadband was narrower and constraints on the window opening in the investigated houses were considerably lower than previously found in office buildings. These findings can be applied to develop an adaptive algorithm for window opening behaviour in residences leading to optimal energy use.	Window; House; Air temperature; Logistic regression; Deadband; Constraints
Window opening behaviour: simulations of occupant behaviour in residential buildings using models based on a field survey	Fabi Valentina, Rune Vinther Andersen, Stefano Paolo Corgnati Politecnico di Torino, Italy	Window opening behaviour has been shown to have a significant impact on airflow rates and hence energy consumption. Nevertheless, the inhabitant behaviour related to window opening in residential buildings is currently poorly investigated through both field surveys and building energy simulations. In particular, reliable information regarding user behaviour in residential buildings is crucial for suitable prediction of building performance (energy consumption, indoor environmental quality, etc.). To face this issue, measurements of indoor climate and outdoor environmental parameters and window "opening and closing" actions were performed in 15 dwellings from January to August 2008 in Denmark. Probabilistic models of inhabitants' window "opening and closing" behaviour were developed and implemented in the energy simulation software IDA ICE to improve window opening and closing strategies in simulations. The present contribution extends the knowledge about the windows control in dwellings and underlines the importance of appropriate occupant behaviour models for a better prediction of energy consumptions in buildings.	Occupant behaviour, Energy modelling, Energy consumptions
Saturday Session 5 Domestic Buildings (continued), overheating and climate change - Chair Kevin Lomas			
Adapting UK suburban homes for a warming climate	Rajat Gupta and Matt Gregg Oxford Brookes University, UK	As climate change becomes more prominent within the next 50 years and beyond, comfort in the built environment is projected to change drastically. This is specifically relevant in the UK's suburbs where 84% of the population reside. To assess this future impact, this paper uses downscaled probabilistic climate change data from the UKCP09 to simulate the impact of future temperature change on the energy consumption of, and comfort in, typical English homes at both neighbourhood and house level (located in Oxford) using two simulation packages with different temporal inputs, DECoRuM and IES respectively. For all homes modelled, user-controlled shading proved to be the most effective adaptation. Increasing the surface albedo of the building fabric and external insulation were also found to be effective. Ultimately among the passive options tested, the research found that none could completely eliminate the risk of overheating in the homes, particularly by the 2050s and beyond.	Climate change, overheating, adaptation, mitigation, suburban housing
Exploring Comfort in the Home: Towards an Interdisciplinary Framework for Domestic Comfort	Andrea Burris, Val Mitchell and Victoria Haines Loughborough University, UK	With increasing costs of energy and the need to cut CO_2 emissions, householders are actively encouraged to reduce their energy consumption. As the biggest uses of energy in the home are for space and water heating, research into comfort has predominately focused on the thermal environment. A wider perspective on comfort is provided by sociological practice-orientated research that seeks to understand how people create comfort at home and psychologically informed approaches relating to understanding the drivers for behavioural change. By gaining a multidisciplinary understanding of how and why occupants create comfort at home, opportunities to maximize energy demand reduction can potentially be identified. Findings from a study of householders and a review of the literature were used to create a framework that incorporates a three-tiered approach to understanding comfort in the home consisting of "comfort needs", "comfort preferences" and the highest level, "comfort aspirations".	Domestic comfort, energy consumption, interdisciplinary framework, user centred design
Using an inappropriate thermal benchmark leads to overheating in UK primary schools	Azadeh Montazami, Fergus Nicol Coventry University, London Metropolitan University, UK	Schools' buildings can have a significant impact on students and teachers' health and performance through their internal environment such as noise level, indoor temperature, air quality and light. Providing good environmental conditions for schools has always been critical. The two main reasons are: firstly of the conflict between comfort factors (thermal, lighting, acoustic comfort and air quality) as they are interrelated and secondly the use of relaxed thermal, air quality, acoustic and lighting benchmarks. In this study, the current thermal benchmark, which is used to design and refurbish the UK school classrooms, is assessed in order to evaluate the extent to which it is lenient and whether it represents the occupants' feelings.	Overheating, School classrooms, Fixed thermal benchmark, Adaptive thermal benchmark
Heat wave vulnerability classification of residential buildings	M.G.M. van der Heijden, B. Blocken, J.L.M. Hensen Eindhoven University of Technology, The Netherlands	General circulation models of climate change predict that the intensity and frequency of heat waves will increase, which are a significant threat to public health (Luber and McGeehin 2008). The effect of heat waves on the public health became apparent during the 2003 heat wave in France, where almost 15,000 heat related deaths (excess of 60%) were reported (Pirard et al. 2005). Between 1,000 and 2,200 heat related excess deaths were reported in the Netherlands (Fischera et al. 2004, Garssen et al. 2005). The total heat related excess mortality across Europe was more than 50,000 (Brücker 2005, Kosatsky 2005). In this study, a first heat wave vulnerability classification for overheating is made of four Dutch residential building types, using historical climate data of five heat-waves in the Netherlands. The four evaluated building types are Terraced houses, Corner houses, Detached houses and Semi-Detached houses, of which the geometry was based on the Dutch reference buildings (SenterNovem 2006). Apart from these four building types, ten other variables/uncertainties such as building orientation, ventilation rate, R_c-values and window areas were taken into account using Monte Carlo analysis. For this analysis, 400 cases were generated for each building type using random Latin Hypercube sampling. From this analysis a first classification was made, which from most to least vulnerable was: (1) Detached house, (2) Corner house, (3) Semi-detached house, (4) Terraced House.	Heat wave, Building energy simulation, Vulnerability, Residential buildings, Climate change

