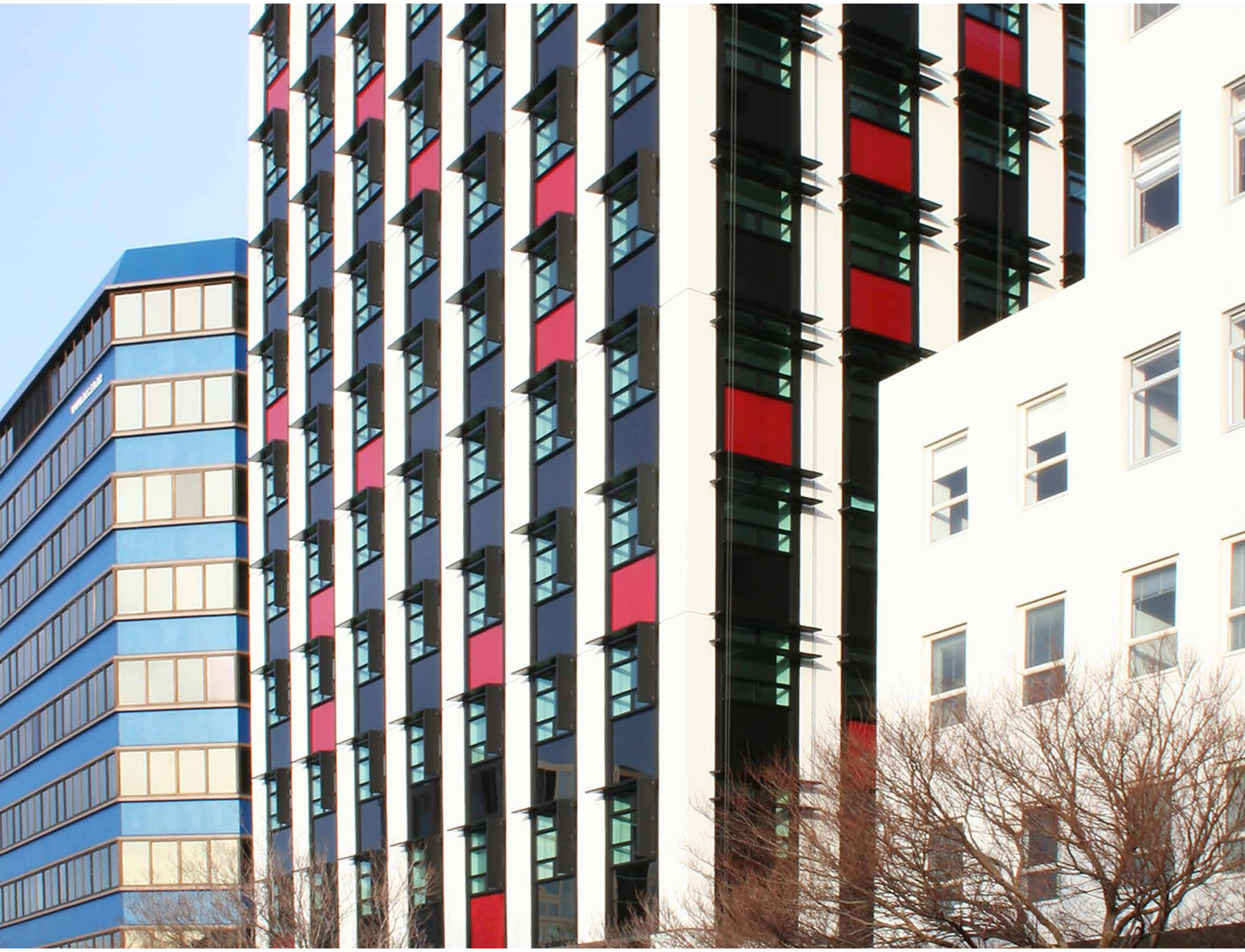
Energy in Buildings and Communities Programme

# EBC NEWS

Issue 68 | November 2018





EBC is a Technology Collaboration Programme of the International Energy Agency (IEA)

## Removing Barriers to Technology Transfer

Dear Reader,

The methods of communication used by EBC to share knowledge about our R&D work are helping to ensure that distance becomes less of a barrier to technology transfer. This edition of our newsletter contains an overview of energy use in New Zealand buildings that draws attention to similarities between their climate and other global locations, including the West Coast of the USA, the Mediterranean in Europe, and parts of Asia. While no two countries experience identical climates, similarities can lead to opportunities for sharing knowledge and ideas about the technologies and approaches created in response. Whether we are under the same roof, or on opposite sides of the world, we are learning from each other.

This edition also discusses three EBC R&D projects closely relating to people: The first of these has paid close attention to the definition and simulation of occupant behaviour in buildings, while the second is implementing proper treatment of occupancy and behaviour into the design process and building operation. Taken together, these outcomes will bring us closer to achieving simulation results during design that accurately estimate the real energy use, and designs that are more occupant-centric. The third project has provided guidance to improve the decision making process to support various contributors, so promoting successful implementation of energy strategies in communities.

The most recent EBC projects are also introduced in this edition and give you a flavour of the direction in which our new strategy will lead the EBC programme in the coming five years. These projects are studying accurate on-site assessment of building heat loss coefficients, deep renovation of historic buildings jointly with the IEA Solar Heating and Cooling programme, the possibility of supplementing ventilation with gas-phase air cleaning, and resilient cooling for residential and small commercial buildings. Finally, I am pleased to inform you that our new Strategic Plan will soon be ready. We will be writing about this in the next edition, but for now please enjoy reading about our latest projects that are already providing new knowledge and tools!

