

DESIGN TO THRIVE

Legacy Document

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Legacy Document of 33rd PLEA International Conference

Design to Thrive

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PLEA 2017 Conference www.plea2017.net

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PLEA 2017 LEGACY DOCUMENT

On the 2nd to the 5th of July 2017 Scotland hosted the 33rd Passive and Low Energy Architecture (PLEA) conference in the spectacular surrounding of Edinburgh. We were lucky to have the opportunity to attract this highly respected PLEA network to Scotland and we certainly made the most of it. Below is a short report on the conference and its thirty-one different topic Forums, written by their Forum Leaders. This provides you with a taste of what was covered in each Forum as an overview of the deliberations of the conference or as a taster to help you navigate to what you want to read in the three volume full proceedings that are freely available on the PLEA 2017 website (www.plea2017.net).

We hope that this document will be particularly useful to students studying in any of the included fields as they can get a flavour here of the breadth of ideas involved, the range of research being done in any subject area and have an up-to-date range of references, from the Proceedings, for further study if needed.

Our thanks go to all involved in preparing this document and the myriads of people who helped to make PLEA 2017 as a whole such a success.

PLEA: Background

PLEA started in 1982 as a small group of international friends dedicated to the idea of sharing knowledge on how to design and operate low and renewable energy buildings. The development of solar buildings lay at the core of its ethos in those early days and still does. PLEA now has a membership of several thousand professionals, academics and students from over fifty countries (www.plea-arch.org) and has been involved with 33 international conferences hosted by countries around the developed and developing world.



Delegates at the 1st PLEA Conference in 1982 in Bermuda. From Left to Right: Lady from Brisbane (Auz); Steven Szokolay (Auz); Donald Watson in the car (US); Natasha Puritser (Italy); Ken Ichi Kimura (Japan); Professor Y. Saito (Japan); anon. (US); Anne Bowen (US); Jeff Cook (US); Arthur Bowen (US – with their twins in the pram). (Source: Ken Ichi Kimura).



The PLEA 2017 Conference

The theme of the PLEA 2017 conference was 'Design to Thrive' and the lessons it had to offer on how to do just that were amazing. The forces underlying the PLEA ideas of 'Natural Energy Buildings' were well flagged by four banners up the staircases of the Assembly Rooms. They read Sun, Wind, Light and Natural Energy Buildings and these reflected the interests and commitment of our sponsors, AES Solar Ltd. from Forres, Natural Cooling Ltd. run by Brian Ford, Velux with their UK HQ in Fife and Historic Environment Scotland who manage some of the most passive and low energy buildings in the world. Bennetts Associates were also a high profile supporter of not only the events but with presentations reflecting their approaches to designing buildings that can adapt over time to the types of changes we are all learning to live with. The RIAS was also an amazing contributor, supplying a free copy of 'Scotstyle: A hundred years of Scottish Architecture' for every delegate's bag, with their excellent presentations and addresses, a keynote speaker's dinner at their Rutland Square headquarters and a brilliant exhibition of the recent best of Scottish architecture on display at the Royal Society of Edinburgh building where many of the forum sessions were held. A huge thanks go to them all.

At the PLEA 2017 we were overwhelmed by the more than fourteen hundred submitted. These eventually resulted 580 individuals presenting over the three days of the conference and a three volume proceedings that included 664 papers on related topics.

Over 750 people attended the conference and its parallel events including 683 registered delegates and their families and an amazing array of keynote speakers. Check out the full programme on www.plea2017.net. Apart from the intellectual stimulation provided, the whole event was great fun too. The opening party on the evening of the 2nd July was in Edinburgh Castle, the conference reception on the 3rd in the ballroom at the Assembly Rooms, the conference dinner was held in the National Museum of Scotland on the 4th when the more energetic delegates got to enjoy a parallel ceilidh at the Ghillie Dhu. For those interested you can download pictures of the whole event taken by Adrian Arbib from PLEA 2017 home page www.plea2017.net.

It was an extraordinary feat to manage all of this while making sure that the 554 presenters all got time to share their work and benefit from the deliberations of the other experts attending. How did we do this?

The PLEA 2017 Team Scotland was formed in 2016 and led the bulk of the thirty-one different subject Forums that are described on the website at:

<https://locus-focus.co.uk/PLEA2017/index.html#forumlist>

They could be further broken down into five different meta-themes:

- Building Better, Safer Places for All (inclusion and resilience)
- Designing to Thrive in a Changing world (affordability and well-being in good buildings)
- Learning from, and building on, the Lessons of the Past (evidence based design evolution)
- Powering our Lives with Sustainable Energy – (clean, durable and affordable futures)
- Empowering Current Generations (Education for change)

The conference was illuminated throughout with the simple fundamental message of passive, low energy buildings in the Edinburgh Assembly Rooms and the Royal Society where generations have deliberated on building design since they first opened at the height of the original Age of Enlightenment two hundred and thirty years ago.

The PLEA Team Scotland was also well supported by CIBSE Scotland who made the best paper awards, by the Scottish Government and in particular Scottish Minister Fiona Hyslop who gave an opening plenary, and Edinburgh City Council and its Provost who hosted a lunch at the Royal Society before the conference for some keynote speakers and made the opening welcome at the conference. They all helped to send the message out that Edinburgh and Scotland have an enormous amount to offer in terms of excellence in architecture, engineering, education, design and forward thinking and practice, telling all who came that we are not only open for business but we are also great to work with too.

Forum Reviews

Each of the PLEA 2017 Forum leaders has provided a short overview of the presentations and discussions from their own forums and for those interested in finding out more about each topic area the names of the Forum Leaders can be googled and they are happy to be contacted directly to provide more information or perhaps build bridges to provide more research sharing and development opportunities.

Passive and Climatic Design

Colin Porteous

MEARU, Glasgow School of Art



A word that springs to mind with PLEA is continuity. The meeting to inaugurate an international series of Passive Low Energy Architecture conferences was held in Miami in 1981 and the first PLEA was held in Bermuda in 1982 and then held annually thereafter with only three exceptions, making this PLEA 2017 in Edinburgh the 33rd such event. Interestingly, there has been a parallel existence in Scotland for the Scottish Solar Energy Group (SSEG), inaugurated in Edinburgh by the late Kerr MacGregor circa 1980 and making its mark at the ISES (International Solar Energy Society) Congress in Brighton in 1982. It launched a biennial series of NorthSun conferences in 1984 at Napier College (a University since 1992) and was involved in the setting up of ISES-Europe in the early 1990s with its first of the biennial EuroSun conferences in 1996. So for Scotland PLEA has a long term involvement with PLEA that we were all please to celebrate in Edinburgh in 2017.

Within the overarching conference theme of '*Design to Thrive*' the most prominent theme at PLEA 2017 was, unsurprisingly, that of cooling. This is an increasingly critical issue. Elizabeth Shove (<http://www.demand.ac.uk/>) gave a polemic keynote talk against standards arguing that minimum standards have paradoxically led the marketplace to providing unnecessarily de-luxe air-conditioning systems in commercial buildings, thus adding considerably to greenhouse gas emissions. There has been a burgeoning of high-end air conditioning as an economic-cultural must even in temperate climates as in Scotland but I think the underlying cause is not standards or regulation, but lack of them. Back in the early 1990s there was an attempt to limit unnecessary active cooling in buildings via the Scottish Building Standards. But this was successfully countered by a powerful industrial air-conditioning lobby and today's statutory Standards still have no curb on this significant energy guzzler that could otherwise have been mitigated against by good design and a fabric-first approach.

Matthias Schuller, CEO of TransSolar KlimaEngineering (www.transsolar.com/), pointed out in another keynote that energy demand per unit area may be going down via energy-efficiency tactics, but the unit area per person is going up. Hence, standards such as the PassivHaus 15 kWh/m² for annual space heating may not bring about as much in the way of energy savings as could be realised if we were more circumspect about the economy of floor-space. Richard Hassell of WOHA (www.woha.net/) treated us to very high-rise examples of PLEA spaces (see some of them on videos on <http://www.plea2017.net/>). Richard also commented rather contentiously that “Le Corbusier’s template is now being realised” (see LC’s 1933 ‘The Radiant City’). This had me pondering on how Jane Jacobs might have responded!?

Two other keynote speakers resonated with me. One was by Joe Clark of ESRU at the University of Strathclyde acknowledged the significant gap between design intent and operational reality. He maintained this was due primarily to the “demandingly stochastic” nature of buildings in use and advocated that we needed to provide “true simulation tools” that afford an “emulation of reality”. Such emulation was to be brought about by “high-resolution, agent-based models” whereby the agency embedded in the model is in charge rather than the user, and the agents interpret results, not the users.

Adrian Leaman (www.usablebuildings.co.uk/), presented his 10 criteria for a good building: uses locational potential; avoids unmanageable complexity; minimises unnecessary dependencies; promotes options – adaptability within reason; communicates design intent to users; meets basic needs unobtrusively; is not hostage to management or design fantasies; remembers its past; recognises constraints, and uses them to advantage; and anticipates buildings including one by Architect Ferran Yusta Garcia who described a simple common-sense methodology to deal with differing conditions, providing a menu of ‘architectural actions’ for different climates. There was one session under the banner of discourse, which Hugo Santos led off on a thoughtful paper on “energy sufficiency” that fitted quite well with most of them. There was also a good mix of papers involving field measurements around the world to complement the predictive work.

Summing up I must emphasize that one special value of PLEA is the imaginative layering of new technological and design thinking on to old techniques. The next PLEA 2018 is to be ably led by Professor Edward Ng in risks and consequences. One way or another, all his criteria had applicable PLEA relevance.

In my forum in PLEA 2017 I included a sub-set of papers on ‘Transition and Outdoor Spaces’, with speakers covering locations such as Dubai, Egypt, China, Cyprus and southern Spain. And there were also papers on wholeHong Kong, whose award-winning, post-earthquake house graced the cover and five central pages of the July/August 2017 issue of The Architectural Review, and exemplifies this closing sentiment. For sure, this building represents ‘passive and climatic design’ at its best.

Comfort and Delight

Fergus Nicol

NCEUB



Comfort in buildings has always been an important aspect of the proceedings at the PLEA conferences. This conference was no exception. Some 50 papers were assigned to this subject of which 43 were presented verbally at the forum. Thermal comfort in buildings (and equally important, its absence) continues to be a favoured topic for scientific research related to architecture. With the increasing interest in adaptive comfort the subject has stopped being merely in the realm of physics and physiology. Human comfort is now seen as related to a broad spectrum of academic influences bringing in psychology, behaviour, culture and many more concerns and thus ensuring its continuing fascination. Even seemingly simple questions such as ‘what do you mean by comfort?’, ‘what do we mean when we define a building as overheated?’ or ‘should buildings create comfort or allow people to make themselves comfortable?’ still need to be answered securely.

The papers were separated into the following subject areas:

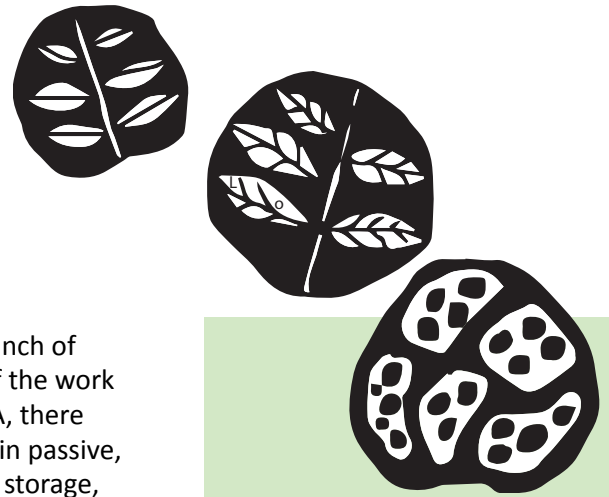
- *Comfort theory*: dealing with such subjects as the effect of the 'openness' of a building, the form of its windows or its thermal mass on occupant comfort, as well as introducing some new approaches to the physical measurement of buildings and the comfort of their occupants.
- *Comfort in educational and health care buildings*: There is an ongoing discussion about the comfort conditions for school children and a number of the papers deal with this as well as the conditions for older students. Conditions in health-care facilities do not always follow the assumption that patients require warm conditions so that the conditions provided were sometimes too warm and comfort was often found in a wider range of temperature than expected.
- *Comfort in workplaces*: Although offices in a variety of climatic zones are the most commonly investigated workplaces because of their relative availability for surveys, the papers presented included two retail establishment and a church. The approaches to comfort include one paper where thermal discomfort is advanced as a cause of conflict between workers.
- *Outdoor comfort*: The interplay between indoor comfort and outdoor climate is now largely recognised and indeed is included in the design of standards such as EN15251 and ASHRAE 55 which use outdoor temperature as a predictor of indoor conditions for comfort in naturally conditioned buildings. Despite the fact that most humans spend the overwhelming majority of their lives indoors the outdoor conditions are important in influencing the clothing and other aspects of the human interaction with buildings. This is important to the way we see and design buildings as well as in our behaviour outdoors, and the design of outdoor spaces.
- *Comfort in residences*: A striking range of climates are represented in this section of the forum reporting research into comfort in residences. Most of the papers concentrate on the improvement of the comfort and energy efficiency created by retrofit and the design of buildings which work with the climate to produce comfort indoors.
- *Environmental factors which effect comfort*: This section is about the relative importance of a range of factors which influence indoor comfort and satisfaction – both in the measurement and the application. This is an important section which will help to take both the quantitative and importantly the qualitative nature of comfort and the ways it can be made more relevant to design and building.

