EBC

Energy in Buildings and Communities Programme

Annual Report 2015

International Energy Agency

EBC Annual Report 2015

Energy in Buildings and Communities Programme

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Cover picture: The LOBSTER field laboratory at KIT Germany for studying occupant behaviour in buildings.
Source: BINE Informationsdienst, www.bine.info

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Chair's Statement

The IEA's new Executive Director, Dr. Fatih Birol, recently called the December 2015 Paris Agreement 'nothing less than a historic milestone for the global energy sector'. In the Paris Agreement, 195 countries expressed their willingness to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. Governments agreed on the need for global emissions to peak as soon as possible, and to undertake rapid reductions thereafter in accordance with the best available science.

The IEA-EBC Technology Collaboration Programme makes such science available in the field of energy efficiency in buildings and communities. The outcomes of our international collaborative research projects address the three determining factors for building and community energy use: technological aspects, user behaviour and policy measures.

Our recently started project 'Annex 70: Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale' seeks to support EBC member countries in the task of developing realistic transition pathways to substantial and long-term reductions in energy use and carbon dioxide emissions associated with their buildings. The emerging field of energy epidemiology provides the means to evaluate the scope for using real building energy use data at scale to inform policy making and to support industry in the development of low energy and low carbon solutions.

Our latest results come from the project 'Annex 55: Reliability of Energy Efficient Building Retrofitting – Probability Assessment of Performance and Cost', completed at the end of 2015. Through this work, robust probabilistic methods and tools for prediction of energy use, lifecycle cost and functional performance of residential buildings are now publically available.

While the above-mentioned project focused on technology aspects, the non-technological factors are important to consider as well. To address this, our current project 'Annex 66: Definition and Simulation of Occupant Behaviour in Buildings' (see the cover picture) is undertaking research on how to develop quantitative descriptions of occupant behaviour in order to analyse and evaluate its impact on building energy consumption.

The EBC Programme provides evidence based knowledge to help the governments and industry of our 22 member countries and beyond to implement the ambitious climate agreement in the most efficient and cost-effective way. This Annual Report for 2015 gives you an insight into the knowledge we have already created or that we are still developing. For the remaining 173 countries, I hope it raises your interest in profiting from it and even joining us!

Andreas Eckmanns
EBC Executive Committee Chair

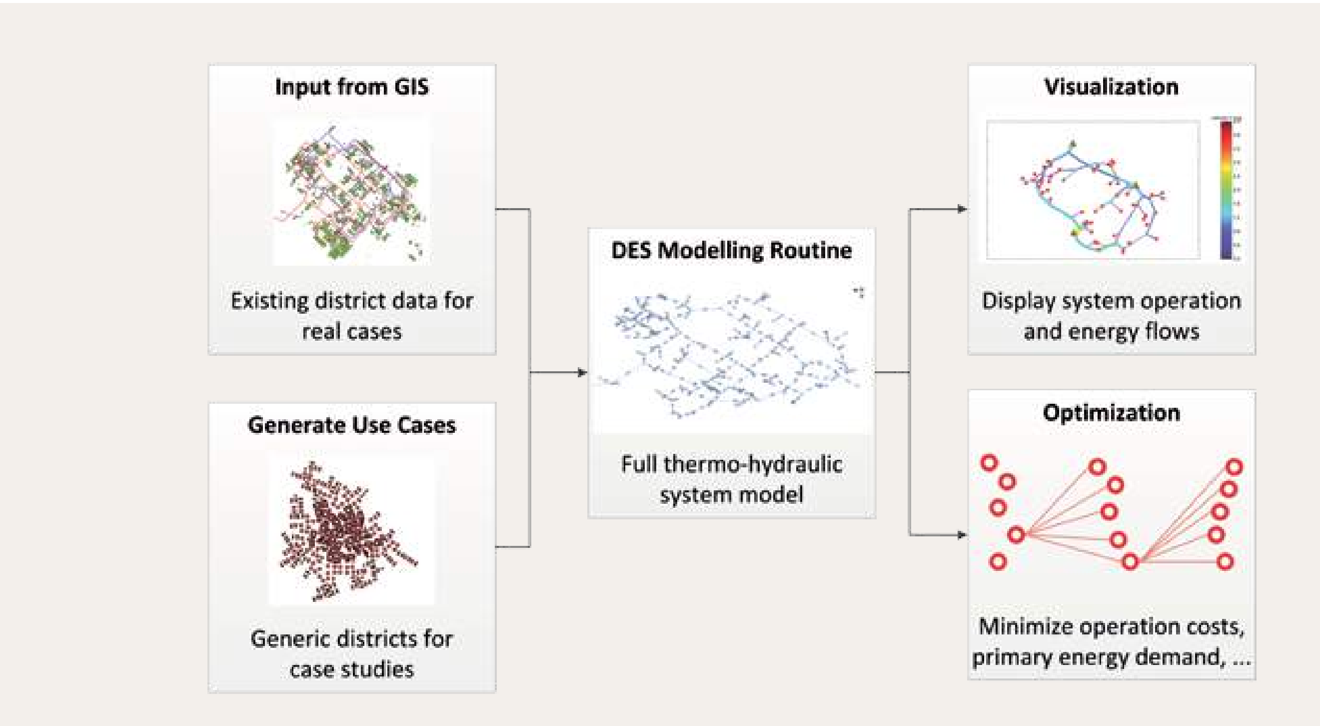
Latest Outcomes for Policy and Decision Makers

Energy Efficiency First: This IEA message is front and centre in the international collaborative R&D activities of the EBC Programme. 22 countries from every part of the world share innovation, expertise and resources to better tackle the historic challenge of accelerating the transformation of the built environment towards much more energy efficient and sustainable buildings and communities. IEA-EBC's vision is that by 2030, near-zero primary energy use and greenhouse gas emissions solutions will have been adopted in new buildings, and a wide range of reliable solutions made available for upgrading the existing building stock.

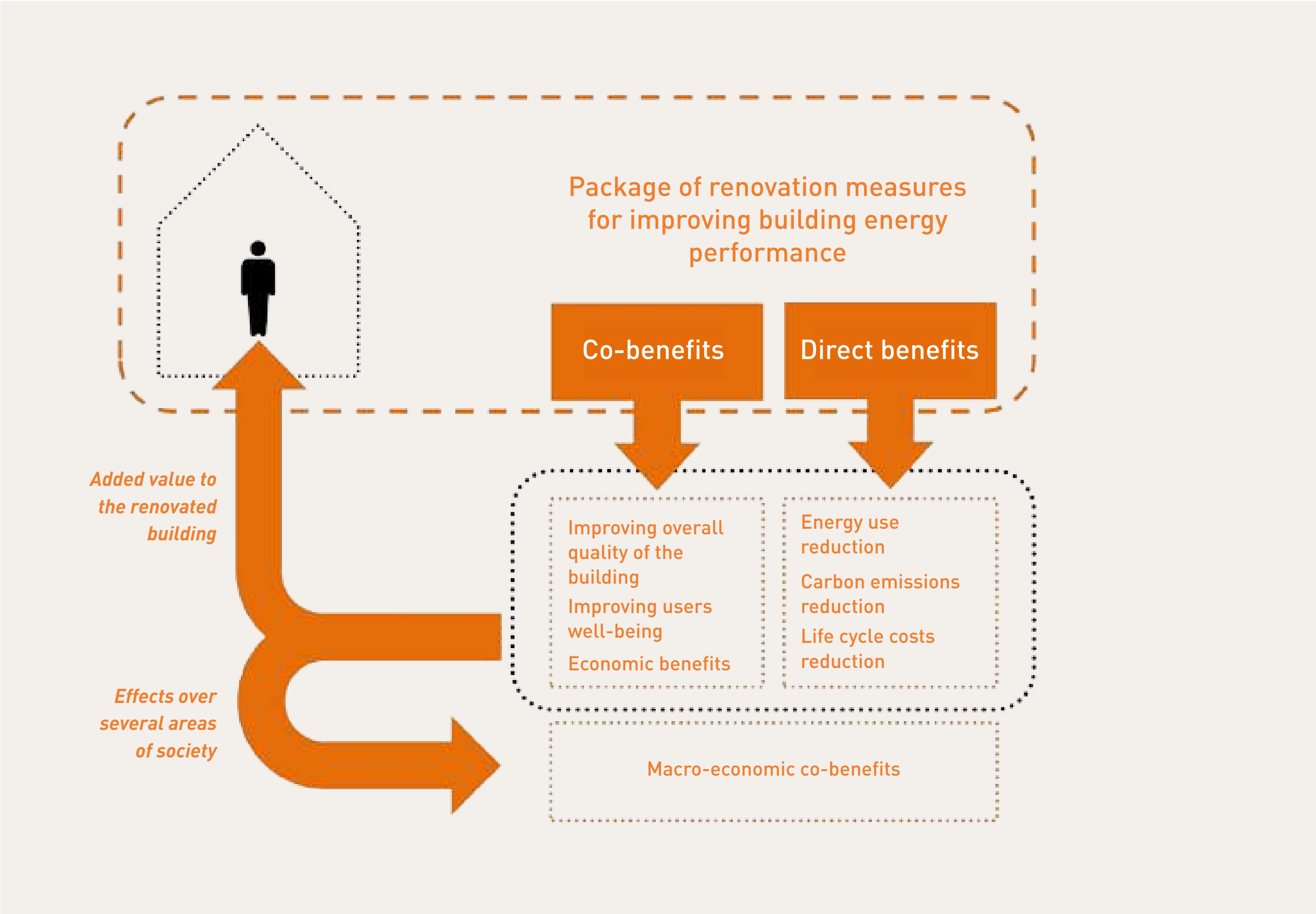
The EBC Programme pursues research that supports more effective policies to advance this vision, and which makes available robust and durable guidance, decision-making tools and integrated systems technologies. A very considerable body of research has resulted from collaborative activities over a period of almost four decades involving typically a full time equivalent of some 80 researchers and an additional annual investment of around US$8.5 million.

The IEA-EBC Strategic Plan 2014-2019 identifies the following high priority research themes:

- Integrated planning and building design
- Building energy systems
- Building envelope
- Real building energy use
- Community scale methods



A common international modelling framework is needed to realise fully integrated, scaleable and connected district energy systems. This is being created through EBC research.
Source: EBC Annex 60



Besides energy, carbon dioxide emissions and cost reductions, the co-benefits of building renovation are important. They increase the added value of the building, which is relevant for building owners, and have influence over several aspects of society that are significant for policy makers. Co-benefits can have significant value, but disregarding them is often a reason for underestimating the full value of renovation works.
Source: EBC Annex 56

Several co-ordinated multidisciplinary research actions address each of these themes. Common to all is an awareness that to adequately realize the huge opportunities inherent in delivering this vision, the social and economic challenges are at least as important as the technical and scientific challenges, and that properly integrated solutions are essential.

Recommendations for Policy

To illustrate policy-oriented recommendations flowing from this research, in order to save energy while guarding indoor thermal comfort standards, current industry codes should be modified to properly accommodate adaptive approaches in building design, operation, and refurbishment; and personal thermal comfort systems, to address the differences between individual occupants, should be further studied. Standards and incentives should be designed around cost effectiveness and with nearly zero carbon dioxide emissions as a target. Future new and refurbished residential buildings with excellent indoor air quality will require regulatory recognition of the possibilities offered by advanced, demand controlled and pollution load adjusted paradigms for ventilation control.

Harmonized international definitions of terms such as 'net zero-', 'near net zero-' and 'very low energy-' buildings have been drafted. The core technologies for deep retrofitting are readily available for application in many countries with various climatic conditions, with different energy pricing, and with diverse construction practices. To facilitate and increase the implementation of these technologies, increased effort is needed to ensure the entire process of building renovation delivering large energy savings becomes mainstream practice, and which becomes available from multiple providers at competitive prices: This should be the standard for energy refurbishment in buildings, starting with the public sector. To allow private funding to increase the number and pace of such projects, performance-related business models such as advanced energy performance contracting should be applied at scale.

As regards energy systems, a greater responsiveness in building energy demand can facilitate the increasing penetration of variable renewables. Therefore means of promoting demand flexibility are being studied. Overheating can become a risk in low energy buildings, and revised compliance methods and tools are required, as well as design guidance to accommodate ventilative cooling solutions.

A new generation of computational tools are making possible new approaches to the entire process: modelling and simulating buildings and district energy systems as integrated, scalable and connected systems represents a new paradigm that can also consider the virtual planning of commissioning and building operation, but which will require a common international framework and needs considerable standardisation of interfaces, for instance. Major work is underway on better defining and simulating occupant behaviour in buildings, which will improve understanding of energy use in buildings and provide insight into human-building interactions, matters that are critical for successful very low energy buildings.

As the energy required to operate buildings is reduced, that embodied in their materials and components becomes proportionately more important. Methods have been developed to analyse total energy use and to evaluate energy and emissions. While many building envelope insulating materials are cost effective and widely available, more R&D is needed to develop and test super-insulating materials to tackle remaining critical points in insulation practices. Increasingly stringent regulatory requirements must be translated into actual energy performance on site. Research on reliable building energy performance characterisation based on full scale dynamic measurement will facilitate real performance assessment and quality checking, and also helps to optimise smarter grids.

To link energy planning and urban design a common language is needed, with better understanding of instruments - whether engaging, enabling, or enforcing - and planning procedures. At the community scale, economic models need to be developed and transposed in regulations to facilitate integration of renewables and waste heat: A holistic approach to both demand and supply appears a promising and cost efficient strategy. A recently completed project has delivered practical guidance on how to achieve ambitious energy and emissions reductions at local and urban scales.