*Andreas Eckmanns*
*EBC Executive Committee Member for Switzerland and Chair of the Communications and Technology Transfer Sub-Committee (CTT-SC)*

**Cover picture: Aorangi House, New Zealand. The renovation of this building demonstrates how the up-cycling of an existing commercial office can not only significantly reduce environmental impacts, but also achieve positive occupant perceptions coupled with leading environmental performance outcomes.**
Source: Studio Pacific Architecture

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# Building Energy Futures for New Zealand

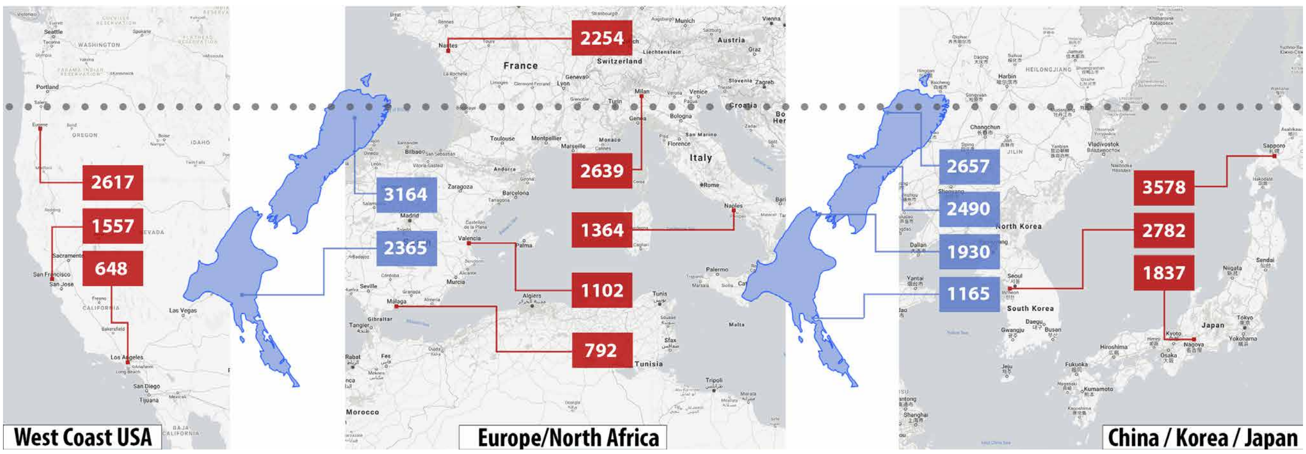
Michael Donn

*While energy efficient design of new building is important, there is also major potential for energy and resources savings through refurbishment of existing buildings in New Zealand. Realising these depends on a clear understanding of the national energy context and how this may evolve in the future.*

The historical cheapness of the largely renewable, hydro-electricity delivered to residential consumers in New Zealand is thought to be a major reason that most houses now use electricity for the majority of their energy needs and have poor thermal performance relative to today's energy prices. This has contributed to the residential and commercial buildings sectors now forming the two major end-uses of electricity. These sectors together represent 20% of primary energy, which is in turn 56% of total electricity use, while the transport sector constitutes 36% of primary energy, mostly supplied by fossil fuels. Retrofit of the existing building stock is key to achieving New Zealand's long term goal to reduce fossil fuel use by all sectors through intensifying electricity generation from renewables.

## The national energy context

As of 2016, New Zealand was 78% self-sufficient in energy supplies, but with 60% of this provided by fossil fuels. The share of electricity generation from renewables reached a 35-year high at 85% in the same year. This was mainly due to strong inflows to hydro lake storage resulting in a 5.6% increase in hydroelectric generation, and lower electricity usage in periods of typically high demand during the year reducing the need for peak demand coal- and gas-fired generation. Solar photovoltaic (PV) power is growing quickly as a generation source from a low base, and increased by 52% in 2016. By the end of 2016, there were almost 12,700 solar PV connections in New




New Zealand shown approximately to scale, but rotated by 180º and overlaid on Northern Hemisphere maps, positioned at the correct distance between the Equator and the Pole. The dotted line represents the 45th-parallel of latitude, halfway between the Equator and the North / South Pole. Heating demand is shown in degree-days to a base temperature of 18ºC.
Source: Adapted from thetruesize.com and Google Maps

Zealand. While a number of thermal electricity plants have been closed in recent years, coal and gas fired thermal plants are currently still needed to meet peak electricity demand in winter; more so in dry years with reduced hydropower. Reductions in gas, coal and other thermal energy sources used to generate electricity plus reductions in the use of transport fuels are the main focus areas for decarbonising of the country's energy supply system.

The Ministry of Business Innovation and Enterprise suggests that the average cost of electricity overall in New Zealand is the 21st highest of the 36 member countries of the Organisation for Economic Co-operation and Development (OECD). Further, an Electricity Authority report (2014) noted that "Residential consumers have seen significant increases in real terms, while commercial customers have experienced a significant reduction in charges." The reality is that residential electricity prices have increased by nearly 300% in real terms since 1974, while non-residential ('commercial') prices have dropped by approximately 20%.

## Evolution of thermal insulation regulations

The New Zealand climate is similar to that found in many other temperate regions at a similar distance away from the Equator. For residential buildings, such temperate regions are heating-dominated, increasingly so with distance from the Equator, while non-residential buildings may generally require some cooling.

More than 60% of the housing units in New Zealand today were constructed before 1977, when the first thermal insulation regulations for single family houses were introduced. These regulations set very basic minimum thermal resistances (known as 'R-values') for roofs, walls and floors based on an analysis using 1972 energy costs and optimised for the warmer parts of New Zealand. It seems that at their introduction there was a reluctance to make capital costs for houses significantly higher in the colder parts of the country by requiring different construction that would accommodate higher levels of insulation.

New Zealand then waited another 23 years before updating the minimum residential requirements. In fact, the most significant change in these minimum levels of insulation did not take place until 2004 when glazing characteristics also became part of the residential insulation regulations. About 90% of New Zealand's housing units were constructed prior to the 2004 modernisation of the regulations.