The way in which the development of the study of thermal comfort can be approached and its importance to the design of buildings is well covered by the papers which are in the Comfort and Delight Forum of the conference. A careful reading of these papers will be rewarding and the authors of the papers are to be thanked for their contribution.

Renewables and Solar Energy

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The term “renewables” covers a diverse, vibrant, and innovative branch of building related research that was encapsulated in the excellence of the work presented throughout this Forum. In keeping with the ethos of PLEA, there was a focus on the sustainable development and occupant comfort in passive, low energy design. Reviews of earth-to-air heat exchangers, battery storage, energy yields, and daylight and thermal gains were presented. The current technologies at the forefront of research and development were related to solar energy systems, with papers evaluating:

- Solar thermal venetian blinds for thermal and visual comfort as well as energy utilisation
- Solar hot water systems for varying building applications
- Photovoltaics and smart mobility in cities, the future of electric vehicles
- BIPV in building façades to optimise space and energy gain
- Solar thermal systems for district heating networks

Issues surrounding renewable energies were also addressed, the major problems facing us today being storage, accessibility, and connectivity to the national grid. Important considerations were tackled such as operational efficiencies, the potential for renewable supply to meet demand with and without storage, and the public perception of renewable technologies and low carbon buildings.

Also, illustrating the diversity of this field were topics such as:

- The regeneration of urban infrastructure through sustainable policy management and urban sustainable development
- A social survey on how the economic crises affect attitudes towards environmental issues and renewable energy sources
- Legislation strategies and incentives for the adoption of solar energy

The papers reinforced the need for an holistic approach that must be taken in terms of the development, adaptation, and uptake of renewable energies. The speakers presented a strong argument for role of solar energy in the transition towards a greener, more sustainable world highlighting the benefits, and drawbacks, associated with this. The session, beginning with three high-calibre keynote speakers, renowned in their field, and followed by a host of stimulating researchers presenting a range of fascinating project. It began and ended on a very up-beat note base on the optimism surrounding the growing understanding of the imperative for working towards 100% renewable economies and developing an architecture that is *Fit for Purpose* in a genuinely low carbon future.

Community Energy

Andrew Peacock

Heriot watt University, Edinburgh



An energy revolution is happening in Scotland and around the world. In 2016 over 60% of energy consumed in Scotland came from renewable generation, from wind, solar, biomass, tidal, hydrogen and methane sources, and a growing proportion from local generation systems. Scotland now has many community energy projects and more on the books each year, encouraged by clear and effective government policy support and implementation, an effective NGO sector and grass roots level interest and investment in local energy generation (<http://www.communityenergyscotland.org.uk/>).

Across Europe and the developed and developing world significant research has gone into optimising the value to local communities of such energy systems through orchestration of demand and supply, improved local weather forecasting, building and community level storage systems and consumption reduction strategies. Integrated research here includes inputs from social scientists, designers, lawyers, physicists, designers, engineers, economists and a surprising range of skills underpinning the extraordinary rise both here and internationally, of community energy schemes.

A common theme of the forum centred on the idea that community energy schemes can act as a conduit or locus for wider community activity. Presentations described situations where this was within the sector, for instance where a supply side energy project led to initiatives that addressed built environment energy efficiency. They also described evidence where these were cross-sectoral, leading to wider societal benefits within the candidate community.

Papers in this Forum covered a gamut of the issues involved in this community energy revolution. Subjects touched on included papers by Raheal McGheon assessing policy constraints and technical feasibility of energy developments in cities; Inji Kenawy looked at land suitability analysis for wind farms in the country of Egypt; Aoi Yamada looked at the feasibility of island level systems in Japan; Priyanka Bendigiri looked at solar potentials for energy efficient communities in developing economies; Visions were popular of how to plan and develop renewable energy urban areas using new strategies and tools including:

A Conceptual Framework for Optimal Urban Energy Planning Tool using BIM and GIS by Liyang Fan; Yamamura Shinji presenting proposal for a comprehensive urban infra-structure planning model for Smart City planning with GIS and 3D modelling I Tokyo; Wenjing He on the energy performance plan analysis in New Ecological City; Daniella Maiullari on building scenarios in Urban Energy Transitions; Tomasz Jasinski on prediction of electricity demand with artificial neural networks in Ontario, Canada and Italy. Finally, Lorna Kiamba presented a paper on Community Energy Structures and the role of community engagement.

The scope and depth of the papers presented really unveiled an exciting new field that will ultimately be responsible for helping us, in all countries and cities and communities to build new energy systems and a safer world, with buildings at the heart of the new energy orders. Do check out these excellent papers in full in Volume 1 of the PLEA 2017 proceedings, pp. 1383 – 1469 on www.plea2017.net.

Overheating

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With the steep rise in global temperatures, overheating is one of the most visible effects of climate change on buildings. Further to forecasts more frequent extreme weather events and longer and warmer summers, the risk of overheating may well become one of the primary causes of building system failure. Present buildings need to invest a considerable amount of their energy usage to reject heat gains, or have the need but not the capacity to. This is particularly true in warm regions but more and more often, this situation has become present in traditionally cold areas as well. The increase in internal loads or the use of architectural designs poorly suited to the local climate, such as over-glazed façades or, paradoxically, over-engineered insulation, is increasing interior overheating exposure time in many buildings, even in winter-dominated climates. This intensifies the vulnerability and weakens the resilience of many contemporary buildings to climate change-associated events, even the most modern developments and high performance buildings designed under Passivhaus standards (Botti).

Overheating mainly affects comfort conditions, but can also lead to health problems, including a reduction in life expectancy or risk of death in the most vulnerable occupants (Gupta, Renganathan, Fosas). User productivity is likewise affected both at home and at work (Gupta, Botti, Calleja). That, together with possible rises in energy consumption and their impact on power generation and distribution systems (particularly electricity grids) make this a problem of public concern nature.

It does not seem possible to establish a single definition of overheating, and this topic has been one of the key drivers of discussion within the forum. We may associate with conditions in which building users are exposed to high thermal stress over periods of time long enough to interfere with body thermoregulation beyond their individual habituation and physiological adaptation capabilities. The issue is not only related to air temperature, but also factors such as air currents, activity, radiant temperatures and other environmental parameters also play fundamental roles (Quezada, Vallejo-Torres, Fosas). The analysis from the perspective of dynamic adaptive comfort and non-linear occupant's response have been drawn as one of the most appropriate approach.

In light of the foregoing, the forum has addressed, some questions listed below to deal with the assessment of the issue and to design the most effective strategies.

Evaluating the risks

A key question is whether we can predict overheating, and mainly, do we agree with the actual definition of Overheating and their metrics? This aspect opens a debate with a broad difference in the approach between temperate and cold climate areas.

There is plenty room for discussion about the Overheating metrics and the threshold fixation. There is an especial relation with cultural and regional factors, so these parameters must be considered with special care in any procedure. From this reflection emanates a basic question: Is it possible to make an accurate assessment of the actual issue?

Inhabitant's behaviour and characteristics have a deep impact in the overheating phenomena, with greater effect on older users because of the longer stays periods and being less responsive (Gupta).

Our architectures should develop an important adaptive and flexible component so that occupants can use different techniques of heat control. This must be adapted to their pace of life and individual specificity providing tools to help them control the overheating of the indoor ambient. These may include an intelligent use of ventilation (preferably natural) and shade management. To this end, the use of a low-hi technology mix, such as the combination of passive systems and the new automated control elements, may be of interest to keep the environments controlled with little investment of energy. This aspect has a special impact improving resilience and adapting to aging process.

The development of realistic and useful prediction models for Overheating forecasting its becoming a real need. We must to make a special effort to arrange opportune and accurate data, especially those of meteorological type and the need for more advance techniques for interpolation of meteorological data between stations (Oraiopoulos). Promising proposals for models based on trends and those components with cyclical behaviour are under development, such the ITCC-TSAM model (Oraiopoulos), or the use of Kriging-based interpolation for models (Wood). The development of proposals for tools to apply in the residential development industry, such as the ARIOS tool, optimized for regional typologies, sets a path for further involvement (Tsukiyama).

Special consideration should be given to architectures with fewer capacities, which cannot afford the classical thermal stress mitigation resources, such as envelopes with suitable mass or adapted materials. Usually these constructions are located in the most disadvantaged areas of the planet, where the scarcity of resources forces to very light or limited quality constructions. These housing models are extremely vulnerable to overheating processes, making living conditions even more painful. An especially extreme case is the temporary construction in refugee camps, which are usually located in areas especially sensitive to extreme climates, such as the desert plateaus of the Middle East. Many of the low-resource architectures have had to deal with the debate sacrifice traditional heat protection techniques, such as the use of thermal mass, for cheaper and faster constructions. There is a significant field of development to achieve the improvement of the behaviour of these elements, while being compatible with a fast and affordable construction.

Strategies for adaptation and mitigation

The forum covered different techniques to design the most suitable strategies for building design, focusing in particular on existing buildings and what actions may be undertaken to improve the response to overheating.

Overheating fighting is strongly related to good design practices and morphological optimization of the buildings. Most of the strategies to be incorporated are usually based on traditional elements, which have been used to great effect in the vernacular architecture, in many cases still in use in the traditional home stock of mild temperate zones. Many strategies are simple in theory (natural ventilation, shading, the use of water and other techniques) although providing adequate solutions to remove or block the heat in an effective way is harder to achieve in real practice for modern developments.

Are those mechanisms historically deployed applicable to today's uses and language? We have to explore and gain knowledge from this traditional and vernacular adaptation to improve the performance of contemporary buildings.

One of the usual problem is that most of the solutions derive from rule of the thumbs approaches. Accurate and scientifically based approaches may displace wilful and sometimes naïve design. Different tools are available to assess the design and to optimize with a parametric approach for every specific circumstance (La Roche). This allows a more accurate and climate responsive design.

Proper control of the heat gains of buildings does not have to be at odds with the freedom of design and the quality of the architectural product. The control of energy gains should not be understood as a linear and rigid imposition, but instead, on most occasions provides enriching elements to the creative process (La Roche, Calleja).

The forum has explored truly feasible and cost-effective solutions, with a look to side effects, such in other buildings components or neighbouring zones (Grant).

Control of the windows and facade shadows, especially in high-rise buildings (La Roche, Gavira Calleja), as well as roofs design in lower buildings (Quezada, Grant); appear as key elements in the overheating control for buildings. We can consider alike other contributions with significant weight in the control of the heat gains such the control of the radiant temperature of indoor envelope. This may be achieved through different techniques getting cooler surfaces, like the reflective coatings, evaporative techniques, and cross-section materials optimization (Grant, Habib, Vallejo-Torres).

Conclusions

- A non-deterministic assessment to the overheating issue, mostly based on the adaptive comfort theory will help to realistic evaluations.
- A crucial issue will be how to design effective retrofitting approaches that do not worsen the problem.
- The dilemma between over-insulating and the overheating risk must be undertaken. How to strike a balance in a changing and dynamic climate?
- How we can apply the different strategies to the current building stock?
- The morphological components of architecture play an extremely important role in the control of overheating: windows, shapes, materials and shadows must be handled accurately.
- A holistic, comprehensive, and sometimes painstaking approach to the problem is needed to design actual adaptable buildings.

Energy Efficiency

David Jenkins

Heriot Watt University, Edinburgh



The submissions to the Energy Efficiency forum were impressive in both range and level of detail. They also demonstrated that the term “energy efficiency” can mean quite different things to different people. However, four sub-themes did emerge.

Firstly, in our session on Modelling for Energy Efficiency, there were examples of both thermal and statistical modelling techniques to aid our understanding of buildings. Some studies focussed on the method, whilst others were concerned with the application and usefulness of the information produced. Despite these varied topics from many different countries, common topics emerged around the danger of over-generalising the building stock, the use of the “zero energy” brand, and the importance of climate.

The session on Standards, Regulations and Policy again allowed for a comparison across many locations. Very specific studies on higher education and laboratory buildings were complemented by wider studies across domestic and non-domestic stocks. A key part of the drive for energy efficiency in buildings, the Energy Performance Certificate, was then looked at in terms of any measurable impact it might have, with the varied methods of producing EPCs across European countries presented as a potential barrier to standardisation and cross-comparison.

In the Building Design and Retrofit session, the need for vernacular and regional filters on the choices we make for design was clear. Examples were provided of buildings being designed with location, activity and, also, the natural world as inspiration. Tailoring technologies and design approaches for specific needs, rather than basing such choices on generic assumptions, was a clear theme.

