Energy Epidemiology: A report on using building data to support energy and carbon policy in Latin America

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Executive Summary

Brazil and the UK both face GHG emissions reductions targets and the challenge of improving energy performance in the built environment. In both countries, energy efficiency in buildings promises large savings with negative costs. When combined with other strategies, energy efficiency promises to reinvent the power sector and has potential for deep cuts in GHG emissions. However, sector fragmentation, lack of priority of energy efficiency, and challenge of accessing or using finances makes the implementation of energy performance improvements challenging, along with the evaluation of policies and cost reduction programmes a complex challenge.

The primary aim of the workshop was to develop strategies that enable a low carbon transition of the Brazilian buildings sector towards improvements in energy performance and energy efficiency through better access and use of energy and building stock data. In particular, it had the specific aims to: share knowledge and best practices on programmes related to energy efficiency in buildings; support the IEA EBC Annex 70 and provide a platform for Brazilian participation and sharing results across Latin America; and to provide Brazil with a basis for the development of evidence-based policies for building energy efficiency to make a significant contribution to meeting National Declared Contributions to the Paris Agreement.

The workshop was framed in the context of the recently established field of Energy Epidemiology, which is the subject of IEA EBC Annex 70. Energy Epidemiology is the systematic study of the distributions and patterns of energy use and their causes in influences in the population. It is data driven, has an emphasis is on empirical evidence and aims for an understanding of underlying and driving factors. It focuses on understanding what is affecting the spread and severity of a state (i.e. energy demand) and it uses research findings to inform past/future practices and policy. Annex 70 is an international collaboration of researchers, industry and government from across the globe who are working to develop methods for improving the empirical evidence on energy demand in the building stock. Annex 70 focuses on identifying, reviewing, evaluating and producing leading edge methods for studying and modelling the building stock including:

- data collection techniques on energy use,
- building features and occupant features, and building morphology;
- analysis of smart meter energy data, building systems, and user behaviour;
- modelling energy demand among sub-national and national building stocks.

The workshop addressed five themes and asked a fundamental question of each.

1. Monitoring and Evaluation (M&E):
    - What are the metrics of success for demand-side energy actions and how can ongoing data gathering be structured for feedback and evaluation?
2. Benchmarking
    - How can building energy data be captured and structured to provide useful information to building owners, users and policy makers?
3. Regulations
    - What are the key enabling factors for development of successful regulatory regimes related to building energy consumption?

4. Data and Analytics
    - What enabling factors can allow improved data availability to be used to improve energy performance?
5. People's influence on performance
    - How do different user expectations and service levels – such as increasing expectations of comfort and environmental quality – affect energy consumption?

After two days of plenary and group sessions the workshop culminated in a set of recommendations that were presented to an audience of government, NGOs, industry and academics in the Policy Summit on day three. The recommend actions were:

- In collaboration with national and state organizations to set out priorities for improving the energy performance of Brazil's building stock;
- To develop a timeline for the national priorities to help build a driving force behind achieving them and delivering on outcomes;
- To use these priorities and to draw on the findings of this report to develop action areas around: data, measurement and verification, benchmarks and occupant influence;
- To take those action areas and put in place a research programme, emphasizing joint-funding across the sector, to address those action areas.

To support the recommended actions a number of enabling mechanisms were identified:

- Forums should be developed to allow increased coordination between academia, NGOs and government entities responsible for setting targets (EPE, MME, MMA); implementing efficiency programs (Procel); funding efficiency (ANEEL, World Bank, Caixa Econômica Federal, BNDES, IADB); and providing monitoring and evaluation of programme effectiveness.
- A clear agenda for applied research should be developed and agreed upon by the key partners mentioned above. This should be linked to the provision of data by the utilities, the energy regulator and the public sector.
- Platforms and processes for effective and ethical sharing of data should be developed and used as the bases for provision of data to researchers.
- Research should aim to inform a roadmap for the implementation of regulations on energy efficiency with explicit timelines and processes, to justify investments and give clarity to stakeholders. Cooperation with the construction industry should help to avoid unnecessary cost increases. Diverse municipal regulations should gradually move towards some harmonisation of minimum standards.
- Increased data access and sharing should be used for third-party monitoring and evaluation to give clarity on the use and effectiveness of energy efficiency investments and evaluate programme success. Academic institutions should help to develop and implement these procedures.

The next steps in following the workshop are:

- To outline programme(s) of work with partners to support the implementation of these mechanisms
- To identify opportunities to fund these collaborative programmes

A follow-up visit by UK researchers Prof Paul Ruyssevelt and Assoc. Prof Ian Hamilton in October 2018 started work on these steps.

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1 Introduction

Brazil and the UK, like other major economies, face emissions reductions targets and the challenge of improving energy performance in the built environment. Energy efficiency in buildings promises large savings with negative costs. Combined with smart grids, demand management and distributed generation, efficiency promises to reinvent the power sector and has potential for deep emissions cuts. However, the sector is fragmented and difficult to model, making the development and evaluation of policies and cost reduction programmes a complex problem. Interactions such as those between smart meters, building users and energy labelling systems are not well understood and there is a need for a strong evidence base for policy and programmes.

International cooperation is required to share best practices and develop cohesive approaches to modelling performance and the impacts of energy efficiency and other factors. The IEA EBC Annex 70 project Building Energy Epidemiology represents a leading international programme for providing data to governments, industry, academia and investors to drive improved building performance at scale.

The UCL Energy Institute and the UFSC Laboratory for Energy Efficiency in Buildings (LabEEE) sought to work with the energy and buildings community to provide thought leadership through a two-day workshop and summit.

By sharing best practices from the UK, Brazil and other Annex 70 participants, the workshop focused on research, innovation and further collaboration among Brazil-UK organizations. Providing a platform for showcasing Annex 70 in Latin America sought to support the wider region in developing research and programmes for energy in buildings. The workshop focused on methodologies and building evidence for policy makers to prioritise energy in buildings and demand reduction as a viable part of energy systems planning and carbon reductions. The summit focused on translating the researcher proposals into priority areas and policy actions that could be taken forward. This report summarizes these findings.

2 Workshop

UCL Energy Institute, University College London and the Laboratory for Energy Efficiency in Buildings at Universidade Federal de Santa Catarina (UFSC) organized a Newton Fund Research Link workshop focused on energy performance of the building stock in the UK, Brazil and Latin America, which took place in Sao Paulo, Brazil from 23-25 April 2018.

The workshop provided an opportunity for early career and established researchers from the UK and Brazil, and more widely, to discuss and present on methodologies and evidence for policy makers to prioritise energy in buildings and demand reduction as a viable part of energy systems planning and carbon reductions.

2.1 Workshop Aims

The overall aim of the workshop was to develop strategies that could enable a low carbon transition of the Brazilian building sector towards improvements in energy performance and energy efficiency through better access and use of energy and building stock data.

The workshop had the following specific aims:

- Aim #1 - Share knowledge and best practices on programmes related to energy efficiency in buildings, with a focus on the application of policy development in emerging economies.

- Aim #2 - Support IEA EBC Annex 70, provide a platform for Brazilian participation and sharing results across Latin America.

- Aim #3 - Provide Brazil with a perspective for the development of evidence-based policies for meeting NDCs using building energy efficiency

Within and from the workshop, these aims are being achieved by creating links between UK and Brazilian research institutions, allowing researchers to showcase their work and develop collaborations to further explore these subjects, share data and publish new research. Further details on these collaborations are provided below.

The inclusion of NGOs and policy makers in the policy summit day of the workshop allowed for international participants to showcase development and implementation of policies in the UK and Brazil and their experiences on how they evaluate those practices.

The challenges faced by implementing effective programmes in Brazil will form a basis for developing proposals appropriate for other emerging economies in Latin America, while the discussions between key participants is being used to develop a roadmap for implementation of evidence-based policies in Brazil.

2.2 Workshop theme challenges

The main focus of the workshop was to identify, discuss issues around developing an evidence base for improving energy performance and reducing carbon emissions in Brazilian building stock, and to develop mechanisms to address those challenges.

The following areas were the outlined preceding the workshop as the main challenges the workshop would focus on:

1. Monitoring and Evaluation (M&E)
2. Benchmarking
3. Regulations
4. Data and analytics
5. People's influence on performance

The intent of the discussions was to refine these general challenge themes into a set of actionable challenges and to develop a set of mechanisms and proposals that could be implemented to address them. The challenges and proposals were used in the Policy Summit that was held with senior Brazilian decision makers following the workshop.

2.2.1 Monitoring and Evaluation (M&E)

The key to evidence-based policy-making is an ability to monitor and evaluate the impacts of ongoing programs. However, buildings have a well-known "performance gap" between expected and actual energy consumption, and gathering high-quality energy performance data for buildings at scale is a challenge under current mechanisms. Efficiency programs need to consider more cost-effective and accurate methods for providing M&E and feedback on their impacts.

<u>Key Theme Question:</u>
What are the metrics of success for demand-side energy actions and how can ongoing data gathering be structured for feedback and evaluation?

<u>Key Identified Challenges</u>

- Who are we monitoring for, and hence what sort of monitoring is required?
- How detailed should monitoring be in these cases?
- What data is already available, to start monitoring?
- What should be the first step for monitoring the Brazilian building stock?
- How can you implement a reliable database with continual improvement?
- How can we ensure quality of data being collected?
- Where is "ownership" of the data held?
- What scale/granularity and kind of data of monitoring is needed as a minimum?
- What do we need to offer stakeholders to get them onboard to disclose data?

<u>Key Actions to Address Challenges:</u>

- Talk in different ways for different users, find out what they need to help incentivize
- Use regulation for providing the data with some confidentiality issues
- Build a structure road map for data collecting
- Automation, sensors, embedded in systems and IoT infrastructure.
- Different ways of accessing/viewing the same data for the needs of different stakeholders.
- Develop standardized data frameworks.
- Partnership and collaboration (national and international)
- Cross data collaboration and monitoring from different database
- Identify the trustworthy institution responsible for managing the database (centralized or decentralized)
- Having a business model that takes advantage of monitoring and evaluation (example: performance contract)

2.2.2 Benchmarking

Benchmarking is a simple method to evaluate building energy performance by comparing the measured performance to a set of known or typical performance levels. In policy terms, it is a low-cost measure which has shown impressive impacts and is a focus of many efficiency programs around the world. However, there are challenges inherent both in the development of benchmarks which accurately represent building characteristics, and in the collection of reliable data from the real buildings to assess performance. In countries which may not have statistical surveys or large quantities of information on building performance, it is difficult to set the benchmark levels accurately. Collecting data is expensive, but where benchmarks are over-simplified, they may lose accuracy or not provide enough information to be useful in driving performance improvements.