No thermal insulation requirements were recommended for non-residential buildings until the implementation of the performance-based New Zealand Building Code (NZBC) in 1993. A simplistic size definition deemed buildings less than 300 m² to be residential (small) and greater than 300 m² to be non-residential (large). Three climate zones were also defined at this time, with slightly different minimum levels of insulation in each. Minimum levels of thermal insulation for non-residential buildings were instituted that were

### Modelled energy use in existing and retrofitted office and retail buildings

| Rank | Climate groupings | Current total energy use [GWh] | Current EUI [kWh/m²/year] | EUI with ECMs [kWh/m²/year] | Net total energy use with ECMs plus PV [GWh] |
|---|---|---|---|---|---|
| **1** | Napier, Nelson, West Coast | 305 | 181 | 130 | -39 |
| **2** | Dunedin | 349 | 186 | 144 | 27 |
| **3** | West Coast North Island - Taranaki, Manawatu | 356 | 249 | 149 | 12 |
| **4** | Christchurch | 543 | 249 | 143 | 49 |
| **5** | Hamilton | 573 | 254 | 82 | -23 |
| **6** | Wellington | 625 | 264 | 131 | 76 |
| **7** | Auckland | 1,383 | 271 | 74 | 29 |
| **Total** | | **4,133** | | | **130** |

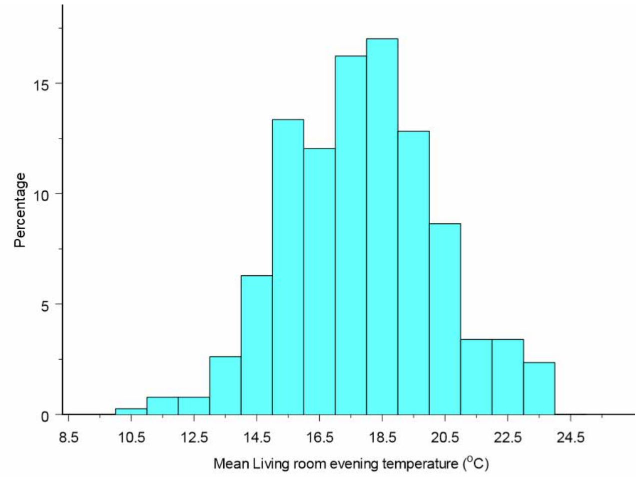
Modelled current total energy use in existing office and retail buildings (third column), related Energy Use Index (EUI, fourth column), EUI after instituting energy conservation measures (ECMs, fifth column), and projected total net energy use if PV is placed on the roofs of ECM buildings (sixth column). These are estimates for seven climate zones based on models calibrated against actual energy use of the actual savings from ECMs plus rooftop PV: the overall total energy saved would be approximately 97%. This reduction is far more than is necessary to eliminate the need for thermal power stations.
Source: Adapted from Cory S, An Exploration of the Feasibility of Converting the New Zealand Commercial Building Stock to be Net Zero Energy, PhD Thesis, Victoria University Wellington, 2016.

essentially the same as the 1977 residential insulation standards. The exception was for 'Climate Zone 1' in the North, where minimum thermal resistances for floors and roofs were recommended, but with no minimum for the walls. By 1993, residential electricity prices were around 50% higher than they had been in 1977. This was the first time an economic cost-benefit analysis was carried out to inform the insulation requirements, although these were shown as economic to individuals, rather than to the nation.

From 1993 onwards, however, merely matching minimum insulation levels has no longer been permitted if the glazed area is greater than 50% of the wall area for non-residential buildings, or greater than 30% of the wall area for residential buildings. In addition to the prescriptive minimum levels of insulation, the 1993 performance-based NZBC required a 'modelling method' to be agreed for proving compliance. This method permitted the use of any tool that complied with the IEA BESTEST procedures progressively developed in a number of projects within EBC and the IEA Solar Heating and Cooling (SHC) Technology Collaboration Programme. Originally, this was prior to the adaptation of the BESTEST procedures within ASHRAE Standard 140, but the latter standard is now referenced within NZBC.

## Energy characteristics of residential buildings

The Household Energy End-use Project (HEEP) was completed in 2005, which monitored 400 randomly selected houses across New Zealand for 11 months. All fuels (natural gas, electricity, solid fuel including wood and coal, solar water heaters, oil and LPG) were monitored. Those households in the lower 20% of energy users have an Energy Use Index roughly half that of those in the top 20%. Additionally, these top 20% of users consume well over 30% of the total energy used in the country, while the corresponding bottom 20% only account for 9% of the total. Electricity accounts for 69% of total household energy use, with solid fuels (mainly wood) accounting for a further 20%. The study determined that the proportion of residential energy used for space heating is low (18%) with domestic hot water as the largest end use (about 50%). There was also found to be a statistically significant relationship between income and domestic hot water energy use and between income and 'residual' energy used for purposes other than domestic hot water or space heating. In fact, average household energy use in the country remained essentially static from the 1970s until the end of the HEEP study. As in many countries, particular space heating concerns for low income families emerged from the study, with moisture and mould issues in over-crowded dwellings.

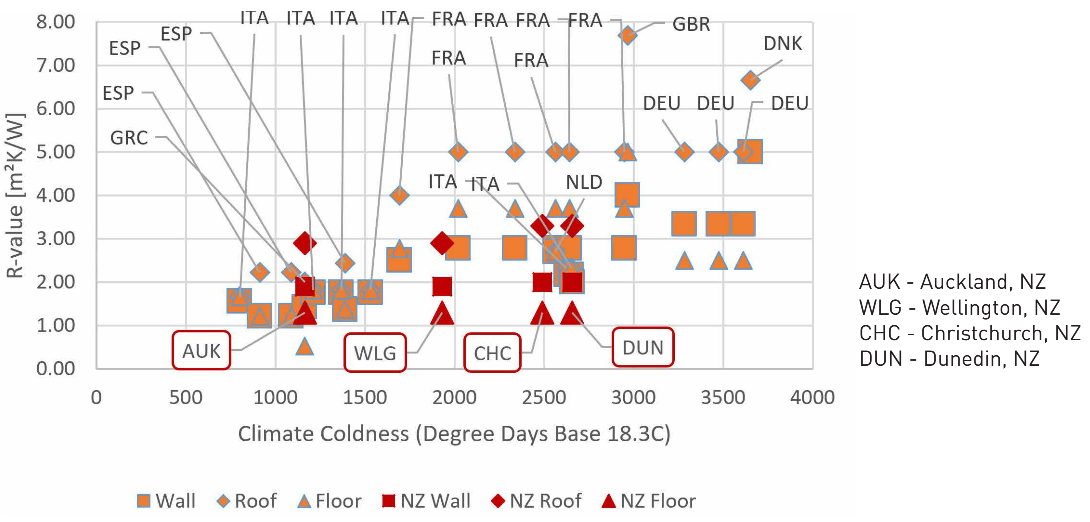



New Zealand house living room temperatures in winter evenings (5pm to 11pm). This shows the basis of the often-quoted low average temperature, just under the World Health Organisation's recommended minimum of 18°C. Curiously, no statistically significant correlation was found between equivalised income and mean winter temperatures, or energy use for heating. Perhaps, for some at least, these temperatures are a choice?
Source: Household Energy End-use Project, 2005

HEEP established that a large part of the peakiness of electricity demand is created by households turning on space heating in the early evening during winter. It has also been estimated that 20% to 30% of households use heat pumps, increasing to 40% in certain regions. A recent analysis by BRANZ has gathered experimental data from one building that indicates running a heat pump all day may reduce both peak load and energy use while also improving overall indoor temperatures. At current electricity prices, it is estimated that heat pumps used to heat 80% of the floor area of a house would have a simple economic pay-back of 6 to 8 years, and a lifetime of 10 to 15 years inland from the sea.