Finally, Monitoring and Case-Studies brought us something more tangible. Empirical evidence demonstrating how technologies, or a building as a whole, perform can provide a level of in-operation understanding of building performance that no theoretical model can replicate. We are now moving towards an age where data is more accessible, with more methods for measuring, storing and processing such data. Modellers should now look towards new ways of making choices on energy efficiency that are empirically-based, linked to proven good practice, enabling the case-studies of success presented at PLEA to become the norm.

Light

Luisa Brotas

NCEUB



The original call for papers for the Light forum aimed at the design of well-lit environments, acknowledging the innumerable advantages to the occupants, owners and reinforcing our responsibility to be sustainable and protect the environment. The response has shown a good international exposure and a vibrant interest in relevant topics gathered in the 44 papers accepted from various countries: Algeria, Australia, Brazil, Chile, China, Colombia, Czech Republic, Denmark, Egypt, Germany, India, Iran, Italy, Japan, Mexico, Netherlands, Norway, Spain, Sri Lanka, Switzerland, Sweden, Thailand, United Arab Emirates, United Kingdom and USA. Of these 32 were presented at the conference in 4 sessions:

- Context and envelope
- Visual and Impact
- Performance and Integration
- Energy and Occupant Delight

Light has multiple facets. It can add liveliness to the architecture of spaces, buildings and objects and enhance the indoors and outdoors amenities to the advantage of people (Theodorson). Daylight in particular has innumerable benefits to the health and wellbeing of people, can promote visual comfort and increase productivity in a working environment (Day). Likewise, a new body of knowledge is emerging on the non-visual effect and its various applications and impact on people (Zang and Du, Noi).

Daylight as a free, non-polluting and sustainable resource can ingeniously interact with the form and layout of buildings, with the shading devices and light redirecting systems, integrate with artificial light, reduce the need for energy, contribute to energy efficiency and lead to low carbon design (Maharroof, Hasse). However, it is also taken for granted, the use of daylight is often undermined or delegated to the later stages of urban planning and the design of buildings and openings. This can compromise its effectiveness and impact. A careful integration of daylight with other specialities, a thorough analysis of the climate, context and envelope of buildings taking advantage of daylight is a way forward and has been looked at by a number of authors and presenters (Mardaljevic, Pereira, Brembilla, Woo to mention a few).

Recent developments in the technology of lamps, luminaires and controls, scientific methods to quantify, assess and support design, new standards, codes of practice and regulations are raising the awareness of important research and practice that can create an impact in good design (Haglund). The impact and visual comfort was interestingly presented in both real scenarios or climate chambers (Shukuya, Lam Lo, Krüger) or in the evaluation and design of components (Wienlod, Triantafyllidou, Jara Cerda).

The papers covered a variety of approaches, from simulations, including genetic algorithms for optimisation, physical model measurements as well as testing in real daylight conditions (Fathy, Roldan Rojas). Daylight data collections and processing were complemented by POE, surveys and questionnaires (Brotas). Light investigations were undertaken at an urban scale and in several types of buildings: residential, educational, offices and working places, shopping centres and hospitals. It also included historical buildings: a church and a chateau or museums and art galleries.

It is hoped that the Light forum of the PLEA17 conference has made a contribution to the dissemination and discussion of the state-of-the-art in the field of light in architectural design in the current framework of sustainable development. Several presentations focused on daylight and solar radiation concepts for sustainable building design and renovation, the impact on people's comfort and wellbeing and the good use of energy resources. The future can be bright and light can lead us through it!

The forum leader wishes to express gratitude for Professor John Mardaljevic, Professor Masanori Shukuya and Dr Jan Wienold for chairing sessions in the forum and contributing to the debate.

Building Performance Evaluation

Tim Sharpe

MEARU Glasgow School of Art



There are very few areas of design and production that do not thoroughly test and evaluate the performance of their artefacts. However, the construction industry is one of those areas. Very few buildings are routinely evaluated to see if they work as intended, to see what didn't work and how it can be avoided, but also to see what was successful and how it can be repeated.

In the contemporary context of rapid change in energy and performance standards, increasing costs and raised occupant expectations this is not an acceptable state of affairs. With changing standards and solutions most new buildings have some form of innovation, so it is vital to evaluate the outcomes. As well as the requirement to reduce energy and carbon emissions, we need to produce buildings that meet the needs of occupants. Architectural design needs to consider the implications of producing buildings that are in some way an experiment - what are the ethical responsibilities to those occupants who are effectively the subjects of these experiments? If design is to evolve it needs to be a position of knowledge and based on evidence. The use of Building Performance Evaluation is a critical tool that needs to become routine.

The range and quality of papers submitted to this Forum – and indeed others – suggests that this situation may at last be changing. For the last two decades, there has been increasing awareness of the importance of BPE as a mechanism to achieve energy reductions in practice. It has been shown to be a tool to improve fine tuning of buildings to improve energy efficiency and comfort, but perhaps more importantly, to improve standards of design and construction.

However, the increasing use of BPE has revealed the presence of Performance Gaps – differences between expected and actual consumption, and it is becoming increasingly clear that this applies not just to energy consumption, but a range of other issues such as Indoor Air Quality.

The need to develop an evidence based approach to design and legislation makes BPE a critical tool and the Forum hosted a wide range of papers that describe BPE projects from every continent and across a wide range of projects including both new buildings and retrofit. The forum received 96 abstract submissions, from which 49 were selected for presentation.

The forum ran in four sessions. The first of these concentrated on BPE studies from non-domestic buildings, primarily schools and workplaces. Topics ranged from benchmarking of energy systems in commercial buildings, through to specific studies on the performance of façade systems and plug loads on campus.

The second session was directed at the use of BPE in retrofit projects. BPE is particularly appropriate to retrofit as it potentially allows for before and after comparison of performance, and 'before' evaluation can directly inform design strategies and decisions. The forum received papers on a number of case studies from Europe, South America, Asia and Australia. These included single building studies, building typologies, and building elements.

The third session focussed specifically on the effects of buildings on users, and user effects on buildings. Buildings are intended for people, but they are often the least considered aspect of design; and they are the subjects of BPE studies. It is clear from BPE studies that the way that occupants use buildings can have significant impacts on their performance. This interaction alters energy use, but also affects occupants in terms of thermal comfort and indoor air quality. Papers in this session covered potential harmful effects, such as overheating, but also the development of new tools for low impact BPE.

The final session included a number of studies from cutting edge projects that identified key findings and lessons learned from these. These papers provide important insights into the use of new design strategies, material and technologies, but also provided exemplars of developing tools and technologies for BPE studies.

The session concluded with a discussion about how BPE can become mainstream. Whilst there is increasing interest and activity in this area it remains at the edge of architectural practice and following a position paper on this the Forum discussed strategies and policies for enabling BPE within the industry. A particular focus was a debate around the use of in-use energy certification, currently adopted in Australia. It is certainly becoming apparent – tragically highlighted to an extreme degree in Grenfell Tower - that there is a major problem with design and regulatory compliance. The emphasis up until has been on the design professions, but perhaps a way forward is to focus on the needs of owners and occupants of buildings. They are the ones that, after all, have to live with the consequences.

Green Infrastructure

Kate Carter

University of Edinburgh



The forum attracted a small but very interesting range of papers with a focus on the green infrastructure and its role in a sustainable future. The research work presented was impressive and informative. The impact of green infrastructure and the complexity of this context must become more understood to ensure that the whole urban context is researched.

The role that trees have in moderating wind in the urban environment (Yuan et al.) has a strong relationship to species and canopy type. The work shows that trees have high potential to offer conditioning in city environments. Simon et al. explores the impact on air quality from urban sited trees and the heat and water stress that result in production of Isoprene leading to high ozone concentrations. Saaroni et al. presented findings on the thermal comfort that can be achieved in outdoor spaces with the use of green infrastructure. They examine the impact of grass relative to paved surfaces and consider the role that Urban Green Islands might have in providing urban scale solutions to overheating in cities.

Green roofs and their proximity to the building surface are studied by Krebs et al. to demonstrate the cooling potential they have in the hot climate of Brazil. Ignatius explores the role that Greenery has in Green Building rating tools and surmises the importance of considering this more carefully in the weighting for sustainable buildings.

Green infrastructure in its broader definition were considered by Gauvreau-Lemelin, looking at the incorporation of hemp into wall structures; and by Naidja et al., considering the geometrical parameters of urban landscape and the contribution this has to shading requirements.

The Green Infrastructure forum demonstrated the significant role that the exterior landscape has in Sustainable cities. It also reinforced the need for detailed modelling and consistent analysis and sharing of information to inform the current and next generation of architects, and urban designers.

Bridging the Performance Gap

Paul Tuohy

University of Strathclyde, Glasgow



A real problem in trying to design genuinely low carbon buildings is the almost universal gap between the simulated performance of buildings and their energy use in real life. The aim of this Forum was to share new knowledge that might enable the performance gap to be reduced or even eliminated. There were 25 papers here and the first session looked at what sort of gaps there are and their possible causes, using information from monitoring studies and performance assessments. One presentation highlighted the lack of correlation between design rating points for IEQ (indoor Air Quality) and post occupancy feedback. Another highlighted fixed and unrealistic input parameters as a problem. More work is obviously needed here.

The second session explored current initiatives aimed at addressing performance gaps. The Australian NABERS was commended for requiring performance ratings based on measured performance, with design ratings for information only. NABERS has both Energy and IEQ ratings and is voluntary. Next the roles of the building user and other people related factors were reviewed and the importance of enabling and supporting appropriate individual sustainable behaviours was highlighted. Involving users in the design process was also highlighted as a key to ensure a fit for purpose outcome. Good examples included where local requirements and customs, comfort expectations, knowledge, tradition design styles, materials and labour were incorporated, leading to buildings that were understood, simple to operate, and sustainable, and districts with valued amenities such as cool green spaces.

The trouble with Post Occupancy Evaluations is that they occur when the mistakes have already been made. The final session looked at new tools and processes and a 'pre-post occupancy' method was presented to enable problems to be addressed during early design. Another paper proposed a formal process of feedback loops in industry process and others presented some inspiring regeneration processes that look beyond energy and IEQ to environmental and socio-economic enhancements. Overall the session provided immensely valuable insights into current gaps and how these gaps can be bridged.

Cool Cities and Urban Heat Islands

Rohinton Emmanuel

Glasgow Caledonian University



Amelioration of UHI provides a local narrative within which strategies for the enhancement of urban quality-of-life can find acceptance and even active support. A political difficulty with action against global climate change is the inability to see results in the here and now. Tackling the urban climate change offers immediate and tangible benefits since the negative consequences of haphazard urbanization is plain to see. This is increasingly being recognised in international efforts. Examples include greater focus on urban climate by the World Meteorological Organisation (such as the “WMO Urban Agenda” – <http://public.wmo.int/en/our-mandate/focus-areas/urban-development-megacities/wmo-and-new-urban-agenda>); World Health Organisation’s (WHO) greater attention to public health – especially ageing in the changing climate (<http://www.who.int/globalchange/en/>), and UN-Habitat III’s smart city and quality of life agenda (http://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Paper-21_Smart-Cities-2.0.pdf). PLEA2017 provided further evidence to the growing importance of UHI mitigation among built environment researchers. A forum on ‘Cool Cities and UHI’ (Forum 11) elicited the second highest number of papers among the 32 Fora presented at the conference.

While simulational studies dominated the proceedings, there were a considerable number of cutting edge approaches to UHI mitigation and the promotion of ‘cool cities.’ Evyatar Erell (Ben Gurion University of the Negev, Israel) pointed out that while air temperature may be a good ‘headline’ indicator of weather conditions, mitigation approaches that exclusively focus on it may lead to inaccurate or even erroneous conclusions. Erell stressed that practical needs in two areas are the most pressing: improving human thermal comfort (especially in outdoor spaces) and conserving energy in buildings.

Hu Du (Cardiff University, UK) attempted to predict real-time UHI effects using the UK Met Office’s postcode-level forecast data for better building energy consumption estimation. Based on a calibration of predicted vs measured temperatures he was able to show considerable differences in summer cooling loads (up to 42% more than a rural building) while also showing a slight reduction (-12%) in winter heating. This will have significant impact on the estimated carbon savings from building energy management approaches.

Chao Yuan (National University of Singapore) presented recent work on developing a fine-scale morphological modelling-mapping approach to UHI studies. This approach could potentially lower computational costs compared to Computational Fluid Dynamics (CFD) simulation and wind tunnel experiments. At the same time, higher resolution wind environment mapping may also be feasible, providing fine-grained information about air flow between buildings.

Pan and Du (University of Hong Kong) showed that Sky View Factor (SVF) plays a leading role in influencing UHI intensity and thermal comfort as measured by the Universal Thermal Comfort Index (UTCI). They showed that an approach they termed as 'urban villages' with high-density mid-rise buildings leads to better outdoor thermal environment than contemporary high-rise but low-density blocks.