Key Theme Question:
How can building energy data be captured and structured to provide useful information to building owners, users and policy makers?

Key Identified Challenges:

- The role of benchmarking:
    - Provide information for asset ratings
    - Transparency programs and regulations
    - Operational efficiency and retrofit
- How can we include comfort in a benchmarking evaluation?
- How can we link asset ratings to the expected operational rating and design solutions?
- How can we produce a market structure to promote engagement and uptake?
- What is the most effective approach to making benchmarking compulsory?
- How do we deal with low data availability and lack of end-use for benchmarks?
- How can the classification and categorisation of building types be optimised, to avoid overlap?
- Who is responsible to creating and maintaining the benchmarks?

Key Actions to Address Challenges:

- Vision is lacking for obtaining large samples but could be done in the future as more buildings are labelled and audited.
- A common data frame is required to avoid fragmentation and cope with different data scopes. This requires ownership by a suitable organisation.
- Data quality standards required
- Lack of skills to use benchmarks in various tools
- BIM and IoT, NILM could help with gathering data from which benchmarks can be derived.
- Capturing comfort benchmark(s)
- Start with small scale pilot projects and roll-out as confidence is developed over time

2.2.3 Regulations

The improvement of efficiency in the building stock has been the target of regulatory regimes in developed countries for several decades. However, Latin American countries have large informal construction sectors and low compliance levels with even the limited regulations that are currently in place. Building codes are often set at a municipal level, increasing

complexity for the builders and leading to low levels of oversight as local governments cut back on spending. An “envelope first” approach based on high levels of insulation will have less impact where most loads are not envelope-dominated, meaning the interactions between other building parameters (such as surface reflectivity) need to be well understood, and their possible deterioration over time should be discussed.

Key Theme Question:
What are the key enabling factors for development of successful regulatory regimes related to building energy consumption?

Key Identified Challenges:
- Lot of interest in building energy efficiency at city level but funding is lacking for local delivery
- Lots of current and past work to build on. Challenge is sustained activity to support effective regulation.
- Buildings need to raise their profile as an important feature of economy
- Informality (fiscal, quality, environmental and labour-related) particularly in the SME non-residential sector?
- Different City/Municipality level regulation. National standards and the relation to Local Regulations. Currently no energy efficiency national standard for non-domestic.
- Training and skills lacking in some sectors, including the management of buildings.
- Implementation and evaluation lacking

Key Actions to Address Challenges:
- Energy labels with suitable assessment methods and tools
- Stock data and survey of technology uptake
- Model of energy use in stock to assess impact of regulation change
- Field demonstration of technologies
- Hand-over documents

2.2.4 Data and analytics

A wide range of machine learning and big data tools are now readily available and are being applied across a variety of different fields with impressive results. However, the effective use of analytics depends on large, high-quality datasets. In most places, building information is currently fragmented and unreliable, if it is available. High quality data collection has traditionally been expensive but may become easier with the availability of low-cost internet-connected devices. There is a potential for using new techniques, data streams and tools to evaluate and improve energy performance in buildings.

Key Theme Question:
What enabling factors can allow improved data availability to be used to improve energy performance?

Key Identified Challenges:
- Understanding the data landscape:
    - What is the data ‘landscape’ that exists in Brazil that can be drawn out and what is the case for their being accessed, federated to create a data-framework?
- Ethics and data management:

    - Are there clear ethics and data management guides and processes available to data users, building owner operators and government that can assist in making it clear how and why data is collected and used?
- Market of/for data:
    - Does a market exist for the use of energy and building data, e.g. national, asset, or operational, and what key data points are most highly needed/valued?
- Platforms for data access and exchange:
    - What type of platform? What are its key characteristics to help enable transparency in energy audit / performance reporting, market characterization/assessment, what level of access?

<u>Key Actions to Address Challenges:</u>

- Understanding the data landscape:
    - Survey and 'map' the:
        - Stakeholders and the wider social groups and their perspectives, interests and priorities
        - Existing initiatives for capturing and generating data within the energy and buildings domain
        - The data typologies/activities, the data collector / generators (observed/observer);
        - The energy and buildings data uses, gaps, synergy and trade-offs that exist;
- Ethics and data management:
    - Put together board(s) that act to evaluate and guide the collection of and use of data; the buy-in across the identified stakeholders and to act and convene in the wider interest;
    - Incentivize honest brokers / trusted third parties who have the responsibility to act between parties with a vested interest but a common need/goal
    - Develop a 'gold standard' of data practices that organizations can seek approval/certification from that provides assurance that they are acting in an agreed best practice.
    - Identify and develop best practices for how to address ethics on data collection and use
- Market of/for data:
    - Outline the value propositions for the market (and stakeholders) for why data is an important component of their 'domain of responsibility'.
    - Use cases for data development and use (examples of how/where data has created value for organizations and stakeholders)
    - Connecting value-quality to ensure data has a trust level and reliability
    - Guidance for how to evaluate the use of data to help create trust in the market and services being offered
- Platforms for data access and exchange:
    - Identify the stakeholders that exist who have interest in developing platforms in order to share resources and efforts
    - A toolbox of 'technical' guides for how to put together platforms, the: who, how, when, over what time, what partners, what arguments
    - Compile, devise, schema for data collection, including variables, attributes, languages, methods, etc..
    - A registry of data platforms and their key features: uses, publishers, users, content, definitions, etc.

2.2.5 People's influence on performance

The ways in which people influence performance of buildings is likely to vary with their comfort expectations. As Brazil has become wealthier, urban centres have built increasing numbers of large, fully-conditioned buildings and low indoor temperatures have become status symbols in some cases. Recent years have brought an additional focus on indoor environmental quality in high-end buildings. Although mixed-mode buildings can offer comfort with much lower energy consumption, this depends on people and how they use a building. HVAC designers and BMS engineers in Latin American markets still argue that control should be taken away from the end-users and left to the operations teams to minimise complaints, although there is a risk that this may also increase discomfort and energy performance.

<u>Key Theme Question:</u>
How do different user expectations and service levels – such as increasing expectations of comfort and environmental quality – affect consumption?

<u>Key Identified Challenges:</u>

- Creating a culture of data transparency: what does data do for non-expert users?
- What user groups have "higher expectations" for comfort and for what classes of buildings? Is it local landlords or tenants, international commercial real estate firms or clients?
- How well do comfort models predict the thermal conditions in real buildings?

<u>Key Actions to Address Challenges:</u>

- Users are not just occupants, they are also designers, facilities managers, real estate developers, policymakers, and manufacturers – Engage with people to understand the diversity of views and needs
- Consider how displays, interaction and feedback, and post-occupancy evaluation can foster interest in and engagement with energy consumption for occupants, facilities managers, designers, and developers
- Can the relationship between decentralized energy production and consumption (net-metering and prosumption) create different vehicles for engagement with occupants, facilities managers, designers, and developers

2.3 Summary of Themes Discussions

There was inevitable overlap in the theme discussions and interactions between the groups discussing each theme was facilitated by movement of some individuals between the groups in the breaks between sessions. Data was at the heart of many of the discussions because without it regulations are set without a true understanding of context, people's influence on buildings cannot be understood and M&E and Benchmarking cannot be performed. So, whilst data was discussed in all the themes, the Data and Analytics theme was able to consider important issues such as ethics, data management, the market for data and potential data platforms in some depth.

The plenary and theme discussions focused on identifying what the needs of the community were, these included having reliable information (data) that was accessible to the broader research and policy community and public. That this information could be collected using advancing and novel methods that make use of existing and emerging best practices with advanced sensing and that it is made use of for improving ongoing energy and environmental performance of buildings. Also, that this information is used in strengthening

the feedback loop to users and building managers in intuitive ways to help increase the value of that information.

Further, the information flow will only be taken up more widely when there are clear and recognized requirements or consistent uses of that information across the actors involved in managing and influencing energy performance. Benchmarking and reporting provides a means for valuing the information drawn from the energy and building information flow. Benchmarks that are constructed with reliable data and have a meaningful user base that values them will ensure that they are kept updated and improved over time. However, to be of most use, benchmarking and reporting needs to be integrated into a regulatory framework to sets out clear requirements around them through, for example, energy labels and targets for incrementally improving minimum performance standards. These benchmarks and labels need to be reflective of what people need from buildings and how they use buildings, including their comfort expectations. Standards and guides that do not account for people's needs and influence risk undermining the value of developing and using energy and building stock data and of reaching widely agreed targets.

3 Policy Summit

A policy summit, focused on policymakers in Brazil was held on 25th April 2018 to inform and update on the outcomes of the workshop.

As energy demand in the built environment grows across Latin America, demand-side actions can become a key factor in energy planning, to meet efficiency targets and mitigate the need for new generation capacity. In general, however, the market is poorly understood, growth patterns are difficult to predict and the impact of operational factors on consumption limits the effectiveness of simple policies.

The Summit brought together an array of researchers and decision-makers from Brazil and the UK to discuss how can we develop evidence-based efficiency of energy demand in buildings policies with measurable impacts, which can be considered alongside supply-side measures in energy planning?

Summit Agenda

9h00	**Opening**	**Introduction to the summit** **Paul Ruyssevelt, UCL**
9h15	Paths towards evidence-based policy making	Summary of key results from the 2-day academic workshop. Key challenges and proposed mechanisms for sector development Ian Hamilton, UCL Discussion and feedback on workshop findings Roberto Lamberts, UFSC
10h15	Strategic policy makers' presentations – UK	UK government's experiences on energy and buildings data structures and policy making and evaluation. Chris Nichols, Department for Business, Energy and Industrial Strategy
10h30	Coffee Break	
10h45	Strategic policy makers' presentations – Brazil	Key groups from the Brazilian government will present their visions, strategies and contributions for sector development Samira Carmo, Ministry for Mines and Energy (MME) Thiago Pastorelli, Energy Research Office (EPE)
11h30	Panel discussion	Proposals for developing and funding research programmes relevant to policy needs Chair: Gilberto Jannuzzi, IEI-Brasil/FAPESP

3.1 Summit objectives

This policy summit was designed to bring together decision makers from the UK and Brazilian governments and key organizations to discuss and propose pathways forward to addressing the information challenge of building energy performance in Brazil.