## Energy futures

The national long term goal is to electrify parts of the economy that are currently using fossil fuels, particularly industrial energy and the light transport fleet. The scenario for 2050 is that electricity generation will double, moving from 25% of total national energy demand to 61%. Electric vehicles are anticipated to reach 40% market share by 2030 and 85% by 2050. Transpower, the company contracted to manage New Zealand's electricity grid, has noted peak consumer




Minimum elemental thermal insulation resistances (R-values) for houses as of 2007 for countries in Europe compared to New Zealand (shown in red). Plotting thermal resistances against coldness of climate (in terms of degree-days) shows clearly Auckland's (AUK) residential insulation regulations are consistent with or slightly better than similar European climates. It is common in discussions about the adequacy of New Zealand's insulation regulations to compare against the German (DEU) or French (FRA) levels, but as can be seen, those are grouped towards the right hand (colder) side. In fact, the insulation requirements in New Zealand seem to have much more in common with Italy (ITA) or Spain (ESP).
Data source: www.eurima.org/u-values-in-europe

demand is at a different time of the year than likely peak renewables availability. The joint SHC and EBC research project, 'Annex 52: Towards Net Zero Energy Solar Buildings', to which New Zealand contributed, identified this as an issue when creating energy efficient buildings that generated more energy than they used over a year. This is now the focus of the current EBC project 'Annex 67: Energy Flexible Buildings', although New Zealand is not participating.

In reality, the biggest single wasted energy opportunity at present is that many older existing non-residential buildings are being refurbished in ways that make the future goals unfeasible. However, Cory (2016) has found that by introducing energy conservation measures during retrofit and adding photovoltaic (PV) panels to the roofs of the existing office and retail building stock in New Zealand, most of the light vehicle electrification planned by 2050 could be achieved without the requirement for extra generating capacity. For the residential buildings sector, making the kinds of savings identified for office and retail buildings would require a lot more action than simply focusing on increased fabric insulation and window thermal performance.

The major research and development need for New Zealand is for new technologies for delivery, storage and control of energy using services such as domestic hot water, lighting and appliances. The research necessary to solve these issues is principally to find the means of retrofitting the 90% of the existing housing stock built to 1970s standards, specifically addressing the following concerns:

- replacing the existing single glazing in a simple, cheap and high performance manner;
- insulating existing building walls for which the owner wishes to preserve the outward appearance of the building and the rooms are too small for insulation on the inside wall;
- resolving the cost implications of delivering appropriate retrofit of houses in the colder parts of the country.

In fact, when coupled to an electricity grid that is already based on up to 85% hydropower, investment in PV panels on roofs and energy efficiency retrofit of offices and shops in New Zealand could solve the decarbonisation of the 36% of primary energy used in the transport sector by making existing generation available for electric vehicles.

## Further Information

https://thetruesize.com
https://www.ea.govt.nz/dmsdocument/16624

*Michael Donn is the EBC Executive Committee Member for New Zealand.*

# Implementation of Energy Strategies in Communities

## Current Project: EBC Annex 63

Helmut Strasser, Oskar Mair am Tinkhof

*A new set of strategic measures and guidance is putting more energy into urban planning processes.*

The coordination of urban and energy planning processes at a local level is a central element for achieving goals for reducing greenhouse gas (GHG) emissions, and in particular those relating to energy-related carbon dioxide ($CO_2$) emissions. But, case studies from several countries have shown there is still a missing link between these processes that would enable the implementation of innovative technologies in large-scale projects. To address this, the EBC international research project, 'Annex 63: Implementation of Energy Strategies in Communities' is closing this gap. It has collected and analysed experiences in the participating countries on a national scale and further developed them to create a set of new strategic measures. These measures support the successful implementation of energy strategies in communities, and include guidance on how they can be applied at a local scale. Finally, stakeholder support materials have been developed enabling the necessary change management process to be started.

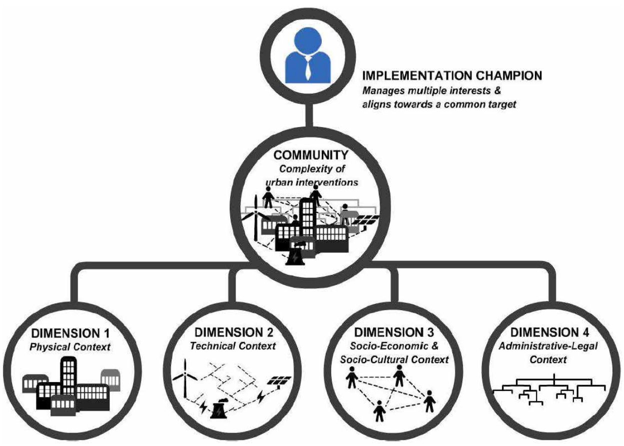



Illustration of the four dimensions involved in community development.
Source: Danish Technical University and Aalborg University, 2017

### Application of strategic measures

In general, the strategic measures describe the relevant implementation tasks. The measures are as given below:

- set visions and targets;
- develop renewable energy strategies;
- make full use of legal frameworks;
- design urban competition processes;
- make use of tools supporting the decision making process;
- implement monitoring of energy consumption and greenhouse gas emissions;
- undertake stakeholder engagement and involvement;
- include socio-economic criteria;
- implement effective and efficient organizational processes.