Collaboration within the IEA and beyond

The critical need for the reduction of energy demand in the buildings sector is relevant to a number of IEA Technology Collaboration Programmes in addition to IEA-EBC. At the building scale, collaboration with the Solar Heating and Cooling, Heat Pumping Technologies, Photovoltaic Power Systems and Efficient Electrical End-Use Equipment Programmes is necessary, while at the community scale, collaboration with the District Heating and Cooling, Demand Side Management, Energy Conservation through Energy Storage and Transportation Programmes is equally important. Beyond this, co-operation with national and EU programmes and with relevant technical committees in ISO, CEN and with organisations such as ASHRAE is also valuable and productive.

Prof J Owen Lewis
EBC Executive Committee Member for Ireland

New Research Projects

BUILDING ENERGY EPIDEMIOLOGY:
ANALYSIS OF REAL BUILDING ENERGY USE AT SCALE
(ANNEX 70)

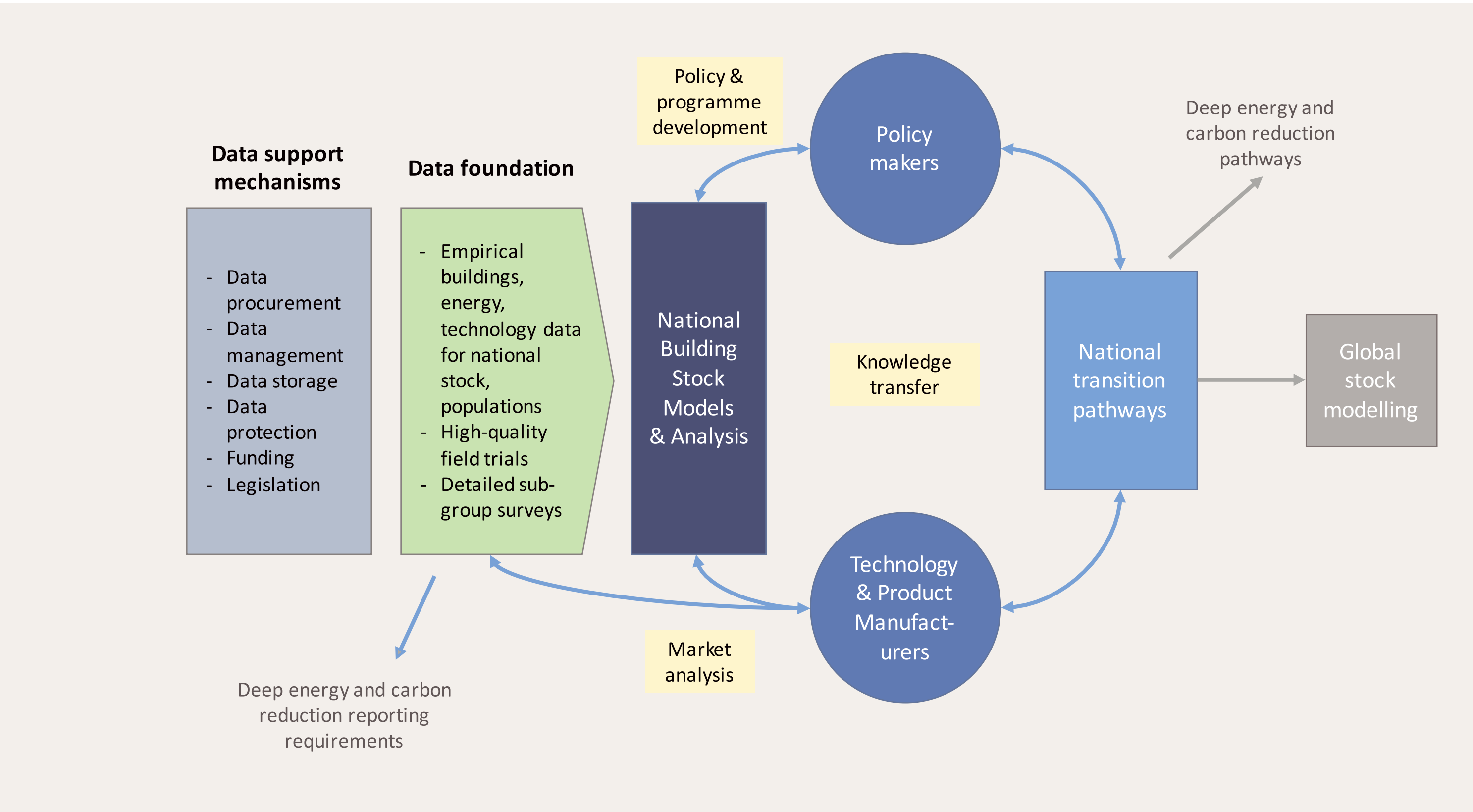
Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale

ANNEX 70

In response to concerns about climate change, energy security and social equity, governments around the world are developing plans to dramatically reduce energy demand and carbon dioxide emissions, or in the case of emerging economies to develop in less energy intensive ways. This transformation will require a raft of technology and policy interventions that, to be truly effective, will require comprehensive empirical evaluation.

The data and models to support the design, implementation and evaluation of such interventions are often absent; consequently, many policies and technologies do not deliver the anticipated impact on energy demand. The collection of, and access to, reliable building and energy use data have historically been limited due to the cost of collection and institutional or governmental structure. In addition, the importance of access to high quality data has been underestimated with an over-reliance on normative models. This situation is changing as new international agreements emerge and countries implement legislatively controlled carbon budgets.

This new project will specifically seek to support decision-makers and investors in their efforts to transform to a low carbon and energy efficient building stock by focusing on developing best practice methods for collecting, accessing, analyzing and developing models with empirical data of energy demand in buildings and communities. The project will focus on analyses of real



Idealised operation of a national building data and stock model.
Source: EBC Annex 70

building energy use at scale and the emerging field of energy epidemiology, which seeks to develop robust and multidisciplinary approaches to such analyses.

Building energy epidemiology is the study of energy demand to improve the understanding of variation and causes of difference among the energy-consuming population. It considers the complex interactions between the physical and engineered systems, socio-economic conditions, and individual interactions and practices of occupants.

The results will facilitate the use of empirical data in undertaking international energy performance comparisons, policy review exercises, national stock modelling and technology and product market assessments and impact analyses. The deliverables will promote the importance and best practices for collecting and reporting energy and building stock data.

Objectives

The purpose of the project is to support participants in the task of developing realistic transition pathways to substantial and long-term reductions in energy use and related carbon dioxide emissions associated with their buildings by:

- evaluating the scope for using real building energy use data at scale to inform policy making and to support industry in the development of low energy and low carbon solutions;
- establishing best practice in the methods used to collect and analyze data related to real building energy use, including building and occupant data;
- comparing across the national approaches to developing building stock data sets, building stock models, and to addressing the energy performance gap in order to identify lessons that can be learned and shared.

Deliverables

The main deliverables of the project will include:

- a registry on national building stock surveys and models (with actual data if available), and
- a series of best practice and information reports on international data, models and methods.

Progress

The project was formally approved in November 2015 with a one year preparation phase.

Meetings

A planning meeting was held in London, UK, in October 2015.

Project duration

2016–2019

Operating Agent

Ian Hamilton, University College London Energy Institute, UK

Participating countries (provisional)

Austria, Belgium, Canada, P.R. China, Denmark, France, Germany, Japan, New Zealand, R. Korea, Sweden, Switzerland, UK, USA

Further information

www.iea-ebc.org

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Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings

ANNEX 69

Reductions in energy use and provision of comfortable indoor environments for occupants are both key tasks for the buildings sector globally. However, establishing the appropriate balance between these often competing issues is challenging. There is now sufficient evidence to show that tight control of indoor temperatures drives high energy costs and greenhouse gas emissions, and may not always provide benefits for occupant comfort and health.

The differing concept of adaptive thermal comfort is regarded as an important advance that may play a key role in low energy building design and operation. According to

A mixed-mode building in southern China with a subtropical climate. On each floor there is a semi-outdoor platform for informal meetings.
Source: Shenzhen iBR, P.R. China

this concept, it is possible for people to achieve thermal comfort as long as indoor temperature is maintained within an acceptable and satisfactory range. That means bioclimatic resources such as natural ventilation could play a significant role in achieving thermal comfort for occupants, while simultaneously reducing energy consumption.

At present, although the adaptive effect has been recognized, the physiologically and psychologically based mechanisms of the adaptive process are still poorly understood. Adaptive responses of people in diverse climatic regions can be quite different, which may result in dissimilar building design strategies and indoor environment solutions. And, evaluation criteria for mixed-mode buildings have not yet been developed, which are actually the most common cases.

Objectives

The project objectives are to:

- establish a worldwide database with quantitative descriptions of occupant thermal adaption responses,
- develop new or improved indoor thermal environment criteria based on the adaptive thermal comfort concept,
- provide a basis for the creation of or revisions to indoor environment standards,
- propose passive building design strategies to achieve thermal comfort with low energy consumption,
- propose guidelines for using the adaptive approach in low energy building design, operation, refurbishment, and
- provide guidelines for new personal thermal comfort systems based on perceived or individual control adaptation.

Deliverables

The following project deliverables are planned:

- a database with a user interface including information on human thermal reactions together with their behaviours and the resulting energy use,
- models and criteria for the application of adaptive thermal comfort in buildings,
- guidelines for low energy building design based on the adaptive thermal comfort concept, and
- guidelines for developing personal thermal comfort systems in low energy buildings.

Progress

Commencement of the project working phase was formally approved in November 2015.

Meetings

- The 1st Experts Meeting and Open Forum took place in Eindhoven, the Netherlands, in May 2015.
- The 2nd Experts Meeting and Open Forum took place in Beijing, China, in October 2015.

Project duration
2015–2018

Operating Agent
Yingxin Zhu, Tsinghua University, China
Co-Operating Agent: Richard de Dear, Sydney University, Australia

Participating countries (provisional)
Australia, P.R. China, Denmark, Germany, Japan, R. Korea, the Netherlands, Norway, Sweden, UK, USA
Observer: Singapore

Further information
www.iea-ebc.org

Indoor Air Quality Design and Control in Low Energy Residential Buildings

ANNEX 68

Highly energy efficient residential buildings must have good airtightness, and they need to be provided with systems to ensure that the need for ventilation is met in an energy optimal way. This means that the ventilation will also need to be reduced to only the absolute minimum necessary, but without sacrificing the quality of the indoor air. So, it is important to adopt and demonstrate an integrated view about such optimization that considers the sources, sinks and transport of relevant pollutants occurring in buildings, weighed against the effects of ventilation that dilutes the pollutants.

The purpose of the project is to use and further develop data, tools and technologies, which in combination will give a new integrated description of the airflow, hygrothermal and air quality conditions in buildings. The project will develop guidelines on optimal use and operation of buildings that combine energy efficiency with healthy and comfortable indoor environments.

Objectives

The key project objectives are to:

- develop guidelines regarding design and control strategies for energy efficient buildings that will not compromise the quality of the indoor environment: operational parameters that will be dealt with will comprise of, but will not be limited to the means for ventilation and its control, thermal and moisture control and air purification strategies and how they can be optimally combined;
- set up metrics for required performance that combine the aspiration for very high energy performance with high IAQ;
- identify or further develop the tools that will assist building designers and managers to improve building energy performance and to provide comfortable and healthy indoor environments;
- gather existing or provide new data about indoor pollutants and their properties pertaining to heat, air and moisture transfer that are needed for the above analyses;
- identify and investigate relevant case studies, in which the above-mentioned performance can be examined and optimized.

Deliverables

The following project deliverables are planned:

- a guidebook on design and operation for high IAQ in energy efficient residential buildings,
- databases containing information about pollutants in buildings and their transport properties,
- a report on contemporary tools for combined prediction of IAQ and energy efficiency of residential buildings, and
- a report on documented field tests and case studies of residential buildings in which optimal combinations of high IAQ and low energy use have been pursued.

Progress

The project was formally approved in November 2015 to start a three year working phase. The project plans have been presented in relevant forums, including at the 36th AIVC Conference, held in September 2015, in Madrid, Spain. Planning of the work has begun to collect input for the definition of performance metrics in terms of indoor air pollutants and energy performance. An overview has been obtained of existing data sources regarding indoor pollutants, as well as to set specifications for possible tools to model integrated heat, air, moisture and pollutant in buildings. Themes for guidelines that should come out of the project are being discussed, and requirements for case studies are being formulated.

The demonstration building as a laboratory for High IAQ Low Energy Design, P+, in Changzhou, P.R. China. The building was designed by project participants and integrates a number of strategies, methods and technologies being studied during the project.
Source: P+ Design Group, Nanjing University and Syracuse University Center for Green Building and Urban Environment

Meetings

Preparation phase meetings to further define the project have been held in Copenhagen Denmark, in March 2015, and Madrid, Spain, in September 2015.

Project duration
2014–2019

Operating Agent
Carsten Rode, Technical University of Denmark, Denmark

Participating countries (provisional)
Austria, Belgium, P.R. China, Czech Republic, Denmark, France, Germany, the Netherlands, Norway, UK, USA

Further information
www.iea-ebc.org

Energy Flexible Buildings

ANNEX 67

The large scale deployment of renewable energy sources foreseen may seriously affect the stability of energy grids. It will be necessary to control energy consumption to match instantaneous energy production. With this objective, built-in energy flexibility in buildings may be utilized for stabilizing energy grids, allowing for a larger roll out of renewable technologies.

The energy flexibility of a building is the ability to manage its energy demand and generation according to local climate conditions, user needs and grid requirements. Energy flexibility of buildings will thus allow for demand side management and load control and thereby demand response based on the requirements of the surrounding grids. Energy flexibility may be obtained in several ways. For example, all buildings have thermal mass embedded in their constructions, which makes it possible to store a certain amount of heat. Depending on the amount, distribution, speed of charging and discharging of the thermal mass, it is possible to postpone active heating or cooling for a certain period without compromising thermal comfort in the building. And if, prior to the shutdown of the heating or cooling system, the thermal mass is pre-heated or pre-cooled, but still within the comfortable room temperature range, it may be possible to prolong the shutdown period.