The aim of the summit was to create a forum for high level discussion of initiatives based on both findings from a two-day workshop on energy and building data needs and objectives for Brazil drawn from the academic community.

Bilateral presentations from the UK and Brazilian delegates provided insights into the process around how initiatives and practices are being put in place and used by government, industry and academia. Following the presentations, a panel discussion was led by Prof. Januzzi regarding the existing Brazilian programs and how to address the building data gap through existing schemes, programs and policies. The key discussions topics are presented below.

3.2 Summit discussions

Brazil and UK: similarities and differences when developing and using building data

- Policies between the two countries are slightly different on energy performance in buildings, but Brazil already has energy performance certificates and labelling schemes.
- The UK National Energy Efficiency Data framework (NEED) and the Building Energy Efficiency Survey (BEES) are examples of consolidated building information databases in the UK. In Brazil the most relevant survey on energy efficiency is the Possession and Use Habits Survey (PPHU), carried out by Procel and its new version is expected to be delivered in the end of 2018.
- In Brazil the infrastructure is still under development and there is a large market for the construction of new buildings. In this scenario, Brazilians can learn from UK cases and experiences, mainly to understand how much the energy efficiency (EE) interventions could cost and how they will perform in the future.

Identifying Challenges

- Brazil has already gathered some buildings data on energy performance from national EE programs, but this information is not centralised or generally available; the challenge then is how to integrate all data systems and platforms ensuring that key sectors are connected and have access to the information they need.
- Normally the creation of databases in the Brazilian buildings sector is done when EE programs have already started, or when there is something to be investigated; the challenge is how to design reliable and easy-to-use databases when programs are designed.
- In general, researchers and designers strongly believe in good building design as the best energy efficiency strategy, however the real energy consumption in operation is normally different from the expected, due mainly to operational practices. In Brazil there is a huge potential for improvement in buildings design aiming for better thermal comfort, which is topic of much academic research, but it is also important to study user behaviour to improve designs for “tropically adapted”, efficient buildings.
- Also, building uses can change during their lifetimes – how can operational energy efficiency be guaranteed when the use is different from the original design?
- Programs and regulations in Brazil are sometimes designed without considering the real situation of the national building stock, and there is a disconnect between what the government is creating as EE tools and what the market requests and is using. Two issues were identified:
    - PBE Edifica, the National labelling scheme for buildings, is still expensive to apply in small commercial buildings and residences, and there are other cheaper sustainability certifications. Why not giving subsidies to use PBE Edifica schemes?

    - It is mandatory for new federal buildings to label and achieve A level on PBE Edifica. However, at present most public buildings are existing buildings or leased, not built by the government.

User influence on performance

- It is important to change the way people use energy in buildings through instruction on operational energy saving best practices.
- It is also necessary to better inform the user and display the operational energy performance in buildings.
- Are the building design and the operational best practices for energy efficiency really adapted to users' needs? How can we better understand the users' needs and consider them in policy planning?
- A widespread marketing plan is needed to disseminate the information.

Data analytics

- How much can the creation of a database relate to innovative IoT (Internet of Things) technologies?
- How can data gathering can be done in a practical way? In UK they have started with public buildings energy data for energy benchmarking.
- How can building data be used and updated? How much user interaction is needed to input building data in systems and platforms?
- The data available must be always carefully analysed. For example, in PBE Edifica, data shows that most certified buildings are level A – however, it is due to the existence of just a small sample of certified buildings, and because as labelling is voluntary, people only apply for it when they want to achieve the A level.

Monitoring and Evaluation (M&E)

- In UK historical experience, for EE programmes with large budgets, models to estimate the energy savings were developed by the government and policy makers. However, afterwards the models and delivery programmes need to draw on the findings to be improved and to also clearly demonstrate the efforts and results of EE programmes.
- Buildings have a long lifetime and it is necessary to understand more about them through energy data for M&V to build better policies. How can this be done in more practical ways? Through benchmarks and labelling only? Which tools and databases could be developed?
- It is not necessary to measure everything and have a perfect database. There are several layers of data collection and using energy bills is a good way to start the gathering process.
- In Brazil there is guaranteed funding for energy efficiency through the Energy Efficiency Program of ANEEL (PEE) and the Procel, but there is not enough transparency on how this budget turned into effective energy savings.

Benchmarking

- Energy benchmarking is an opportunity to collect data from existing buildings. But how can its reliability be checked? How many buildings must be collected to build reliable databases? How can confidentiality be ensured?
- In the UK, the energy benchmarks had to be updated after the implementation of EE programmes; it is important to have as a vision the improvement of Brazilian energy benchmarks. However, Brazil is still in an initial stage: the benchmarking tool is still being developed for most building uses and many people are still unaware of the Energy Benchmarking tool; training courses are needed to instruct users.

- How can energy benchmarking metrics address user comfort?

Regulations

- Laws should have an equal focus on existing buildings as they are the majority in National stock, and policies could be created to reduce taxes and promote adoption.
- Mandatory policies and penalties are needed to enforce the Brazilian law related to buildings. However, cooperation and articulation between all sectors are necessary to make the policies effective designed and implemented.
- From the UK experience and learning, mandatory certification and labelling should learn from voluntary systems, and it is important focus in just one labelling to not confuse the market.
- How to boost competition in buildings market?
- Energy consumption data from energy companies of public buildings are already been discussed with ANEEL.

General issues and conclusions

- In Brazil, by the national law nº 12.527/2011, all citizens have the right to access information from public administration. This law can be used to collect energy consumption from public buildings, for example. The Open Government Partnership efforts could support the opening of energy data.
- There are a number of ways to show organisations that there is value in sharing data; the energy utilities need to be convinced of this. Benchmarking clubs can also support and promote data sharing.
- Brazil has interesting programs for building EE, but needs more cooperation between the main actors working with buildings energy performance.

4 Recommendations

The recommendations below are proposed following the discussions of the Researchers Workshop and Policy Summit. The recommendations capture the consensus of the researcher, policymakers and private sector attendees present at the events and were developed as part of a focus to help build a momentum going forward. These recommendations are intended to be guiding statements that reflect the general views of those in attendance and are not meant to be a prescriptive outcomes. It is hoped that in due course these recommendations may be addressed through efforts led by the wider scientific, business and policy making communities.

1. In collaboration with national and state organizations to set out priorities for improving the energy performance of Brazil's building stock;

2. To develop a timeline for the national priorities to help build a driving force behind achieving them and delivering on outcomes;

3. To use these priorities and to draw on the findings of this report to develop action areas around: data, measurement and verification, benchmarks and occupant influence;

4. To take those action areas and put in place a research programme, emphasizing joint-funding across the sector, to address those action areas.

To enable these recommendations, we propose that:

A. Forums should be developed to allow increased coordination between academia, NGOs and government entities responsible for setting targets (EPE, MME, MMA); implementing efficiency programs (Procel); funding efficiency (ANEEL, World Bank, Caixa Econômica Federal, BNDES, IADB); and providing M&E of programme effectiveness.

B. A clear agenda for applied research should be developed and agreed upon by the key partners mentioned above. This should be linked to the provision of data by the utilities, the energy regulator and the public sector.

C. Platforms and processes for effective and ethical sharing of data should be developed and used as the bases for provision of data to researchers.

D. Research should aim to inform a roadmap for the implementation of regulations on energy efficiency with explicit timelines and processes, to justify investments and give clarity to stakeholders. Cooperation with the construction industry should help to avoid unnecessary cost increases. Diverse municipal regulations should gradually move towards some harmonisation of minimum standards.

E. Increased data access and sharing should be used for third-party monitoring and evaluation to give clarity on the use and effectiveness of energy efficiency investments and evaluate programme success. Academic institutions should help to develop and implement these procedures.

5 Manifesto

1. Brazil and the UK both have mandates to improve building energy efficiency and reduce carbon emissions, while also needing to improve the health, comfort, productivity and security of citizens and businesses as this will involve the investment of R$/£billions over the coming decade.

2. Governments and business need to report on the effectiveness of their policies and the technologies deployed and instrument these to be as effective as possible by learning from empirical evidence and thereby develop a practice for better future policies that improve the development of technologies and their installation.

3. Governments and businesses need to plan for future change. The main planning tools are computer models of the present and future energy system, which are underpinned with assumption that may not reflect the existing conditions. If governments and businesses are to have confidence in future investments and policies these models and predictions need to be grounded via empirical data.

4. An energy epidemiology approach can be used to support the above challenges by bringing together data on buildings, their technologies, occupants and energy use from large populations of buildings. This method has helped the UK to provide the evidence base to develop and target better energy efficiency policies, develop better models to plan for the future and identify where technologies and their deployment can be improved. The UK is committed to share the knowledge it has acquired from a decade of energy epidemiological research via a range of mechanisms supported via UK agencies including the Newton Fund administered via the British Council. This has included establishing an international research programme via the IEA Energy in Buildings and Communities Annex 70 – Building Energy Epidemiology.

5. Governments need to support the access to and linking of data where it can be evidenced that this data and its analysis can support the common good. Data about energy use, buildings, technologies, occupants, and climate, is already collected by government, business, utilities and NGOs in both Brazil and the UK. The value of this data is greatly increased if it can be linked at property level and then anonymized.

6. The development of an evidence base using an epidemiological approach in the Brazilian context can be started through a pilot project, e.g. the collection of data on schools and their energy use. This could provide a learning experience for students via “Inquiry by design” who would participate in data collection and analysis and this could not only engage the pupils at the Schools but also the local University and be a test bed for energy and comfort labelling, survey methods, etc.

7. Government should develop a clear strategy for its collection and analysis of building energy data. The process could start with a mapping of the existing data resources – this could be logged on a Wiki site to allow continued updating. A government data plan also needs to be developed which identifies what data could support policy and the opportunities for low cost collection of any new data required.

8. The UK would welcome the opportunity to support Brazil in the above activities.

6 Next steps

Following this workshop, it is intended that there will be follow on engagement between the Brazilian and UK organizations who attended.