Several papers provided evidence from the field of the efficacy of UHI mitigation approaches from around the world. These include the evaluation of a sustainable urban redevelopment project in Thessaloniki, Greece, in terms of microclimate improvement by Chatzidimitriou, et al.; impact of increasing surface albedo on pedestrian thermal comfort in Delft, the Netherlands (Taleghani, University of Salford, UK); empirical results from cool roofs, cool pavements and trees by Werneck and Romero in Brasilia, Brazil; cool islands by small green spaces in central London (Hanrahan and Hill) and the cooling effect of shading and MRT in outdoor comfort in Florence, Italy, (Pearlmutter et al.).

Perhaps the most rewarding outcome of Forum 11 at PLEA2017 is the potential for collaboration between the climate-sensitive design community as represented by PLEA and UHI researchers from the International Association for Urban Climate (IAUC). This came in the form of a PLEA-WUDAPT collaborative initiated during the sessions.

Recent advancement in urban climate science has occurred through careful observation in controlled circumstances. While this knowledge is embodied in urban climate models the absence of useful urban data, that is consistent in scale and coverage, is a major impediment to the development of an urban climate science that is useful globally. The World Urban Database and Access Portal Tools (WUDAPT) framework can provide a great service to the emergence of urban climate science by gathering climate-relevant data and providing the tools to utilise these data.

The entry level WUDAPT protocols (called Level 0 and based on Local Climate Zone maps and associated lookup tables of range of values of form and function parameters) have gained wide currency across the world. It is now time to move up to Level 1 or 2 of the protocols, which will provide enhanced level of detail, specificity and numbers of form and function parameters. Crowd-sourcing methods based on building typology (BT) might provide a means to generating the desired details on building form and function. In particular, the meeting heard from of several leading proponents of the WUDAPT process (J Ching, G Mills, J Hidalgo) a proposal to use architectural archetypes as the basis for deriving information on BT.

Such an approach could proffer mutual benefits: Establish common but systematic guidance and approach to crowdsourcing with “Local Experts in LCZ paradigm.” A call from the WUDAPT community was thus issued to the PLEA audience to join hands in this quest at a critical juncture in the ‘Anthropocene’ period. Several volunteers signed up for this effort. The following approach was agreed upon as the way forward for PLEA-WUDAPT collaboration:

- a. Provide guidance on BT within city, regional and worldwide variability.
- b. Crowdsourcing leadership and/or participation
- c. Sampling deployment strategies
- d. Identifying and incorporating Cadastre, Metadata

It is hoped that this bottom-up approach might lead to a more formal linkage between the two communities, leading to a long and fruitful collaboration in the years to come.

Adaptation to Climate Change

Rajat Gupta

Oxford Brookes University



Unprecedented rises in global temperatures have begun to have a huge range of impacts of varying severity. These impacts have resulted in system failures including overheating of buildings, breakdown of communities, the rising costs of keeping cool or warm and the growing inability of sections of the population to afford the necessary energy to do so.

The idea of adaptation or ‘bouncing forwards’ to a better safer future is key, and this forum was designed to share and discuss new research and innovative thinking to make that happen. There were 19 international papers presented, that focussed on measuring impacts of climate change on urban environments, and providing tools and resources to deal with those impacts. The forum was organised into three sessions focussing on:

- Urban scale solutions
- Building scale solutions
- Innovative methodologies

The papers presented in the urban scale solutions session included measurement and simulation of microclimatic effects of green infrastructure in São Paulo and cooling effects of pavement watering in Paris during extreme hot weather. A key theme of the session was the increased interest in incorporating urban environmental factors (elevation, greenery, and buildings) into the geo-spatial analysis of urban hot areas during hot weather.

The building scale solutions session had papers focussing in improving thermal comfort and energy use in dwellings across Nigeria, Albania and Cuba, along with flood mitigation in Bogota. Some of the innovative solutions included incorporation of vertical farms and green roofs for improving the indoor thermal environment during hot weather.

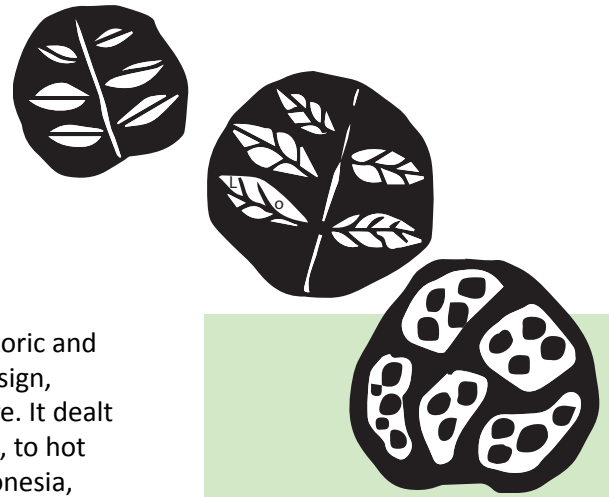
The innovative methodologies session revealed novel approaches to assess the climate-responsive adaptability of buildings in warm humid climates of India and Taiwan. A new method of definition of climatic classification based on human comfort was proposed for Mexico to establish a better relationship between occupant perception and their climate.

The attendees of the Forum felt that much of the new thinking on how we can ‘climate-proof’ our citizens, buildings, cities and regions had been aptly covered by papers in this Forum.

Vernacular Buildings

Isaac Meir

University of the Negev



The broad range of topics presented in the conjoined Forum on Historic and Vernacular Buildings traced the interfaces between architectural design, details and materials, environment and climate, tradition and culture. It dealt with different geo-climatic regions – from hot humid Meso-America, to hot hyper-arid North Africa, to cold dry Tibet, subtropical India and Indonesia, and the broader regions of the People’s Republic of China. Building typologies, traditional materials, their potential upgrade, surveying and monitoring methodologies were presented. What characterized most of the presentations was a very sensitive relationship to the traditional and the vernacular, considering them as legitimate potential solutions for the understanding of current and future needs. A key issue here is that the critical observation and analysis of such prototypes and cases is an imperative need, lest we fall into the “Traditional Technology Trap” (Roaf, S. 1990, *Dialog*, 25: 26-33). A message must be that people in less industrialized societies and in past ages have managed to make the best use of what was available in terms of materials and technologies. However, these may not be optimal or sufficient for today’s needs, influenced by population growth, rapid urbanization, rising living standards in developed countries with Less Developed Countries following closely and, not least, environmental challenges of worrying magnitude, climatic exacerbation among them.

Thus, traditional prototypes, materials and technologies need to be considered in a critical manner and provide appropriate upgrades and solutions for a changing climate, and changing socio-economic trends.

The tools and methods at our disposal today allow us indeed to analyse extensively what could only be assessed in the past. Different simulation software, including shading, temperature and air movement, allow the architect to test different options and reach a fairly good pre-construction understanding of microclimatic conditions, energy usage projections, thermal comfort and overall building performance. Important too are economically accessible and relatively simple monitoring systems can provide the architect with post-construction, post-occupancy data, both on the building performance and its usability.

Much of the know-how is out there, but needs to be geographically and culturally contextualized, avoiding a blind romanticism and idealization of the historic and the vernacular. Only such a process will ensure the appropriate adaptation of past knowledge to future needs, granting it the legitimacy inherent in what has been tested, evaluated and shown to be suitable for future needs.

Historic Buildings and Refurbishment

Amar Bennadji

Robert Gordon University, Aberdeen



This forum heard from a wide range of contributors who offered an equally wide range of viewpoints. Several themes emerged from the session.

Can traditional architecture contribute to new ways of designing and operating buildings? Which in itself could be perceived as a leading question.

And a building is more than just a home, it and its residents will also need to interact in a viable and successful community. In the upgrade of older buildings, care needs to be taken not to cause a different set of technical and social problems. The risks might be addressed by modelling although, understandably, there are reservations about its effectiveness.

Sometimes, a traditional building is not acting as it was designed. Progressive loss of traditional building performance, through modern interventions, will degrade performance (passive performance, e.g. ventilation, in particular). Progressive isolation from the environment and the evolution of expectation of comfort was also explored: how is traditional housing progressively changing, and how it is no longer performing as it used to do.

Humanising modernism – it can be done. Studies discussed the successful re-use of post-war buildings in dense urban contexts, but for this to work it needs strong leadership from civic authorities. Repair and upgrade rather than demolition for carbon and resource retention. Design quality in post war Social Housing is actually quite good; it is easy to criticise some aspects of post war construction, but it is our heritage and its architectural quality should be respected; and indeed it is still popular.

A desire to implement non mechanical solutions, and the re-instatement of natural amenity, especially in monuments.

However, pilot studies took place and results of monitoring will inevitably speed up the renovation of other buildings once revealed and confidence of buildings owners or historic buildings trusts is established, so we can just watch the space now and hope an era of massive refurbishment will take off.

Conclusion:

The refurbishment of historic buildings seems to still be a serious issue as many questions are still to be answered by the research community in the built environment.

The major concern is what historic buildings will we leave to future generations if we are not sure about the consequences of any refurbishment undertaken as many phenomena such as, moisture migration through buildings' fabric, and its potential damaging capabilities are still to be assessed and this involves years of monitoring and observation.

The introduction of computer generated analysis of buildings' behaviour did add a lot to the understanding of historic buildings by the research community but we are still hesitant to take these data as fact since no comparison with real buildings have been observed hence the delay in taking serious repairs and energy improvement of historic buildings at the moment. However, pilot studies took place and results of monitoring will inevitably speed up the renovation of other buildings once revealed and confidence of buildings owners or historic buildings trusts is established, so we can just watch the space now and hope an era of massive refurbishment will take off.

Digital Design

Joe Clarke

University of Strathclyde, Glasgow



Building performance simulation provides an unsurpassed means to test the robustness of proposed design solutions under realistic operating conditions and in terms of the many conflicting cost and performance attributes that need to be kept in balance. That said, the approach will necessarily correspond to an ideal state with respect to system operational parameters, including occupant interactions. Performance in practice may therefore be different from the design intent, a gap that can be addressed by routine conditions monitoring supporting remedial action informed by timely feedback. This is an emerging possibility enabled by notions such as 'design by simulation', 'internet of things', 'big data analytics' and automatic diagnosis applied to building estates. This conference theme was established to encompass paper presentation addressing developments in the application of building performance simulation at the design and operational stages with particular emphasis on approaches that connect the two phases and thereby help to bridge the performance gap.

While the papers assigned to this session cover some aspects of the above, this coverage is by no means complete. The session summary provided here is therefore a significant but partial snap-short of developments in the digital design field.

16 papers were presented in two thematic sessions as follows.

Building Performance Assessment

Yun Kyu Yi, Performance-based 3D interior space layout optimization.

Antonio Carbonari, Buildings with large glazed surfaces: optimization of solar control strategies in relation to the building's thermal inertia.

Francisco Carrasco, Computational simulation analysis and calibration of insulation in social housing in the city of Valparaíso, Chile.

Roy Sigalingging, Assessing cooling energy load and dehumidification in housing built to Passivhaus standard in Jakarta, Indonesia.

Bianca Negreiros, Thermal performance simulation of green roof on social housing in hot and dry climate in Brazil.

Kazuaki Nakaohkubo, Shape optimization of louver by numerical analysis of solar radiation.

Joana Gonçalves, The environmental potential of multi-storey housing in central São Paulo: an opportunity for reoccupying the city.

Jiwei Li, The analysis and design strategy research of the new edition "Assessment Standard for Green Building of China".

Design Tools

Pil Brix Purup, Towards a holistic approach to low-energy building design: consequences of metrics for evaluation of spatial quality on design.

Mathieu Schumann, Interdisciplinarity around design tools for new buildings and districts: the ANR MERUBBI project.

Helge Simon, Evaluation of ENVI-met's multiple-node model and estimation of indoor climate.

Emanuele Naboni, Outdoor comfort simulation in architectural design process: a qualitative assessment of tools.

Giuseppe Peronato, Integrating urban energy simulation in a parametric design environment.

Hidenori Kawai, Outdoor space modelling for BIM-based building thermal simulation.

Thomas Leduc, Limit the buildings envelope in order to prevent the surroundings mask effect: towards an efficient implementation in the SketchUp context.

Anas Hosny, A parametric sensitivity analysis of the impact of built environment geometrical variables on building energy consumption.

A summary of the messages inherent in these papers is as follows:

- There is much focus on optimisation whereby simulation is employed to provide performance outcomes against design parameter variations that represent specific issues such as space layout and solar control.
- Simulation is routinely being employed to improve the performance of specific building types or, conversely, to understand the essential features of designs observed to perform well in practice or that represent a higher performance standard than the norm.
- Simulation is regarded as the best method to evaluate the performance of new technologies before deployment and is especially useful in identifying likely impacts across a range of issues such as energy, comfort, air quality and environmental impact.
- Simulation is being used as the underpinning technique in the development of design standards and assessment procedures at the national level.
- There is a marked trend to develop holistic tools that address hitherto separate problem domains such as the linking of building physics and indoor/ outdoor micro-climate.
- There is growing focus on urban issues such as city-scale shading, solar/ daylight access, local energy schemes and urban canyon comfort.
- There is a continuing focus on the need for multi-discipline engagement in modelling studies in order to ensure acceptable trade-offs between conflicting performance requirements.
- There is growing recognition that many problems require the application of complementary assessment tools and that this, in turn, requires greater compatibility between the BIM applications that generate 3D models.
- There is a growing requirement for automated parametric.