Is there a method for understanding human reactions to climatic changes? – Developing experimental designs for climate chambers and field measurements to reveal further insights to adaptive processes	Marcel Schweiker, Sabine Brasche, Wolfgang Bischof and Andreas Wagner Karlsruhe Institute of Technology, Germany	The adaptive comfort model states behavioural, physiological and psychological adaptive processes as reasons for the discrepancies between predicted mean vote and observed comfort votes. However, little is known about the individual portions of these processes. This paper presents a new experimental design which is meant for climate chambers with at least one façade connected to the exterior. This design consists of distinctive settings with respect to variations in outside conditions and the number of control opportunities so that one or more of the three adaptive processes are suppressed. Results of a trial analysis of the data gained through a first implementation of this experimental design in a climate are presented and discussed. One of the main results shows that the permission to interact with the built environment by means of using a fan or opening a window alone leads to a significantly increased satisfaction with the thermal conditions. This statement is supported by the regression lines of the comfort temperatures calculated according to the Griffith method.	Adaptive comfort, inside-outside climate chamber, neutral temperature, interaction
Future context for thermal comfort: Impact of a changing climate on energy demand and human thermal comfort	Bryan Mann, Ulrike Passe, Shannon Rabideau, Eugene S. Takle Center for Building Energy Research, Iowa State University	Typical climate conditions for the 20th century may not provide the full range of temperature, precipitation and humidity extremes that likely will be encountered for the built environment of the 21st century. It is important to understand the impact of changing climate on building energy consumption, building design and thermal comfort in existing buildings. Therefore sensitivity studies were conducted for an exemplary location: Mason City Iowa. Based on future scenario climates for the period 2040-2070 produced by eight global/regional climate models, future typical meteorological year (FTMY) data sets were developed for this location and basic energy calculations were conducted in Energy Plus for a typical residence as well as the US DOE commercial reference buildings. Our results show that the increase in energy consumption resulting from projected change in climate over the next 50 year at this location results primarily from responding to an increase in ambient humidity in summer. Therefore, the largest energy cost for maintaining desired levels of health and comfort in the future at this location will be attributed to managing higher ambient humidity levels. Put another way, in order to reduce energy consumption by buildings at this location in the future, priority should be given to finding innovative ways to manage humidity or to adapt	Climate Change, Building Energy Consumption, Future Typical Meteorological Year Data, Adaptation
Saturday session 6 Short papers with poster - joint chairs Hom Rijal and Craig Roussac			
Effect of Air Movement in Housing during Japanese Summers	Teruyuki Saito and Satoru Kuno Nagoya University, Japan	Previously, Kuno et al. conducted experiments and showed that the mean comfort votes of four female subjects were not uncomfortable when the room air temperature was 32°C and air movement by natural ventilation was more than 0.6 m/s. We conducted a chamber experiment in April 2011 using a device that produced uniform air movement. The speed of air movement was changed as requested by each subject. Mean values of final chosen air speed by six male subjects were 0.70 m/s at 32°C and 0.87 m/s at 34°C. In August 2011, we started a new experiment at two model houses. In the last summer experiment, comfort votes of twelve female subjects were not uncomfortable when the air temperature was 32–34.5°C and air movement by natural ventilation was more than 0.6 m/s. We consider that moderate and constant transpiration of moisture from the skin leads to a comfortable feeling for humans.	Thermal sensation, thermal comfort, air movement, hot environment
Accuracy of mean skin temperature calculations and measurements in thermal comfort-related assessment	Carolin Schmidt, Daniel Wölki, Gunnar Grün, Christoph van Treeck Fraunhofer Institute for Building Physics	People inside spaces are subjected to different inhomogeneous indoor climate conditions like radiation, convection and conduction. Those environmental effects have to be considered in local and global thermal sensation and comfort models. Local models are formulated based on measured skin surface temperatures at different body parts. Global comfort prediction is based on calculated mean skin temperatures taken as input parameter. Thereby, the evaluation of weighted mean skin temperatures is a key parameter which is influenced by several effects. A wide variation of local skin temperatures influences area measurements, if such values are derived from single-point measurements. Additionally results may deviate significantly due to inadequate definitions and interpretations of individual body parts in literature. The paper analyses calculation methods with special focus on accuracy and uncertainty. The dispersion of values is demonstrated, quantified and recommendations are given for body segment definition with respect to measurement positions. Appropriate weighting functions are derived.	Thermal comfort, thermal sensation, inhomogeneous indoor climate, mean skin temperature, local skin surface temperatures.
Analysis of human interactions together with human-body exergy consumption rate	Marcel Schweiker, Masanori Shukuya and Andreas Wagner Karlsruhe Institute of Technology, Germany	These days research on occupant behaviour is increasing. Nevertheless, still less is known about the effect of interactions on the occupants themselves. On the one hand, knowing such effects would permit conclusions regarding the purpose of behaviour. On the other hand, this would allow a more careful design of interaction opportunities, which fulfil the occupants' desire for comfortable conditions without posing a danger to their health. This paper describes the analysis of data deriving from field measurements in a student dormitory in Tokyo, Japan. The focus was on the effect of the interaction with the window on the Human-Body Exergy-Consumption (HBx-) rate of the occupant themselves. In conclusion, with respect to thermal conditions, occupant behaviour aims at an optimum rate of exergy consumption, being in congruence with the need to consume as little exergy as possible, but at the same time being able to discard as much of the generated entropy as possible.	Adaptive comfort, field study, exergy consumption, neutral temperature, interaction