Next steps for most researchers will entail developing research proposals that will target specific funds to address the challenges that have been identified through this interaction. We provide an outline of several research initiatives that are currently being developed by several of the attending organizations.

Next steps for decision and policy makers or funders could include building a programme of activities around the challenges and the proposed mechanisms to address these. Using this report and its findings can provide assurance that broader research, NGO and business communities have input into and voiced their interest and commitment to these issues. This can help ensure that there are willing partnerships that can be brought forward to develop world leading research and implementation to improve the Brazilian building performance.

6.1 Brazil-UK Research Initiatives

University of Sao Paulo initiative by Dr. Alberto Hernandez Neto

A proposal to submit several projects to FAPESP (research funding institution in São Paulo) where one or more Brazilian researchers from São Paulo submit a project that incorporates one or more researchers from UK as a consulting researchers. Such projects will allow to UK researcher(s) to work together (mostly long distance) with the Brazilian team.

The projects would have a main goal and each project will address a certain aspect of this goal. For example, a main goal could be to evaluate building performance and its impact on the energy demand and CO_2 emissions on Brazil. Based on this goal, a research project can be developed to address the range of themes of the workshop, including: benchmarking, measurement & evaluation, data analytics, user´s influence, regulation and other relevant topics.

The projects will have a similar introduction and can be cross referenced with each other. Such projects can be submitted together to FAPESP to acknowledge that there is a group of researchers working together.

Projects are intended to be 1 to 2 years long.

University of Edinburgh, Dr. Martin Pullinger

One critical issue discussed at the workshop related to the limited amount of data available for evaluating the energy performance of buildings, retrofits and other interventions. Dr. Pullinger, and colleagues from the University of Edinburgh, have developed a sensor system along with disaggregation algorithms and a methodology for using these, along with surveys and secondary datasets, to evaluate the energy and indoor environmental (temperature, humidity, comfort, etc.) outcomes of building-level interventions, including measuring the role of occupant behaviour in shaping the effects of interventions. This was part of the EPSRC-funded IDEAL project (EP/K002732/1). A future collaboration with Brazilian researchers might involve developing this methodology and adapting it to be applicable to evaluating

building level interventions and energy performance in Brazil. Adaptations would include reducing the cost and increasing the flexibility of the system for installation in different contexts, as well as adapting it to address Brazilian building energy demand concerns.

University College London, Dr. Ian Hamilton & Prof. Paul Ruyssevelt

An application has been made to the UCL Global Engagement Funds 2018/19 to support a follow up workshop in Brazil to further disseminate the report findings among Brazilian academic, industry and policy makers.

The primary aim will be to establish the foundations for one or more projects which will pursue the development and adoption of the ECR workshop recommendations. These will be jointly pursued by UCL and the partners in Brazil subject to the availability of suitable funding sources.

The proposed workshops will:

- Present the ECR workshop key recommendations to senior decisionmakers in government, industry and research institutions ;
- Make the case for activities and enabling mechanisms that can support the delivery of the key recommendations
- Identify the key decision-makers with whom future contact should be maintained
- Provide a clearer insight into how the ECR workshop recommendations might be enacted
- Identify possible sources of funding for future projects which build on the recommendations

The main outcome will be a fuller understanding of the importance and relevance of the ECR workshop report recommendations to national and state government, industry and senior academics as a basis for further work to support their enactment or adoption.

Brazilian Efficient Cities Initiative, Roberto Lamberts and Edward Borgstein

The Brazilian Sustainable Construction Council (CBCS) is a non-profit organisation based in São Paulo. With funding from the Instituto Clima e Sociedade (an affiliate of ClimateWorks), the CBCS is developing a pilot programme to support municipal governments in improving energy and water efficiency. As well as broad support, knowledge sharing and training, this programme is piloting interventions in three cities, related to the improvement of efficiency in municipal buildings and the implementation of public policies to promote improvement across the building stock in the city.

Municipal governments are typically responsible for hundreds or thousands of buildings, the bulk of which are administrative buildings, schools or health facilities. Working closely with these municipal governments is an effective way of gathering data, implementing pilot projects, applying recommendations across the building stock and monitoring performance. Learning from one municipality can often be applied to other cities of similar sizes.

The CBCS has indicated it is willing to partner in research activities, collecting data and leading interaction with the municipal governments. This will allow the development of highly effective research programs. Proposals are currently being developed for submission to relevant funders.

7 Appendices

Below are the following appendices:

1. Meeting Agenda
2. Participant Biography's
3. Workshop Reading Materials
4. Presentations

7.1 Agendas

Energy Epidemiology: using building data to support energy and carbon policy in Latin America

23-24 April 2018 | Radisson Paulista, Alameda Santos 85, Jardins, SP 01419-000

Monday 23 April 2018

08:30 – 09:00 Registration – tea and coffee provided

09:00 – Welcome
Roberto Lamberts, Laboratory for Energy Efficiency in Buildings, Universidade Federal de Santa Catarina

09:05 – Workshop introduction
Paul Ruyssevelt, UCL Energy Institute, University College London

09:25 – British Council Presentation
Presentation Camilla Almeida, Newton Fund Project Manager, British Council

Morning session I - Energy performance in Buildings

09:40 – Brazil's non-domestic energy and buildings context
Presentation – Roberto Lamberts, UFSC

10:10 – UK's non-domestic energy and buildings context
Presentation – Tadj Oreszczyn, UCL

10:40 – Workshop instructions
Ian Hamilton, UCL & Edward Borgstein, Mitsidi

10:50 – Coffee Break

11:15 – Identifying the Challenges
Presentation – Prof. Gilberto Jannuzzi, Universidade Estadual de Campinas
Presentation – Dr. Kathryn Janda, UCL Energy Institute

12:30 – 14:00 Lunch Break

Afternoon session I – Working Groups

Each participant goes to their breakout group

14:00 – Identifying the Challenges (for each breakout group)

Measurement: Jannuzzi / Borgstein

- Fabiana - Mapping urban temperatures
- Carlos - Assessing thermal comfort and IAQ in low energy retrofit dwellings

Benchmarking: Ruyssevelt / Hernandez Neto

- Ing Liang - Energy benchmarking and legislation in Brazilian commercial buildings: challenges and experience
- Lennart - Integrated energy assessment models for city planning tools

Data analytics: Nicholls / Hamilton

- Sérgio – Cost optimality of energy retrofit in buildings
- Pegah – Data for building energy efficiency

Regulations: Oreszczyn / Lamberts

- Karin – Discussing the multi-criterial and systemic character of land use regulation
- Michele – Energy efficiency and zero energy buildings
- Ozlem – Challenges of energy efficiency retrofit optimisation

Users influences: Janda / Soares Gonçalves

- Leticia – Developing user profiles for mixed-mode office buildings
- Martin – Designing smart systems to understand and shape energy use in buildings

Discussion of presentations

15:30 – Priority challenges for non-domestic energy and buildings in Brazil
Group discussions on prioritizing the sub-challenges

16:00 – Coffee Break

Afternoon session II – Plenary Feedback

16:20 – Working Group challenges presentations to plenary & Discussion
Ian Hamilton, UCL

17:30 – Workshop Day 1 Close
Paul Ruyssevelt, UCL

Tuesday 24 April 2018

08:30 – 09:00 Registration – tea and coffee provided

09:00 – Welcome & Recap
Paul Ruyssevelt, UCL & Roberto Lamberts, UFSC

Morning session I – Addressing the challenge to improving building energy performance

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09:20 – Addressing the challenges
Presentations – Edward Borgstein
Presentation – Mr. Chris Nicholls, UK Dept. of Business, Energy and Industrial Strategy

10:50 – Coffee Break

Morning session II – Working groups

Each participant goes to their breakout group

11:15 – Identifying the mechanisms to address the challenges (for each breakout group)
Measurement: Jannuzzi / Borgstein
- Ana - Collecting data from small scale commercial and retail buildings
- Hu - Long-term and short-term building performance evaluation and modelling

Benchmarking: Ruyssevelt / Hernandez Neto
- João - Procel: Resource application plan for the buildings sector
- Ana Paula - Energy simulation tools for early stage design of buildings

Data analytics: Nicholls / Hamilton
- Monica – Daylight performance of office buildings in Sao Paulo
- Oluyemi – The potential of energy storage in rural Latin America households
- Ilias – The role of net metering PV systems for improving energy performance of buildings

Regulations: Oreszczyn / Lamberts
- Larissa – Energy and climate change plans for the state of Minas Gerais
- Xinfang – How can energy use in buildings be part of Brazil's energy system

Users influences: Janda / Soares Gonçalves
- Joana – Environmental performance of climatic responsive office buildings

Discussion of presentations

12:30 – 14:00 Lunch Break

Afternoon session I – Working Groups

14:00 – Summarise questions and mechanisms discussed
Prepare summaries of key questions to be addressed and the mechanisms that can be employed.
Each participant goes to their breakout group

14.30 – 16.00 World Café: Employing the mechanisms: opportunities, constraints and strategies

- Three half hour sessions will take place in which the convenors of each group will stay in the group room and host participants from other groups to contribute to further discussion of the themes.
- The objective is to cross-fertilise between groups and to look at the opportunities, constraints and strategies for employing the mechanisms to address the questions.
- Participants don't have to move groups and if they do they can always come back to their 'home' group in the final session.
- The final session should summarise the issues associated with employing the mechanisms

Sessions:
14.30-15.00, 15.00-15.30 and 15.30 -16.00

Theme based group discussion

- Measurement: Jannuzzi / Borgstein
- Benchmarking: Ruyssevelt / Hernandez Neto
- Data analytics: Nicholls / Hamilton
- Regulations: Oreszczyn / Lamberts
- Users influences: Janda / Soares Gonçalves

16:00 – Coffee Break

Afternoon session II – Plenary Wrap up

16:20 – Working Group presentations on mechanisms and supporting proposals
Edward Borgstein, Mitsidi

- Measurement: Jannuzzi / Borgstein
- Benchmarking: Ruyssevelt / Hernandez Neto
- Data analytics: Nicholls / Hamilton
- Regulations: Oreszczyn / Lamberts
- Users influences: Janda / Soares Gonçalves

17:00 – Panel discussion for workshop findings
Roberto Lamberts, UFSC
Panel Members: Group convenors

18:00 – Workshop Day 2 Close
Paul Ruyssevelt, UCL

Workshop theme challenges:

M&E – what are the metrics of success for demand-side energy actions and how can ongoing data gathering be structured for feedback and evaluation?