On this basis, the detailed activities must be translated to fit within national framework conditions. These have to be set in relation to typical tasks within urban planning, to different scales of planning, from city to community or project scale and to fit within time-scales appropriate for planning processes. Urban planning processes are complex with long durations (typically greater than 10 years), which include many iterations and have a high risk of missing at least some of the goals. Thus, the role of an 'implementation champion' has turned out to be crucial. While working towards the main goal, they help to define reachable interim targets and guide the stakeholder group in an iterative process. They lead and facilitate the planning and implementation process from the beginning and they are able to set the right activities at the right times. Typically, politicians or managers of urban planning departments may take on this role. It has been shown in the project that if no one accepts it, in reality there is a high risk of failing to meet the goals. Thus, it is essential to actively give the mandate to an appointed person. Intermediary organizations with close links to the city can also help to overcome bottlenecks in resource capacities.

## Stakeholder support materials

Stakeholder support materials have been developed within the project to overcome the existing gaps identified. An Excel-based self-assessment tool supports analysis of the status quo regarding the implementation of the nine strategic measures in a municipality. A simple to understand 'traffic light' system helps to assess the awareness, available skills, regular application, quality and efficiency of application, and gives a first overview about existing potentials for improvements. Recommendations for the optimisation of an organisation with respect to capacity building and skills form a second part of the support materials. As moderation and technical skills are essential for implementation champions, further support materials developed include workshop plans, and a presentation slide library to accommodate various purposes and target groups. An overview of existing educational materials for academic lectures has also been created. All reports and materials are available on the project website.

## Recommendations

Analysis of urban and energy planning processes has shown that making changes to existing processes is very complex because these must take into account the needs of different stakeholders (for example politicians, administrators, investors, and planners) and the impacts of different topics (for example visions, goals, process flow, and organisation). Therefore, social skills and practical recommendations are necessary to initialize the change process.

A key recommendation for policy and decision makers arising from this project is that simple upscaling of building-level solutions to the district scale is not possible. To optimise the energy supply for urban development projects, solutions at an individual building scale are necessary, but a broader framework is needed at an early planning stage (urban planning). Therefore, it is important to include all relevant stakeholders early in the planning process and to understand their potential contributions. This can be done by restructuring existing urban planning processes and strengthening them with additional internal or external expertise. The well-implemented adaption of urban planning processes is likely to have a more significant impact on energy use and $CO_2$ emissions within a country compared to the optimisation of only the building stock. So, if the energy strategy recommendations are deployed at a large scale, high impacts could be achieved with low costs, and creating the basis for national or regional change management processes.

## Working Group on Cities and Communities

The IEA Energy Technology Perspectives 2016 'Towards Sustainable Urban Energy Systems' (IEA, 2016) highlighted the relevance of energy-related $CO_2$ emissions reduction potential at urban scale. Experience in this project has shown that cities face quite extensive challenges when it comes to transformation processes for their energy and mobility systems. Thus, the outcomes of the project are intended to support cities' efforts. Additionally, a requirement for further information exchange between researchers has been found for different technologies with relevance to the urban scale, as well as on technological and non-technological issues, such as urban planning processes. Thus, the recently started EBC-led project, 'Working Group on Cities and Communities', is creating a forum for knowledge exchange on such 'urban issues' for the benefit of the IEA Technology Collaboration Programmes' research and other activities.

## Further information

www.iea-ebc.org

# Definition and Simulation of Occupant Behaviour in Buildings

## Completed Project: EBC Annex 66

Tianzhen Hong and Da Yan

*A new methodological framework developed using interdisciplinary approaches and a suite of supporting tools promote deeper understanding of occupant behaviour, enabling stakeholders to better integrate the human dimension in building design and operation to reduce energy use and improve occupant comfort.*

Energy-related occupant behaviour is a key factor influencing building performance. Occupant behaviour in buildings refers to: (1) occupant presence in spaces and movement between spaces, (2) occupant interactions with building systems, and (3) occupant adaptations (for example, changing clothing, or consuming hot or cold drinks). Occupant actions such as adjusting a thermostat, switching lights on or off, opening or closing windows, and pulling blinds up or down can have a significant impact on building performance.

It is complex area and requires an interdisciplinary approach to be properly understood. On one hand, behaviour is influenced by external factors such as culture, economy, and climate, as well as by internal factors such as individual comfort preference, physiology, and psychology. On the other hand, occupants' interactions with building systems strongly influence building operations and associated energy use and operating costs; in turn, building operations influence occupant behaviour, thus forming a closed loop. Previously, however, the influence of occupant behaviour has been under-recognized and over-simplified in the design, construction, operation, and retrofit of buildings. Many past studies of occupant behaviour have lacked in-depth quantitative analysis. Moreover, the available models of occupant behaviour have been developed by different researchers and have showed inconsistencies, lacking consensus on how to approach experimental design and modelling methodologies. To overcome these concerns, the completed EBC international research project, 'Annex 66: Definition and Simulation of Occupant Behavior in Buildings', has investigated the impact of occupant behaviour to create quantitative descriptions and classifications, develop effective calculation methodologies, implement these within energy modelling tools, and demonstrate them with case studies.

### Research approaches and outcomes

Using interdisciplinary research approaches, the project has made significant contributions by: (a) identifying quantitative representations and classifications of occupant behaviour; (b) developing methods for occupant behaviour measurement, modelling, evaluation, and application; (c) implementing occupant behaviour models in building performance simulation tools; (d) demonstrating applications of occupant behaviour models in design, evaluation and operational optimization of buildings through 32 case studies covering various building types across several countries. The major project outcome is a scientific methodological framework to guide occupant behaviour research in the areas of: data collection; model building and evaluation; simulation tool development, integration, and application; interdisciplinary issues. Research outcomes from the project were also presented in more than 100 peer-reviewed journal articles, as well as in a book, 'Exploring Occupant Behavior in Buildings: Methods and Challenges'. Except for the latter document, the final report, the other deliverables, and occupant behaviour modelling tools are available at the project website.