Calculation of Human-body Exergy Balance for Investigating Thermal Comfort under Transient Conditions	Masanori Shukuya, Kayo Tokunaga, Moe Onoma, and Yasuyuki Itoh Tokyo City University, Japan	Application of the concept of exergy to human-body thermo-physical phenomena has revealed so far the following: mean radiant temperature, which is a little higher than air temperature, provides the human body with the lowest possible exergy consumption rate for winter conditions; and a combination of mean radiant temperature, which is a little lower than air temperature, and moderate air velocity to be given by natural ventilation provides the human body with the lowest possible exergy consumption rate for summer conditions. Supposing that it will become important to have an exergetic understanding on the adaptive behaviour of occupants in the built environment, we have tried a couple of unsteady-state calculation of human-body exergy balance for summer and winter conditions. As the results, we confirmed that it is essential to take a variety of passive technology prior to that of active technology for realizing low-exergy space heating and cooling systems. .	Unsteady-state thermal phenomena, exergy consumption, environmental temperature, adaptive thermal comfort, human behaviour
Numerical evaluation of radiative heat exchanges between human beings and cooling radiant systems	Sara C. Francisco, António M. Raimundo, Adélio M. Gaspar, Divo A. Quintela Universidade de Coimbra,Portugal	This paper presents a method of evaluating the radiative heat exchanges between the human body and surrounding surfaces. With the purpose to predict the detailed view factors for realistic human body shapes and complex configurations of the enclosures, an algorithm that calculates the view factors has been developed based on the Stokes' theorem. The performance of the algorithm and its accuracy on predicting view factors for complex geometries are analyzed against analytical solutions or results obtained by other authors, using different methodologies. The algorithm is used for the evaluation of radiative heat exchanges between a sitting human being and a system of cooling radiant panels, for several positions and operating conditions of the radiative system. The results obtained clearly demonstrate a high importance of the radiation heat transfer mechanism on the human thermal comfort. Significant effects of the position and the operating conditions of the radiative system are also observed.	Thermal radiation; Radiative view factors; Stokes' theorem; Human indoor environment interaction
How the sensory experience of buildings can contribute to wellbeing and productivity	Trevor Keeling, Derek Clements-Croome, Rachael Luck, Philip Pointe University of Reading and Buro Happold	Buildings should have productive environments that contribute to occupant wellbeing. An important aspect of this is how the user experiences the building through the full range of their senses. This paper reviews the current understanding of wellbeing and productivity as reported in published papers to examine how they relate to comfort and sensory design. It explores the idea that comfort is just one aspect of wellbeing and productivity. Designing for wellbeing and productivity gives a greater range of possible design solutions than designing for comfort alone.	Sensory design, wellbeing, productivity, comfort, buildings
User perspectives on outdoor noise in buildings with operable windows	John Goins, Chungyoon Chun, Hui Zhang, University of California, USA	Recent research suggests that buildings with operable windows in general, and mixed-mode (MM) buildings in particular can provide improved thermal comfort and control opportunities for users. Yet, there have been concerns about outdoor noise sources like traffic or construction noise when windows are opened. Concerns like these may hinder the installation of operable windows in buildings. This paper examines 23,000 office building occupants' perspectives on noise from both sealed and naturally ventilated/MM buildings. Results suggest that occupants near operable windows are more satisfied than those near sealed windows or those far from either window type. Among occupants dissatisfied with noise, complaints about indoor noise sources --like people talking-- are about 10 times more prevalent than outdoor noise complaints	Acoustics, occupant satisfaction, office design
Predictive thermal comfort model: Are current field studies measuring the most influential variables?	Stephanie M. Gauthier, David Shipworth UCL Energy Institute, UK.	Thermal comfort has widespread implications, including health and energy consumption, yet little is known about the interrelation between thermal-discomfort response and physical dependencies. Empirical research on occupants' interaction with their home environment calls for a holistic socio-technical approach. The aim of this paper is to report on an evaluation of the sensitivity of the predictive thermal-comfort model, as described in the BS EN ISO 7730 standard. In light of the results of this analysis, this paper presents a methodological framework to measure the occupants' activity levels. One of the key aims is to gather accurate measurement while using 'discreet' observatory systems to have minimum impact on the occupants' behaviour. With recent emergence of, and advancements in, more accurate and affordable sensing technologies, this problem can potentially be overcome.	Activity level, Thermal comfort, Predictive model, Sensitivity analysis
Predictive clothing insulation model based on outdoor air and indoor operative temperatures	Stefano Schiavon, Kwang Ho Lee, University of California, USA	Clothing affects people's perception of the thermal environment. In this research two predictive models of clothing insulation have been developed based on 6,333 selected observations taken from ASHRAE RP-884 and RP-921 databases. The database has been used to statistically analyze the influence of 20 variables on clothing insulation. The results show that the median clothing insulation is 0.59 clo (0.50 clo (n=2,760) in summer and 0.66 clo (n=3,580) in winter). Clothing insulation is correlated with outdoor air temperature (r=0.45), operative temperature (r=0.3), relative humidity (r=0.26), air velocity (r=0.14) and metabolic activity (r=0.12). Two mixed regression models were developed. In the first one clothing insulation is a function of outdoor air temperature measured at 6 o'clock in the morning and in the second one the influence of indoor operative temperature is also taken into account. The models were able to predict only 19 and 22% of the total variance, respectively. These low predicting powers are better than the assumption of constant clothing insulation for the heating (1 clo) and cooling (0.5 clo) seasons..	Clothing, behavior modeling, thermal comfort, occupant behavior, weather

Natural vs mechanical ventilation: Towards sustainability	Luisa Brotas, Fergus Nicol London Metropolitan University, UK	Achieving a pleasant indoor environment with low energy consumption is a major goal of good building design. Recent concerns about greenhouse emissions associated with CO2 from buildings, the security of the energy supply and the rising price of oil, make reducing demand, promoting energy efficiency, diversifying the energetic resources and the adoption of renewable energies. With a requirement for high levels of insulation to reduce fabric heat losses the weight of heat loads associated with infiltrations in dwellings in the UK have gone up from one fifth to one third. This has made imperative reducing infiltration rates to minimum levels required for air quality. There is a trend to promote the use of mechanical ventilation with heat recovery as the way to reduce the heating loads significantly and promote good indoor conditions. Do people feel satisfied within a domestic environment where they have no control over air-change rates? Comments given by occupants in *Passivhaus* expressed concerns about opening windows and disturbing the air flow which results in energy needs above the limits required by the standard. Existing strategies such as solar air pre-heating have been replaced with mechanical systems with heat recovery. The adoption of a prescriptive approach such as MVHR is an easy way to comply with regulation requirements but avoids the design challenge. Several studies have shown higher levels of occupant's satisfaction in office spaces where people can take action to restore their comfort levels. Generally, occupants are not in favour of fully air conditioned or spaces with non-opening windows. This paper looks at the impact on indoor air quality and comfort levels for the occupants of natural and mechanically ventilated spaces. Results from a monitoring survey in dwellings are presented. In climates such as UK the main issue is a reduction of heating and infiltration loads. However, given the global warming trend cooling may also need to be addressed.	*Natural Ventilation, Mechanical Ventilation, Heat exchangers, Indoor air quality*
Comparison of outdoor comfort field data against calculations of the thermal indices PMV and PET	Eduardo Krüge, Rohinton Emmanue, Patricia Drach, Oscar Corbella Technological University of Parana, Brazil	We carried out an extensive series of measurements and surveys in a pedestrianized area of Glasgow, UK (55°51'N, 04°12'W) to understand the thermal preferences of local population and to define a preliminary comfort range using selected thermal indices. Nineteen monitoring campaigns were carried out and 763 outdoor comfort surveys were administered to street users. Weather variables were collected using a Davis-Vantage Pro2 weather station, equipped with temperature and humidity sensors, anemometer, pyranometer and a globe thermometer. Concurrent thermal comfort surveys were carried out using an adapted version of ISO 10551. Weather data were post-processed in Rayman and WinComf for obtaining the thermal comfort indices PET and PMV, respectively, allowing comparisons with thermal sensation/preference votes. Analysis of these outcomes point out to the need for simplifications of the original thermal comfort protocol, with no significant effect on the quality of the results obtained.	Outdoor thermal comfort, thermal sensation, preference votes, thermal comfort indices, thermal comfort protocols