Currently there is, however, no overview or insight into how much energy flexibility different building types and their usage may be able to offer to future energy systems. The aim of the project is thus to increase knowledge on and demonstrate the energy flexibility buildings can provide for energy grids, and to identify critical aspects and possible solutions to manage this energy flexibility.

In-depth knowledge of the energy flexibility that buildings may provide is important for the design of future smart energy systems and buildings. The knowledge is, however, not only important for the utilities, but is also necessary for companies when developing business cases for products and services supporting the roll out of smart energy networks. Furthermore, it is important information for policy makers and government entities involved in the shaping of future energy systems.

Objectives

The project objectives are:

- the development of common terminology, a definition of 'energy flexibility in buildings' and a classification method,
- investigation of occupant comfort, motivation and acceptance associated with the introduction of energy flexibility in buildings,
- investigation of the energy flexibility potential in different buildings and contexts, and development of design examples, control strategies and algorithms,
- investigation of the aggregated energy flexibility of buildings and the potential effect on energy grids, and
- demonstration of energy flexibility through experimental and field studies.

Deliverables

The following project deliverables are planned:

- a source book on principles of energy flexible buildings containing major findings from the project,
- terminology report with a definition of energy flexibility in buildings, indicators for characterization of energy flexibility in buildings,
- guidelines on modelling of energy flexibility in buildings,
- user perspectives report,
- control strategies and algorithms report,
- test procedures and results from laboratory and full scale tests report, and
- design examples on optimization of energy flexibility in buildings report.

Progress

The project working phase was approved in June 2015. Literature reviews are being carried out on existing terminology, definitions and flexibility indicators, on user needs, motivation and barriers and on applied and tested control possibilities. These will be concluded in 2016, with the information sourced then used to inform the project work. A common simulation exercise has also been started in 2015 to give a first impression about how to characterise energy flexibility in buildings. This consists of a preliminary characterization of energy flexibility in a single family house with a heat pump and PV systems.

Meetings

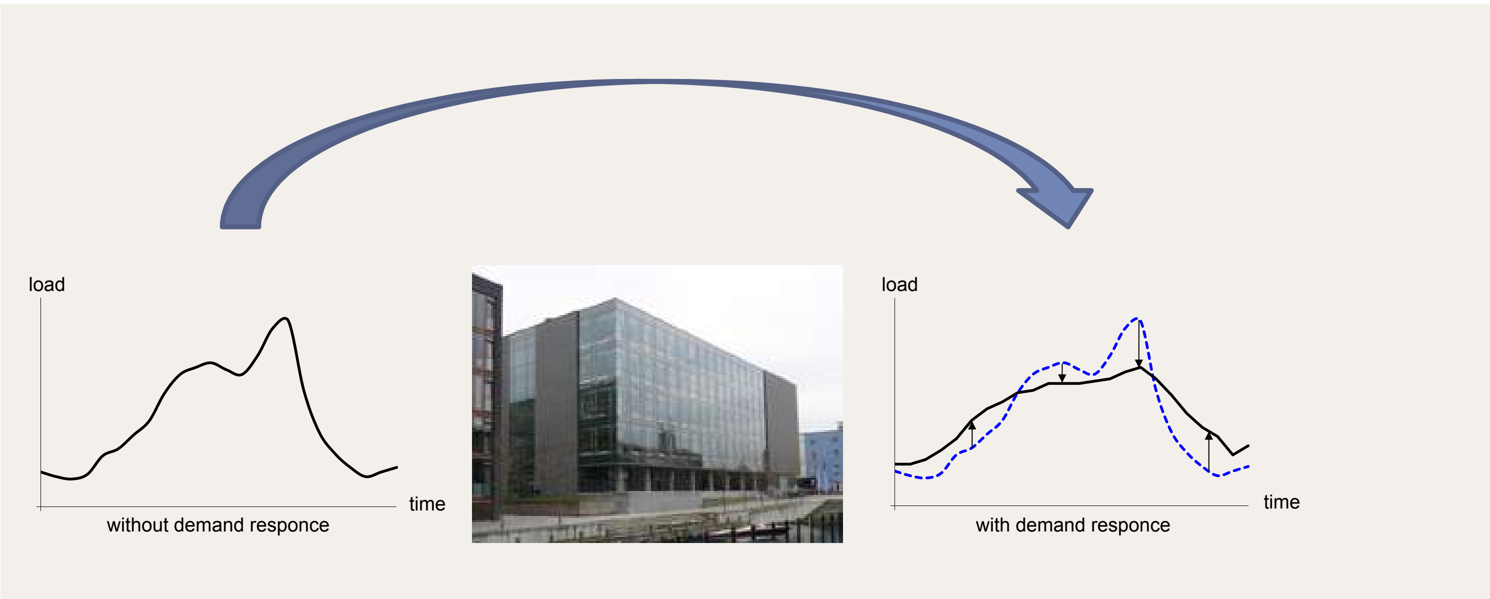
- The 2nd project definition workshop took place in Brussels, Belgium, in March 2015.
- The 1st working meeting took place in Lisbon, Portugal, in September-October 2015.

Project duration
2014–2019

Operating Agent
Søren Østergaard Jensen, Danish Technological Institute, Denmark

Participating countries (provisional)
Austria, Belgium, Canada, Czech Republic, Denmark, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Switzerland, UK
Observer: Finland

Further information
www.iea-ebc.org



The energy flexibility of a building can be applied for peak shaving, i.e. high peaks in energy demand during the day are moved to periods with low usual energy demand.
Source: EBC Annex 67

Definition and Simulation of Occupant Behavior in Buildings

ANNEX 66

Energy-related occupant behaviour in buildings is a key issue for building design optimization, energy diagnosis, performance evaluation, and building energy simulation, crucially for low energy buildings. This is due to its significant impact on real energy use and indoor environmental quality. Examples include adjusting thermostats for comfort, switching lights, opening or closing windows, pulling up or down window blinds, and moving between spaces. However, its influence is often under-recognized, or oversimplified, during design, construction, operation, or retrofit. Occupant behaviour is complex and uncertain, requiring a multi-disciplinary research approach. But, many existing studies on this topic, mainly from the perspective of sociology, have lacked in-depth quantitative analysis. Being able to model and quantify its impact on the use of technologies and energy performance is essential.

So, this project is creating a standard occupant behaviour definition platform, establishing a quantitative simulation methodology to model occupant behaviour in buildings, and is improving understanding of the influence of occupant actions on building energy use and the indoor environment. Prior to this project, the models developed by different research teams were often inconsistent, lacking consensus in terminology, in experimental design and between the methodologies. With this in mind, it is necessary to characterise and simulate occupant

Occupant behaviour research and applications.
Source: LBNL, USA

behaviour in a consistent and standardised way. The intention is to provide scientific descriptions and a clear understanding of energy-related occupant behaviour in buildings, as well as research methodologies and simulation tools, and thus to assist with improved building design, operation, and energy technologies evaluation.

Objectives

The overall project objective is to address the following fundamental research question: How should quantitative descriptions of occupant behaviour be developed in order to analyse and evaluate its impact on building energy consumption? The specific objectives to address energy-related occupant behaviour in buildings are to:

– identify quantitative descriptions and classifications, develop adequate calculation methodologies, implement models with building energy simulation tools, and
– demonstrate models in building design, evaluation and operation optimization by case studies.

Deliverables

The following project deliverables are planned:

– a standard definition and simulation methodology for occupant presence and movement models,
– guidelines for behavioural data collection using systematic measurement, modelling and validation approaches,
– an occupant behaviour 'XML schema', with a software module that can be integrated within building energy modelling programs, a software developers guide, and sample computer codes to demonstrate the use of the schema and module,
– a report on the methodologies to develop and validate occupant behaviour models, and
– a report on the application of occupant behaviour models.

Progress

An occupant behaviour literature database referencing almost 500 publications has been developed and published at the project website. Moreover, a new simulation tool with detailed consideration of occupant behaviour has been developed. This will help to achieve better accuracy in building simulation in comparison with actual building performance. Sociologists and psychologists have also strengthened the project's theoretical principles based on their own research findings. Two open forums took place in 2015, in which representatives from industry shared information about their own related work, and who explained how research outcomes from this project will be applied. Co-ordination with ASHRAE is also helping to integrate project outcomes into their standards, guidelines, and research projects. Significantly, a special issue of Energy and Buildings was published in 2015, which contains seven articles on advances in occupant behaviour modelling and simulation originating from this project.

Meetings

– The 1st Open Forum and Experts Meeting took place in Berkeley, USA, in March 2015.
– The 2nd Open Forum and Experts Meeting took place in Karlsruhe, Germany, in August 2015.

Project duration
2013–2017

Operating Agent
Da Yan, Tsinghua University, P.R. China, and
Tianzhen Hong, Lawrence Berkeley National Laboratory, USA

Participating countries
Austria, Canada, P.R. China including Hong Kong S.A.R., Denmark, Germany, Italy, R. Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, UK, USA
Observer: Hungary, Poland

Further information
www.iea-ebc.org

Long-Term Performance of Super-Insulating Materials in Building Components and Systems

ANNEX 65

Most of the energy savings in new buildings in certain industrialised countries have been achieved by an improvement of airtightness and increasing of envelope thermal insulation levels, while renewable energy supplies have contributed to energy production with less carbon dioxide emissions. Yet new buildings represent only a small part of the total building stock, typically adding less than 1% each year. Therefore, renovation is of the utmost importance for buildings sector to reduce energy use.

Among the available renovation solutions, increasing thermal insulation and airtightness can appear to be the most suitable. Moreover, it may seem that these technologies are already well developed and many insulating materials are available on the market. However, these renovation solutions are still limited by various challenges. Installing even high performance thermal insulation often does not attain the expected performance due to thermal bridges commonly occurring around windows reveals, balconies, and terraces. And the refurbishment of metropolitan apartments, for example, may be not economically feasible, because reducing the floor area by installing internal insulation may also reduce the return on total capital investment by the owner. In addition, when particular traditional insulating materials are used, they can increase fire risk due to increased flammable mass in external walls.

Currently, there are two novel insulating materials now on the market:

- vacuum insulation panel (VIP) products, and
- advanced porous materials (APM), such as aerogels and porous silica.

These new materials are known as super-insulating materials (SIMs). While the number of manufacturers is growing, this is still a niche market, but which is spreading globally. Furthermore, SIMs have reached a sufficient level of quality to be trust by customers for specific applications under well-defined conditions. However, there is still a need for design and calculation methods,

Aerogel mats installed in a single house to avoid thermal bridges.
Source: Agence ARC Urbanisme and Architecture and ISOLProducts SAS

testing and assessment procedures to characterize the suitability of new SIMs for wider applications in practice. Actually, overall performance and durability of SIMs must be investigated when the operating conditions are more severe (high temperature, high humidity, under deformation, and so on). Furthermore, guidelines for design, installation and inspection must be also provided.

Objectives

The project objectives are to:

- understand the state-of-the-art on the development of SIMs and their applications in the buildings sector,
- develop experimental and numerical tools to provide reliable data (properties and durability) for the supply chain,
- produce guidelines for design and secure installation of components and systems including SIMs, especially for retrofitting,
- support standardization and assessment procedures, and
- extend end user knowledge and increase their confidence in using SIMs by applying sustainability analysis.

Deliverables

The following project deliverables are planned:

- a report on the state-of-the-art for SIMs, components and systems integrating them with relevant case studies,
- scientific information on how to assess SIMs through reliable testing and ageing methods,
- guidelines for design, installation and inspection based on case studies, and
- a report on sustainability aspects of SIMs.

Progress

In 2015, an initial draft of the state-of-the-art report has been completed, with case studies selected, and development of guidelines for design, installation and inspection has continued. A review of experimental facilities has also been finished, confirming that the laboratories can measure thermal conductivities with different methods and some of them are able to characterise material microstructures. In the past year, industry partners have supplied samples for life cycle assessment, which were sent anonymised to the testing laboratories. Unfortunately, there were some difficulties in defining a testing procedure for VIP films. Although the methodology for life cycle assessment is well defined, gathering data from industry has proved difficult.

Meetings

- The 2nd project meeting and the 1st Plenary Meeting took place in Munich, Germany at FIW, in February 2015.
- A special session was organised during the IBPC Conference in Torino, Italy in June 2015.
- The 3rd project meeting and the 2nd Plenary Meeting took place in Nanjing, China, in September 2015, in connection with the IVIS2015 (International Vacuum Insulation Symposium).
- A special session was organised during the Advanced Building Skins Conference in Bern, Switzerland, in November 2015.

Project duration
2013–2017

Operating Agent
Daniel Quenard, CSTB, France

Participating countries
Belgium, Canada, P.R. China, France, Germany, Italy, Japan, R. Korea, Norway, Sweden, Switzerland
Observers : Greece, Israel

Further information
www.iea-ebc.org

LowEx Communities – Optimised Performance of Energy Supply Systems with Exergy Principles

ANNEX 64

The buildings sector in industrialised countries is typically characterised by large heating and cooling energy demands. This energy is commonly provided by the combustion of fossil fuels, which involves related greenhouse gas (GHG) emissions. There are still large potentials in providing heating and cooling energy with lower or without carbon dioxide emissions. At the community level, different energy sources are available that do not involve combustion processes. But these energy sources are often characterised by high fluctuations and different 'quality' or 'exergy' levels, for instance electricity (high exergy) from photovoltaic generation, or low temperature heat (low exergy, 'LowEx'), for example from solar energy, or waste heat sources. Low quality, LowEx energy sources are of particular interest, because these can supply most heating and cooling demands very efficiently.

To identify potential savings and synergies, holistic analysis of energy flows is necessary. The application of exergy analysis principles is especially important, allowing the detection of different available energy quality

Overlooking the city of Kassel, Germany
Source: © Stadt Kassel – Vermessung und Geoinformation

levels and the identification of optimal contributions to an efficient supply system. From this, appropriate strategies and technologies with great potential for the use of LowEx energy sources and a high share of renewable energy sources for heating and cooling of entire cities can be derived.