## Research findings

Key research findings from the project are as follows:

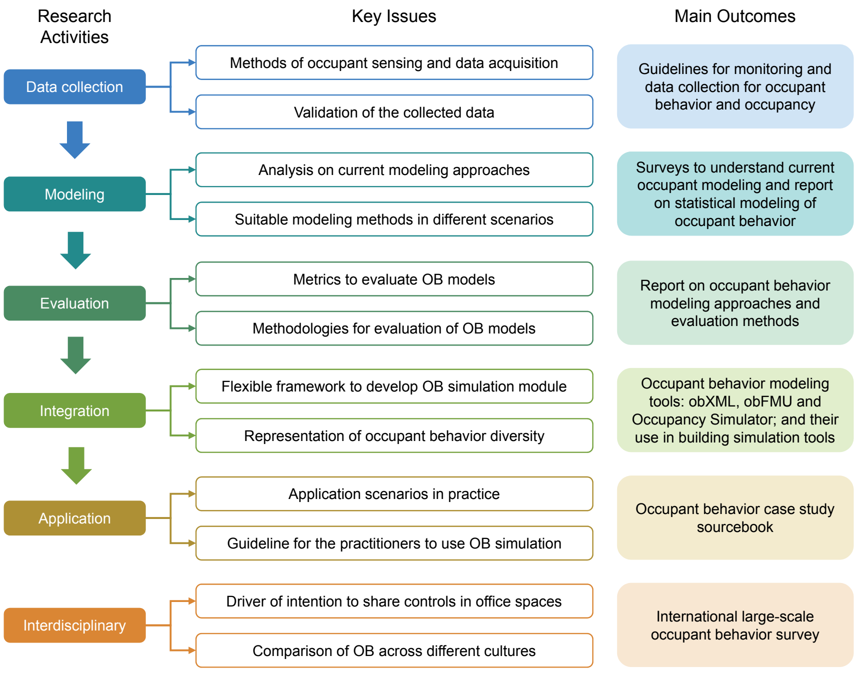
1. Occupant behaviour has significant impacts on energy use and occupant comfort. Insights into behaviour, developed through quantitative representation and simulation of occupant-building interactions, can help building designers, engineers, and policy makers understand and reduce the gap between simulated and measured energy performance.
2. Data collection is fundamental to occupant behaviour modelling. Methods of collecting data are evolving with the rapid development of information and communication technologies (ICT) and sensors.
3. Occupant behaviour models need to be integrated with building performance simulation programs in a standardized and interoperable way to enable ease of adoption. The choice of model (deterministic or probabilistic) depends on the building context. Evaluation of models requires the use of explicit, application-specific metrics that quantify model performance under the given application.
4. User-friendly interfaces and modelling guides are needed for effective behaviour model application.
5. Energy policy makers can take advantage of occupant behaviour modelling to improve decision making. The availability of quantitative behaviour models can facilitate the development of more effective policies for reducing energy use that leverage knowledge of likely occupant actions and their influence on building performance.
6. Interdisciplinary research across the building, social, behavioural, data and computer sciences is needed to understand and quantify the impact of human behaviour on building performance.

## Continuing research

Leading on from this project, research efforts are continuing to tackle some of the remaining challenges revealed by the work. These efforts are further integrating human factors in the building life cycle to improve performance, including, 'EBC Annex 79: Occupant Behaviour-centric Building Design and Operation', and the ASHRAE 'Multidisciplinary Task Group on Occupant Behavior in Buildings'.

## Further information

www.iea-ebc.org




The research activities, key issues addressed, and the main outcomes of the project.
Source: EBC Annex 66

# On-site Assessment of Building Heat Loss Coefficients

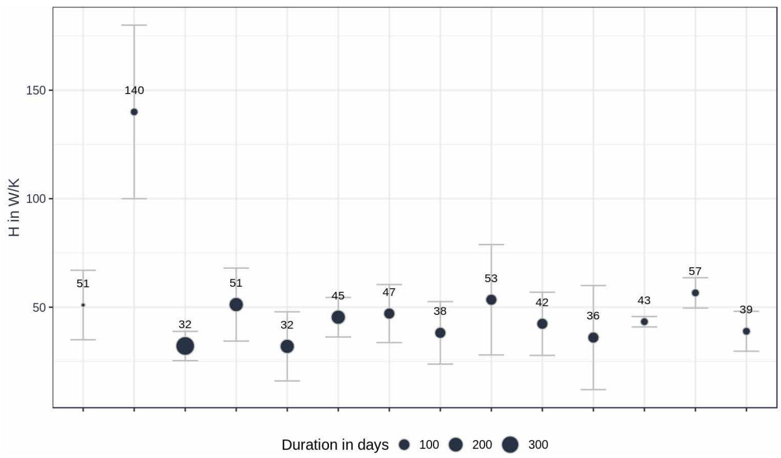
## Current Project: EBC Annex 71

Staf Roels

*Actual building performance has to match the designed performance. This requires robust protocols for gathering and analysing on-board monitored data to assess the real-life performance.*

Many current claims about the energy efficiency for buildings and building districts are based on theoretical models, often supported by speculative assumptions and unconfirmed extrapolations. The available literature on real-world performance of energy-efficient building technologies is sparse, yet it suggests almost unanimously a significant gap between predicted and achieved performance. This can be attributed to limitations, inaccuracies and assumptions in the numerical models to predict the performance, as well as to inadequate workmanship and other construction errors. It is essential though that the energy-efficient technologies used in buildings do more than simply satisfy regulations based on theoretical requirements. They must make genuine, measurable differences in real-world applications. Building owners, investors and governments need to know that the investments they make are actually delivering as expected. Hence, ensuring that real performance matches the design intent is critical. This requires reliable methods and procedures applicable to the real world.

Recently, statistical methods and system identification techniques have been shown to be promising tools to characterise and assess the as-built performance of buildings. So far though, the studies are isolated and often based on dedicated tests making use of time-consuming monitoring techniques. A thorough analysis of the applicability of the methods, investigating the balance between cost of data gathering versus achieved




One of the UK case study dwellings used for the exploratory exercise and example results. The new, well-insulated social house in Gainsborough is shown (left), and preliminary results for the estimated overall heat loss coefficient of the same dwelling (right), with each dot corresponding to a certain method, the measurement time span indicated by the size of the dot. The standard deviations as predicted by each method are indicated by the grey bars.
Sources: B. Sodagar, University of Lincoln, UK (left), and EBC Annex 71 (right)

precision and reliability of the outcome is lacking. This balance is one of the key topics of research in the international EBC project, 'Annex 71: Building Energy Performance Assessment Based on In-situ Measurements'. This project is focusing on residential buildings and is combining in-situ measurements with dynamic data analysis techniques to develop characterisation and quality assessment methods for individual dwellings and building communities.