Workshop 3: Personal Control and Occupant behaviour in office buildings Facilitators: Gail Brager and Rune Andersen

Workshop description: The workshop is about personal control and behavioral adaptation of building occupants. The main focus is on man-environment interactions and control at room level or workstation level over thermal environment (heating, cooling) and indoor air quality (ventilation). Think: operable windows, clothing protocols, thermostats, ceiling fans, personal ventilation systems, and so forth. The main goal of the workshop is to map what is and what is not known about personal control over indoor climate and occupant behavior and it's effect on comfort, health and productivity and to identify new control related research areas. Many studies have shown that offering the right amount of personal control over indoor climate results in less building related symptoms, more comfort and increased performance of the occupants. But what is the mechanism behind this? How does the (ab)use of building controls affect energy use? Can we achieve 100% satisfaction (PD=0%) with the right mix of controls? Is offering full control always the right solution? Or do people in some situation actually prefer central control? What is most energy efficient – automated controls or offering full control to the occupants? Is it just about controlling the indoor climate or should we also look at control over the visual and acoustic environment? What is the relation between available control, perceived control and exercised control? How about group use of operable windows, thermostats etc in open plan offices, class rooms and other larger spaces? What design criteria (limits) should be used when designing personal climatisation solutions? Are high tech personal control solutions preferred over low tech solutions like operable windows? Do we know enough about occupant behavior to predict how controls will be used in practice? What are new personal control research areas that should be addressed in the future?

Workshop format & program: This workshop will be highly INTERACTIVE. The general idea is: we bring the questions, all together generate the answers.

Impact of Available and Perceived Control on Comfort and Health in European Office Buildings	Atze Boerstra, Tim Beuker, Marcel Loomans & Jan Hensen BBA Indoor Environmental Consultancy Netherlands	The objective of this study was to find out how perceived control and access to control options like operable windows and thermostats affects comfort and health of European office workers. For this, the HOPE database was re-analyzed which contains data from indoor environmental quality surveys with around 6200 employees in 60 office buildings that are placed all over Europe. Statistical analyses were conducted to find out what the impact is of available controls on the perceived control of building occupants. Furthermore the effect of perceived control on comfort and health was determined. No significant relation was found between *available* controls and perceived control apart from available solar shading. Between *perceived* control and comfort or health, multiple significant correlations were found. Our findings suggest that designing future office buildings with the right *mix* of controls will lead to healthier and more comfortable building occupants.	Personal control, Individual control, operable windows, adjustable thermostats, building related symptoms.

Window signaling systems: control strategies & occupant behavior	Katie Ackerly, Gail Brager University of California, USA	Signaling systems that tell building occupants when to open and close windows have become a popular strategy for balancing the comfort benefits of manual windows with the efficiency benefits of automation in mixed-mode buildings. Data from surveys, interviews and site observations in 16 U.S. buildings reveal a diversity of design objectives, control sequences and circumstances to anticipate when designing buildings with window signaling systems. Signals influence window use patterns for a minority of occupants, although greater participation is possible if the signals are linked to an internal policy with clear, tangible comfort benefits. Low levels of participation likely occur because most occupants (though not all) tend not to pay attention to their windows, or the signals, unless they're uncomfortable, at which point it matters little what the signals say. However, occupants who do discover value in the signals are more likely to be more satisfied with their personal control.	Mixed-mode, operable windows, personal control, behavior .

Workshop 4 How to make comfortable low energy buildings that really do work? Facilitators Paul Tuohy and Jake Hacker

Workshop description: Many buildings are intended to be robust, comfortable, low energy, and low carbon. However in most cases the intended performance is not achieved in practice. In this workshop the question to be answered is 'how do we address this and create buildings that really do work?'

Three papers will bring forward some relevant information to help stimulate ideas:

Paper 1: The first paper gives insight into reasons found for performance gaps in buildings that are promoted as best practice and examples to be replicated. Whether current initiatives such as EPBD, LEED, BREEAM, Soft Landings, Green Star, BCVTB, or BIM will address these gaps is briefly reviewed.

Paper 2: There is increasing reliance on building simulation in design of advanced buildings; the second paper investigates the variations in predicted performance resulting from different simulation users; and discusses weaknesses in the current use of simulation and the potential impact this can have.

Paper 3: To have a design that is informed by feedbacks from actual performance of similar buildings would appear to be a key to design success. The third paper reviews predicted energy performance, actual energy performance, and occupant satisfaction for 60+ buildings. The buildings are categorized considering occupant and climate adaptation opportunities and building servicing strategy; the performance of the different building categories is analyzed and relative performance highlighted.

Workshop Format: The Windsor conference is a great opportunity to gather diverse inputs. The intention is to break into 'buzz' groups of 4-7 persons to briefly consider the following:

1. Best practice examples: Can we identify buildings and building types that really do work? What are the key things that make these buildings successful? Can we identify processes for creating buildings that really do work? What are the key things that make these processes successful?
2. What can be done to improve current industry or policy initiatives so that comfortable low energy buildings are created (e.g. EPBD, LEED, BREEAM, Soft Landings, Green Star, BCVTB, BIM etc…).

Then each buzz group gives an update to the others on the output from their group discussions and a broader discussion chaired.

Why advanced buildings don't work?	Paul Gerard Tuohy, Gavin B Murphy University of Strathclyde, UK	The intent of policy is to achieve robust comfortable low energy buildings. However there are obvious policy disconnects and, where there is evidence, it appears that in general advanced buildings do not achieve their intended performance. There are many industry and policy initiatives aimed at improving industry processes such as: Soft Landings, BREEAM, LEED, Green Star, AGBR and BIM. In this paper the performance of buildings likely to be promoted by current policy is investigated and a number of significant and recurring problems identified. The possibility that these problems will be resolved by current initiatives is discussed and it is concluded that important gaps remain to be addressed.	Building performance, Policy, Advanced buildings, Monitoring, POE
Computational analysis - Evaluation of the impact of the user expertise on the results of simulation tools	Alberto Hernandez Neto, Flávio Augusto Sanzovo Fiorelli,; Anarrita Bueno Buoro, University of São Paulo, Brazil	The use of simulation tools has increased over the years due to the requirement of more complex energy analyses. The outputs provided by such tools are quite dependent on the available information about occupancy profile of building and schedules from systems such as: lighting, electric equipment, air conditioning, window openings and others. It is very important for users to be aware of the limitations and uncertainties regarding the thermal models of each tool when evaluating their outputs. The user should have the expertise to choose the most suitable tool depending on the type of analysis being done. This paper evaluates the performance of two different buildings, a budget hotel and an office building, located in the city of São Paulo, Brazil. Both buildings characteristics were entered into the simulation tool *EnergyPlus*™. For the office building, comparisons were performed between the actual profile of the energy consumption and their simulation results for evaluating the main parameters that affect the simulation results. For the budget hotel, measured temperature profiles were compared with simulation results, in order to calibrate the model. This calibration is done in order to verify the most appropriate strategies and changes that could be done in the building considering environmental issues. The comparisons between the acquired data and the simulation results were appraised and the authors analyzed how the results vary depending on how well the building's characteristics were modelled. Some aspects of how to improve the data gathering and model input process were analyzed in order to enhance the reliance of simulation results and therefore reduce errors on forecasting of the thermal behaviour of buildings.	Building characteristics modelling, thermal behaviour forecast, case studies