Advanced technologies have to be adapted and further developed to realise the identified potentials. An additional task is to develop and test appropriate business models for the implementation of energy systems based on LowEx principles. For this reason, it is important to demonstrate the potential of low exergy thinking on a community level, as an energy and cost efficient solution for achieving 100% renewable and GHG emissions-free energy systems.

Objectives

The project objectives are to:

- increase the overall energy and exergy efficiency of community systems,
- identify and develop promising LowEx technical solutions and practical approaches to future network management,
- identify business models for distribution and operation,
- develop assessment methods and tools for various stages of planning, and
- transfer knowledge to community stakeholders.

Deliverables

The following project deliverables are planned:

- an easy to understand, practical and applicable design guidebook for key stakeholders within communities,
- holistic balancing methods and tools to display various stages of planning and design of buildings, groups of buildings and community energy supply systems, and
- a project website and communication platform making use of local networks and energy-related associations.

Progress

In 2015 the project research was focussed on actual on-going case studies in the participating countries. The analysed studies have shown that there is certainly a potential for improving energy efficiency and GHG emissions reductions. Some of the successfully completed studies have indicated a cost reduction potential for innovative low temperature heat grid solutions for communities based on the exergy analysis approach and a carbon dioxide-free heat delivery process. The project has started to explore these case studies and their innovative approaches to community energy supply systems, with the intention of fully documenting for publication. In September 2015, a first workshop was organised in Denmark with an external industry partner from outside the actual research project. The output from this workshop was used to identify possible practical applications of the research approaches being studied.

Meetings

- The 2nd meeting for the working phase took place in Delft, the Netherlands, in April 2015.
- The 3rd meeting for the working phase took place in Vejle, Denmark, in September 2015.

Project duration
2013–2017

Operating Agent
Dietrich Schmidt and Christina Sager-Klauss, Fraunhofer Institute for Building Physics IBP, Kassel, Germany

Participating countries
Austria, Denmark, Germany, the Netherlands, Sweden, Switzerland, USA

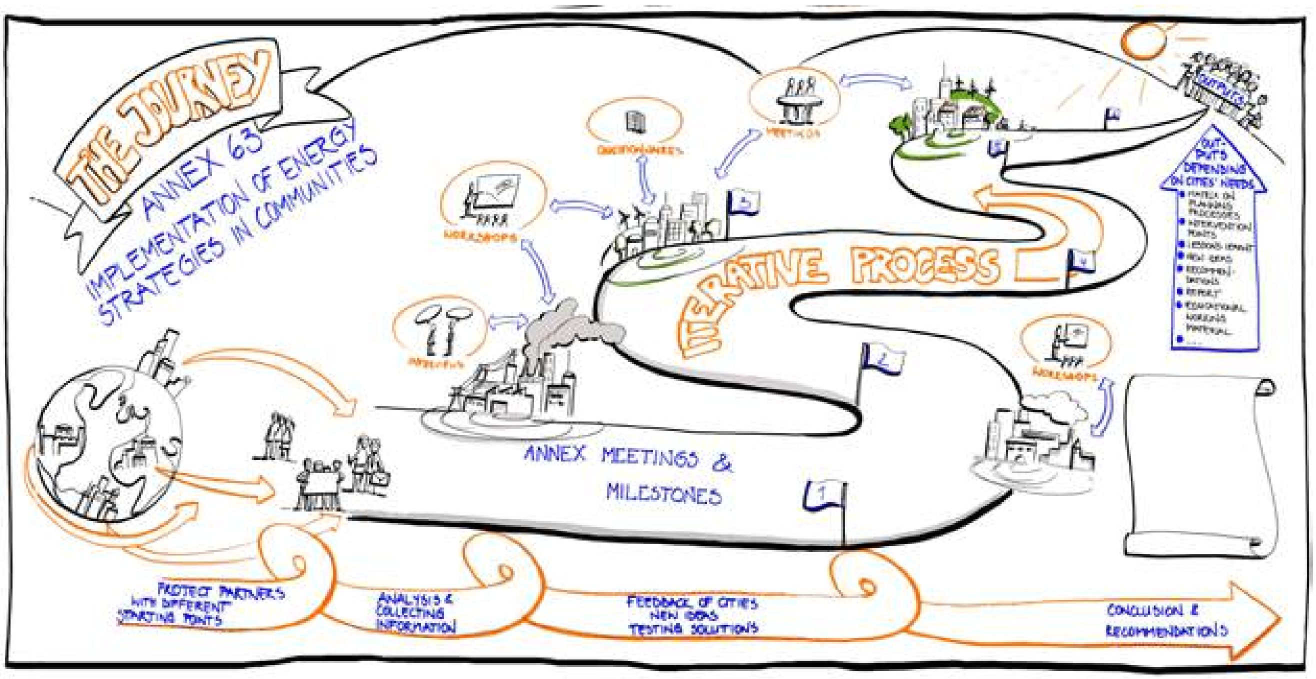
Further information
www.iea-ebc.org

Implementation of Energy Strategies in Communities

ANNEX 63

To mitigate climate change and energy shortages, a drastic reduction of both energy use and greenhouse gas (GHG) emissions is essential for largescale progress towards more sustainable cities and communities. Notably, cities consume the major part of energy production worldwide and account for a roughly equal share of GHG emissions. To achieve the global goals, it is widely accepted that due to the integrated nature of our cities, including transportation and industry, more emphasis should be placed on system wide reductions of energy demand and related GHG emissions and higher shares of renewable energy supplies. On the other hand, urban energy planning is an activity that is characterized by the presence of multiple actors with sometimes conflicting views, broad scales – both spatial and temporal – and the lack of any unequivocal solution. Barriers to reaching satisfactory solutions can be summarized in terms of categories of multi-problem statements, conflicting objectives, conflicting views, dynamic context, scientific, political and administrative complexities, multiple strategies and multiple stakeholders. Unclear or fragmented municipal strategies, missing guidance on stakeholder involvement, or focusing only on financial benefits are some of the obstacles to successful implementation of energy strategies in communities.

A problem of this kind can only be addressed by considering each aspect in an integrated way, and therefore lacks a single 'one size fits all' solution. By looking at a range of case studies, from different countries and from different perspectives, the project is developing a robust review and analysis of successful methods and approaches to overcome the challenges of urban energy planning. Early experiences in the development of net zero energy communities have revealed not only challenges, but also significant opportunities emerging,



EBC Annex 63 considered as a journey
Source: Anita Berner

including increased budgets for investments derived from energy savings, increased comfort and quality of life, and local production that boosts local economies.

Objectives

The overall objective is to develop recommendations on procedures for implementation of optimised energy strategies at the community scale. In particular, the specific objectives are to:

- develop recommendations for effective translation of a city's energy and CO_2 reduction goals to the community scale and optimisation of policy instruments for the integration of energy and CO_2 reduction goals into common urban planning processes,
- develop new techniques for stakeholder cooperation along with holistic business models involving a wide range of stakeholders,
- devise methods for monitoring and evaluation,
- involve cities and urban planners to integrate energy planning into urban planning procedures.

Deliverables

The following project deliverables are planned:

- reports on an implementation methodology for energy strategies for communities and on planning process,
- documentation of case studies,
- documentation of national workshops and involvement of cities,
- supporting material to meet cities' needs (specifications for competitions and contracts), and
- an expert group summary on recommended best practices.

Progress

Templates for an urban and energy planning processes questionnaire and for case studies were developed during 2015. By the end of the year, feedback on national planning processes from eight participating countries and 24 case studies had been received and analysed. Based on this feedback, three key intervention points for municipalities in the planning process have been identified, specifically to 'encourage' (through tools and instruments), to 'enable' (through regulations, restrictions, subsidies, financial aspects and negotiation), and to 'enforce' (through sanctions). The analyses have shown that until now 'energy' has not often been considered an issue during early planning. In general, it has emerged that linking energy planning and urban planning offers multi-dimensional challenges (multiple stakeholder groups, multiple issues and conflicting interests), and thus formulating the problem itself has been a problem. No single solution is likely to exist, so the project is developing guidance to support the problem-solving process.

Meetings

- The 2nd project meeting took place in March 2015, in Salzburg, Austria.
- The 3rd project meeting took place in October 2015, in Minneapolis, USA.

Project duration
2014–2017

Operating Agent
Helmut Strasser, Salzburg Institute for Regional Planning and Housing (SIR), Austria

Participating countries
Austria, Belgium, Canada, Denmark, France, Germany, Ireland, Japan, the Netherlands, Switzerland, USA

Further information
www.iea-ebc.org

Ventilative Cooling

ANNEX 62

One of the major challenges in highly insulated and airtight buildings is the increased need for cooling, which is not only required in summer and midseason periods, but can even be needed in winter, particularly in office buildings. Ventilative cooling refers to the use of natural or mechanical ventilation strategies to cool indoor spaces. This effective use of outside air reduces energy used by mechanical cooling, while giving a comfortable thermal environment. The most common technique is the use of increased daytime ventilation airflow rates and night ventilation, but other technologies may also be considered. Ventilative cooling can be an attractive and energy efficient passive solution to avoid overheating because:

- ventilation is already provided in most buildings through mechanical systems, or natural systems using opening windows,
- ventilative cooling can remove excess heat gains and increase air speeds, so improving the thermal environment, and
- the possibilities for using the free cooling potential of low temperature outdoor air increase considerably as cooling becomes required outside of the usual summer period.

Objectives

The project objectives are to:

- analyse, develop and evaluate suitable design methods and tools for prediction of cooling need, ventilative cooling performance and risk of overheating in buildings,
- give guidelines for integration of ventilative cooling in energy performance calculation methods and regulations, including specification and verification of key performance indicators,
- develop recommendations for flexible and reliable ventilative cooling solutions that can create comfortable indoor conditions under a wide range of climatic conditions,
- demonstrate the performance of ventilative cooling solutions through analysis and evaluation of well documented case studies.

Deliverables

The following project deliverables are planned:

- an overview and state of the art report on ventilative cooling,
- a ventilative cooling source book,
- ventilative cooling case studies,
- guidelines for ventilative cooling design, and
- recommendations for legislation and standards.

Fangxing Green Building Exhibition Center, Meixi Lake, Changsha, P.R. China. The building uses ventilative cooling though automatic window opening in mid season conditions.
Source: Liang Tang

Progress

During 2015, a state-of-the-art report was published. A number of potential ventilative cooling performance indicators for energy use, thermal comfort and indoor climate have been developed and tested on reference cases, including evaluation of their usefulness in design, compliance and monitoring. The planned outcome is several key performance indicators for use in compliance checking and design.

An analysis of the performance and functionality of existing ventilative cooling prediction methodologies (inter-method comparison) has been carried out, which has included their strengths and limitations, uncertainties, input data requirements, operator skills needed and prediction performance. The results would be used for recommendations on the use of existing analysis and prediction methods and tools at different design stages and for compliance checking.

A number of new approaches and technologies for more effective use of ventilative cooling have been under development and testing, with initial results produced.

Meetings

- The 3rd Expert Meeting took place in Changsha, China, in April 2015
- The 4th Expert Meeting took place in Boston, USA, in October 2015

Project duration
2013–2017

Operating Agent
Per Heiselberg, Aalborg University, Denmark

Participating countries
Austria, Belgium, P.R. China, Denmark, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Switzerland, UK, USA

Further information
www.iea-ebc.org

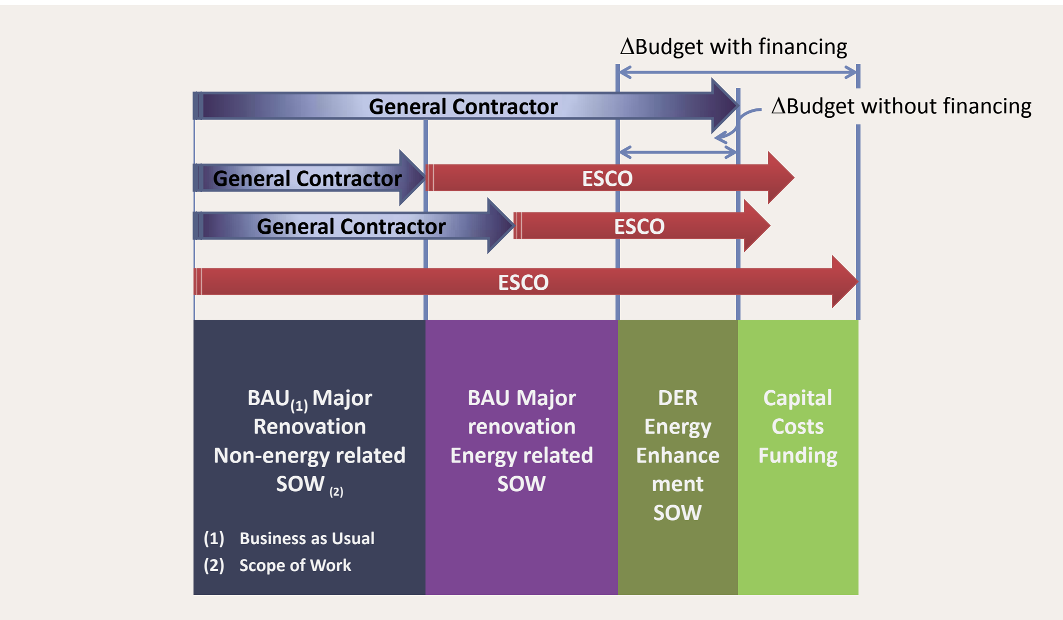
Business and Technical Concepts for Deep Energy Retrofits of Public Buildings

ANNEX 61

Many governments worldwide are setting stringent energy reduction targets for existing public buildings. However, the funding and know-how available for owner-directed energy retrofit projects have not kept pace with these new requirements. Energy use reductions typically achieved in 'business as usual' retrofit projects vary between 10% and 20% including heat and electricity. In fact, in commercial and public buildings with low internal loads, such as offices, barracks, and educational buildings, it can be reduced by at least 50%. Renovated buildings can cost effectively achieve the Passivhaus standard, or even approach net zero energy status.