Benchmarking – how can building energy data be captured and structured to provide useful information to building owners, users and policy makers?

Regulations – what are the key enabling factors for development of successful regulatory regimes related to building energy consumption?

Data analytics – what enabling factors can allow improved data availability to be used to improve energy performance?

User influence on performance – how do different user expectations and service levels – such as increasing expectations of comfort and environmental quality – affect consumption?

Acknowledgments:

This work was supported by a Researcher Links grant, ID [2017-RLWK8-10616], under the Brazil-UK partnership. The grant is funded by the UK Department of Business, Energy and Industrial Strategy (BEIS) and delivered by the British Council. For further information, please visit www.newtonfund.ac.uk.

Invitation to the
Brazil-UK Energy in Buildings Summit

25th April 2018

Radisson Paulista, Alameda Santos 85, São Paulo, SP[1]

Energy Epidemiology: using building data to support energy and carbon policy in Latin America

As energy demand in the built environment grows across Latin America, demand-side actions can become a key factor in energy planning, to meet efficiency targets and mitigate the need for new generation capacity. In general, however, the market is poorly understood, growth patterns are difficult to predict and the impact of operational factors on consumption limits the effectiveness of simple policies.

How can we develop evidence-based efficiency policies with measurable impacts, which can be considered alongside supply-side measures in energy planning?

UCL ENERGY INSTITUTE | RCUK Centre for Energy Epidemiology | Energy | LabEEE | UFSC | Newton Fund

[1] Please not that as places are limited, this event is by invitation only. If you are unable to attend and would like to suggest a person to take your place, please contact the organisers.

Summit Agenda

9h00	**Opening**	Introduction to the summit ***Paul Ruyssevelt, UCL***
9h15	**Paths towards evidence-based policy making**	Summary of key results from the 2-day academic workshop. Key challenges and proposed mechanisms for sector development ***Ian Hamilton, UCL*** Discussion and feedback on workshop findings ***Roberto Lamberts, UFSC***
10h15	**Strategic policy makers' presentations – UK**	UK government's experiences on energy and buildings data structures and policy making and evaluation. ***Chris Nichols, Department for Business, Energy and Industrial Strategy***
10h30	**Coffee Break**	
10h45	**Strategic policy makers' presentations – Brazil**	Key groups from the Brazilian government will present their visions, strategies and contributions for sector development ***Samira Carmo, Ministry for Mines and Energy (MME)*** ***Thiago Pastorelli, Energy Research Office (EPE)***
11h30	**Panel discussion**	Proposals for developing and funding research programmes relevant to policy needs ***Chair: Gilberto Jannuzzi, IEI-Brasil/FAPESP***
12h30	**Lunch** at the Radisson Paulista Hotel	

Summit objectives

This policy summit is designed to bring together decision makers from the UK and Brazilian governments and key organizations to discuss and propose pathways forward to addressing the information challenge of building energy performance in Brazil.

The aim of the summit is to create a forum for high level discussion of initiatives based on both findings from a two-day workshop on energy and building data needs and objectives for Brazil drawn from the academic community.

In advance of the Summit, a short 'best practices' and 'use cases' document will be circulated drawing from across Brazil, Latin America, Europe and more widely, to inform the discussion. Bilateral presentations from the UK and Brazilian delegates will add to this document by providing insights into the process around how example initiatives and practices were put in place and used by government, industry and academia.

It is anticipated that the attendees and the organizations they represent are key actors in being able to put forward ways of meeting the information challenge in Brazil going forward.

Key UK Delegates

Chris Nicholls is a senior economist in the UK Government's Department for Business, Energy and Industrial Strategy. He leads a team of analysts responsible for advising on optimal design for policies aimed at improving the energy efficiency of domestic residential buildings. He has also worked on understanding energy use and abatement opportunities in non-domestic buildings, and renewable heat policies.

Most of his career has focused on the built environment, having also worked in a construction trade association, and co-authored the Barker Review of Housing Supply, an independent review of the UK's new housing market.

Dr. Ian Hamilton is an Associate Professor at the UCL Energy Institute, University College London in London, UK. His research interest is focused on the nexus between energy demand, energy efficiency, indoor environmental conditions and health. Ian is the Operating Agent for the International Energy Agency's 'Annex 70 - Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale'. Ian is a Co-investigator on the 'RCUK Centre for Energy Epidemiology', a centre focused on analysis and evaluation of energy demand big data, the UK-China Total Performance of Buildings and the UK's Health Protection Research Unit 'Healthy and Sustainable Cities'. Ian is widely published in his field including several Lancet Medical Journal Commissions on climate change and health.

Professor Paul Ruyssevelt, Professor of Energy and Building Performance and Deputy Director of the UCL Energy Institute where he takes the lead on research in the field of energy use in non-domestic buildings. An architect with 30 years' experience in the field of low energy and sustainable buildings he has worked in both academia and industry. He is PI on the four-year iNUMBER project to provide the tools and analysis required to develop high quality low carbon cities in India, he represents the UK on the IEA Energy in Buildings and Communities programme and he plays a leading role in Annex 70 which is developing Building Energy Epidemiology in an international context

Professor Tadj Oreszczyn FCIBSE MInstE, PhD, CEng is the Director of The Bartlett School of Environment, Energy and Resources (BSEER) and Professor of Energy and Environment at the UCL Energy Institute. Prior to becoming the Director of BSEER in August 2014, Tadj was the founding Director of the UCL Energy Institute. Tadj is also the Director of the RCUK Centre for Energy Epidemiology (CEE) based at the UCL Energy Institute. This centre undertakes research to help the UK reduce it's energy demand in buildings and transport and is one of six government funded research centres in energy demand. The centre is currently leading the establishment of an International Energy Agency Annex (70) in building energy epidemiology.

Dr. Kathryn Janda, Principle Research Fellow at UCL Energy Institute and the Environmental Change Institute at Oxford University, is an interdisciplinary, problem-based energy demand scholar. Katy is a socio-technical scholar interested in the intersection of people, energy, and buildings. She studied energy innovations, transitions, and their drivers since 1990. Katy is particularly interested in the dual role of organisations as both adopters and providers of sustainable innovations. Research topics have included: energy standards for non-domestic buildings; the role of building professionals in driving 'middle-out' change; and implications of ownership in the commercial real estate industry (including green leasing).

Key Brazil Delegates

Prof. Gilberto Jannuzzi, Professor of Energy Systems at the Mechanical Engineering Faculty of the University of Campinas, Brazil, holds a PhD from Cambridge University and has done post-doctoral work at the Lawrence Berkeley Laboratory, returning there several times as visiting researcher. He also spent time at the Centre International de Recherche sur l'Environnement et le Développement and the UNEP Collaborating Centre on energy and Environment. He has coordinated several projects for Brazilian and international agencies in the areas of energy efficiency, energy and environmental sustainability, energy planning, and energy R&D policy. Professor Jannuzzi was the Technical coordinator of the Brazilian Energy Research and Development Fund since its creation in year 2001 until early 2003, and the representative of Brazilian Academia in the National Committee of Energy Efficiency Indicators during 2009-2012. He is currently member of the FAPESP program on Global Climate Change and President of the Regional Summit Leaders-Sciences network (rls-sciences.org). He is also the Director of International Energy Initiative Brasil, a small, independent, international non-governmental public-purpose organization led by internationally recognized energy experts

Prof. Roberto Lamberts, Professor of Civil Engineering at the Federal University of Santa Catarina (UFSC), is specialised in energy efficiency, with a focus on the thermal performance of buildings, bioclimatic design and thermal comfort. He leads the Energy Efficiency in Buildings Laboratory at UFSC and is a member of the editorial committee for the Journal of Building Performance Simulation, Energy & Buildings, Science and Technology for the Built Environment and Ambiente Construído. He is a member of IBPSA and the Brazilian Council for Sustainable Construction (CBCS). He is also a member of the working groups set up by the Ministry for Mines and Energy to support the development of building energy performance labelling in Brazil.

7.2 Participant Bios

Energy Epidemiology: using building data to support energy and carbon policy in Latin America

23-24 April 2018 | Radisson Paulista, Alameda Santos 85, Jardins, SP 01419-000

Participant Bios

[Begin Next Page]

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Edward Borgstein has spent a decade developing systemic alternative energy solutions, with a focus on high-efficiency buildings and industry. He built the first Passivhaus retrofits in the UK, led development of energy benchmarks in Brazil and Uruguay, helped launch the EDGE building certification in Latin America and worked on Brazil's national energy efficiency action plans for buildings and industry. He founded Mitsidi Projetos, a multidisciplinary consultancy in São Paulo. Edward currently works with the Rocky Mountain Institute in the Sustainable Energy for Economic Development (SEED) programme across East Africa.

Joana Carla Soares Gonçalves is an Associate Professor of Environmental Design at the Faculty of Architecture and Urbanism of the University of Sao Paulo, FAUUSP, and currently the Head of the Technology Department (2015), where she teaches since 1998. In 1998 she got her Master's degree in Environment and Energy from the AA Graduate School in London. In 2003 she got her PhD degree from the FAUUSP. Between 2009 and 2013 she joined the teaching staff of the Environment and Energy Programme of AA Graduate School, where she contributes as visiting lecturer and reviewer since 2013. Since 2014 Joana is the coordinator of the Working Group on Sustainable Buildings of the Environmental Agency of the University of São Paulo (SGA-USP). In FAUUSP, she is the coordinator of exchange programmes with three institutions in the UK: University of Portsmouth, University of Nottingham and University of Westminster. In 2011 she was guest lecturer at the GSD in Harvard University. In 2014 she was awarded the title of Visiting Professor of the Faculty of Architecture and the Built Environment of the University of Westminster, London. She is the author of a number of scientific and technical publications, including the book "The environmental performance of tall buildings" (2010), by Earthscan, London; she was one of the coordinators of the Buildings' chapter in the UNEP Green Economy Report (2011); she was contributing author and organizer of "Edificio Ambiental" (2015), by Oficina de Textos, São Paulo. More recently, she contributed to the technical publication "Buildings for Extreme Environments: Tropical", published in 2017 by CIBSE. In January 2017 Joana Carla Soares Gonçalves became one of the six Directors of the international organization named PLEA (Passive and Low Energy Architecture), representing the academic community of environmental research from Brazil.