Robustness of a building: Relationship between building characteristics and energy use and health and comfort perception	S.M.M. Juricic, E.R Van Den Ham, S.R Kurvers École Nationale des Travaux Publics de l'État, France Technical University of Delft, the Netherlands	Buildings sometimes use much more energy than expected and occupants show high levels of health symptoms and low perceived comfort. This paper aims at showing that some building characteristics or combinations of building characteristics simultaneously lead to low energy use and higher perceived health and comfort and are therefore considered to be more "robust", meaning that these building types better live up to the expectations set up during design stage. This study is based on the statistical analyses of two different existing field study databases. The influence of various building characteristics and systems, like HVAC characteristics, design related characteristics or user interaction to the building characteristics, on perceived health and comfort and on energy use has been studied independently for each database and then compared. Specific combinations called 'design profiles' have been defined and have been compared with the same indicators. Statistically significant results showed that certain single characteristics and some design profiles clearly contributed to reasonable energy use, better health and comfort perception or to both, which confirms the robustness hypothesis..	Perceived comfort and health, energy use, robustness, building characteristics, HVAC
Sunday Session 7: Hot climates - invited Chair Jens Pfafferott			
Temperature performance and thermal comfort study in vernacular houses in East Nusa Tenggara, Indonesia	Tri Harso Karyono, I Ketut Suwantara, Rini Nugrahaeni, Iwan Suprijanto, Robert Vale Tarumanagara University, Ministry of Public Works, Bali, Indonesia	More than 350 different ethnic groups inhabit Indonesia. Many of them are still maintaining their own local traditions and cultures, and some are still living in their own vernacular houses. About 80% of Indonesian region is rural, minimising urbanisation process like conserving these vernacular houses is one of the appropriate way to achieve sustainability. Vernacular houses are built by local communities, using local materials which are available in their surrounding environments. Some are wondering whether these kinds of buildings are thermally comfortable. Recent study has been made in three different vernacular houses namely Uma Lengge, Sao Ria and Uma Kbubu in three locations in the Province of East Nusa Tenggara, Indonesia. This study was an attempt to see whether these houses, which were built without any scientific basis, are thermally uncomfortable i.e. not too warm for the inhabitants. This paper discusses the study and draws some conclusions from it.	Vernacular houses, indoor climate, outdoor climate, thermal comfort, thermal performance
Extreme adaptation to extreme environments: case study of hot dry, hot sub-humid, and hot humid climates in Mexico	G. Gómez-Azpeitia, G. Bojórquez-Morales, R.P. Ruiz , I. Marincic, E. González, A. Tejeda University of Colima, Mexico	The paper discusses the results of a field study carried out in four cities in Mexico: Hermosillo, Mexicali, Merida and Colima, during the warmest seasons of 2006-2007. The cities' climates are hot dry, hot sub-humid and hot humid. The respondents were inhabitants of low cost housings without air conditioning. The research was performed during warm seasons and according to ISO 10551. The measurements were processed by the adaptive conventional method and also by alternative methods, useful for asymmetric climates. Individuals declared comfort at very high temperatures; therefore the resulting neutral temperatures are higher than 30oC, except in Colima (28.8oC). The upper limits of comfort ranges achieved temperatures up to 35oC. The results suggest how great is the capacity of humans to adapt to conditions as extreme as those measured in the study.	Acclimation, Thermal comfort, Adaptive approach, Field studies
A field survey in Calcutta. Architectural issues, thermal comfort and adaptive mechanisms in hot humid climates.	Margot Pellegrino, Marco Simonetti, Laurent Fournier, Politecnic of Turin, Italy	This paper presents and discusses results of a small-scale field survey on occupant comfort and related perceptions observed in two university buildings in Calcutta, India, in 2011. These buildings were free running and ventilated by fans. The study was made in two different days, collecting a full set of architectural observations, objective physical measurements and subjective assessments through questionnaires. The study found a neutral temperature of 30.9ºC from the regression of votes on the 7-points ASHRAE scale, compared to 28.5ºC as calculated following the PMV of ISO 7730. These values are much higher than the comfort range of 23 – 26 °C specified by Indian Codes. This finding could have enormous energy implications to building design, HVAC design and practice in India. Results also show a large gap between the predicted comfort conditions and the real perception of the users. They also indicate a higher neutral temperature, compared to previous studies. The role of humidity and air movement were further investigated. Multiple regression analysis helped in understanding the relative influence of each parameter for the comfort perception.	Tropical climate, quality of architecture, adaptive comfort, field survey
Comfort Temperatures for the Low-Income Group in a Hot-Humid Climate	Yayi Arsandrie, Stanley Kurvers, Regina Bokel, Kees van der Linden Delft University of Technology Netherlands Muhammadiyah University of Surakarta, Indonesia	The results presented in this paper are part of the doctoral research that is being done at Delft University of Technology, Netherlands. One of the main objectives is to find the level of thermal comfort accepted by people from the low-income group in Surakarta, Indonesia. Personal aspects (gender and clothing index), characteristics of the dwelling (ventilation, orientation) and surrounding factors (effect of vegetation) were investigated to observe if they significantly influenced the people's responses. Furthermore, these findings will be used to improve the dwellings in the community. A field-survey was conducted in this research involving 426 people from four kampongs in Surakarta. The neutral temperature in this group is found at 32.5°C and the comfort bandwidth ranges from 30 to 35°C, which is shown by four methods of deriving thermal comfort. Various factors were shown to influence the indoor air temperatures and the thermal response of the people..	Dwelling, Hot-humid climate, Low-income group, Thermal comfort