The key to making deep energy retrofit (DER) cost effective on a whole life basis beyond a 50% energy reduction against the pre-renovation baseline is to ensure that its timing coincides with major renovation work to a building, which already has allocated funding to deliver minimum energy requirements. In such cases, the cost effectiveness of the additional funding for DER must be evaluated based on a bundle of core technologies and energy efficiency measures, not on each in isolation. Such a bundle could include improvements in building envelope insulation, airtightness and mitigation of thermal bridges, heat recovery, efficient lighting design and control, dedicated outdoor air systems, and the use of high performance mechanical equipment. But, achieving DER requires not only the application of a bundle of technologies and measures, but also the application of a quality assurance process that begins with project planning, and continues with integrated building design and post-construction whole building commissioning.

In terms of financing, DERs can be achieved through energy performance contracts alone when energy prices are high, when significant savings are available by implementing low-cost measures, and / or when large contributions of funds for the energy related scope of major renovation works have been budgeted for. Particularly high energy savings have been



Deep energy retrofit implementation strategies.
Source: EBC Annex 61

documented using only public funds for projects, which can be expected to achieve energy savings (site energy reductions) of up to 80%. When public funds are limited, different combinations of these two strategies can be used to achieve DER during major renovations.

To extend the scope, number and pace of DERs, this international R&D project has concluded it is necessary to combine private funding sources with major building renovations. But, private funding is not yet commonly attracted to energy efficiency works in buildings, especially DERs. This project has generated valuable data showing the cost effectiveness of DERs, which are essential for creating the necessary market confidence.

Objectives

The project objectives are to:

- provide a framework and selected tools and guidelines to significantly reduce energy use (by more than 50%) and improve indoor environmental quality in government and public buildings, and in building clusters undergoing renovation,
- research, develop, and demonstrate innovative and highly effective bundled packages of core technologies and energy efficiency measures for selected building types and climatic conditions,
- develop and demonstrate innovative, highly resource-efficient business models for refurbishing buildings and community systems using appropriate combinations of public and private funding,
- support decision makers in evaluating the efficiency, risks, financial attractiveness, and contractual and tendering options.

Deliverables

The following project deliverables are planned:

- A Prescriptive Guide to Achieve Significant Energy Use Reduction with Major Renovation Projects report
- Advanced Business Models Using Combined Public and Private Funding report
- Documented results of several realized projects and case studies demonstrating whole or a part of the developed models for deep energy retrofit using combined public and private funding.

Progress

By the end of 2015, a total of 25 case studies spanning nine countries had been collected and analyzed. Core bundles of energy efficient technologies and measures have been selected and the technical characteristics of these technologies identified through modelling and economic analysis. The results have highlighted the fabric and windows insulation levels that need to be bundled with other demand side technologies for DER in different countries and climates. Six DER pilot projects from three countries have been newly identified, monitored and their progress documented. Furthermore, reporting has been progressed, with publication of all deliverables planned for 2016.

Meetings

- An interim Experts meeting was held in Chicago, USA, in January 2015
- The 4th Experts meeting was held in Reading, UK, in April 2015.
- The 5th Experts meeting was held in St Nikolai, Austria, in September 2015.

Project duration

2012–2016

Operating Agents

Alexander Zhivov, US Army Engineer Research and Development, USA, and
Rüdiger Lohse, KEA - Climate protection and energy agency of Baden - Württemberg GmbH, Germany

Participating countries

Austria, Denmark, Germany, USA
Observers: Estonia, Finland, Latvia

Further information

www.iea-ebc.org

New Generation Computational Tools for Building and Community Energy Systems

ANNEX 60

Building and district energy system integration can significantly reduce energy use and peak power demand, while providing required indoor air quality and electrical demand flexibility for smart grid integration. This increased integration among subsystems and along the building life cycle poses, however, new challenges for building simulation programs to support decision making during product development, building design, commissioning and operation. For example, by providing electrical load shifting capabilities at time scales of hours to minutes, and fast power regulation at time scales of seconds, buildings are becoming controllable assets of the smart electrical grid that support the integration of intermittent renewable energy sources. This dynamic integration across technologies and time scales results in new functional requirements that are not addressed by existing building simulation programs.

The automotive and aerospace sectors have produced two open, non-proprietary standards, the Modelica modelling language for dynamic modelling of engineered systems, and the Functional Mockup Interface (FMI) standard to link Modelica models with those embedded in legacy tools and with control systems. This project is transferring these technologies to the buildings sector and thereby to build a foundation for new generation computing tools based on open standards. The Modelica language allows graphical 'plug and play' modelling of building systems, electrical systems, district heating and cooling networks and controls. The FMI standard and co-simulation middleware allow efficient linking of existing simulation software and the Modelica technology, while BIM allows data and process integration to support the stakeholders of the building life cycle.

Objectives

The project objectives are to develop, demonstrate and deploy next-generation computational tools that allow buildings and energy grids to be designed and operated as integrated, robust, and performance based systems.

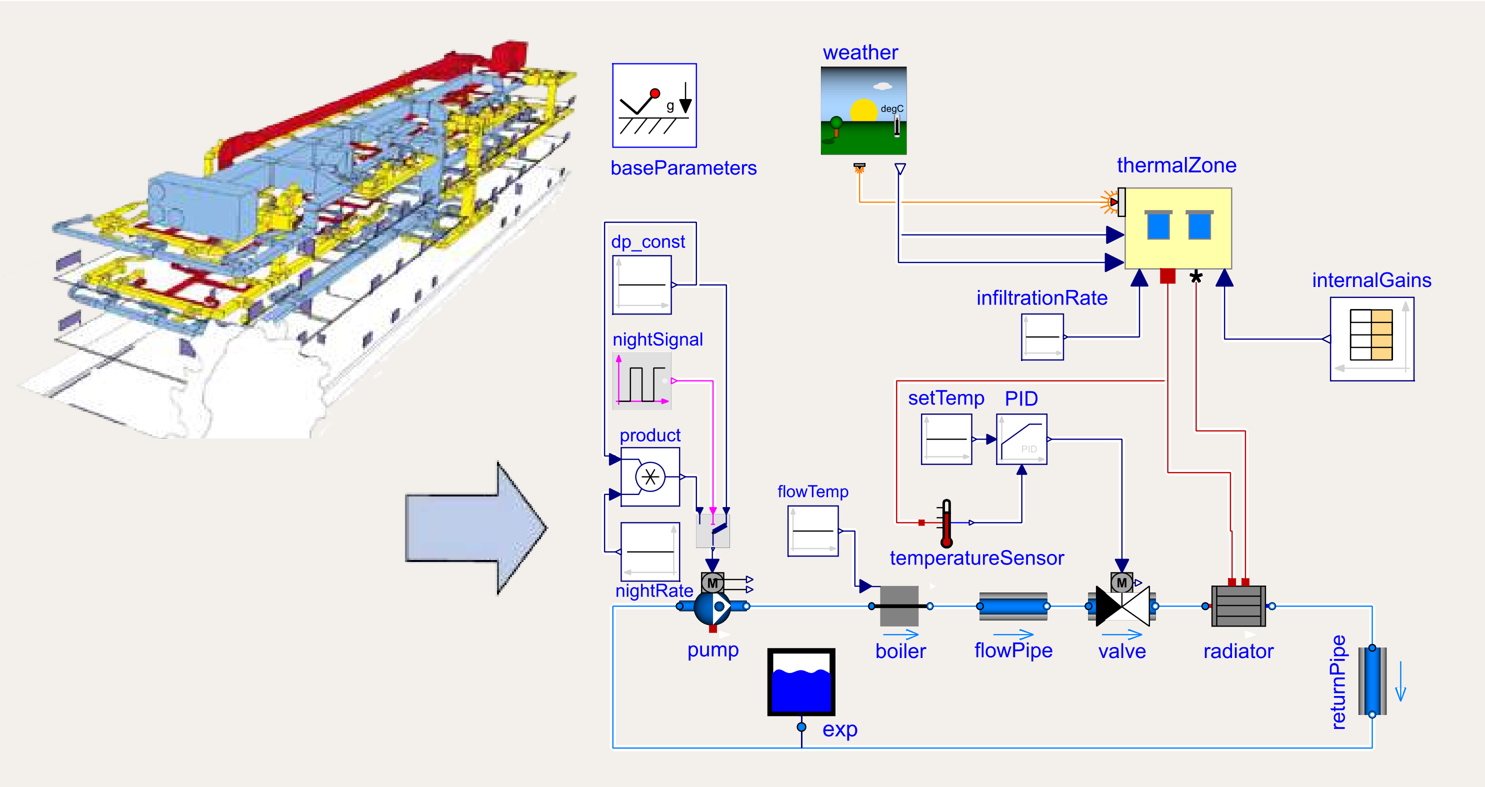
Deliverables

The following project deliverables are planned:

- validated and documented models that can be used within multiple open source and commercial Modelica simulation environments,
- case studies that demonstrate to designers the co-design of building energy and control systems taking into account system dynamics (energy storage and controls), uncertainty and variability, and
- a guidebook that will explain how these technologies can be used in applications that are beyond the capabilities of traditional building simulation programs. Applications include rapid virtual prototyping, design of local and supervisory control algorithms, and deployment of models in support of commissioning and operation.

Progress

Following shared efforts in developing, validating and documenting models, the open-source Modelica library has been further developed in 2015. It now forms the core of four existing Modelica libraries created by the project participants. Further progress has been made in efficient simulation through novel parallel computation and numerical methods, the outcomes of which have been the development of co-simulation software and a cyber-physical system simulator.



Transformation of 3D Building Information Modeling into the object oriented simulation modeling language Modelica for building and HVAC systems energy performance simulation.
Source: RWTH Aachen University

To translate information from BIM to energy performance simulation environments, testing of the BIM to Modelica translator is being carried out for six distinct applications. This software framework has supported the Modelica libraries developed within the project and is a major step towards the translation of BIM files created in the Industry Foundation Classes open data format into Modelica.

In support of district energy network simulation, in a common exercise the project is comparing the approach and accuracy of district energy network models that have been implemented by different users. This is intended to give insight into how to further develop tools needed to assess the energy performance of such systems. In addition, several case studies have been generated that use Modelica and Functional Mockup Units in real time as part of a building management system to support controls, fault detection and diagnostics algorithms.

Meetings

- The 5th expert meeting was held in Galway, Ireland, in April 2015.
- The 6th expert meeting was held in Leuven, Belgium, in September 2015.

Project duration
2012–2017

Operating Agents
Michael Wetter, Lawrence Berkeley National Laboratory, USA, and Christoph van Treeck, RWTH Aachen University, Germany

Participating countries
Austria, Belgium, P.R. China, Denmark, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland, USA
Observers: Brazil, Slovakia, United Arab Emirates

Further information
www.iea-ebc.org

High Temperature Cooling and Low Temperature Heating in Buildings

ANNEX 59

It is important to minimise temperature differences in heating, ventilation and air conditioning (HVAC) systems, because high differences result in reduced efficiencies and therefore increased energy use. This project is thus starting from a new perspective and from this is developing a new thermodynamic concept for analysing HVAC system design, so-called 'entransy', which quantifies heat transfer potential. Entransy is transported during heat transfer processes, when it also dissipates. The extent to which it dissipates is strongly dependent on temperature differences, and by minimising these, processes can be made more energy efficient. In fact, temperature differences within HVAC systems can be classified into three types, arising from:

- heat and moisture exchange,
- heat transmission through fluid media, and
- thermal mixing losses in indoor spaces due to indoor terminal devices.

High temperature cooling and low temperature heating would be achieved by reducing temperature differences in heat transfer and energy transportation processes within buildings. In depth investigations of HVAC system performance and indoor thermal environments have been conducted in the project based on a model reference office building and several real case study buildings covering different building types and climatic conditions. On-site measurements have been made for buildings adopting high temperature cooling or low temperature heating.

The beneficiaries of the outcomes will be designers and industry, including manufacturers of chillers, radiant panels and supply air terminals. The outcomes are also expected to contribute to the development of new HVAC terminal devices.

Objectives

The main project objectives are to:

- establish a methodology for analysing HVAC systems from the perspective of reducing mixing and transfer losses,
- propose novel designs for indoor terminals and novel flow paths for outdoor air handling equipment, and
- develop high temperature cooling and low temperature heating systems in buildings with fully utilized heat and cold sources, high efficiency transportation and appropriate indoor terminals.

Case study buildings with high temperature cooling and low temperature heating systems. From left: Xi'an airport Terminal 2, P.R. China; a campus building of Nagoya University, Japan; Museum of Earthquake Reduction, Japan.
Source: EBC Annex 59

Deliverables

The following project deliverables are planned:

- Guide Book of New Analysis Method for HVAC Systems,
- Demand and Novel Design of Indoor Terminals in High Temperature Cooling and Low Temperature Heating Systems report,
- Novel Flow Paths of Outdoor Air Handling Equipment and Their Application in High Temperature Cooling and Low Temperature Heating Systems report,
- Design Guide for High Temperature Cooling and Low Temperature Heating Systems report, and
- Application and Real-Time Tests of High Temperature Cooling and Low Temperature Heating Systems in Typical Buildings with Different Climate Conditions report.

Progress

In 2015, project reporting was advanced, with publication of all deliverables planned for 2016. The project has characterised temperature differences throughout HVAC systems and within the indoor spaces that they serve, and has concluded how these can be minimized to reduce entransy dissipation, so resulting in highly energy efficient buildings.