Alberto Hernandez Neto - Mechanical Engineering, graduated at Escola Politécnica da USP (EPUSP) in 1988, Master (1994) and PhD. (1999), both in Mechanical Engineering, working as Professor of the Mechanical Engineering Department of the Escola Politécnica at University of São Paulo since 1989. Consulting activities in optimization and rational use of energy in air conditioning and refrigeration systems. These activities include energy analysis of air conditioning and refrigeration systems as well as the conditioned buildings in order to reduce energy consumption using energy simulation tools as EnergyPlus. Consulting activities are related to supporting processes of Leed Certification for the World Green Building Council. Participation and coordination of more than 10 research projects, with over 100 articles in Brazilian and international journal as well as in international congress. Participation in several projects for companies such as: Telefônica, Caixa Econômica Federal (one of the largest Brazilian banks), Multibrás/Whirpool and GM. ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers) member and Consultant of EnergyPlus, which is a validated simulation tool for Green Building Leed Certification.

Michele Fossati - I am a Civil Engineer (2001), Master in Production Engineering (2004) and PhD in Civil Engineering (2008) by Federal University of Santa Catarina - UFSC. Since 2008, I am a researcher at the Laboratory of Energy Efficiency in Buildings - LABEEE / UFSC. I have performed three postdoctoral internship: in eco-efficiency of buildings (2009); development of energy efficiency regulation of residential buildings (2013) and typological characterization and energy evaluation of energy efficiency of Brazilian residential buildings (2015). I am currently an adjunct teacher in the Department of Architecture and Urbanism at UFSC and a researcher with an emphasis on sustainability and energy efficiency of buildings. I have experience in the area of construction technology, Quality Management Systems in construction companies, sustainability, eco-efficiency and energy efficiency of commercial, service, public and residential buildings. I coordinate the residential core of the Brazilian Center for Energy Efficiency in Buildings - CB3E, member of the Technical Secretariat of Buildings of MME, coordinated by Eletrobras.

Lennart Poehls - After my undergraduate studies at the TU Braunschweig in Germany, I worked as competition architect in Italy, but my research activity started in 2009 at the Federal University of Rio Grande do Sul in Porto Alegre. As a Master student I investigated the correlation between the existing Brazilian legislation and indoor comfort in office buildings. By simulating a variable set of architectural elements regulated by law, I was able to identify those prescriptive legal rules that had a positive impact on the indoor temperature and comfort. After concluding my Master degree, I continued to study performance related aspects of architecture. My doctoral thesis analyses the possibility to reduce energy consumption by using energy assessment methods already during the architectural design's first steps. While these stages present the best cost-benefit relation, information required to feed the input of classical computational energy simulation are still undefined or missing. My thesis argues for the need of architect-friendly but reliable assessment, including a case study for a simplified simulation input model and its respective validation. Already during these studies, I collaborated in the creation of performance models for a city planning software, research which today is intensified in form of my post-doctoral studies at the Technology for Urban Planning Research Group at the Federal University of Rio Grande do Sul, Brazil.

Ana Paula Melo - In 2005, I graduated from the Federal University of Santa Catarina with a bachelor of Civil Engineering and completed my master in 2007 under the guidance of Roberto Lamberts. I started my PhD in 2008. In 2010 I was awarded a scholarship from The Brazilian Federal Agency for Support and Evaluation of Graduate Indication (Capes) and I joined Jan Hensen,Äô s laboratory at TU/e University until 2011. In 2012, I received my diploma under the guidance of Roberto Lamberts and Jan Hensen. My thesis focused on the development of a surrogate model using artificial neural network for building shell energy labelling. In 2015 I received my first postdoc diploma from the Federal University of Santa Catarina, and in 2018 my second postdoc diploma from the Federal University of Santa Catarina under the guidance of Roberto Lamberts. I have been publishing international and national conference articles, and journal articles.

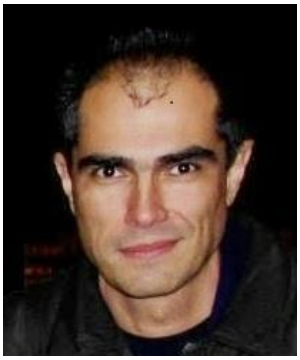
Leticia Neves – I am an Assistant Professor in the Department of Architecture and Construction of the School of Civil Engineering, Architecture and Urban Design, University of Campinas, since 2016. I obtained my PhD in the same University, in 2012. My research interests include sustainable and bioclimatic architecture focused on thermal comfort, natural ventilation and energy efficiency in buildings. Currently, I am developing a research project funded by FAPESP Research Program on Global Climate Change, named “Development of metamodels for energy performance analysis of mixed-mode office buildings”. In this project, I developed a database of 153 mixed-mode office buildings located in the city of Sao Paulo, and I am developing on site measurements and building energy simulations aiming to develop metamodels for energy analysis to be used by architects in early design stages.

João Krause – Graduation: Architecture and Urbanism Universidade Federal Fluminense – UFF. M.Sc.: Civil Engineering/ Structures Pontifícia Universidade Católica PUC-Rio. D.Sc.: Civil Engineering/ Structures Pontifícia Universidade Católica PUC-Rio. Experienced researcher on physical and mechanical behaviour evaluation of composite materials, mainly laminates composed by natural lignified sources. Invited Professor at the Centro Universitário de Brasília, UniCEUB Extension Course on Buildings Design, Construction and Maintenance: Lecturer on Pathological Manifestations and Restoration of Historical Heritage and Monuments. Architect on Procel Edifica Energy Efficiency in Buildings. Programa Nacional de Conservação de Energia Elétrica, Centrais Elétricas Brasileiras S.A. Eletrobras.

Ana Cristina Villaça – I am a Brazilian architect and urban planner with MSc in Urbanism (Federal University of Rio de Janeiro/ PROURB). I have experience in the Brazilian construction industry, developed some works for the government, and some experience as a lecturer in Architecture graduation and post-graduation courses in Brazil. I am in the conclusion phase of a PhD research at SBRC/UOW, Australia. I identified a gap in the knowledge about the performance of the smaller scale commercial and retail building stock. I developed a data collection method to gather relevant data to allow the characterisation of the performance of these buildings and sub-sector. The method adopts several qualitative and quantitative methods and techniques to collect data from the physical (existing) buildings, the service systems installed and the occupants,Äô needs. Data analysis considers the three aspects of sustainability (social, economic, and

environmental) and the type of business inside the building. Specific business-based benchmarks were created to facilitate comparison of the performance of small buildings according to the use. A decision support tool is being developed to guide the stakeholders during the planning phase of upgrades.

Karin Marins – I am Brazilian and an assistant professor at Escola Politécnica (Engineering School) of the University of São Paulo (USP), in Brazil. My background includes a BSc. Degree in Architecture and Urbanism (FAU USP, 2000), masters in Environmental Management (USP, 2002), MSc. in Sustainable Energy Engineering (KTH - Stockholm, 2005, sponsored by STINT), and PhD. in Architecture and Urbanism (FAU USP, 2010). My PhD. thesis was about urban energy planning involving urban morphology, buildings, urban mobility and power/ heat generation at the district scale. I mainly work on the district and neighbourhood scale, urban space performance and quality are major research subjects. I am also involved in developing and assessing methods and tools to support early-stages decision-making steps in urban planning and urban design, as well as to improve urban parameters and land use policies and building codes. Urban morphology/density, energy/microclimate and mobility have been central topics under investigation. Presently, I coordinate a team of 10 people, being 2 PhD. candidates, 5 MSc. candidates and 3 undergraduate students under the initiation research program, all of them affiliated to USP. Most of them are going to defend their works this year in the related research fields I have mentioned. I also teach the undergraduate courses urban and regional planning and urban project development, and the graduate course sustainability in urban development, at Escola Politécnica of the University of São Paulo.



Sérgio Fernando Tadeu - In recent years, I focused my studies in Civil Engineering, specifically under a research line on the cost optimality of energy retrofit of buildings in the European Union and in Brazil. In 2012, after the master's degree in "Energy for sustainability in buildings and urban environment" (MIT Portugal Program), I started my PhD in Civil Engineering at the University of Coimbra, and had my PhD viva in February 2016. This work examined the profitability of investment in the energy retrofit of buildings. It aimed to obtain a comprehensive view of this issue and identify opportunities for improving the methodology imposed

by the European Commission. Related with this research, I submitted a project in a competitive call to São Paulo Research Foundation (FAPESP). I got the project approved from the FAPESP, with the reference number 2016/00880-9, and a budget of approximately 50,000 EUR (including fellowships). The project was focused on the profitability of energy rehabilitation of buildings in Brazil. In this project, as well as the Head Researcher, I was also Supervisor of Technical Training in IT of five fellows and Supervisor of Internship of two fellows of Civil Engineering. The work started in February 2017 for a period of one year.

Monica Marcondes Cavaleri - Post-Doc Researcher and consultant at the Laboratory of Environment and Energy Studies (LABAUT) - Department of Technology, Faculty of Architecture and Urban Planning of the University of S√£o Paulo (FAUUSP). Ph.D. in Architecture at the Faculty of Architecture and Urbanism of the University of S√£o Paulo (FAUUSP), São Paulo, Brasil; Thesis entitled Façades design solutions for office buildings with natural ventilation in S√£o Paulo. M.A. Architect at the Environmental and Energy Studies Programme, Architectural Association Graduate School (AA), London; Dissertation entitled Double-skin façades on high-rise office buildings in São Paulo. A possible environmental efficient solution?

Raphael Bertrand Heideier - Bachelor in Naval and Oceanic Engineering from the Polytechnic School of USP (2006), a master's degree in Electrical Engineering from the Polytechnic School of the University of Sao Paulo (USP) (2009), with emphasis on risk analysis in commercialization of electric power and PhD in Electrical Engineering from Polytechnic School of USP (2017), with emphasis on Photovoltaic Generation. He has worked as a consultant - Visio Consultoria, in the area of renewable energy since 2009.