Aesthetics and Design

Ola Uduku

University of Manchester



This proved to be a lively and also thoughtful set of papers which despite having the 'catch all' phrase of *Aesthetics and Design*, focused on specific interpretations of how aspects of design affected the overall architectural aesthetic of various buildings in some instances or within a philosophical appreciation of architectural style in other papers.

The first session commenced with a strong comparative analysis by Hawkes and Lawrence on the difference in style between two relatively recent architecture school additions at the Macintosh and Manchester schools of architecture. Further paper presentations followed which compared architectural design with stylistic concerns, including Passivhaus design (Carter and Zhao) and also philosophical approaches to style, (Veglia and Fionnocharrio).

In the next session discussions included explorations of how colour affected design, (Nigra and later on Hagenlocker) the influence of Frank Lloyd Wright's housing designs on perceptions of style, (Desmond) and other approaches to style from different nationalities and regions. The final session gave space for practitioners to discuss their approaches to style in architectural design, (Donovan and Widera).

After each session a short period of discussion followed which was well utilised. Given the number of speakers it was a feat to keep sessions within time. We had only one 'no show' from our 18 paper givers and incredibly full attendance throughout. As at the end of the sessions there was no doubt that the panel had been popular to many attenders - this might well have been because of the diversity and quality of the speakers.

It was a challenge to have the sessions run together successfully and I would like to thank the presenters for doing such a good job in keeping within time and the attenders for being model audiences. Most papers were of publishable quality and thus it is hoped after the late publication of the PLEA proceedings the authors will also ensure that this will take place through their individual efforts as the original panel chair was unfortunately unable to contribute to the session. I would otherwise be willing to work with a relevant journal to put together an edition focusing on key papers presented in this panel.

Low Carbon Building Design

Gokay Deveci

RGU, Aberdeen



Forum 16 provides a demonstration of the complexity that faces us when setting out to design Low Carbon Buildings (LCBs). In the 1990s we focussed on energy efficiency in buildings, following the simple design mantras like those embedded in the Passive House movement: Good windows, no draughts or cold bridges and lots of insulation. Towards the end of the 20th century the fashion appeared for relying largely on mechanical ventilation and heat exchange for air changes, though how this led to low carbon emissions than simply opening a window in most seasons is unclear. By the 2000s the integration of solar energy into buildings provided a very successful means of substantially reducing carbon emissions from buildings and so became popular. By the 2010s the falling price of solar energy made it a must have feature of LCBs, except with some architects who could not grasp its benefits and some who felt that solar panels spoil the clean lines of their designs.

In the 2000s Sustainability became the over-riding concern for environmental designers but rather to the confusion of many as they tried to juggle apples and pears in order to ascertain the relative merits of designs. Parallel to the sustainability ratings programmes there also emerged the typically much more detailed and scientific field of carbon accounting, involving various methods of assessing the carbon emissions resulting from buildings over their build or life time. Life Cycle Assessment enabled a much more rigorous approach quantifying carbon impacts but one clear problem was that the top down accounting methods, designed for use by governments to enable them to mark their progress against national and international carbon reduction targets, were incompatible with the bottom-up approaches used on the ground to base-line, benchmark and rate comparative performances between buildings.

Then in the 2010s, as the impacts of a warming climate began to seriously manifest themselves on the ground, the European, American and Australian quests to move to lower carbon building types and stocks moved, as energy efficiency had a decade before, towards the back seat and the driving concerns turned towards issues of resilience.

F16

What became apparent in Forum 16 was that actually good design decisions lead not only to lower carbon buildings but also to more robust, and resilient, ones in which people are more likely to be able to survive successfully than in many high energy, fragile, high carbon models. What is also clear from the papers is that for designers, things have become much more complex in the quest for carbon reductions than simply upping the U Value of a wall.

For those interested in following the ideas deliberated on in this Forum – turn to the fourteen opening papers in the third Volume of the PLEA 2017 Proceedings, available from the home page of the conference website: www.plea2017.net.

The papers in this Forum cover many different aspects of issues related to the field. Three papers deal with the challenge of managing and designing for carbon reductions at the city and district levels, others then look at effecting generic reductions on different sectors of the housing stock, from historic to high rise buildings. Several deal with low carbon designing for actual individual buildings and building elements, like the envelope, and two others deal with the metrics of accounting for carbon reductions. Some take a first cost approach to carbon assessments while others look at whole life costs for the stocks.

What is really interesting are the ‘next step’ papers, that are now not only looking at how the buildings are structured, fitted out and furnished, but also how they are used, viewed and habituated to with evidence from studies in schools, homes, offices and timber historic buildings. There is even a paper on ‘productive’ envelopes where the skin of the building offers a carbon exchange opportunity through its covering of living plants. Perhaps most fascinating of all is the example of energy (and hence) carbon storage in ice – in the historic ice-houses of Iran. See how they do the math on that one, which raises another important question of ‘how do you carbon account for energy storage’?

Read the papers and explore the challenges they embody in the proceedings if you are interested. Everyone should be because once the scale of the climate change impacts currently unravelling become even more apparent everyone will eventually have to learn how to count and reduce their building carbs. A final thought – when exactly will that great Building Diet begin?

Culture and Society

Andrew Toland

University of Technology Sydney, Australia



Compared to the substance and materiality of buildings themselves, sun, wind, air, light and temperature seem like highly ephemeral elements. However, building physics and other methodologies of environmental architecture now measures and is able to design with these parameters with incredible precision. By contrast, the social and cultural dimensions of environmental architecture are often either overlooked, or often thought of as difficult to quantify. Papers in this session, however, demonstrated that careful and robust enquiry into these dimensions of sustainable practice can shed valuable light on issues on effecting environmental change within the built environment.

The papers presented explored a diversity of issues ranging from the history of early conceptual frameworks for understanding environmental technologies within architecture (McGlynn); the development of tools for measuring social sustainability of projects in rural China (Li and Ng); theorisations of pedestrian comfort in a Brazilian climatic context (Lelis Rabelo); self-construction design guidelines for informal communities in Medellín, Colombia (Lopera Aguirre); and the uses of 'nostalgia' in permaculture design (Loveday).

Despite the wide spread of papers, the subsequent discussion uncovered numerous overlapping themes. Of particular interest were the lively contributions around the questions of the ways in which non-physical characteristics of environmental performance should be measured and valued. As environmental issues and aspirations increasingly become woven into the fabric of daily life, they are becoming part of architectural culture in ways that go beyond the conventional partitioning of the discipline into various fields of technical specialisation. At the same time, society had large is arguably still have yet to experience the kind of 'cultural shift' necessary to transform lifestyles and consumption patterns in ways that might have a significant impact on carbon emissions, resource depletion, energy sources and flows, or declines in biodiversity.

Another notable feature of the discussions the papers elicited was the important reminder that questions of environmental sustainability are not just issues of popular concern in developed societies, but are also being debated and acted upon in developing and non-western contexts, and raise significant issues, questions and challenges in relation to widely differing cultural conceptions of the relationship between society and what in the West we call 'nature' or 'environment'.

Another key issue was cultural and social modalities for effecting change within the material realm. Because architecture and design is a key conduit for translating 'culture' into material realities and giving form to collective social ambitions, an explicit consideration of cultural and social formations and their connection to the arena of environmental architecture and design seems more urgent than ever.

It is also worth adding one more note of contemporary urgency that may help to draw attention to the themes under consideration amongst the papers in the forum: in an age where the United States has announced its withdrawal from the Paris Climate Agreement, and with governments in several important countries toying with, or even actively pursuing a strategy of turning back the clock on a whole range of environmental policies and initiatives, it's important to recognise that culture itself, and the role it has in structuring the values and ordering of society, has become 'weaponised'.

That might seem like a sensationalist claim until one turns one's mind to the way in which, over the past few years, vast amounts of money have been poured into using big data collected from social media and other sources, by firms like Cambridge Analytica and SCL Elections, to produce targeting algorithms with the express intention of reshaping people's beliefs, opinions and understanding of the world – in other words what anthropologists used to classically call 'culture', and more recently call the social 'imaginary' – shifting that in favour of certain agendas and interests.

In this situation, the goals of environmental sustainability, mitigating and adapting to climate change, advocating and pursuing particular policies and standards with regards to the built and natural environments, find themselves now operating within and having to adjust themselves to dealing with this new reality. Under these conditions, consideration of effective strategies for social dissemination of values environmental sustainability, careful attention to the history of their production within fields of knowledge or as popular affects, or advocating and pursuing particular policies and standards – as articulated in the papers of this forum – are all important ways that scholarship and design practice is able to contest the self-interested agendas of environmental retrenchment.

Future City Visions

Circe Monteiro

University of Recife, Brazil



Where better to talk about the future of cities than in one of the most durable in the world. Beneath the great fortress of Edinburgh Castle the stone streets and buildings have an air of being able to survive another thousand years without changing gear. So it was fitting that in this forum with its ten papers given by speakers from seven different countries that a wide range of case studies, methodologies and findings were presented. The challenges of dealing with issue around the planning, design and development of such complex entities as cities integral to the range of ideas presented in this Forum.

For the development of new cities in China the effectiveness of copying from examples of successful cities elsewhere, such as Singapore, were explored and reviewed by Ying Hu and Zhongjie Lin to provide a balanced case study of the pros and cons of so doing. Design tools to maximise the energy and carbon benefits of new urban areas were presented by Shota Tamura for the planning of Fuchu in the Hiroshima district of Japan. Serge Faraut provided a comparable study of evaluating the benefits of different town-scale building morphologies. But then cities are not just about energy as a case study from Medellin in Colombia showed where the presenting author Annie Gomez Patino argues that actually investment in low cost housing should be maximised because such developments are a Public Health issues as well and a cost and design challenge. Leena Thomas presented work from Sydney, Australia in which sustainability and resilience were seen as multi-variate and related to what properties were wanted, needed and planned for at the urban scale. Using a set of mapping indicators priorities for the planners could be set and decisions made on the basis of well-conceived and executed evidence based data collection and analysis.

Such an approach would also illuminate the opportunities of building the adaptive capacity (AC) of settlements which was reinforced in a number of papers. AC can be built physically as Simone Medio showed by exploiting underused areas in cities like building of the available and utilisable roofs, as has been done in Amsterdam. AC can be increased using new data collection techniques where the feasibility of bike sharing schemes in Budapest has increased through the use of location sensors and Smart management systems. But ultimately education of citizens in the available opportunities open to them and their integration into the decision making processes are essential in order for change to happen at all and for the right change to happen. Inji Kenawy provided an excellent example of the importance of putting real, local people into design and planning processes in his illuminating study of the desertification of Siwa in Egypt and the importance of citizen participation in building resilience in the region. This message was reinforced by Craig Martin in the study from delft of the Societal Impact Methodology that has been rolled out across a number of European cities to connect citizens to the societal and technological costs and impacts of new developments in existing European cities.

This Forum provided a fascinating range of papers and highlighted how complex and important the challenge is of getting city planning and design right for the long term health and well-being not only of the citizens of those cities but also the planet. Never has this been truer than now when the system capacities of cities are not only straining under the pressures of burgeoning populations but also under the strain of extreme weather events and trends.

One of the biggest wake-up calls of the Forum and the Conference was provided in the presentation by Professor Ken Ichi Kimura on the impacts of the failure of the Fukushima nuclear plant in Japan on the lives, buildings and regions affected by this catastrophic event. Very difficult to think about how to plan for such catastrophes, but as we are finding in a warming world – we will have to think harder to prepare our societies and our built environments for what is to come, to lessen its impacts or at best to avoid it.

Transition Communities

Keith Baker

Glasgow Caledonian University



Empowering and enabling communities should be fundamental to designing thriving, low carbon built environments, but the desires and needs of communities, particularly the poorest, are often given little consideration by professionals, academics and policy makers. It's too easy to think we know best, or that the technical evidence we consider is beyond the grasp of the communities we serve. Yet our opening paper from the Philippines, which gained one of the conference awards, showed how even the poorest can be effectively engaged and empowered, in this case through helping them secure tenure and assert their rights to safe and secure housing. This emphasis on empowerment has strong parallels with both Scottish history and the current Empowering Communities agenda, and demonstrated how much can be learnt from sharing knowledge across even substantial environmental, social and economic divides.

Other papers covered issues of community living, an example of how increasing standards have led to the normalisation of the provision of low cost sustainability features, such as cycle racks, which until recently were seen as 'nice to have' options for richer developments. The issues of tools was explored with a paper from the USA that raised a difficult question for those of us whose research often strays into the political sphere. The team's analysis of data from the USA's Leadership in Energy and Environmental Design (LEED) certification program showed that education has been a more significant factor than income in driving up price premiums for higher rated properties. This provided data that emphasised the importance of income in community dynamics. A paper from Switzerland demonstrated how the tools of the future will need to reflect the transitions in the mind sets of both practitioners and the communities they serve to arrive at effective solutions.