An Open Forum, 'High Temperature Cooling and Low Temperature Heating in Buildings', was held in October, 2015, at Beijing Institute of Architectural Design, P.R China. The theme of this Open Forum was the application of high temperature cooling (HTC) and low temperature heating (LTH) system in design, including HTC and LTH indoor terminals and fresh air handling. Since 2012, more than 500 projects in China adopted the idea of HTC and LTH, with 16°C - 18°C chilled water temperature and separate dehumidification equipment according to local weather conditions. The project outcomes were also presented at the 6th International Building Physics Conference on Building Physics, held in Torino, Italy in June, 2015.

Meetings

- The 8th project meeting was held in Torino, Italy, in June 2015.
- The 9th project meeting was held in Beijing, P.R. China, in October 2015.

Project duration
2012–2016

Operating Agent
Yi Jiang, Tsinghua University, P.R. China

Participating countries
Belgium, P.R. China, Denmark, Italy, Japan, R. Korea

Further information
www.iea-ebc.org

Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements

ANNEX 58

To reduce energy use, policy makers are becoming increasingly demanding about the energy performance of new and renovated buildings. With few exceptions, such requirements relate to how buildings are rated in the design phase. There is, however, significant evidence that the real as-built energy performance of buildings may deviate substantially from the theoretically designed performance. As a result, there is growing interest in full scale testing of components and whole buildings to characterise their actual thermal performance and energy efficiency.

Quantifying the actual performance of buildings, verifying calculation models and integrating new advanced energy solutions for nearly zero or positive energy buildings can only be effectively realised by in situ testing and dynamic data analysis. However, practice shows that the outcome of many on site activities can be questioned in terms of accuracy and reliability. Full scale testing requires a high quality approach during all stages of research, starting with the test environment, such as test cells or real buildings, accuracy of sensors and correct installation, data acquisition software, and so on. It is crucial that the experimental setup (for example the test layout or boundary conditions imposed during testing) is correctly designed, and produces reliable data. These outputs can then be used in dynamic data analysis based on advanced statistical methods to provide accurate characteristics for reliable final application. If the required quality is not achieved at any of the stages, the results become inconclusive or possibly even useless.

This project is therefore developing the necessary knowledge, tools and networks to achieve reliable in situ dynamic testing and data analysis methods that can be used to characterise the actual energy performance of building components and whole buildings. As such, it is not only of interest for buildings researchers and practitioners, but is also valuable for policy and decision makers, as it enables the major step to be made from (stringent) requirements on paper towards actual energy performance assessment and quality checking. Furthermore, it will be possible with the developed methodology to characterise the dynamic behaviour of buildings, which is a prerequisite to optimise smart energy and thermal grids. Finally, the project has developed a data set to validate numerical building energy simulation models.

Objectives

The project objectives are to develop:

- common quality procedures for dynamic full scale testing to realise better performance analysis, and
- models to characterize and predict the effective thermal performance of building components and whole buildings.

Deliverables

The following project deliverables are planned:

- a report on the state of the art of full scale testing and dynamic data analysis, including a survey of existing full scale test facilities for the benefit of the building industry, engineers and consultants,
- a decision tree to guide people in choosing the correct (full scale dynamic) test and method to characterise a certain performance,
- a description of the methodology to perform dynamic data analysis and performance characterisation, intended for the building research and associated communities, combined with practical guidelines based on the lessons learned from the common exercises within the project,
- a few, well-documented dynamic data sets that can be used for developing dynamic data analysis procedures and for validation purposes, aimed at software developers and the building research community, and
- a synthesis report, demonstrating the applications of the developed framework, intended for building designers and industry, government and other public authorities.

Progress

First drafts of the project reporting deliverables have been developed during 2015. A decision tree to guide and optimise full scale testing has been developed and published. Also, a detailed full scale dynamic test was performed on a test house and the data arising have been made available for the validation of common building energy simulation models.

Meetings

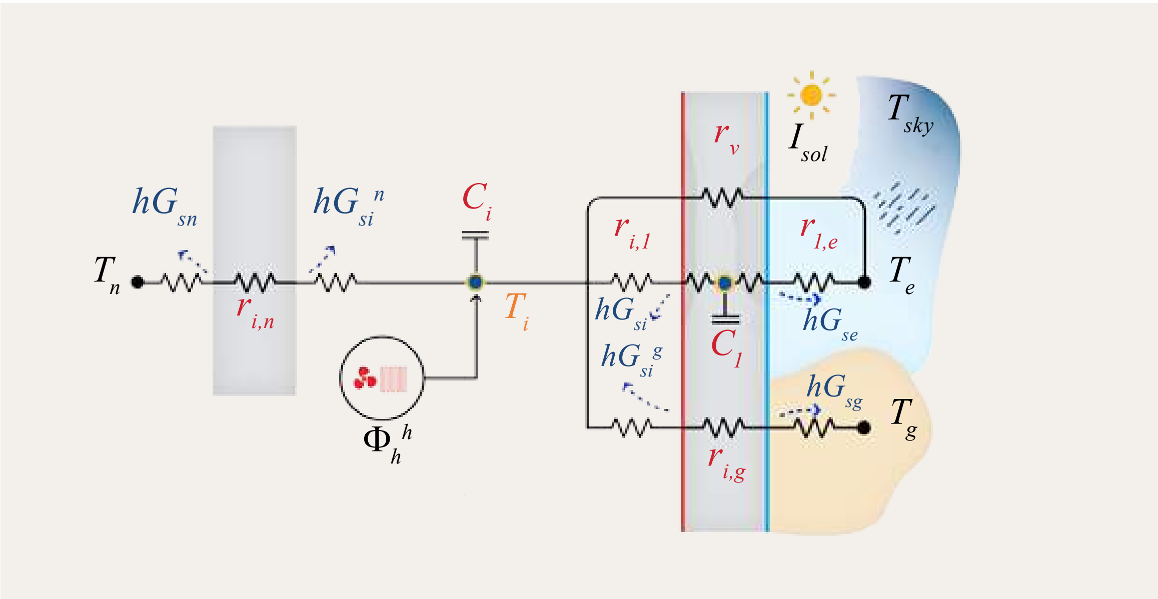
The final expert meeting took place in Prague, Czech Republic in April 2015.

Project duration
2011–2016

Operating Agent
Staf Roels, University of Leuven, Belgium

Participating countries
Austria, Belgium, P.R. China, Czech Republic, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, UK, USA
Observer: Finland

Further information
www.iea-ebc.org



Modelling buildings as 'reduced-order systems' to characterise the effective heat storage capacity (analogous to electrical capacitance), solar aperture and overall heat loss coefficient of the building. Source: KU Leuven

Evaluation of Embodied Energy and Carbon Dioxide Equivalent Emissions for Building Construction

ANNEX 57

Construction-related embodied energy and carbon dioxide emissions account for more than 20% of global energy use and carbon dioxide emissions. To address this concern, this project is examining embodied energy (EE) and carbon dioxide equivalent emissions (EC_{eq}) reduction methods with the aid of more than 160 case studies.

As a common method for achieving longer building lifespan in Japan, for example, the thickness of concrete surrounding reinforcement (reinforcing bars) is increased and the seismic resistance levels are elevated by 25% to 50% above the minimum criteria. In this way, the resulting buildings have lifespans twice as long as standard buildings and the annual EE-EC_{eq} is reduced by 45%. The additional investment required for this purpose represents only around 3% to 9% of the construction costs, and therefore, significant economic effects can last throughout the life cycle.

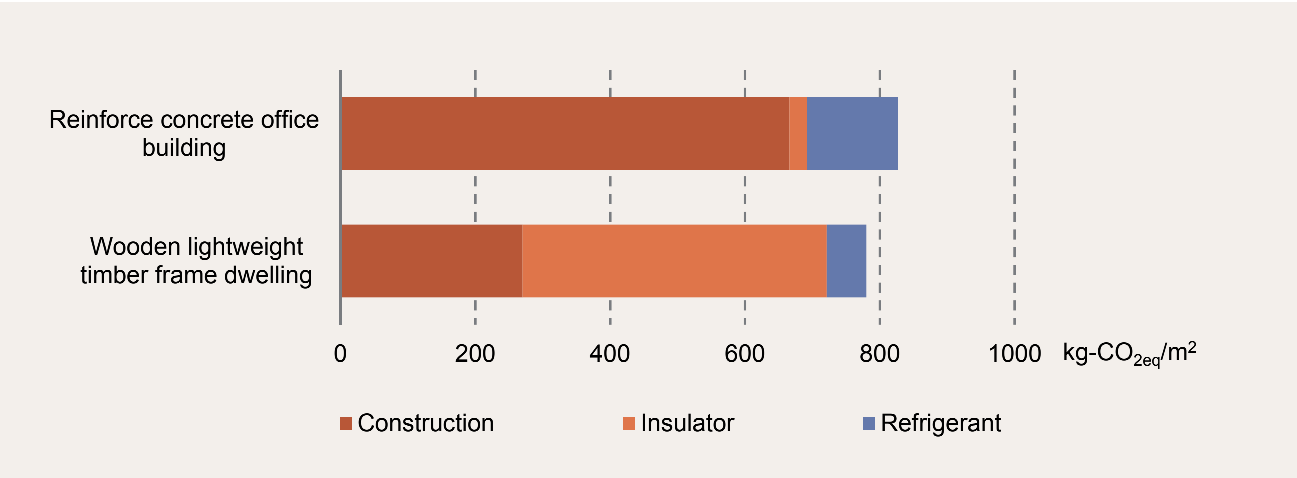
By selecting thermal insulants containing no chlorofluorocarbons (CFCs) and refrigerants with low global warming potential, the global warming effect caused by housing construction can be reduced by as much as 65%. But, in many regions, reduced use of CFCs alone is not sufficient, so it is necessary to also actively promote the implementation of other technologically and economically feasible measures. Examples of other effective measures include:

– recycling of the steel waste produced by building demolition (at end of use),
– reuse or thermal recycling of the wood waste produced by demolition (at end of use), and
– achieving a longer use of concrete by developing high-strength concrete.

These are expected to have significant effects on EE-EC_{eq} reduction in the future.

Overall the project has concluded that EE-EC_{eq} can be effectively reduced by means such as:

– realization of long-lasting buildings,
– no use of CFCs within thermal insulants or as refrigerants,
– reuse and recycling, and
– use of high-strength concrete.



An example of construction-related equivalent carbon dioxide emissions for a reinforced concrete office building and a wooden lightweight timber frame dwelling.
Source: EBC Annex 57

Long-life and low carbon office (Japan)		
	Standard	Resilient
Reference period (years)	50	100
EC (kg-CO_2/m^2 year)	22	12

The strength of the structure was increased by 30% to be more resistant to earthquakes. This reduced EC due to longer service life, effectively cutting down the annual EC by about 40%.

An example of one of the case studies analysed in the project.
Source: EBC Annex 57

These are feasible approaches from both technological and cost perspectives, and so are recommended for implementation through public policy.

Objectives

The project objectives are to:

- collect existing research results concerning EE-EC_{eq} to summarize them into a state of the art report,
- develop methods for evaluating EE-EC_{eq} resulting from building construction, and
- develop measures to design and construct buildings with reduced EE-EC_{eq}.

Deliverables

The following project deliverables are due to be published:

- Final Project Report, including case studies from individual countries,
- Guidelines for Building Designers and Consultants, Policy Makers, Construction Product Manufacturers, Procurers and Educators, and
- Project Summary Report, outlining the technical and policy-relevant output from the project.

Progress

The project is nearing completion of the Final Report, Summary Report and Guidelines, with publication planned for 2016. Further to this, four papers related to the project have published in an academic journal in USA. The preliminary projects results were presented during a special session, 'More than just embodied energy?', held during the Vienna Congress on Sustainable Building, in February 2015. The aim of this session was to discuss the project's activities and to collect external feedback about the work. As part of this session, standards, methods and experiences with the assessment of embodied energy impacts during the design process were explained and successful examples from Germany, Switzerland and Austria were presented.

Meetings

- The 8th expert meeting took place in Venice, Italy, in April 2015.
- The 9th expert meeting took place in Zurich, Switzerland, in October 2015.

Project duration
2011–2016

Operating Agent
Tatsuo Oka, Utsunomiya University, Japan

Participating countries
Australia, Austria, P.R. China, Czech Republic, Denmark, Germany, Italy, Japan, R. Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA
Observer: Brazil, Finland, Poland

Further information
www.iea-ebc.org

Cost Effective Energy and Carbon Dioxide Emissions Optimization in Building Renovation

ANNEX 56

While new buildings with high energy performance are becoming routinely technologically attainable, large scale improvement of existing buildings to similar levels of performance has proved difficult to trigger. Repeatedly, because of the high investment costs, the chosen renovation option is a solution that only improves building aesthetics and restores functionality. From a long term perspective however, this reduced initial investment in the renovation works usually results in a more expensive process from a life cycle cost perspective.

Although existing buildings have their own physical constraints, achieving significant reductions of energy consumption and carbon dioxide (CO_2) emissions does not always require a highly efficient solution for the envelope, which usually involves complex construction works that discourage the owners. In fact, the use of renewable energy sources harvested on site may also foster the reduction of non-renewable energy consumption and CO_2 emissions.

In this context, the main challenge of this project is to understand how far it is possible to reach with energy efficiency measures, and when starting to use renewable energy produced on site becomes more cost-effective. The identification of this transition point involves not only evaluating and assessing energy renovation activities according to their cost effectiveness and optimizing the energy use and CO_2 emissions reduction, but also considering the overall added value achieved in the renovation process.

The methodology developed within this project provides the basis for the assessment and evaluation of packages of renovation measures that are intended to improve the energy performance of existing residential buildings. It has been tested in a number of relevant buildings from the participating countries and allows for the possibility of exceeding the cost-optimal reduction of energy and CO_2 emissions by considering co-benefits and overall added value achieved in the renovation process. The methodology also includes a framework for the integration of embodied energy use in the life cycle impact assessment.