André Lucena – André F. P. Lucena é economista formado pela PUC-Rio, com mestrado e doutorado em Planejamento Energético e Ambiental. Foi pesquisador do Lawrence Berkeley National Laboratory nos EUA, trabalhando em avaliação de impactos de mudanças climáticas sobre infraestrutura de energia. Atualmente é professor adjunto do Programa de Planejamento Energético da COPPE/UFRJ, atuando em pesquisa nas áreas de planejamento energético integrado, modelagem energética, mudanças climáticas globais e economia da energia e do

meio ambiente. Foi autor do Painel Brasileiro de Mudanças Climáticas e autor colaborador do Quinto Relatório de Avaliação do Painel Intergovernamental sobre Mudanças Climáticas da ONU (IPCC). Recentemente foi convidado a participar como autor líder no capítulo de edificações do Sexto Relatório de Avaliação do IPCC

Fabiana Lourenço e Silva Ferreira - from S. José dos Campos, SP, Brazil, graduated in Architecture and Urbanism (1988-1992) and master in Civil Engineering (2001-2003). Since 2013 I am a teacher at Paulista University (UNIP). In 2015 I started my doctorate degree at Earth System Science Center (CCST), a research center inside the Brazilian National Space Institute (INPE). My doctoral supervisor is Dr. Ênio Bueno Pereira and I stay at the Laboratory of Modeling and Studies of Renewable Energy Resources (LABREN). My masters dissertation took focus on the albedo of materials used on roofs in Brazil and how its spectral characteristics influences their surface temperature. This study was published as an article in Energy and Buildings in 2005. The title is: Measurement of albedo and analysis of its influence the surface temperature of building roof materials. My doctoral research is based on the hypothesis that the integration of passive solar technologies, such as vegetation and albedo expansion in urban areas, is a passive strategy to cool the surfaces given their negative feedback effect at the urban climate system. The title is: Integration of passive solar technologies as strategy to promote thermal and energetic efficiency in residential areas in Brazil.

Larissa Santos - graduated in Energy Engineering and have Master degree in Energy Systems, both degrees awarded by the Pontifical Catholic University of Minas Gerais (PUC MINAS). Actually I am an Environmental Analyst at the State Foundation for the Environment (FEAM), in which works on energy and climate change, with topics related to energy efficiency in the sectors of industry, building and transportation, mitigation of greenhouse gases, territorial capacities in adaptation to climate change and modeling. Already taught classes as Assistant Professor at PUC MINAS in the course of Energy We Engineering. Currently, had received trainings of Energy Efficiency in Buildings of the Japan International Cooperation Agency (JICA), in Kitakyushu, Japan and on the International Energy Agency (IEA) in Rio de Janeiro, Brazil. I am going to get in the PHD this year to study Energy Efficiency in building and I already did some subjects that I need in the PHD, like Energy in the Constructing Environment and Thermical simulations in buildings.

Isabela Issa - From 2012 to 2013, I worked on an ecodesign academic project with the University of São Paulo (USP) and Technical University of Denmark (DTU). A guide was developed and tested in two case studies, one of them in a Danish company which produces electrical equipment and has invested a lot in the energy efficiency of their products over time. As partner and consultant at Mitsidi Projetos, I have been working with technical studies and subsidies for public policy since 2015. As a team member, I have worked on projects regarding sustainable and efficient strategies for sustainable housing, development of an energy benchmark for public buildings, training and capacity programs in energy efficiency in buildings, and recently with net zero energy buildings (NZEBs). In the industrial context, I have worked in a project for the National Confederation of Industry (CNI) studying 14 national energy efficiency in industry programs worldwide and have identified several data sources for industrial energy performance benchmarking. Furthermore, in the last moths we have been working with the NGO Transparência Brasil to promote transparency in public buildings consumption data, aiming to achieve energy and emissions reductions through mandatory benchmarking.

UK Delegate Bios

Chris Nicholls is a senior economist in the UK Government's Department for Business, Energy and Industrial Strategy. He leads a team of analysts responsible for advising on optimal design for policies aimed at improving the energy efficiency of domestic residential buildings. He has also worked on understanding energy use and abatement opportunities in non-domestic buildings, and renewable heat policies.

Most of his career has focused on the built environment, having also worked in a construction trade association, and co-authored the Barker Review of Housing Supply, an independent review of the UK's new housing market.

Dr. Ian Hamilton is an Associate Professor at the UCL Energy Institute, University College London in London, UK. His research interest is focused on the nexus between energy demand, energy efficiency, indoor environmental conditions and health. Ian is the Operating Agent for the International Energy Agency's 'Annex 70 - Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale'. Ian is a Co-investigator on the 'RCUK Centre for Energy Epidemiology', a centre focused on analysis and evaluation of energy demand big data, the UK-China Total Performance of Buildings and the UK's Health Protection Research Unit 'Healthy and Sustainable Cities'. Ian is widely published in his field including several Lancet Medical Journal Commissions on climate change and health.

Professor Paul Ruyssevelt, Professor of Energy and Building Performance and Deputy Director of the UCL Energy Institute where he takes the lead on research in the field of energy use in non-domestic buildings. An architect with 30 years' experience in the field of low energy and sustainable buildings he has worked in both academia and industry. He is PI on the four-year iNUMBER project to provide the tools and analysis required to develop high quality low carbon cities in India, he represents the UK on the IEA Energy in Buildings and Communities programme and he plays a leading role in Annex 70 which is developing Building Energy Epidemiology in an international context

Professor Tadj Oreszczyn FCIBSE MInstE, PhD, CEng is the Director of The Bartlett School of Environment, Energy and Resources (BSEER) and Professor of Energy and Environment at the UCL Energy Institute. Prior to becoming the Director of BSEER in August 2014, Tadj was the founding Director of the UCL Energy Institute. Tadj is also the Director of the RCUK Centre for Energy Epidemiology (CEE) based at the UCL Energy Institute. This centre undertakes research to help the UK reduce it's energy demand in buildings and transport and is one of six government funded research centres in energy demand. The centre is currently leading the establishment of an International Energy Agency Annex (70) in building energy epidemiology.

Dr. Kathryn Janda, Principle Research Fellow at UCL Energy Institute and the Environmental Change Institute at Oxford University, is an interdisciplinary, problem-based energy demand scholar. Katy is a socio-technical scholar interested in the intersection of people, energy, and buildings. She studied energy innovations, transitions, and their drivers since 1990. Katy is particularly interested in the dual role of organisations as both adopters and providers of sustainable innovations. Research topics have included: energy standards for non-domestic buildings; the role of building professionals in driving 'middle-out' change; and implications of ownership in the commercial real estate industry (including green leasing).

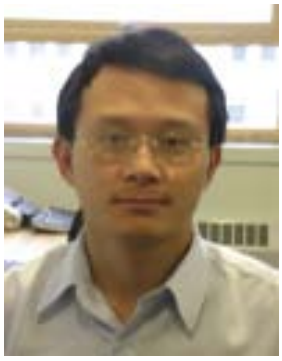
Dr Hu Du is Sêr Cymru Research Fellow at Welsh School of Architecture, Cardiff University and the PI of three ongoing projects funded by European Commission, British Council and Welsh Crucible. He is interested in building performance modelling and evaluation, sustainable building technologies, building adaptation in a changing climate, innovative refurbishment of existing buildings, building optimization and statistical analysis of big data. He has been very active in pursuing research in low carbon building field where he has been working on 16 research and innovation projects funded by Innovate UK, EPSRC, Welsh Government, European Commission, British Council and Welsh Crucible.

Dr Jimenez-Bescos has expertise in areas such as industrial, bioengineering and building services engineering. Carlos has been awarded funded on a resilience-based interdependency assessment tool, energy and indoor environement projects. His research focuses at international, National and regional level, with a focus on engaging stakeholders to mitigate and adapt to climate change and understand the best low carbon technology solutions. His main focus is on Indoor Air Quality and energy monitoring issues dealing with implications on health and well-being as well as thermal comfort. He has expertise on the use of building simulation to assess the performance of low carbon technology, retrofitting solutions and low energy design, such as Passivhaus and deep renovations.

Xingfang Wang is a Research Fellow in the Energy Systems and Policy Analysis Group at the University of Birmingham. My role within the group focuses on energy policy to support the transition to low-carbon energy system in the future. My current research explores what types of policy and institutional framework are needed to support the role of energy storage in the energy system at different scales and locations, provided by different technologies. I am also involved in the Energy Storage Prioritisation Assessment for Mexico project, an Energy Storage Innovation project, and the ‘Resilient Cities’ theme of the University of Birmingham’s Institute of Global Innovation.

Özlem Duran holds undergraduate degree in architecture and has worked as an architect for many years. In 2007, she started MSc. in Istanbul Technical University and completed her dissertation in the Applied Sciences University of Stuttgart where she worked as a researcher later on. She is a member of Lo-Lo CDT at Loughborough University where she completed MRes in 2013 and was recently awarded her PhD in building energy demand focusing on the 'Evaluation of Retrofitting Strategies for Post-War Office Buildings'. She was also a tutor/guest lecturer in Loughborough University during her PhD studies and a part-time lecturer at Nottingham Trent University in Architectural Technologies since 2017.

Pegah Noori Khah serves as Building Energy Data Analyst at C40 and is based in London. In her role, she provides cities with technical assistance on building energy data analysis that will inform and support ambitious policies. In addition, she supports technical workshops, building energy data related research products and peer to peer comparison research. Prior to joining C40 Pegah worked for Siemens Global Centre of Competence for Cities as an Infrastructure Researcher. There she worked on projects including C40's Air Quality research, Digitalization and Industry 4.0 study, and an infrastructure overview project with Myanmar. Pegah holds a Masters in Smart Cities and Urban Analytics from University College London and a BA in Architectural Engineering from Azad Tehran Central Branch, Iran. She speaks Persian and English.



Dr Ing Liang Wong is a lecturer in Sustainable Design and Construction at Glasgow Caledonian University. He previously involved in energy studies on existing building stock in the UK (EPSRC-Carbon Trust funded TARBASE Project) after graduated with a PhD in transparent insulation materials. His research interests include energy efficiency in buildings, particularly daylighting design and transparent insulation materials, cost optimisation of renewable energy systems, whole life costing, risk management, energy benchmarking and policy studies. Since 2015, he has engaged in research for energy benchmarking and policy issues in Brazilian commercial buildings with colleagues from Universidade Tecnológica Federal do Paraná (UTFPR), Brazil.