## An exploratory exercise

In an exploratory exercise, monitored data from two dwellings in the UK have been analysed. One was a well-insulated newly built house in Gainsborough owned by a social landlord, and the other a traditional, uninsulated semi-detached dwelling in Loughborough. Within the framework of quality assessment, project participants were asked to determine the overall heat loss coefficients of the dwellings, and regarding building behaviour characterisation, to translate the dynamic behaviour of each dwelling into a simplified model that can be used for the prediction of the energy use. Compared to a standard dwelling, both case studies were highly instrumented, but participants could manipulate the measured data to explore the reliability of different identification techniques regarding cost of input data and obtained accuracy of the outcome.

## Towards a cost-accuracy matrix

Available techniques that can be applied vary from simple routines, such as the averaging or energy signature method, to advanced dynamic data analysis methods, such as AR(MA)X-models and stochastic state space models. The most simple techniques are less useful for (dynamic) building behaviour identification, as they typically yield only a static performance indicator. But, their ease of use might be beneficial in quality assessment. The advanced models are typically used for characterisation purposes, while most of them can also be applied in a quality assessment framework. To evaluate the impact on the accuracy obtained, the project participants were free to reduce the amount of input data, aggregate data, or neglect information. They have evaluated various methods for different time spans and data quality. The outcome of the exploratory exercise has been used to develop the concept for a matrix that links the expected model accuracy for a specific application to a list of required measurements and a suitable statistical method. This 'cost-accuracy matrix' is currently being fully developed within the project, along with detailed guidance.

## Further information

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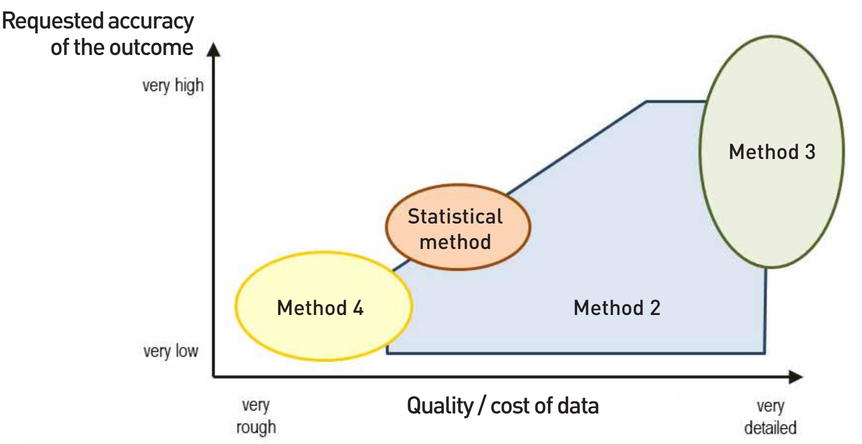
## The cost-accuracy matrix




The principle of the cost-accuracy matrix is to link statistical methods with available (required) input data and requested accuracy of the outcome. The basic idea is that starting from the required level of accuracy (y-axis), a certain method and corresponding measurement accuracy (x-axis) can be determined. Or, the other way around, knowing the data acquisition technique (variety and accuracy of the available data) the most interesting method and maximum attainable level of accuracy of the outcome can be found.
Source: KU Leuven, Belgium

# EBC International Projects

## New Projects

### EBC Annex 77 / SHC Task 61: Integrated Solutions for Daylighting and Electric Lighting

Contact: Jan de Boer
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This new joint EBC and SHC research project is focusing on identifying, creating and improving strategies combining daylighting and appropriate lighting control systems for buildings to lead both to very highly energy-efficient lighting schemes, and also to solutions offering excellent lighting conditions for people. Over its duration, it is anticipated to bring together between 30 and 40 international experts and organisations, involved in dynamic daylighting and electric lighting and their controls. The main focus areas are the perception of occupants concerning lighting quality, human interfaces and control strategies. The aims of the project are to:

- propose models for lighting controls integrating occupant behaviour and expectations;
- identify high performance approaches to control solutions for electric lighting and daylighting;
- conduct onsite and laboratory monitoring of innovative solutions and document the findings.

Part of the work is to create pre-standardization technical proposals to inform CEN, ISO, and other standardization bodies.

#### Further information

www.iea-ebc.org

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### EBC Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications

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Since air cleaning may potentially simultaneously improve indoor air quality in buildings and reduce energy use for ventilation, it can be considered as an interesting technology to explore for future application. There is, however, a need for better evaluation of its potential to improve indoor air quality (and possibly as a partial substitute for ventilation) and the energy implications of using gas phase air cleaning. There is also a need to develop standard test methods for the performance of gas phase air cleaning devices related to typical indoor sources such as bio-effluents from occupants and emissions from materials and indoor activities. This new EBC project is bringing together research organisations and industry to investigate the possible energy benefits of using gas phase air cleaners (as a partial substitute for ventilation) and establish procedures for improving indoor air quality, or reductions in ventilation by gas phase air cleaning. The project is also establishing a test method for air cleaners that considers the influence on the perceived air quality and substances in the indoor air.

#### Further information

www.iea-ebc.org

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# EBC International Projects

## New Projects

### EBC Annex 79: Occupant Behaviour-Centric Building Design and Operation

Contacts: Andreas Wagner
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The purpose of this new EBC project is to provide new insight into comfort-related occupant behaviour in buildings and its impact on building energy performance. An open collaboration platform for data and software is being developed to support the use of 'big data' methods and advanced occupant behaviour models. It is promoting the application of this knowledge in building design and operation processes by giving technical support for policy making and supporting practitioners. With the overall goal to integrate and implement occupancy and occupant behaviour into the design process and building operation, the project is focusing on:

- Improvement of knowledge about occupants' interactions with building technologies' interfaces. A specific focus is on comfort-driven actions caused by multiple and interdependent environmental influences that are not yet covered by current models.
- Deployment of 'big data' (for instance data mining and machine learning) for the buildings sector as the availability of various data related to occupants' behaviour in buildings increases rapidly.
- Sustainable implementation of occupant behaviour models in building design practice and controls strategies by developing guidelines and preparing recommendations for standards. Focused case studies are being used to implement and test the new models and strategies in different design and operation phases.