Energy savings in housing through enlightened occupant behaviour and by breaking barriers to comfort:- a case study of a hostel design in Nigeria.	Mike Adebamowo & Olumide Olusanya, University of Lagos, Nigeria	Energy efficiency is a critical issue for high-quality housing especially now with the reality of climate change, global warming and economic recession. Energy does not only represent a high percentage of the running cost of any building it also has a major effect on the comfort of the occupants. Quite a substantial work has been done on the study of energy savings in buildings through optimized building shape and form, improved building envelopes and systems and improved efficiency of home products and devices. However less literature is available on energy savings through enlightened occupant behaviour and design that breaks barriers to comfort. This is what this paper seeks to address. In addition the paper will also answer other pertinent questions such as:- how do we reduce energy use in housing without compromising comfort?, how should buildings be designed with flexible thermal control options and how do occupants respond to and interact with their buildings? This research is done through a case study of the hostel building at the Institute for Venture Design, Abeokuta, Nigeria, owned by Fate Foundation and designed by Prof. Olumide Olusanya.	.
The Effect of Different Transitional Spaces on Thermal Comfort and Energy Consumption of Residential Buildings	Mohammad Taleghani, Martin Tenpierik, Andy van den Dobbelsteen Delft University of Technology, The Netherlands	This paper focuses on the effect of courtyards, atria and sunspaces on indoor thermal comfort and energy consumption for heating and cooling. One of the most important purposes is to understand if certain transitional spaces can reduce the energy consumption of and improve thermal comfort in houses. To conduct this research, 4 building types were modelled and simulated in three different climates with DesignBuilder. From these simulations, the energy consumption of the dwellings is determined. Moreover, the indoor temperature data were plotted on adaptive temperature boundary charts. This paper shows that a courtyard is the least efficient dwelling type for the Netherlands, while an atrium has better energy efficiency and indoor thermal comfort. Moreover, a sunspace is not recommended for the hotter climates of Cairo and Barcelona since there is a risk of overheating in summer. The paper also reports that although a building type may not be energy-efficient (in comparison with other types), it may still provide a comfortable addition to a dwelling.	Energy consumption, Thermal comfort, Transitional spaces, Residential building
Sunday Session 8 Comfort models and outdoor comfort			
The Indoor climate: towards comfort ánd health - Building and occupant energetics (Keynote speech)	Wouter van Marken Lichtenbelt, Maastricht University Medical Center The Netherlands	**Saving energy in buildings: increasing energy expenditure in occupants** Standards and guidelines related to the indoor environment are related to avoiding discomfort and reducing health related risks. Fixed criteria and targets are often proposed for that. However, (thermal) comfort and health are often treated as synonyms, which is not necessary correct. The hypothesis therefore is that changing indoor conditions (focus on thermal conditions inside and outside the comfort limits in time and/or building zones) will positively influence health. This is especially evident for healthy ageing and for obesity.With respect to ageing, health benefits of variable temperature conditions are important to study. Especially in houses for older people the indoor climate is very tightly controlled and for instance in wintertime fixed at a high level. On the other hand physiological studies clearly show that heat and cold acclimatization does take place when regularly exposed to warm or cold environments, and that acclimatized subjects are less vulnerable during heat and cold waves. Such knowledge is apparently important for deciding whether or not ageing people should be exposed to (mild) temperature variations.The health benefit related to obesity is complex, since the development of obesity and related disorders is a very slow process. Functional parameters are desperately needed. Fortunately recent physiological studies indicate that the development of such parameters is within reach. For example, with respect to body heat production in the cold the most well-known and very effective response to cold is shivering. This however is a response to extreme cold, uncomfortable, and thus beyond the scope of the indoor environment. Interestingly, we and others have shown that in adults mild cold induced thermogenesis (i.e. non-shivering thermogenesis - NST) occurs. That means that in mild cold conditions the human energy balance can be influenced without much discomfort. The mild cold temperatures are within the temperature ranges as indicated by the adaptive model of DeDear (1998).. NST is individual specific and blunted in obese subjects. In rodents brown adipose tissue (BAT) is responsible for NST. In adult humans it was for long believed that adults do not have significant amounts of BAT. We recently showed with advanced techniques that BAT is present and active in adult humans and is negatively related to body mass index or body fat percentage. We also showed that other tissues such as skeletal muscle are involved in NST. Finally we just revealed that cold acclimatization goes hand in hand with increased themal comfort. This information provides us with tools to measure health benefits of exposure to environmental temperature variations and to develop functional tests. This can lead to develop ideas for indoor climate with drifting temperatures, that are healthy (less obesogenic; temperature training during ageing), reasonable comfortable, and can save energy in buildings in the mean time.	
Predicting outdoor thermal sensation from two field studies in Curitiba, Brazil and Glasgow, UK using the Universal Thermal Climate Index (UTCI)	Eduardo Kruger, Peter Bröde, Rohinton Emmanuel, Dusan Fiala, Technological University of Parana, Brazil	We present a comparative analysis of outdoor human thermal sensation against predictions with the Universal Thermal Climate Index (UTCI) for two sets of data collected in Curitiba, Brazil (subtropical climate in elevation) and in Glasgow, UK (maritime temperate climate). Surveys took place during daytime in pedestrian areas with microclimate measurements and concurrent administration of thermal sensation and preference questionnaires. Comparisons were made with regard to clothing levels (predicted by UTCI˝s clothing model versus actual garments observed) and votes of thermal sensation in relation to ambient temperature variations and to UTCI values. Results suggest that clothing levels are fairly well predicted by UTCI˝s clothing model for both cases. A small offset was noticed for Glasgow from the onset of the summer period, with UTCI overestimating actual clothing. More noticeable however were differences between clothing levels for Curitiba and Glasgow for the same ambient temperature range (roughly 15-20°C), which is also reflected on the thermal sensation votes for both locations. As those divergences are found for the start of the summer period in Glasgow, it is suggested that people under those climatic conditions accept lower air temperatures and indeed regard those as comfortable presumably due to acclimatization. For calculated UTCI, similar discrepancies have been observed for both cases, with a slight overestimation of actual thermal sensation for Curitiba and a slight underestimation of actual thermal sensation for Glasgow.	Outdoor comfort surveys, thermal comfort index, thermal sensation, UTCI