Objectives

The project objectives are to:

- define a methodology for establishing cost optimized targets for energy consumption and CO_2 emissions in building renovation,
- clarify the relationship between CO_2 emissions and energy targets and their eventual hierarchy,
- determine cost effective combinations of energy efficiency and renewable energy supply measures,
- highlight the relevance of additional benefits achieved in the renovation process,
- develop or adapt tools to support decision makers in accordance with the developed methodology,
- select exemplary case studies to encourage decision makers to promote efficient and cost effective renovations, and
- develop guidelines, specifically targeted to policy makers and to professional owners to support their actions in energy and CO_2 emissions related activities, based on the project findings.

Deliverables

Supported by a dedicated website and bi-annual newsletters, the following deliverables are already available or are close to publication:

- methodology report on Cost Effective Energy and Carbon Emissions Optimization in Building Renovation,
- report on Parametric Calculations and Trade-off Analyses for the Assessment of the Impacts of Energy Related Building Renovation Measures,
- report on the Integration of LCA into the Assessment of Renovation Measures and Demonstration of the Relevance of LCA for the Assessment of Building Renovation,
- report on Co-Benefits of Building Renovation,

- Decision making tools,
- 'Shining Examples' brochure,
- report on Detailed Case Studies,
- User Acceptance Issues Literature Review report,
- Renovation Guidebook for Policy Makers,
- Renovation Guidebook for Professional Owners.

Progress

During 2015, the 'Methodology Report on Cost Effective Energy and Carbon Emissions Optimization in Building Renovation' was published. The remaining deliverables are due to be published in 2016. For dissemination of results and findings, the project organised a dedicated session during the '6th International Building Physics Conference on Building Physics for a Sustainable Built Environment', held in Torino, Italy, in June 2015 and convened the final project international workshop, 'How to achieve the best performance in the renovation of existing buildings (lower energy consumption, lower CO_2 emissions, higher added value) with minimal effort (investment, workload, intervention in the building, hassle of residents)?', in Porto, Portugal, in September 2015.

The use of the methodology developed by the project based on several representative residential buildings in the participating countries has allowed the conclusion to be drawn that it is essential to explore the full potential of cost-effective energy related renovation measures. In addition, the shift to renewable energy sources would not interfere in the cost effectiveness of the renovation solution for the building envelope. Furthermore, the same analysis has showed that the inclusion of embodied energy in materials in the assessment of the buildings energy performance has increasing impacts on the environmental performance of highly-efficient insulation measures. But, in renovation processes these impacts are low and play a much smaller role than in the construction of new buildings. These conclusions have led to specific recommendations about the depth of building envelope interventions and the use of renewable energy sources, which have been included in the Renovation Guidebooks targeted to policy makers and building owners.

Meetings

- The 8th project meeting took place in Lund, Sweden in March 2015.
- The 9th project meeting took place in Porto, Portugal in September 2015.

Project duration
2010–2016

Operating Agent
Manuela Almeida, University of Minho, Portugal

Participating countries
Austria, P.R.China, Czech Republic, Denmark, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland
Observer: Finland

Further information
www.iea-ebc.org

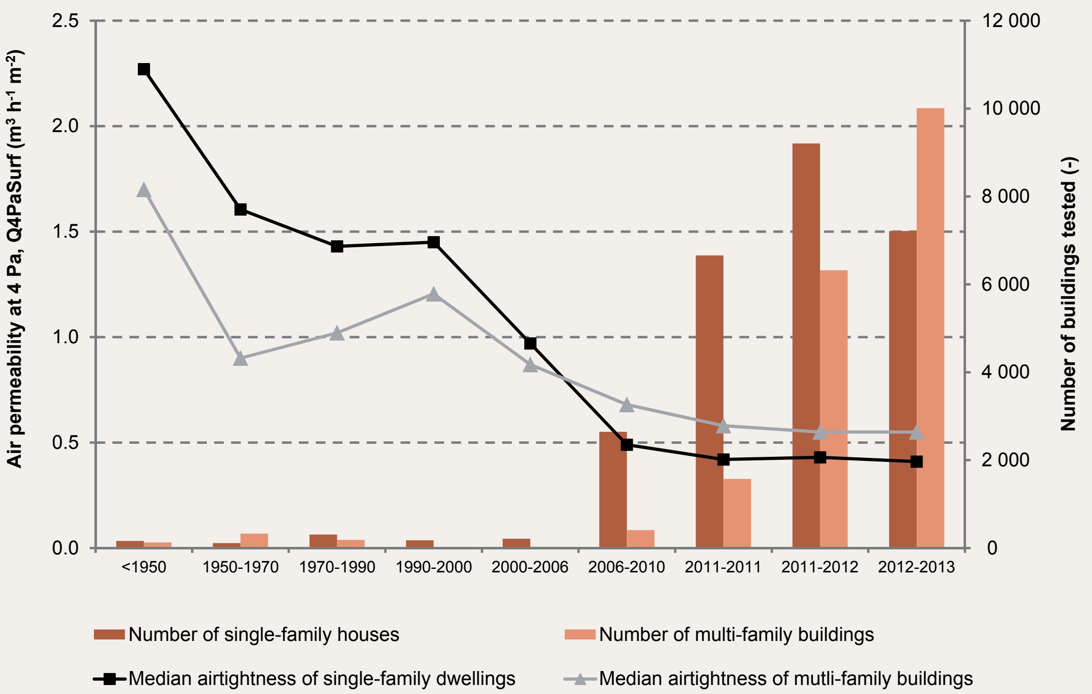
Air Infiltration and Ventilation Centre

ANNEX 5

The primary objective of the Air Infiltration and Ventilation Centre (AIVC) is to provide reliable reference information on research and development in the fields of air infiltration and ventilation, which are key aspects to achieve healthy and comfortable nearly zero energy buildings. This EBC information centre was inaugurated in 1979 and from then onwards has produced a number of landmark reports and guides, in addition to organising events such as the annual AIVC conferences, thematic workshops and webinars. Since 2011, AIVC activities have been structured around 'projects', integrating activities and products such as webinars, workshops, position papers, technical papers, and so on. The full AIVC project list is available at the website.

In relation to airtightness and ventilative cooling, the AIVC has joined forces with two other information platforms, TightVent and venticool. TightVent is focusing on airtightness of buildings and ductwork and was launched in January 2011. Venticool is focusing on ventilative cooling and was launched in September 2012. The main goals of TightVent and venticool are to:

- raise awareness of airtightness and ventilative cooling issues respectively, which are relevant concerns for a wide range of buildings and may even be critical in nearly zero energy buildings, and
- provide appropriate support tools and knowledge transfer to ease market transformation.



Evolution of air permeability of French residential buildings and the number of buildings tested from before 1950 until 2013.
Source: '6 years of envelope airtightness measurements performed by French certified operators: analyses of about 65 000 tests', A. Bailly, G. Guyot and V. Leprince, 36th Annual AIVC Conference Proceedings, 2015

PROGRESS

In 2015, AIVC focussed on two projects, a workshop on quality and compliance issues, the 36th AIVC Annual Conference and support to and dissemination for EBC Annex 62, 'Ventilative Cooling' and EBC Annex 68, 'Indoor Air Quality Design and Control in Low Energy Residential Buildings'.

The first AIVC project, 'Competent tester schemes for building airtightness testing' is being run in collaboration with TightVent. This has produced several papers that have been presented both at the AIVC workshop and conference held in 2015 with particular attention to data collection and analysis in these schemes. The outcomes from the second AIVC project 'Residential Ventilation and Health' have been reported in a book on residential ventilation and health. This book was peer reviewed, and with the support of the Indoor Environmental Quality Alliance, is planned to be published as an AIVC Technical Note in 2016.

In 2015, the 36th AIVC Annual Conference was held in Madrid, Spain. This has once again provided an opportunity for about 160 researchers and practitioners from around the world to exchange ideas and to present their latest findings, including in the field of policy and standard development. The AIVC supported EBC Annexes 62 and 68 by holding specific sessions during this conference, enabling these projects' participants to discuss their approaches and findings with a wider audience. The AIVC also contributed to the organization of two webinars on ventilative cooling.

Website

The search engine for the AIRBASE bibliographic database now contains nearly 22000 references and 15000 full documents (PDFs), which is an increase of more than 5000 documents compared with 2014.

NEW PRODUCTS

AIVC Conference Proceedings

36th Annual Conference, 'Effective ventilation in high performance buildings', held on 23rd - 24th September 2015, in Madrid, Spain

AIVC Newsletter

- March 2015
- September 2015

OTHER EVENTS

'Voluntary and Regulatory Frameworks to Improve Quality and Compliance of Ventilation and Airtightness', workshop held in March 2015, in Lund, Sweden (co-organised with QUALICHeCK, TightVent and venticool)
'Ventilative cooling potential and compliance in Energy Performance regulations', a webinar series with status and perspectives from various countries (in cooperation with EBC Annex 62, venticool, and QUALICHeCK), held in December 2015

Project duration
1979–present

Operating Agent
Peter Wouters, INIVE eeig, Belgium

Participating countries
Belgium, Czech Republic, Denmark, France, Germany, Italy, Japan, R. Korea, the Netherlands, New Zealand, Norway, Spain, Sweden, UK, USA
Observers: Greece, Finland, Poland

Further information and reports
www.iea-ebc.org
www.aivc.org

Completed Research Projects

ELIABILITY OF ENERGY EFFICIENT BUILDING RETROFITTING – PROBABILITY ASSESSMENT OF PERFORMANCE AND COST (ANNEX 55)

Reliability of Energy Efficient Building Retrofitting – Probability Assessment of Performance and Cost

ANNEX 55

Nowadays, building energy use and durability issues are some of the most important topics in industrialised countries. Even though considerable progress has been achieved concerning new buildings (low energy, passive houses, zero energy) and advanced building services, the buildings sector still generally accounts for the largest share of energy-related carbon dioxide emissions. While in many industrialised countries, new buildings are constructed every year corresponding to approximately 1% of the existing building stock, commonly more than 50% of the building stock dates from before the first energy crisis in the 1970s. Hence, a large potential for energy savings and consequently carbon dioxide emissions reduction is presently available in the existing building stock.

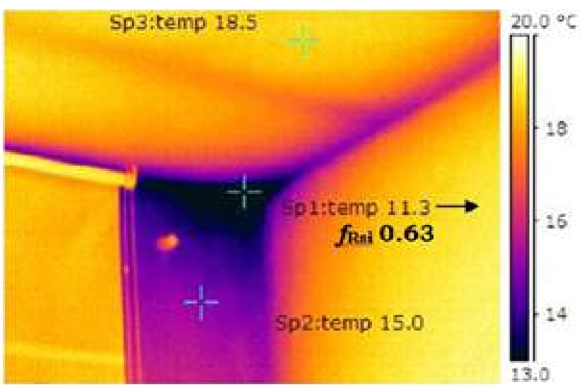
Retrofit measures are therefore of the utmost importance for upgrading the building stock. But, many building owners are only interested in the initial capital cost. Looking at the risks associated with the actual performance of such measures and the costs incurred highlights the need for life cycle thinking. So, applicable calculation methods are required in this area. For this purpose, probability assessment in life cycle costing of solutions supports sound decision making relating to investments. For industry, customer relationships are based on future expectations and confidence. These need to be supported by proper probability assessments.

The project has significantly improved methods and tools for integrated evaluation and optimization of retrofitting measures, including energy efficiency, life cycle cost and durability. For decision makers, designers and practitioners, it has demonstrated the benefits of the renewal of the existing building stock and how to create reliable solutions.

Achievements

The project has delivered decision support data and has developed tools for evaluating energy retrofitting measures, focussing on residential building envelopes. These tools have been based on probabilistic methodologies. The main results of such probabilistic risk assessments are probabilities or likelihoods, i.e. quantities that show how many out of all the possible cases do or do not meet the desired performance.

A complete probabilistic assessment is an iterative process, usually beginning with the application of qualitative methods and progressing to quantitative methods, if necessary and appropriate. If a quantitative analysis of building envelope performance is to be



Visible mould growth at the corners of a building envelope, possibly caused by a thermal bridge.
Source: Framework for Probabilistic Assessment of Performance of Retrofitted Building Envelopes report, EBC Annex 55

carried out, a numerical model of the building envelope must initially be established. With the numerical model created and the supporting data assembled, calculations can be made to estimate the spread in performance and to identify any critical conditions or events. Ultimately, the results of the numerical analyses should be compared with the retrofit targets (also known as performance criteria) allowing the identification of optimal retrofitting techniques.

To inspire the application of probabilistic assessment by others, the following examples of retrofit cases have been investigated in the project:
- performance of a timber framed wall with additional insulation placed on the inside of the wall,
- thermal comfort in an office after window retrofit,
- performance of a massive brick wall with additional insulation placed on the inside of the wall,
- performance of concrete walls with additional insulation placed on the inside of the wall, and
- hygrothermal conditions in cold attic spaces.

Specifically, the project has:
- developed and validated probabilistic methods and tools for prediction of energy use, lifecycle cost and functional performance based on assessment of energy retrofitting measures,
- applied and demonstrated probabilistic methodologies on real life case studies to enhance energy savings, secure performance and apply cost analyses, and
- created guidelines for practitioners, including assessment of common retrofitting techniques.

Publications

The key deliverables resulted from the project are the following publications:
- Stochastic Data report,
- Probabilistic Tools report,
- Framework for Probabilistic Assessment of Performance of Retrofitted Building Envelopes report,
- Practice and Guidelines report, and
- Guidelines for How to Use the Developed Framework for Practitioners report.