#### Further information

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### EBC Annex 80 Resilient Cooling for Residential and Small Commercial Buildings

Contact: Peter Holzer
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The focus of this new EBC project is resilient cooling applications for existing residential and small commercial buildings. A focal point of the project is resilient cooling applications for 'nearly zero energy buildings' (nZEBs). The project is encompassing both active and passive cooling technologies and systems. A range of technologies of concern are being evaluated regarding minimisation of energy use, greenhouse emissions and other critical environmental, as well as socio-cultural impacts. The project is investigating resilient cooling applications with respect to the wide variety of external influencing parameters such as climate, building typology, internal loads and occupancy profiles, at various levels of Building Management System (BMS) capability and automation, for new buildings and retrofitting of existing buildings. Furthermore, the project plans to closely co-operate with activities such as the Mission Innovation Innovation Challenge #7, 'Affordable Heating and Cooling of Buildings', the Kigali Cooling Efficiency Programme and the IEA Global Exchange on Efficiency: Cooling.

#### Further information

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# EBC International Projects

## Current Projects

**Annex 5: Air Infiltration and Ventilation Centre**
The AIVC carries out integrated, high impact dissemination activities, such as delivering webinars, workshops and technical reports.
Contact: Dr Peter Wouters
aivc@bbri.be

**Annex 63: Implementation of Energy Strategies in Communities** is developing robust approaches for implementing community-scale optimized energy strategies.
Contact: Helmut Strasser
helmut.strasser@salzburg.gv.at

**Annex 64: Optimised Performance of Energy Supply Systems with Exergy Principles** is covering the improvement of energy conversion chains on a community scale, using an exergy basis as the primary indicator.
Contact: Dr Dietrich Schmidt
dietrich.schmidt@ibp.fraunhofer.de

**Annex 65: Long-Term Performance of Super-Insulating Materials** is investigating potential long term benefits and risks of newly developed super- insulating materials and systems and to provide guidelines for their optimal design and use.
Contact: Daniel Quenard
daniel.quenard@cstb.fr

**Annex 67: Energy Flexible Buildings** is investigating how energy flexibility can provide generating capacity for energy grids, and is identifying critical aspects and possible solutions to manage such flexibility.
Contact: Søren Østergaard Jensen
sdj@teknologisk.dk

**Annex 68: Design and Operational Strategies for High Indoor Air Quality in Low Energy Buildings** focuses on design options and operational strategies suitable for good energy performance, such as demand controlled ventilation, improvement of the fabric by using low pollutant emitting products.
Contact: Prof Carsten Rode
car@byg.dtu.dk

**Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings** is studying the underlying mechanism of adaptive thermal comfort, and is applying and evaluating the thermal adaptation concept to reduce energy use through design and control strategies.
Contacts: Prof Yingxin Zhu, Prof Richard de Dear
zhuyx@tsinghua.edu.cn,
richard.dedear@sydney.edu.au

**Annex 70: Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale** is focusing on developing best practice methods for collecting, accessing, analyzing and developing models with empirical data of energy demand in buildings and communities.
Contact: Dr Ian Hamilton
i.hamilton@ucl.ac.uk

**Annex 71: Building Energy Performance Assessment Based on In-situ Measurements** is advancing in-use monitoring to obtain reliable quality checks of routine building construction practice to guarantee that designed performance is obtained on site.
Contact: Prof Staf Roels
staf.roels@bwk.kuleuven.be

**Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings** is based on previous EBC research based on life cycle assessment to include in-use operational impacts and addresses environmental impacts in addition to primary energy demand and greenhouse gas emissions.
Contact: Rolf Frischknecht
frischknecht@treeze.ch

**Annex 73: Towards Net Zero Energy Resilient Public Communities** is advancing 'near zero energy communities', to enhance existing masterplanning strategies and modelling tools, and expand their application with standardized country-specific building data on specific building types.
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ruediger.lohse@kea-bw.de

**Annex 74: Competition and Living Lab Platform** is benefitting from the lessons learned from the Solar Decathlon events worldwide, and is extending the format with new competitions and a series of networking events under a common umbrella.
Contacts: Prof Karsten Voss, Prof Sergio Vega,
kvoss@uni-wuppertal.de,
sergio.vega@sdeurope.org

**Annex 75: Cost-effective Building Renovation Strategies at District Level** is examining the cost-effectiveness of methods combining energy efficiency and renewable energy measures at the district level.
Contact: Dr Manuela Almeida
malmeida@civil.uminho.pt

**Annex 76 / SHC Task 59: Deep Renovation of Historic Buildings** is examining conservation compatible energy retrofit approaches and solutions, which allow the preservation of historic and aesthetic values while increasing comfort, lowering energy bills and minimizing environmental impacts.
Contact: Dr Alexandra Troi
Alexandra.Troi@eurac.edu

**Annex 77 / SHC Task 61: Integrated Solutions for Daylighting and Electric Lighting** is fostering the integration of daylight and electric lighting solutions with the benefits of higher occupant satisfaction and energy savings.
Contact: Dr-Ing Jan de Boer
jan.deboer@ibp.fraunhofer.de

**Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications** is examining the possible energy benefits and indoor air quality implications of using gas phase air cleaners.
Contacts: Prof Bjarne Olesen, Dr Liam O'Brien,
wagner@kit.edu, liamobrien@cunet.carleton.ca

**Annex 79: Occupant Behaviour-Centric Building Design and Operation** is advancing comfort-related occupant behaviour in buildings and its impact on building energy performance.
Contacts: Prof Andreas Wagner, Dr Pawel Wargocki, bwo@byg.dtu.dk, paw@byg.dtu.dk

**Annex 80: Resilient Cooling for Residential and Small Commercial Buildings** is investigating relevant applications for nearly zero energy buildings and is encompassing both active and passive cooling technologies and systems.
Contact: Dr Peter Holzer
peter.holzer@building-research.at

**Working Group: HVAC Energy Calculation Methodologies for Non-residential Buildings** is analysing national energy calculation methodologies with the intent of securing good agreement between their results and energy use in reality.
Contact: Dr Takao Sawachi
tsawachi@kenken.go.jp

**Working Group: Cities and Communities** is integrating the decision-making issues encountered by energy planners within cities and associated stakeholder groups into the R&D being carried out by the IEA Technology Collaboration Programmes.
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EBC

Energy in Buildings and Communities Programme

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