Validating Fanger's PMV model in a "real" field study.	Mohammad Kotbi, Steve King and Deo Prasad University of New South Wales Australia	Fanger's predicted mean vote (PMV) model of thermal comfort perception is criticised for the consistency of its results with the actual mean vote (AMV). This is mainly because Fanger‟s PMV model assumes some particular circumstances that hardly ever occur in real world experience, such as the similarity of personal variables and other psychological parameters. However, a broader ongoing research project examining thermal comfort in mosques in Riyadh, Saudi Arabia, has provided an unusually well formed vehicle to validate the PMV model in a real field study. Comparing the results of the predicted mean vote (established by monitoring the relevant variables to match the outputs of the application of PMV model), and the actual mean vote(s) of this real field study is thought to be the most appropriate basis for the validation of the PMV model. In this paper, the overall context of the mosque as the case study is described. The methodology and the methods including the instrumentation and the questionnaire are highlighted. Preliminary results of monitoring and perception surveys are reported, including some analysis of the PMV/AMV relationship.	Thermal comfort, PMV, AMV, Validating, Field study, Mosque
Perception of Transient Thermal Environments: pleasure and alliesthesia	Thomas Parkinson, Richard de Dear, and Christhina Candido The University of Sydney – Australia	Recent research indicates that dynamic thermal environments can potentially deliver higher levels of occupant satisfaction than static, homogenous indoor environments. The physiological concept of alliesthesia presents a coherent framework for investigating *thermal pleasure* arising from environmental or metabolic transients. This project investigated the relationship between core and skin temperatures and thermal pleasure in transient thermal environments. Pilot studies recorded skin temperature (Tsk) and core temperature (Tc) of six healthy males through a series of environmental and metabolic changes. Preliminary results indicate that sudden changes in ambient temperature were rated pleasantly whenever a positive alliesthesial effect was induced (i.e. opposite polarity of Tsk and Tc). This decayed as the subject returned to thermoneutrality. The same environmental step change invoked a displeasure response when the core temperature was stable. It is possible that higher levels of occupant satisfaction in transient or textured thermal environments may be explained by the hedonic overtones from the alliesthesial effect.	Alliesthesia; thermal pleasure; transient; core temperature; skin temperature.
Effects of different cooling principles on thermal sensation and physiological responses	Lisje Schellen, Marcel Loomans, Martin de Wit, and Wouter van Marken Lichtenbelt, Eindhoven University of Technology, The Netherlands	Applying low exergy cooling concepts in the built environment allows reduction of high quality energy sources. However, application of low exergy cooling systems can result in whole body and local discomfort of the occupants. Non-uniform thermal conditions, which may occur due to application of lowex systems, can be responsible for discomfort. However, in some cases combinations of local and general discomfort factors, for example draught under warm conditions, may not be uncomfortable. Two different cooling principles were studied: passive and active cooling. Active cooling occurred through either convection or radiation. Ten healthy male subjects (age: 20-29; BMI: 18-25) were exposed to four different experimental cases: (a) *passive cooling* through convection and (b) *active cooling* through convection, and *active cooling* by radiation via the (c) ceiling or (d) floor. Physiological and thermal sensation data indicate significant differences between the different cases.	Thermal sensation, Physiology, Cooling, Non-uniform thermal environments
Papers appearing in the proceedings but authors unable to present			
Façades and office buildings in São Paulo (Brazil): aiming for thermal comfort and natural ventilation	Monica Marcondes, Marcia Alucci, Joana Gonçalves University of São Paulo, Brazil	This work focused on office buildings in the city of São Paulo, Brazil, aiming to identify façades' design solutions which provide internal thermal comfort conditions for at least 80% of the occupied hours during the year without use of air conditioning. Two building models were proposed. Annual dynamic thermal simulation of sixty four scenarios of office buildings with different configurations (building form, layout and orientation) and ventilation conditions (stack effect and wind effect) were carried out with TAS. The operative temperature was adopted as thermal comfort criteria. The relationship between the ventilation rate and the heat gain in the office through the façade was identified for each case study. The results of the thermal performance were tested against ASHRAE 55 (2004) and CEN EN 15251 (2007). The results provided inputs for the design of possible façades' solutions for the cases of office buildings which fulfilled the criterion of 80% of the annual occupied hours in comfort. The study showed: (i) the extent to which the choice of comfort criteria can impact building design and performance; (ii) it is possible to keep efficient natural ventilation and provide adequate thermal comfort conditions for the office building in São Paulo in a wide variety of architectural and ventilation scenarios; (iii) following the proposed design method several combinations of materials and aperture types are possible for the façades of diverse cases, depending on the relationship "heat gains versus ventilation rates".	Thermal comfort, office building, natural ventilation, façade, tropics
Neutral Temperature in Outdoors for Warm and Cold Periods for Extreme Warm Dry Climate	G. Bojórquez-Morales, G. Gómez-Azpeitia, R. García-Cueto, C. García-Gómez, A. Luna-León, R. Romero-Moreno Autonomic University of Baja California,México	To generate design proposals that favor thermal comfort of the users is necessary to estimate the neutral temperature and ranges of thermal comfort in outdoors. A study of thermal comfort of an outdoor recreational space, in warm and cold periods in a desert climate, is presented. A questionnaire based on ISO 10551 was designed. Dry bulb temperatures, gray globe temperatures, relative humidity and wind speed were measured. 822 surveys were applied to the warm period and 863 to the cold period. Neutral temperature and ranges of comfort with the method of averages by thermal sensation interval's, were estimated. Passive, moderate and intense activities were analyzed. The periods studied showed a behavior of asymmetric climate. Neutral temperatures are approximately symmetrical with respect to their range of thermal comfort. Persons subject to intense activity have better adaptation to climate.	Thermal comfort, Neutral temperature, Adaptive method, Outdoor spaces, Extreme warm dry climate
Influences of wind and humidity on thermal comfort of urban canyons in Bandar Abbas, Iran	Masoud Dalman, Elias Salleh, University Putra Malaysia.	Urban forms and canyons have an important role on the microclimate and thermal comfort situation in urban areas. Bandar Abbas city, located in southern part of Iran at the northern rim of Hormuz Strait, is an example of an urban growth area with a combination of traditional and modern urban fabrics. The hot and humid climate of Bandar Abbas, especially in long summers causes thermal stress for urban activities. To understanding the influence of microclimate factors and thermal comfort situation in the study area, two different typologies of traditional and new residential development (Modern) urban fabrics have been studied in south east of Bandar Abbas. The results indicate that traditional urban fabric is more thermally comfortable than the new residential urban fabric. According to the field measurements, thermal comfort calculation and wind simulations, the canyons with North-South direction represents better orientation for air circulation benefiting from sea breezes as compared to other canyon orientations.	Microclimate, hot-humid, urban canyon, thermal comfort, Computational Fluid Dynamics