Project duration
2010–2015

Operating Agent
Carl-Eric Hagentoft, Chalmers University of Technology, Sweden

Participating countries
Austria, Belgium, Denmark, Germany, the Netherlands, Portugal, Sweden, UK, USA
Observers: Brazil, Estonia, Slovakia

Further information
www.iea-ebc.org

External view of a case study building before renovation (left), and junction of the external walls at the installed ceiling of a cellar as a photograph (middle) and a thermal image (right).
Source: Framework for Probabilistic Assessment of Performance of Retrofitted Building Envelopes report, EBC Annex 55

Background Information

EBC and the IEA

THE INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster cooperation among the twenty eight IEA member countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D). The current framework for international energy technology RD&D cooperation was approved by the IEA's Governing Board in 2003. More information about the energy technology RD&D framework can be found at: www.iea.org/techinitiatives.

This framework provides uncomplicated, common rules for participation in research programmes, known as 'Implementing Agreements', and simplifies international cooperation between national entities, business and industry. Implementing Agreements are legal agreements between countries that wish to pursue a common programme of research in a particular area. In fact, there are now over 40 such programmes. There are numerous advantages to international energy technology RD&D collaboration through the IEA Implementing Agreements, including:

- Reduced cost and avoiding duplication of work
- Greater project scale
- Information sharing and networking
- Linking IEA member countries and non-member countries
- Linking research, industry and policy
- Accelerated development and deployment
- Harmonised technical standards
- Strengthened national RD&D capabilities
- Intellectual property rights protection

ABOUT EBC

Approximately one third of primary energy is consumed in non-industrial buildings such as dwellings, offices, hospitals, and schools where it is utilised for the heating and cooling, lighting and operation of appliances. In terms of the total energy end-use, this consumption is comparable to that used in the entire transport sector. Hence the building sector represents a major contribution to fossil fuel use and related carbon dioxide emissions. Following uncertainties in energy supply and concern over the risk of global warming, many countries have now introduced target values for reduced energy use in buildings. Overall, these are aimed at reducing energy consumption by between 5% and 30%. To achieve such a target, international cooperation, in which research activities and knowledge can be shared, is seen as an essential activity.

In recognition of the significance of energy use in buildings, in 1977 the International Energy Agency has established an Implementing Agreement on Energy in Buildings and Communities (EBC-formerly known as ECBCS). The function of EBC is to undertake research and provide an international focus for building energy efficiency. Tasks are undertaken through a series of 'Annexes', so called because they are legally established as annexes to the EBC Implementing Agreement. These Annexes are directed at energy saving technologies and activities that support technology application in practice. Results are also used in the formulation of international and national energy conservation policies and standards.

OBJECTIVES AND STRATEGY

The objectives of the collaborative work conducted by the EBC Implementing Agreement are derived from the major trends in construction and energy markets, energy research policies in the participating countries and from the general objectives of the IEA. The principal objective of the EBC is to facilitate and accelerate the introduction of new and improved energy conservation and environmentally sustainable technologies into buildings and community systems. Specific objectives of the EBC programme are to:

- support the development of generic energy conservation technologies within international collaboration;
- support technology transfer to industry and to other end users by the dissemination of information through demonstration projects and case studies;
- contribute to the development of design methods, test methods, measuring techniques, and evaluation/assessment methods encouraging their use for standardisation;
- ensure acceptable indoor air quality through energy efficient ventilation techniques and strategies;
- develop the basic knowledge of the interactions between buildings and the environment as well as the development of design and analysis methodologies to account for such interactions.

The research and development activities cover both new and existing buildings, and residential, public and commercial buildings. The main research drivers for the programme are:

- the environmental impacts of fossil fuels;
- business processes to meet energy and environmental targets;
- building technologies to reduce energy consumption;
- reduction of greenhouse gas emissions;
- the 'whole building' performance approach;
- sustainability;
- the impact of energy reduction measures

on indoor health, comfort and usability;
– the exploitation of innovation and information technology;
– integrating changes in lifestyle, work and business environments.

MISSION STATEMENT

The mission of the IEA Energy in Buildings and Communities Programme is as follows: 'To accelerate the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge and technologies through international collaborative research and innovation.'

NATURE OF EBC ACTIVITIES

a. Formal coordination through shared tasks: This represents the primary approach of developing the work of EBC. The majority of Annexes are task-shared and involve a responsibility from each country to commit manpower.

b. Formal coordination through cost shared activities: EBC currently supports one cost shared project, Annex 5, the Air Infiltration and Ventilation Centre (AIVC). In recent times, Annex 5 has subcontracted its information dissemination activities to the Operating Agent, by means of a partial subsidy of costs and the right to exploit the Annex's past products.

c. Informal coordination or initiation of activities by participants: Many organizations and groups take part in the activities of EBC including government bodies, universities, nonprofit making research institutes and industry.

d. Information exchange: Information about associated activities is exchanged through the EBC and through individual projects. The EBC website (www.iea-ebc.org), for example, provides links to associated research organizations. Participants in each project are frequently associated with non IEA activities and can thus ensure a good cross-fertilization of knowledge about independent activities. Information exchange additionally takes place through regular technical presentation sessions and 'Future Buildings Forum' workshops. Information on independent activities is also exchanged through the EBC newsletter, which, for example, carries regular reports of energy policy development and research activities taking place in various countries.

EBC PARTICIPATING COUNTRIES

Australia
Austria
Belgium
Canada
P.R. China
Czech Republic
Denmark
France
Germany
Italy
Ireland
Japan
R. Korea
New Zealand
The Netherlands
Norway
Portugal
Spain
Sweden
Switzerland
UK
USA

COORDINATION WITH OTHER BODIES

In order to achieve high efficiency in the R&D programme and to eliminate duplication of work it is important to collaborate with other IEA buildings-related Implementing Agreements. The coordination of strategic plans is a starting point to identify common R&D topics. Other actions are exchange of information, joint meetings and joint projects in areas of common interest. It is a duty of the Chairs of the respective Executive Committees to keep the others informed about their activities and to seek areas of common interest.

COLLABORATION WITH IEA BUILDING-RELATED IMPLEMENTING AGREEMENTS

The EBC Programme continues to coordinate its research activities, including Annexes and strategic planning, with all IEA Building-Related Implementing Agreements through collaborative projects and through the BCG (Buildings Coordination Group), constituted by the IEA Energy End Use Working Party (EUWP) Vice Chair for Buildings and the Executive Committee Chairs of the following IEA research programmes:
– District Heating And Cooling (DHC)
– Demand Side Management (DSM)
– Energy in Buildings and Communities (EBC)
– Energy Conservation through Energy Storage (ECES)
– Heat Pumping Technologies (HPT)
– International Smart Grid Action Network (ISGAN)
– Photovoltaic Power Systems (PVPS)
– Solar Heating and Cooling (SHC)
– Energy Efficient Electrical Equipment (4E)

Beyond the BCG meetings, EBC meets with representatives of all building-related IA's at Future Buildings Forum (FBF) Think Tanks and Workshops. The outcome from each Future Buildings Forum Think Tank is used strategically by the various IEA buildings related Implementing Agreements to help in the development of their work programmes over the subsequent five year period.

Proposals for new research projects are discussed in coordination with these other programmes to pool expertise and to avoid duplication of research. Coordination with SHC is particularly strong.

COLLABORATION WITH THE IEA SOLAR HEATING AND COOLING PROGRAMME

While there are several IEA programmes that are related to the buildings sector, the EBC and the Solar Heating and Cooling programmes focus primarily on buildings and communities. Synergies between these two programmes occur because one programme seeks to cost-effectively reduce energy demand while the other seeks to meet a large portion of this demand by solar energy. The combined effect results in buildings that require less purchased energy, thereby saving money and conventional energy resources, and reducing CO_2 emissions. The areas of responsibility of the two programmes have been reviewed and agreed. EBC has primary responsibility for efficient use of energy in buildings and community systems. Solar designs and solar technologies to supply energy to buildings remain the primary responsibility of the SHC Programme.

The Executive Committees coordinate the work done by the two programmes. These Executive Committees meet together approximately every two years. At these meetings matters of common interest are discussed, including planned new tasks, programme effectiveness and opportunities for greater success via coordination. The programmes agreed to a formal procedure for coordination of their work activities. Under this agreement during the initial planning for each new Annex/Task initiated by either programme, the other Executive Committee is invited to determine the degree of coordination, if any. This coordination may range from information exchange, inputting to the draft Annex/Task Work Plan, participating in Annex/Task meetings to joint research collaboration.

The mission statements of the two programmes are compatible in that both seek to reduce the purchased energy for buildings; one by making buildings more energy efficient and the other by using solar designs and technologies. Specifically, the missions of the two programmes are:

- EBC programme – to accelerate the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge and technologies through international collaborative research and innovation.
- SHC programme – to enhance collective knowledge and application of solar heating and cooling through international collaboration in order to fulfill the vision.

The two programmes structure their work around a series of objectives. Four objectives are essentially the same for both programmes. These are:

- technology development via international collaboration;
- information dissemination to target audiences;
- enhancing building standards;
- interaction with developing countries.

The other objectives differ. The EBC programme addresses life cycle environmental accounting of buildings and their constituent materials and components, as well as indoor air quality, while the SHC Programme addresses market impacts, and environmental benefits of solar designs and technologies. Both Executive Committees understand that they are addressing complementary aspects of the buildings sector and are committed to continue their coordinated approach to reducing the use of purchased energy in buildings sector markets.

NON-IEA ACTIVITIES

A further way in which ideas are progressed and duplication is avoided is through cooperation with other building related activities. Formal and informal links are maintained with other international bodies, including:

- The International Council for Research and Innovation in Building and Construction (CIB),
- The European Commission (EC) including the BUILD UP initiative,
- The International Standards Organization (ISO), and-
- The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

Recent Publications

Air Infiltration and Ventilation Centre (AIVC) – Annex 5

Database

AIRBASE – bibliographical database, containing over 21,000 records on air infiltration, ventilation and related areas, Web based, updated every 3 months

Technical Notes

- TN 67 Building airtightness: a critical review of testing, reporting and quality schemes in 10 countries, 2012
- TN 66 Building air leakage databases in energy conservation policies: analysis of selected initiatives in 4 European countries and the USA, 2012

AIVC Conference Proceedings

2015 Spain - Effective ventilation in high performance buildings

Towards Net Zero Energy Solar Buildings – Annex 52

- Source Book Volume 2: Modelling, Design, and Optimization Net Zero Energy Buildings, Andreas Athienitis, William O´Brien, Wiley, 2015
- Analysis Of Load Match and Grid Interaction Indicators in NZEB with High-Resolution Data, Jaume Salom, Anna Joanna Marszal, José Candanedo, Joakim Widén, Karen Byskov Lindberg, Igor Sartori, March 2014
- Evaluation tool for net zero energy buildings: application on office building, March 2013
- LCE analysis of buildings - Taking the step towards Net Zero Energy Buildings, Annamaria Belleri, Assunta Napolitano, May 2013
- Measurement and Verification protocol for Net Zero Energy Buildings, Federico Noris, Assunta Napolitano and Roberto Lollini, September 2013
- Source Book Volume 1: Net Zero Energy Buildings: International Projects of Carbon Neutrality in Buildings, Karsten Voss and Eike Musall, Detail, Germany, 2012

Integration of Micro-Generation and Related Energy Technologies in Buildings – Annex 54

- An International Survey of Electrical and DHW Load Profiles for Use in Simulating the Performance of Residential Micro-cogeneration Systems, Ken Darcovich, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- Current Updates on the Development and Implementation of Micro-Cogeneration System Models for Building Simulation Programs, Ken Darcovich, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- Impact of Microgeneration Systems on the Low-Voltage Electricity Grid, Maurizio Sasso, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- Methodologies for the Performance Assessment of Micro Hybrid Polygeneration Systems, Maurizio Sasso, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- Synthesis Report on the Viability of Micro-Generation Systems in Different Operational Contexts, Maurizio Sasso, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- A Comparative Review of Microgeneration Policy Instruments in OECD Countries, Adam Hawkes, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- Impact of Support Mechanisms on Microgeneration Performance in OECD Countries, Adam Hawkes, Evgueniy Entchev, Peter Tzscheutschler, October 2014
- Integration of Microgeneration and Related Technologies in Buildings: Final Report, Evgueniy Entchev, Peter Tzscheutschler, October 2014

Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) – Annex 55

- Stochastic Data, Carl-Eric Hagentoft, Nuno M. M. Ramos, John Grunewald, Göteborg, Chalmers University of Technology, 2015
- Probabilistic Tools, Carl-Eric Hagentoft, Hans Janssen, Staf Roels, Liesje Gelder van, Payel Das, Göteborg, Chalmers University of Technology, 2015
- Framework for probabilistic assessment of performance of retrofitted building envelopes, Carl-Eric Hagentoft, Angela Sasic Kalagasidis, Carsten Rode, Göteborg, Chalmers University of Technology, 2015
- Practice and guidelines, Carl-Eric Hagentoft, Marcus Fink, Andreas Holm, Florian Antretter, Göteborg, Chalmers University of Technology, 2015
- Risk management by probabilistic assessment, Development of guidelines for practice, Thomas Bedner, Carl-Eric Hagentoft, Chalmers University of Technology, 2015

Methodology for Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation – Annex 56

- Methodology for Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation, Methodology and Assessment of Renovation Measures by Parametric Calculations, Walter Ott, Roman Bolliger, Volker Ritter, Stéphane Citherlet, Didier Favre, Blaise Perriset, Manuela de Almeida, Marco Ferreira, University of Minho 2014
- Shining Examples of Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation, University of Minho 2014

Ventilative Cooling – Annex 62

- State-of-the-art Review, Maria Kolokotroni, Per Heiselberg, Department of Civil Engineering, Aalborg University, 2015

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Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction – Annex 57
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Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements – Annex 58
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High Temperature Cooling and Low Temperature Heating in Buildings – Annex 59
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EBC is a programme of the International Energy Agency (IEA)