These themes all have a strong resonance in Scotland, which as well as being home to the Enlightenment has an extensive and growing network of transition communities, ranging from rich and urbanite Edinburgh to the struggling former coal towns and isolated communities in the highlands and islands. All have their own local traditions, cultures, dialects, and, most importantly, needs; and, as our opening papers showed, in order to really understand those needs and how they can be met through transitions you have to immerse yourself in the mind sets and attitudes behind them. This is one of the joys of studying transitions – empowering ourselves by questioning conventional wisdom, and then using that learning to understand how to empower and enable our communities.

Education and Training

Ashraf Salama

University of Strathclyde, Glasgow



No other professions have undergone as dramatic a transformation in the past decades as that of the design and construction professions. Education for the creative and construction industries continually needs to assimilate the changes in rapidly evolving building markets into the courses to create fit for purpose and effective young professionals. Aimed at broadening and deepening the debate on how well the education and training (ET) of design professionals are in fact contributing to shaping a *Thriving Future for Designers* papers were invited for the Forum on subjects relevant but not limited to: teaching delivery models, experiential and inquiry-based learning, design studio experimentation, trans-disciplinary experiences, and the way in which these help shape such a future. Over 60 papers were received, 34 papers were accepted, of which 31 papers were presented as part of the ET Forum Sessions. The diversity of topics and issues were grouped under the following headings:

- a) *Built Environment Education for Sustainability - Expanding the Scope:* This theme represents an attempt to address the way in which the scope of built environment education for sustainability is expanding. Issues relevant to the notion of sustainable architecture and its underlying the multitude of perspectives and understandings, were part of the discussions.
- b) *Community and Social Responsibility in Architectural and Urban Education:* This theme generated a lively discussion about the role of the university in shaping the future of social sustainability within and beyond the boundaries of learning settings such as studios or classrooms.
- c) *Renovation, Technology, and Materiality in Design Pedagogy:* Sustainable architecture and innovative technologies for deep renovation of school buildings, as part of design learning experience was an important key topic.
- d) *Architectural Education across the Boundaries of Cultures and Regions:* From all corners of the globe teaching experiences, and experiments were discussed. Themes included experiential aesthetics, institutional challenges of architectural education, diploma and graduation projects and sustainable traditional construction techniques in the architectural curriculum.
- e) *Design Learning for Efficiency:* A rich range of approaches addressing energy included papers on teaching for lighting design, energy conservation, smart building design, the development of appropriate metrics for them and the integration of education, research, and knowledge with BIM (building information modelling). The role of social media in teaching was also a popular topic.

Education at all stages of careers is critical for architects and engineers in a rapidly changing world and the lively debates and warm discussions here were an indication of the rising challenge of getting education right in for all education markets and providers.

Construction

Phil Banfill

Heriot Watt University, Edinburgh



The 19 papers in the Construction Forum confirmed the truth of the twin adages that (1) everything has to be built out of something and (2) the art of construction is using available those somethings in such a way that they are not exposed to conditions that they cannot tolerate. Consequently, the forum heard about timber, rammed earth, reinforced concrete, glass facades and various thermal insulation products, being used in both residential and non-residential buildings, constructed using both on-site and off-site prefabricated methods in countries across the world – Australia, China, Malaysia, Japan, Bangladesh, Switzerland, Netherlands, UK, Brazil, Mexico and North America. Topics covered included life cycle assessment, airtightness, thermal comfort, insulation detailing, the sustainable materials supply chain, design practices, cost trends and road traffic noise. This wide diversity of subject matter precluded any possibility of classification into themes and it was gratifying that every paper held something of interest to the audience that enabled some detailed question and answer sessions to take place.

Clearly construction research world-wide is healthy and there is sufficient breadth of subject matter to keep researchers busy between PLEA conferences.

Water and Waste

David Kelly

Heriot Watt University, Edinburgh



Water plays a crucial role in the way we all live our lives and its supply and waste systems are inter-twined with the very fabric of our built environments. We depend on clean and safe water supplies to meet our daily needs: we use it for drinking and bathing, for growing food and producing resources, for creating beautiful urban vistas and also for providing fun and recreation. Our modern civilisations and civic societies are built on foundations of reliable sanitation and drainage systems for distributing and storing wastewater and rainwater. Yet, the management of these vital water systems are facing significant challenges globally due to rising populations, urban densification, and climate change impacts. The growing frequency of water shortages, flooding, and watercourse pollution are all signs that our existing infrastructures are stressed and increasingly less able to cope. New ways of organising and regulating the flow of water in and around our cities, towns, and villages is needed that not only sustains a healthy natural environment whilst meeting human needs, but that also harmoniously integrates water cycle management into our built environments.

Despite the importance of this topic, the Water & Waste forum was actually one of the smallest at PLEA 2017, with just seven accepted academic papers. Perhaps this reflects the apparent delay in water reaching the attention of government agendas and every day designers. Now, however, water policy and action is taking an increasingly centre stage position within other environmental issues such as energy, carbon, and climate change, not least because of the rising incidences of system failures, often related to extreme rainfall events. This is an important and exciting area for future research and development.

The challenge of urban flooding was the focus of two of the papers, both presenting very different approaches. The first looked at a range of design and construction strategies for the sustainable adaptation and retrofit of existing housing for *flood resistance*, whilst the second presented a shift in *flood resilience* through the design of sustainable floating housing to cope with flash flood events. The need to recast urban planning to incorporate sustainable water management approaches was the focus of a further two papers that highlighted the need for a holistic strategy for combining water/wastewater treatment, water distribution, and rainwater management, in a sustainable and environmentally-focused way.

Application of the circular economy thinking was also presented as a way of overcoming currently linear water consumption and disposal models. Two papers addressed the issue of water conservation, emphasising the importance of understanding end-use behaviours for successful water reduction strategies within buildings, and for the need for universal water policies, which is becoming especially pertinent in developing countries due to the escalating impacts of economic growth, rising middle classes and related increasing per capita water consumption patterns. The final paper of this forum tackled the issues of both water conservation and food production with the presentation of a novel building integrated aquaponic system that produces food (fish) and uses condensation water from air conditioning systems (a waste resource) as a sustainable water supply.

The topics discussed cover the breadth of water related challenges facing society today: flooding, urban water management, water conservation, sustainable food production. These are topics that require multi-disciplinary and multi-sector action, and urgently. Built environment researchers and practitioners are ideally placed to pioneer a whole range of sustainable water futures, many of which were touched on in these papers at PLEA 2017.

Sound

Laurent Galbrun

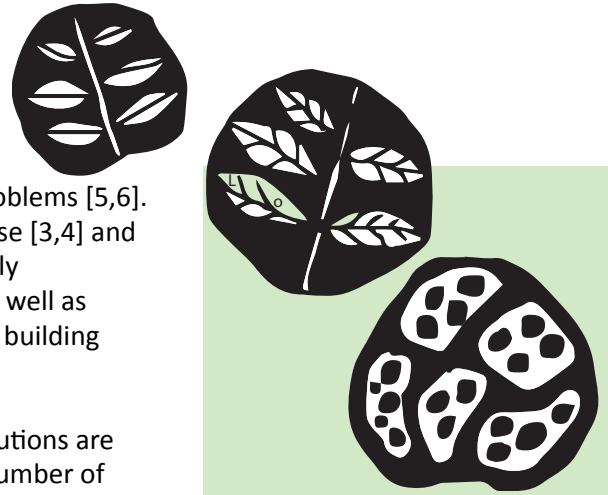
Heriot Watt University, Edinburgh

The sound forum covered both indoor [1-4,7] and outdoor noise problems [5,6]. In particular, emphasis was placed on office noise [1,2], hospital noise [3,4] and urban noise [5,6]. The presentations highlighted noise issues typically associated with large indoor open spaces and high activity levels, as well as correlations between urban noise and geometrical parameters (e.g. building geometry, street height and street width).

The studies confirmed that traditional engineering noise control solutions are not sufficient for dealing with today's acoustical challenges, and a number of innovative approaches and solutions were presented. For office noise, these included the definition of geometric indicators that can be used to quantify workplace geometry and noise geometry [1], as well as the use of water features that can improve the office soundscape and provide privacy through masking [2]. For hospital noise, the development of sound absorbers that can fulfil hygienic requirements was described [3], as well as an intervention proposal for improving the acoustics of a children's hospital [4]. Urban noise papers focused on urban and building geometries and how these affect urban noise [5,6], providing indicators that could be used for urban planning. Finally, one study also described innovative natural ventilation designs that can insure effectiveness in ventilation as well as sound attenuation [7].

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Transport

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As I tried to demonstrate in my Keynote plenary talk on PLEA 2017 opening day, we are facing several simultaneous revolutions:

- The electric vehicle, boat, plane revolution.
- The related battery revolution.
- The solar and new renewable energy revolution.

In the presentation I used the Norway's Electric Vehicle Revolution as a case. Although the revolution was about technological advances it was also about people. It was people that got together across traditional professional borders to push authorities including the Brundtland Government to introduce the World's best electric vehicle incentives. But it was not easy. It took a world famous singer, an aggressive environmentalist and me – an architect/now professor to grab the attention of the press so that our message and proposals could gain momentum back in 1989. We embarrassed the oil exporting Norwegian Government led by Brundtland – the head of the UN Commission of Environment and Development.

Today, the challenges are very different.

Today, the global industries of transportation are finally delivering the products we claimed they could have delivered decade or two ago but did not want to because they had invested in expensive production lines that made a lot of money for them. So why should they kill their money machines?

Today, the industry has understood the challenges ahead, although many are still dragging their feet refusing to see that Detroit – the home of car production - fell because of huge misjudgements as to what kind of vehicles the public would ask for the next day. The industry has understood that climate change, the two degrees C target, less use of raw materials, recycling, energy efficiency and the use of renewable energy have already led to fundamental changes. The production lines of the factories will need to reflect these changes or suffer closure as a result of less demand for their out-dated products.

So, when I met all the engaged PLEA 2017 people in Edinburgh I realised that the world is a completely different place from my first PLEAs (number 2 and 3) back in the early nineteen eighties in Greece and Mexico. In those days we were the revolutionaries talking of what could happen. Now it has happened and we must shift our focus to make sure we stay at the forefront of the revolutions of the future. We must deliver new knowledge that is applicable to the challenges of the future.

PLEA 2017 did just that – pointed forward, while documenting the past. It was a great event!

In the Forums we saw many great thoughts and projects described in a scientific low-voice way. We found gems all over the place as soon as we sat down and concentrated to what was presented. At times the sheer numbers of interested papers became overwhelming and hence the Proceedings become crucial as a building stone for the future.

In the Transport Forum we saw presentations on one of the main future challenges, in my view: The link between the built sector and the transport sector. Can the two sectors assist each other by sharing energy storage battery or other capacity? It seems they can and hence we can reduce the challenges of powering the two sectors by new renewable energy and storing it. We can also reduce the peak load challenges on the grid. In order to do this we must engage with each other as architects, technologists and other professionals to talk together and do work together. It is about sharing knowledge and developing new solutions across the traditional professional barriers.

The Transport Forum saw presentations on “Urban development as a strategy to reduce environmental consequences from mobility and transport” (Rynning), “Human powered mobility programming needs in mid-sized US Cities” (Rakha), “A design framework for sustainable mobility hub Networks in mid-sized cities” (Martinez) and the “Upgrading of urban highways” to respond to future demands (Moghadam).

All the above pointing forward at issues can will power the next revolutions, if we care enough about the planet, and I am convinced we do.

Resilience, Aging and Adapting to Change

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Population ageing and environmental sustainability in the face of a rapidly changing are two of the great challenges facing societies today. Architecture and urban design are first lines of defense and pivotal factors in successfully engaging with, and providing achievable solutions to both.

The resilience, sustainability and functionality of our dwellings within the context of their built environment are key to realising the benefits of the personal longevity dividend: the benefit of living well for as well and as long as possible. Homes in particular not only reflect the social and economic conditions of their occupants, but can also dictate them. They ideally, meet the everyday needs and preferences of older citizens and their lifestyles, and additionally provide crucial protection against extreme natural events and other hazards. Many societies have developed stratagems and action plans to promote 'aging in place', 'lifetime homes' and 'age-friendly cities' that support older people to continue to age and live well in their own homes and communities and to remain independent for as long as possible and to reduce reliance on institutionalized aged care provision. But how do these respective policies play out in practice? Do such innovative and explorative policies that are being developed in the face of rapidly aging populations have the outcomes sought and expected?

How should such innovative next step policies cope with emerging demographic and emerging occupancy trends? How can quality of life for older people be maintained in shifting social, climatic and economic landscapes? Finally and most importantly in the context of PLEA, what is the place of people promoting passive, low energy architecture in delivering design and new architectures that works for our changing populations and our ageing and warming world?