Outdoor Thermal Condition Evaluation by Microclimate Observation Case Study of Kuala Lumpur	Mansoureh Tahbaz Shahid Beheshti University, Iran	Using outdoor public spaces as a place of social interaction is in a great consideration these days. Providing tolerable thermal condition as long as possible is one of the primary stages for people's presence in these places. Outdoor thermal indices are introduced to help architects making appropriate decisions in climate responsive design procedure. By doing some field study research in extreme climatic condition of tropical city of Kuala Lumpur, this article will introduce a research method of data collecting and data analyzing using outdoor thermal indices. How to do an effective and helpful research for design requirements is the aim of this method. Field data are collected by a Kestrel portable weather station in different outdoor spaces of the city centre. Weather data are analyzed in three levels of meso, local and microclimate. Architectural properties of the place are explained as the respective climatic design solution. Software named SIKRON is designed to speed up the analyzing process.	Thermal indices, UTCI, heat stress, microclimate, kestrel weather station
The response of Critical regionalism to contextual changes over time in SE Asian residential architecture – A case study of Singapore	Anupama Udaykumar	In today¨s age of Globalization, the revival of a culture¨s heritage through architecture is a means to resuscitate local identities and promote a psychological sense of belonging. However, the last thing we need today is another thoughtless revisit into tradition or in an attempt to be a part of the Global village, employ a Globalized architecture which would only result in buildings that would struggle to adapt to the changed environmental, social, economic or even political context. Hence Critical Regionalism; where the architecture has to evolve over time to have any validity. This paper focuses on the response of Critical Regionalism through time and changing context for residential architecture in the Tropical region of South-east Asia, with specific focus on Singapore. It traces the translation of Regionalistic principles into the high-rise, high-density housing model with the help of a case study of the Bedok Court Condominium in Singapore. The case study is followed by a theoretical discussion of what the new age Critical Regionalism has to incorporate in order to be successful, with the help of the theories of Singaporean architect Tay Kheng Soon and a ventilation Case study of Hong Kong.	Critical Regionalism, Singapore, vertical translation, Bedok court condominium, Tay Kheng Soon
Urban residential comfort in relation to indoor and outdoor air temperatures in Ibadan, Nigeria	Adewale Oluseyi Adunola Obafemi Awolowo University, Nigeria	Indoor and outdoor air temperatures remain the dominant climatic factor affecting thermal comfort in the tropics. A thermal comfort survey was conducted in Ibadan metropolis, Nigeria. Ten percent (12) of the 119 neighbourhoods identified from the metropolitan map were selected by stratified random sampling comprising 2 low, 3 medium and 7 high residential densities. Indoor and outdoor measurements of air temperature and other relevant climatic elements were done in representative buildings in the neighbourhoods. Significant variations of air temperature and thermal response manifested across the residential densities and neighbourhoods. The variation of temperature across residential densities and the effect on indoor thermal comfort give inference to the impact of the urban microclimate on indoor comfort. Mean comfort vote was related to indoor and outdoor temperature by linear equations. The equations confirmed the concept of the dynamic relationship between architecture and climate	Air temperature, thermal comfort, tropical climate, urban microclimate, urban residential densities
Thermal comfort considerations and space use within residential buildings in Ibadan, Nigeria	Adewale Oluseyi Adunola and Kolawole Ajibola Obafemi Awolowo University, Nigeria	Indoor thermal comfort is of utmost concern with respect to the use of residential accommodation spaces. A thermal comfort survey was conducted among residents of 528 buildings in 12 selected residential areas of Ibadan metropolis in Nigeria. The impact of the urban microclimate on the building spaces was found significant. Indoor comfort assessment varied according to the different building design typology. It was found that the differences in temperature between spaces in each of the buildings were within the range of 0.1 to 0.7 deg C. Residents exhibited thermal consideration in the use of spaces and utilized movement adaptive actions. The living room space was the most comfortable and most used space. There was very strong correlation between the most comfortable spaces, the most used spaces and first choice spaces voted by respondents. It was confirmed that pattern of use of spaces was related to indoor comfort	Adaptive action, residential design typology, space use, thermal comfort, urban microclimate
Computer simulation of pedestrian's transient thermal comfort in a complex urban context: a bottom-up modeling approach	Liang CHEN* and Edward NG The Chinese University of Hong Kong	This study aims to take a bottom-up modeling approach to simulate pedestrian's transient and dynamic thermoregulatory condition while walking in the complex outdoor urban environment. Effective assessment of pedestrian's thermal comfort is a complicated issue and traditional steady-state bio-meteorological indices such as PMV have been shown to be unsuitable for this task. A dynamic simulation model that allows pedestrian's adaptation to the varying local microclimate to be examined is expected to provide a solution to this problem. The present study adopts a bottom-up modeling paradigm and uses a promising modeling technique, the agent-based modeling approach, to simulate each individual pedestrian's movement behavior and thermal comfort condition. A modified two-node model is implemented to assess pedestrian's thermoregulation. The simulation system is implemented with a geographical information system (GIS) framework, allowing a complex urban context and the corresponding urban microclimate to be modeled. Based on the simulation, both spatial and temporal analyses can be conducted. A case study is carried out to demonstrate how the system can be effectively applied in the real world.	Pedestrian thermal comfort, two-node model, thermal transient, agent-based modeling
Faults & claims about thermal environments in relation to building equipment and energy saving measures in smaller office buildings	Noriko Umemiya and Ryota Matsui Osaka City University, Japan	Building equipment, energy-saving systems, and claims of inappropriate indoor thermal environments were analyzed in relation to the floor area using responses to a questionnaire survey of service managers of 157 buildings. Results show the following. 1) In smaller buildings (<5000 m^2), set temperatures are higher in summer and lower in winter, effects of 'uncomfortable radiation from windows' are greater, energy-saving systems decrease indoor thermal comfort, but claims of 'hot' and 'cold' are fewer. 2) Claims of 'hot' and 'cold' are unrelated to the setting temperature and whether the air-conditioning control system is central or local. Finally, 3) the adoption rates of 'COOL-BIZ' or 'WARM-BIZ' are higher than those of temperature mitigation of air conditioning.	Smaller office buildings, energy management, energy saving measures, claims of 'hot' and 'cold'