Ilias Tsagas is a renewable energy systems and energy policy researcher with a background in renewable energy technologies, the energy and climate change politics, and the policy-making process. He is currently writing up his PhD thesis in the University of Greenwich, London concerning the effect of the UK's Electricity Market Reform (EMR) in the country's energy governance and electricity market investment. At least a component of the thesis refers to the demand reduction side of the energy system. Furthermore, Ilias is working as reporter for the solar photovoltaic (PV) industry in the last 6 years. Part of his reporting covers the rooftop segment of the PV market and its linkage to the topics of energy efficiency, demand management and smart technologies. Ilias is mainly writing for the global version of PV Magazine (in English) and also contributes partially to PV Magazine Latin America (published in Spanish).

I am a Postdoctoral Research Associate within the Birmingham Centre for Energy Storage at the University of Birmingham. My current research focus is on the development of novel energy system models, gathering and analysing data for input to the novel models and using model results to improve understanding of the role and value energy storage has in selected systems. These models are being primary deployed using the University of Birmingham campus as a case study. Following this case study, the models will be deployed on other projects both in the UK and internationally, especially in developing countries such as Brazil.

Martin Pullinger, Senior Researcher, University of Edinburgh, UK. Building energy use is shaped by occupant needs and by policy to reduce demand and increase demand flexibility. I research the role of digital technologies in better enabling these potentially competing pressures to be met. With colleagues, I research quantitative approaches to measuring and understanding the energy using activities that drive building energy demand, using smart meter and other sensor data. I also research digital energy feedback, smart control systems and, increasingly, within-building energy storage, in real-world settings. Outputs contribute to monitoring, design and evaluation of building systems designed to combine these different energy demand goals and occupant needs.

7.3 Workshop Reading Material

The following papers and reports are provided for information and to help in the working group discussions, further detail of each work is available via the links.

Using epidemiological methods in energy and buildings research to achieve carbon emission targets.
Ian Hamilton, Alex Summerfield, Tadj Oreszczyn, Paul Ruyssevelt
https://doi.org/10.1016/j.enbuild.2017.08.079

Energy demand reduction from buildings is widely recognised as a key component of greenhouse gas abatement strategies. As governments shift towards large-scale sectoral interventions, a far more robust research and evidence base is needed to support the development, implementation, and on-going evaluation of energy demand policy.

The shift to a low carbon built environment will require both a step change in the energy performance of buildings alongside more efficient provision of energy services, and an aggressive decarbonisation of the energy used. Yet the prerequisite data of building stocks needed to support this essential shift in energy performance of buildings are not necessarily available or are inaccessible or incomplete. As more information on building energy use is collected through high frequency sensors and building form analytics become more sophisticated, the analysis methods applied to the myriad and diverse sub-sectors of the building stock 'population' need to be commensurate with the heterogeneity of the building stock.

This paper describes and illustrates the basis of the IEA EBC Annex 70: Building Energy Epidemiology, which draws on the health sciences to posit 'energy epidemiology' as a whole-system approach for empirical research that provides a methodological framework for building physicists, engineers, social scientists, and economists to engage in cross-disciplinary studies. It makes the case that the development and application of an epidemiological approach to investigating energy demand can advance understanding of the inter-related factors for policy guidance and evaluation and provide insights on the mechanisms that influence energy demand. The aim of the IEA EBC Annex 70 is to work in an international collaboration to identify user needs around energy demand in buildings and to establish best practice methods and harmonized formats for data collection, analysis and modelling.

To illustrate this process, we present an example from the UK on the application of energy epidemiological methods to building energy performance in the residential sector. The case study investigates the potential effectiveness of the policy and technical measures proposed by the UK Government.

Policy implementation for broad, deep, and urgent reductions in energy demand from the building sector requires a far better understanding of the underlying relationships between people, energy use, buildings and the environment.

Co-benefits of Energy and Buildings Data: The Case For supporting Data Access to Achieve a Sustainable Built Environment
Ian Hamilton, Tadj Oreszczyn, Alex Summerfield, Phil Steadman, Simon Elam, and Andrew Smith
https://doi.org/10.1016/j.proeng.2015.08.537

Supporting the development of a strong evidence base on which to improve the energy performance of buildings requires having access to research from different 'levels' of data. This includes high-level studies to carefully constructed representative samples, exploratory and investigative studies. As sensors and data collection becomes more widely applied within buildings (and the broader built environment) a clear articulation of the potential benefits and risks of data access is needed to avoid unintended consequences and regressive positions to data access.

The objective of this work is to identify and discuss the co-benefits of energy and built environment data and the mechanisms needed to enable them. We outline a number of potential benefits and limitations of making energy and buildings data more widely available.

Access to and linking/ matching together data can provide numerous benefits, including: research benefits, education and training, academic benefits, funder benefits, policy benefits, among others. However, there are also concerns of making data accessible including: privacy, management of access and communication protocols, commercial sensitivity, intellectual property, and archiving and legacy repository. The mechanisms needed to support data access should include requirements from funders for long-term data management and sharing, funding available for data archaeology, journal requirements for publication, government support and evaluation requests, and industry interest in capturing wider benefits from proprietary data.

How much information disclosure of building energy performance is necessary?
David Hsu
https://doi.org/10.1016/j.enpol.2013.08.094

Many different governments have begun to require disclosure of building energy performance, in order to allow owners and prospective buyers to incorporate this information into their investment decisions. These policies, known as disclosure or information policies, require owners to benchmark their buildings and sometimes conduct engineering audits. However, given substantial variation in the cost to disclose different types of information, it is natural to ask: how much and what kind of information about building energy performance should be disclosed, and for what purposes? To answer this question, this paper assembles and cleans a comprehensive panel dataset of New York City multifamily buildings, and analyzes its predictive power using a Bayesian multilevel regression model. Analysis of variance (ANOVA) reveals that building-level variation is the most important factor in explaining building energy use, and that there are few, if any, relationships of building systems to observed energy use. This indicates that disclosure laws requiring benchmarking data may be relatively more useful than engineering audits in explaining the observed energy performance of existing buildings. These results should inform the further development of information disclosure laws.

Evaluating energy performance in non-domestic buildings: A review
E.H. Borgstein, R. Lamberts, J.L.M. Hensen
https://doi.org/10.1016/j.enbuild.2016.07.018

Evaluation methods can be used to determine what constitutes good energy performance in a building. With an increasing focus on energy use of buildings worldwide, this evaluation assumes a fundamental importance. This paper provides a comprehensive review of the available methods for analysing, classifying, benchmarking, rating and evaluating energy performance in non-domestic buildings.

Methodologies are grouped in five categories: engineering calculations, simulation, statistical methods, machine learning and other methods. Techniques for evaluating buildings are described, their principal applications are shown and limitations are identified. The use of performance evaluation in energy efficiency programmes and standards is mapped.

There is a need to further develop interactions between the main modelling techniques to produce simple, robust and validated models. Also, evaluation techniques must be developed to consider comfort or service provision in the buildings as a factor in energy performance.

Urban building energy modeling – A review of a nascent field
Christoph F. Reinhart, Carlos Cerezo Davila
https://doi.org/10.1016/j.buildenv.2015.12.001

Over the past decades, detailed individual building energy models (BEM) on the one side and regional and country-level building stock models on the other side have become established modes of analysis for building designers and energy policy makers, respectively. More recently, these two toolsets have begun to merge into hybrid methods that are meant to analyze the energy performance of neighborhoods, i.e. several dozens to thousands of buildings. This paper reviews emerging simulation methods and implementation workflows for such bottom-up urban building energy models (UBEM). Simulation input organization, thermal model generation and execution, as well as result validation, are discussed successively and an outlook for future developments is presented.

3DStock: A new kind of three-dimensional model of the building stock of England and Wales, for use in energy analysis
Stephen Evans, Rob Liddiard, Philip Steadman
http://journals.sagepub.com/doi/abs/10.1177/0265813516652898

This article describes the development of a new three-dimensional model of the British building stock, called '3DStock'. The model differs from other 3D urban and stock models, in that it represents explicitly and in detail the spatial relationships between 'premises' and 'buildings'. It also represents the pattern of activities on different floors within buildings. The geometrical/geographical structure of the model is assembled automatically from two existing national data sets. Additional data from other sources including figures for electricity and gas consumption are then attached. Some sample results are given for energy use intensities. The first purpose of the model is in the analysis of energy use in the building stock. With actual energy data for very large numbers of premises, it is possible to take a completely new type of statistical approach, in which consumption can be related to a range of characteristics including activity, built form, construction and materials. Models have been

built to date of the London Borough of Camden and the cities of Leicester, Tamworth and Swindon. Work is in progress to extend the modelling to other parts of Britain. Because of the coverage of the data, this will be limited however to England and Wales.

An Epidemiological Approach to Simulation-Based Analysis of Large Building Stocks
Brian Coffey, Andrew Stone, Paul Ruyssevelt, Philip Haves
http://discovery.ucl.ac.uk/1517598/1/Coffey_Epidemiological_approach_simulation-based.pdf

This paper describes a novel approach to building stock energy modelling: individual building simulation models are auto- generated for each building in the stock, and the resulting set of virtual buildings is selectively sampled, simulated and analysed in much the same way that an epidemiologist might study a population through surveys and statistical analysis. A conceptual and software framework is described, along with initial case study results for a London borough.

Buildings don't use energy: people do
Kathryn B. Janda
https://www.tandfonline.com/doi/abs/10.3763/asre.2009.0050

Reducing energy use in buildings is a critical component of meeting carbon reduction commitments. There are several ways of accomplishing this goal, each of which emphasizes actions by a different set of stakeholders. This article argues that building users play a critical but poorly understood and often overlooked role in the built environment. In the face of climate change, the article finds purely architectural solutions, such as those proposed by the Architecture 2030 Challenge, to be necessary but not sufficient to achieve climate change mitigation targets. To fully address the task ahead, it argues that architects need to develop their professional expertise to improve buildings *and* seek ways of integrating user involvement in building performance. Moreover, from a professional standpoint, this paper suggests it may be wise for architects to claim a leadership role in this area before another group of building professionals does.

7.4 Presentations

WORKSHOP AND SUMMARY PRESENTATIONS ARE FOUND HERE:

https://energyepidemiology.org/workshops/workshop-2018-brazil-uk/