The Ageing, Resilience and Adaptation forum was an innovation for PLEA and focused on reporting findings, applied research, tool development and policy relevance. The forum explored three broad themes:

- Rethinking Housing in Aging Societies – to what extent, and how is the housing market responding to the aging population, changing needs and preferences?
- Adapting Indoor and Outdoor Spaces for Changing Needs – what are the indoor and outdoor adaptations needed to ensure that dwellings and neighbourhoods perform well and are fit for purpose for the diverse and changing needs of the aging population?
- Tools for Enabling Good Living – what are the practical tools and information that will help and empower us to live well as we age? How can older people be involved in the design of dwellings, products and services to ensure aging well in place?

At the forum, participants wrote down issues and insights on to sticky notes, and these ideas form the basis of the report-back summaries and conclusions below:

Rethinking Housing in Aging Societies

- A much greater variety of living options are needed. In particular, there is a ‘missing middle’ of housing supply. Greater diversity and choice would see the availability of small, but not too small, dwellings, accessory dwellings, dual-key dwellings, and purpose-built housing for multi-generations.
- Housing options in the general community and housing market need to be widened, rather than maintaining a narrow emphasis on age-segregated housing. Buildings, neighbourhoods and spaces should be designed to bring together young and old and foster intergenerational support. Social integration focusing on young engaging with the older generation will reduce social exclusion and young people can take advantage of elders’ experience and knowledge.
- Housing for the older population needs to be located close to services. Often these options are missing on the market, with development of new housing far from services.
- Simply designed homes, with resilient materials and features work better for older people, perform better and are more easily remediated in a disaster. Fortified dwellings involve heavy reliance on steel and concrete, but in a crisis, these may be left standing while everything around, including essential infrastructure, is unusable. This is neither sustainable nor resilient.
- As baby boomers retire, there is a need to consider generational change in housing preferences and expectations.
- Unaffordability should not be a barrier to changing housing to better suit the needs of householders as they age. Thought needs to be given to incentives to help people make the needed changes to support them as they age.
- Housing need is not only a matter of ensuring affordability, but requires attention to design, enabling policy, procurement and allocation of uses.

Adapting Indoor and Outdoor Space for Changing Needs

- The misalignment of sustainable design and resilient design must be resolved. 'Green wash' has led to a mismatch between disaster-readiness and accessibility. Perhaps it is time to consider 'Sustainability' as a stepping stone from which it is time to move on to thinking that social and economic resilience is what we need to be aiming for now.
- There is still little public and decision-maker awareness of the benefits and cost effectiveness of universal and accessible design. New ways of informing policy makers, planners and consumers about these benefits need to be developed.
- Thoughtless design of accessible features, e.g. ramps, can result in stigma and render the resident unsafe or exposed to crime, because the design signals vulnerability.
- Isolation by design may be an unintended consequence if thought is not given to how security features could unintentionally contribute to spatial isolation.
- Seamless transitions from indoors to outdoors should be fundamental to good design for the aging population.

Tools for Enabling Good Living

- How resilient is smart technology? Older people need access to passive as well as active technologies, because reliance on smart technologies may not be a resilient choice.
- More functions and services are expected to be delivered via smart technologies, and increasingly these will only be available electronically. It would be good to see how tools can be fully developed through electronic platforms.
- With the increasing prevalence of smart technologies, there is a need to consider cyber security and the vulnerability of elders to abuse and exploitation. Good design is not just responsive, but also responsible.
- To what extent do tools enable community connections? Is there a danger of technological isolation?
- Older people need to be in control of smart technology, not the other way around. Designers need to think about how tools and technology can enable independence. E.g. enabling people to plan for change before the need forces it.
- Find out what types of technologies work for and are preferred by older people. Are there ways of matching users with tools and technology?
- Be mindful of the need for user skill and knowledge development to ensure effective use of tools.
- There was interest in the Forum for discussing and refining tools and solutions for urban connectivity, and good design. It was considered that there is potential for using online conferencing.

Conclusions

Three big challenges were identified:

- The older population is often ignored in architecture and design, mirroring the stigmatization of aging. It was noted that the forum attracted predominantly women, raising the question of whether male-dominated professions are reinforcing the lack of attention to and low valorising of older people. The challenge is for architecture and design professions to act as leaders and enablers in addressing the dual challenges of climate change/sustainability and aging populations.
- Planning and policy for aging societies face the challenge of realising that one size does not fit all. The opportunities and innovative potential of supporting diversity must include involving more disciplines to really make a difference in future urban design.
- Designing for the community must involve knowing who is in the community, and the importance of clearly defining need (who, how and what kind of need). Older people and their families must be involved and engaged with design, even if this is difficult, e.g. designing for dementia. The challenge is to develop effective ways of engaging with all users.

The really big message of this Forum is that societies ignore these issues at their Peril.

Placemaking and Wellbeing

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Edinburgh School of Architecture and
Landscape Architecture



Place before buildings, but how and who to make judgements about successful places?

In the welcome to PLEA delegates, Fiona Hyslop, Scottish Government Cabinet Secretary for Culture, Tourism and External Affairs, spoke about the intention of Scotland's 'Place Standard' (launched at the end of 2015). This evidences national high-level policy intention to ensure community participation in development, making an explicit connection between good places and good health [www.placestandard.scot]. Neil Baxter, CEO of the RIAS, quoted Danish urban designer Jan Gehl's approach of "first, people" for approaching contemporary urbanism. Visualisations and standardisations of successful places- where priority for pedestrians of all mobilities, cyclists, and incorporation of landscape and planting- are popular in government policy documents and similar ingredients have become ubiquitous in public presentations of new urban development proposals.

However, the challenge of navigating and influencing the space between these ideas, images, standards, intentions and the pragmatics and complexities of implementation or local interpretation are of course tremendous. Gehl's ideas have been absorbed into many urban design policies and projects. He was a consultant for Edinburgh City Council, completing a report 'Edinburgh Revisited: Public Space, Public Life' which revisited earlier work of 1998. Their methodology for "the study of people's well-being" aims to "turn the design process upside down" (Appendix 1 of the report), analysing first life, then space, then buildings. Methods include empirical survey and analytical mapping methods which explore the way urban areas are used, which then inform the design process. In the design they describe the formulation of a comprehensive programme of activities based on the type of life inherent in an area; then develop a public space network that can support the public life through scale, form and climate; then they consider how buildings contribute.

For some time, sociological research and urban theory have been building on and exploring Henri Lefebvre's argument for understanding the production of space as not only the domain of formal design, but also of use and the users. The study and exercising of spatial practice, critical spatial theory and socio-spatial practices have emerged alongside more conventional site analysis. In this re-assertion of the social in design, there are echoes of the recent shift by UNESCO/ World Heritage to include both the intangible and the tangible in evaluating the significant aspects of heritage sites. The Scottish Place Standard tool aims to "structure conversations about place" and its criteria consider both the physical and social aspects of place.

The Placemaking and Wellbeing forum explicitly focused on this important area of necessary research and practical tools and mechanisms. The Forum identified a need to re-think and research further the notion of everyday expertise, and how it might be exposed and active in the alteration and construction of a place. This approach would extend users being observed in how they live well in a place (Gehl), or consulted through staged interview or workshop as part of established formal process, to acknowledge and disseminate the evolving and sophisticated knowledge of living and dwelling in a particular place with its micro-climatic, spatial, social, material and cultural dimensions and conditions. Deeper ethnographic methods, post-occupancy studies and extensive interdisciplinary case study work were suggested, to 'listen' better to the field in order to inform precise and socially responsible action in practice.

Adrian Pitts and Yun Gao's survey of sustainable and green design in a series of villages of rural southwest China drew attention to administrative blocks in Kunming, and the incorporation of concrete in many vernacular buildings as part of the complex navigation of improvement which might extend to utilising solar gain, strategies for improved ventilation. *Matthew Jones and Amanda Spence* presented the on-line 'Place Planning' tool, developed through academic and national design agency collaboration, reflecting on how its contribution to community wellbeing in rural Wales, UK could be evaluated. The 'Shape my Town' toolkit encompasses dimensions of the physical landscape, townscape and streetscape. *Sahira Bleibeth* has been researching the forbidden spaces of Palestine, using discourse analysis to approach everyday practices in the Jenin refugee camp and Old Town. *Shruti Shiva's* work on Mumbai, and the 'chawl' social-urban block, aims to reassess new models for collective social and affordable housing. Reimagining these vertical urban villages as a productive urban paradigm draws attention for the need for careful socio-spatial research and environmental analysis which evidences the specific qualities of the place and collective wellbeing that are valued. *Francesco Pomponi* shared examples of social housing case studies in Italy. *Nikolett Watson-Puksas* focused on the social-activist aspects of resilient cities and environmental justice in the context of Budapest. *Zhongie Lin's* research at a policy and regional scale compared the implementation of an 'Eco-city' model in Japan and China, finding quite divergent outcomes. **Andrew Jenkins** situated research and examination of the socio-economic landscape and urban agriculture in Manchester, UK, shed light on other aspects of the production of space and place.

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The forum's discussion converged on a general agreement that the experts of successful places are often the local inhabitants, who should of course then be active, acknowledged and empowered co-producers of future place and wellbeing processes. The role of formal top-down design policy, guidance, legislation and implementation is called into question as the definition and role of the expert becomes collaborative and contextualised. The 'designer' can be reconceived as a listener, collaborator, negotiator, as well as a formal expert in spatial, material, environmental form or occupation. A variety of research methods and practices – qualitative, quantitative and hybridised – was evident in the range and depth of work in the Forum presentations. The complexity of implementation- from the intangible legislative, social and strategic, intertwined with the tangible construction, material, spatial, environmentally analysed detail perspectives - demands interconnected research methods and strategies to be designed. In the end it is often easier to evidence and pinpoint discomfort, what is not working, not wanted than to measure, evaluate and make judgements on what is a good place, and whether it engenders individual and collective wellbeing.

Health and IAQ

Grainne McGill

MEARU, Glasgow School of Art



Both indoor and outdoor air quality have a fundamental influence on the health, wellbeing and comfort of building occupants. The air we breathe can contain more than 900 different chemicals, biological material, and particles, many of which may be potentially harmful to human health. In developed countries, people spend on average 90% of their time indoors and so architects and built environment professionals have a profound responsibility for creating a healthy indoor environment.

Exposure to indoor pollutants of ambient origin can be minimised through building design features by reducing air infiltration, installing filters and/or through careful design and positioning of openings. Whilst improvements to building fabric performance, brought about by increased awareness of climate change, is likely to reduce penetration of ambient pollutants indoors, there are emerging concerns that mitigation strategies may have unintended consequences, particularly regarding exposure to pollutants of indoor origin. At present, knowledge and understanding of air quality principals and policies among designers remain critically lacking.

In what way do the design, construction, management, operation and maintenance of buildings impact on the quality of air (both perceived and measured) and the health of building occupants? How do we ensure decarbonisation of buildings whilst ensuring a healthy and comfortable indoor environment?

This forum on Health and Air Quality was a first for PLEA, reflecting the growing worldwide responsiveness and awareness to this area among architects and built environment professionals. The aim of this forum was to accelerate and strengthen the global health and air quality agenda, by providing a platform for researchers to present new research findings, stimulate debate and advance knowledge by fostering intellectual exchange.

Papers were received from researchers and practitioners based in the UK, Ireland, Denmark, Taiwan, Chile, Brazil, Thailand and Kuwait. Presentations were predominately in the fields of architecture and engineering, exploring the following three broad themes:

- *The built environment and health*
How can architectural design features influence occupant health? What building related features are perceived as the most important for health?
- *Strategies and tools to improve indoor air quality in homes and buildings*
Which tools are available to help increase occupants' awareness of indoor air quality in the home and how effective are these? What practical tools and strategies are available to help improve thermal comfort and ventilation provision, whilst minimising energy consumption?
- *Ambient air quality*
How can architectural design influence ambient air quality? What other social, economic and environmental factors are at play?

The built environment and health

The session kicked off with a presentation from Sadiqa Al Awadh (Kuwait University), who provided evidence on the potential benefits of reintroducing courtyards in residential buildings in the Middle East and Arab regions, to help improve access to natural light and reduce levels of vitamin D deficiency, particularly among Muslim women. She highlighted the importance of architectural design as a mediating factor to encourage occupants to spend more time outdoors, in the privacy of their own home. This provoked a discussion regarding the importance of considering cultural, social, and climatic elements in design and the suitability of particular parameters to measure vitamin D deficiency in humans.

Following this, Richard Williams (VELUX) outlined key findings from a pan-European study investigating citizens' attitudes and behaviours regarding comfort, energy consumption and environmental impact in the home environment. He noted that three of the top five factors citizens perceived as most important for health were related to the home environment: sleeping well, ventilating for fresh air, and plenty of daylight. The study found that attitudes towards the importance of fresh air in the home were depended on gender (higher for women) and age (higher for the elderly). The Q&A session that followed emphasised the opportunity to support these findings with physical measurements and highlighted the value of the Active House Specification as a tool for designing and evaluating comfort, energy and environmental factors in buildings.

Strategies and tools to improve indoor air quality in homes and buildings

Gabriela Zapata-Lancaster (Cardiff University) demonstrated the benefit of simple, transparent devices in increasing awareness and understanding of the effect of occupant activities on indoor humidity levels in the home. She noted that occupants provided with a therma-hygrometer showed a better understanding of their home environment. She revealed that monitoring of humidity and temperature had a greater impact on householder behaviour than electricity monitoring. The discussion that followed highlighted the complexity of occupant behaviour with regards to lifestyle choices and values, and the challenges associated with trying to change behaviour through interventions. The issue of control was also discussed, where it was noted that environmental preferences often vary among building occupants, and as such, the level of control should reflect the type and diversity of occupation.

Following this, Carmina Bocanegra-Yanez (University of Strathclyde) showed how detailed building modelling and simulation could be used as a tool to assess indoor air quality and improve the design of ventilation systems in low energy homes. The findings indicated significant variations in the results of the detailed emission modelling when compared to emission rates obtained assuming constant environmental conditions. Further scenario testing (based on monitoring data from a Passivhaus development in Scotland) identified a risk of exposure to high levels of formaldehyde in airtight homes if MVHR systems are deactivated/ inoperable. The Q&A session revealed intentions for future work, which included improvements to the software tool used (based on the findings) and extension of the study to include other parameters, such as PM2.5.

The theme continued with a presentation from Yu-Lieh Wu (University of Technology Taiwan), who explained the importance of independent temperature and humidity control in air conditioning systems and the value of providing dehumidifying capacity in air conditioning systems to improve occupant comfort and health. He presented the results of a study that evaluated the effect of desiccant solution droplet on dehumidification efficiency. He demonstrated that changes to the spray pattern using a spiral nozzle compared to a circular nozzle in the dehumidification tower could be used to improve dehumidification efficiency.

Ambient air quality

The session concluded with a presentation from Paz Araya (Universidad de Chile, Santiago) who provided an overview of the complex relationship between firewood heating consumption and air pollution in the south of Chile. She discussed a number of important factors influencing this, including the standard of housing insulation, the quality of firewood, the local economy, forest resource sustainability, energy security and energy poverty. The discussion that followed highlighted the importance of considering both indoor and ambient air quality in design, and the challenges associated with the need to ventilate to remove pollutants of indoor origin, whilst minimising exposure to ambient air pollutants, particularly in polluted cities.

Conclusion

A number of challenges and research gaps were highlighted:

- How do we ensure that strategies to reduce energy consumption in buildings (such as increased airtightness and control of ventilation to minimise heat loss) do not result in increased exposure to air pollutants indoors?
- How do we balance the need to ventilate with the need to reduce exposure to pollutants of ambient origin? How do we increase awareness of indoor and ambient air pollution among the general public?
- Is increased awareness of indoor air pollution enough to change occupant behaviour?
- How can we best use available tools to improve the design of ventilation systems whilst minimising energy consumption?
- What level of occupant control is suitable for ventilation strategies in the home?

Overall, the forum brought together academics and practitioners with a wide range of expertise and interests, which reflects the significant diversity of research in this field and the interrelationship and connectivity with other fundamental elements of passive and low energy architecture.

It is hoped that this will continue to be a prominent theme in future PLEA conferences, given the profound impact of air quality on the health, wellbeing, productivity and learning of building occupants and the growing worldwide awareness of the challenges of designing passive, low energy and healthy homes and buildings.

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Materials

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Carbon Accounting

Francesco Pomponi

Edinburgh Napier University



Construction practices and the production of building materials have some of the largest impacts on society on the planet. These range from the environmental impacts of raw material extraction and refinement to the effects materials can have on the well-being of occupants within buildings. Interesting new approaches were proposed in the Materials Forum that had four different topic sessions covering: Carbon and Life Cycle Assessments; innovation in Materials; market Opportunities for new Materials and their thermal Characteristics.

The Carbon and Life Cycle Assessment of Buildings session highlighted that within the discipline there is still little consensus on important aspects of carbon assessment. Semantic issues often stifle more substantive debate and standards and guidance on carbon assessment vary from country to country, region to region with little evident progress on harmonising accounting systems. One problem is that each material product from a particular place will have its own unique carbon and energy life cycle, including the time and manpower to make them, factors often poorly accounted for in many methods. *Innovation in Materials* was shown to benefit from collaboration between academia and industry. An example was of the great improvements in the durability of traditional materials that resulted from developments in polymer, biopolymer and bioplastic research. Architects often lead the need for innovation but making it happen requires a truly multi-disciplinary and organisational co-operation.

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There are *huge new opportunities* in material's research, capitalising on the 'eco / green premiums' that new types of materials can offer across the whole life cycle of a structure. Around the world the depletion of raw materials is occurring at an alarming rate making change imperative and papers on the imperative for 'circular economy' were very thought provoking. As one author pointed out 'cities will become the mines of the future'. Some authors suggested *low-tech* materials should be focused on, utilising nature's innovations to inform developments. The use of plants in responsive facades to provide solar shading was an example in contrast to *high-tech* solutions that require high energy input to construct, automate and run. There was an emphasis on better understanding and exploitation of the basic *thermal characteristics of materials*, from traditional materials, through to novel products and materials with active controls.

A number of big challenges were identified including the need to overcome vested interests in the materials industry and its fundamental conservatism. Also closer working between academia and industry to innovate would help as would a greater understanding of material performance. Demand for better materials from architects would help to stimulate new markets with the PLEA emphasis in the sessions on low tech approaches.

Ventilation

Brian Ford

Natural Cooling Ltd.



The 'Swann Room' in the Royal Society of Edinburgh did not seem very promising at first. Tucked away in the basement labyrinth of small dark rooms, I feared that not many delegates would find it. However, soon after starting our first session the room was packed, with standing room only, creating a hot and stuffy atmosphere. After suffering for a while, someone found a door at the top of a stair at the back of the space and opened it resulting (in combination with the open lower entry door) in a demonstration of the simplicity and effectiveness of natural ventilation to remove internal heat gains and achieve thermal comfort !

The first session focused primarily on aspects of thermal comfort and performance analysis, while the focus of the second session was more on building applications and post occupancy evaluation. Nine papers were presented, with authors from North and South America, Europe, the middle East and China – a very wide spread, and an indication of the global relevance of natural ventilation.

Time was given for questions and discussion at the end of each presentation, resulting in a lively debate on a range of issues.

Antonio Castillo's excellent presentation (paper 0627) on a new 'Heat Balance Index' for application in hot climates, will help both academics and practitioners to account for the humidity of the air when modelling naturally driven airflow, and its impact on thermal comfort. While recognition of the validity and benefits of the Adaptive Comfort model (in both ASHRAE and ISO standards) has helped practitioners to propose NV strategies for buildings in many parts of the world, the implications of high humidity in warm climates requires careful evaluation, and this paper is a significant contribution to this process. Other presentations (Joyce Carlo paper 0234 and Bakr Gomaa paper 0052) underlined the fundamental importance of basing performance analysis on reliable assumptions, and this formed the basis of questions addressed to some of the other authors.

The application of different ventilation strategies to different building types, in different climatic regions, presented in the second session, were discussed in the context of both theoretical applications (Saba Alnusairat paper 0264, and Miguel Galvez paper 0089) and post-occupancy evaluation (Elisur Mogollon paper 1369 and Grainne McGill paper 1184). Miguel Galvez presentation on the evaluation of overheating risk and the opportunity for natural ventilation in cities of the Chilean coast, will be extremely useful to practitioners seeking passive cooling solutions in Chile, and indicates the wider value of ‘applicability mapping’ of passive cooling solutions in different parts of the world.

Post-occupancy evaluation is now firmly established as an (almost) essential part of new projects in the UK. The comparison of three new-build housing projects in Scotland, presented by Grainne McGill (paper 1184) was an excellent illustration of the huge value of this approach, not just for fellow academics and practitioners but also for contractors, clients and policy makers. However, I was a little concerned to find that only a small proportion of participants in the Ventilation Forum knew about the historic UK PROBE studies which have been so important to our ability to benchmark performance for different building types.

The Ventilation Forum at PLEA 2017 provided an inevitably limited ‘snap-shot’ of the current ‘state-of-the-art’, but it is indicative of the continuing growth of interest in the design, performance prediction and evaluation of natural ventilation strategies to achieve thermal comfort in buildings.

Windcatchers and Windows

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Windcatchers are some of the most sophisticated natural air-conditioning systems in the world, and records of them adorning buildings date back to the Middle Kingdom in Egypt over 1000BC. In many hot countries they flourished most prominently on the homes of the richer classes during periods when their economies were buoyant. Modern architects and engineers have long sought to emulate the visual and functional elegance of these traditional devices and as we enter and on increasing pressure to run buildings for as much of the year as possible on natural ventilation. We were extremely honoured to have the doyenne of windcatcher research, Professor Mehdi Bahadori, opening this Forum with a presentation based on his own experience in, and research on, the Windcatchers of Iran. This gave a flavour of the extraordinary potential for the use of windcatchers in modern buildings in different climates that was reinforced in the strong paper by Mehrnoosh Ahmadi and Mario Grosso on the 'Potential cooling energy reduction by a wind tower model in the Milan and Rome climates' that showed reductions of between 70 – 90% in energy use might be possible in windcatcher buildings there while maintaining comfort indoors.

The substantial savings that can be achieved in using natural ventilation in many climate was highlighted in a paper by Pimolsiri Prajongsan on 'Window use: Potential and challenges to energy-efficient residential buildings in hot-humid climates'. Christina Mediastika, Juliana Anggono, Fefen Suhedi and Hariyate Purwaningsih presented research from Indonesia on 'Open Windows for natural ventilation and outdoor noise reduction in tropical climates', highlighting that design decisions are never one dimensional but come with many knock on impacts that have to be dealt with the success in the reality of the real buildings in real markets.

The research widened to look at windows as areas of glass in walls and filters of solar gain, not just conduits for natural ventilation. Hence window sizing, glass choice and building form were highlighted here. Three papers presented research on the impact of glazing choices on energy use and then comfort. Beatriz Arranz et al. presented an 'Evaluation of the performance of an Innovative Glazing System'. Elena Garcia-Nevado presents a study by a team on the impact of façade design on energy demand in urban contexts and proposed an index of optimised fenestration approaches for use in cities and Ruey-Lung Hwang showed research looking at the impact window glass selection on thermal comfort in office buildings.

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What was clear is that there is tremendous interest in the increasingly important subject of making windows work well in many different contexts. This is a multi-dimensional challenge encompassing sound, light, heat, health and cost. Some of the studies presented relied on simulation to inform results while a number of others use indoor and outdoor laboratory testing to reach their conclusions. Several people who have completed papers in the third volume of the PLEA 2017 proceedings (see: www.plea2017.net) were not able to attend so did not present but do also look at their interesting papers on pages 5206 to 5276 that cover also the critical issue of the impact of shading of windows on their success, including the use of Jaali screens, the impact of windows on health in hospitals and also the development and testing of green window prototypes. Windows are by no means simple elements in a building but as we become less able to afford rising energy costs of mechanically heating and cooling buildings they will become increasingly critical as key design features of low energy and low carbon buildings.

A Final Reflection on the PLEA 2017 Forums

What you hear in the snapshots of the PLEA 2017 Forums are a myriad of different voices and viewpoints on passive and low energy architecture from around the world. These reflect the enormous and rather daunting scope of what we might be expected to know and understand in the teaching and practice of architecture.

What they also show is how very important the architectural profession is, and increasingly will be, in building the resilience of our societies and economies to our rapidly changing world in the buildings, settlements and regions that it is our lot to understand, envision and design for.

We were particularly pleased that PLEA 2017 was able to demonstrate that we in Scotland take such responsibilities very seriously. We have not only a strong academic community but one that is also a well-connected to our wider PLEA community, encompassing people from cities, government, professionals and communities across our unique and beautiful country. These communities all have a role to play as building blocks in the solid foundations upon which we must build if we want to create a truly resilient society, economy and environment in Scotland.

Strong solutions must all start with strong values – and in PLEA 2017 we hope that we showed the world where our Scottish architectural values lie, grounded in our own culture's inherent belief in the idea that every citizen is important, as is every building, because ultimately they are what will make us rise or fall, together.

If any of the Forum subjects interest you please do access the full papers on that theme in the three volumes of the excellent PLEA Proceedings that can be accessed from the PLEA 2017 home page (www.plea2017.net).

Thanks to all who joined us at PLEA 2017 in Edinburgh and for your great contributions to the above Forums. Thanks also to the Forum Leaders who made each unique assembly so interesting and to the members of the Scientific Committee who did such a Stirling job of reviewing the abstracts and the papers. We hope the conference has left an important legacy for all of you who were there, and those who come after you.

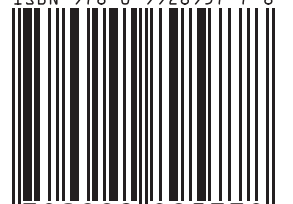
Best Wishes,
Susan Roaf
Heriot Watt University



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PLEA 2017 Dinner in the National Museum of Scotland (source: Prof Sergio Altomonte)

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