EBC

Energy in Buildings and
Communities Programme

Annual Report 2016

Energy in Buildings and
Communities Programme

International Energy Agency

EBC Annual Report 2016

Energy in Buildings and Communities Programme

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Cover picture: Ageing of Granular Aerogel and Aerogel Plaster in a Climatic Chamber.
Source: University of Perugia

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Birmingham B4 6AT
United Kingdom
www.iea-ebc.org
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Chair's Statement

For the IEA EBC Technology Collaboration Programme, 2016 was characterized by new approaches. Within the programme, we entered the unknown territories for us of competition development and conference co-organisation. Our recently approved 'Energy Endeavour' competition framework and knowledge sharing platform is an atypical project for EBC. In this project, the existing Solar Decathlon competition format will be evolved to address building renovation, building energy systems, life cycle resource optimization and possibly even mobility issues. It is a major opportunity to extend the outreach of the EBC Programme to a wider audience.

On the occasion of our 80th Executive Committee Meeting, held in November 2016 in Sydney, Australia, we collaborated with the Energy Efficiency Council to incorporate key components of the usual EBC Technical Day into their National Energy Efficiency Conference. Further support came from the Head of IEA's Energy Efficiency Division, Brian Motherway, who delivered a keynote address. To add a true international perspective to the conference was an exciting experience for both organisations - and has the potential to serve as a future model of collaboration for all of our member countries.

No less than four new EBC research projects have been approved in 2016: 'Building energy performance Assessment Based on In-situ Measurements', 'Assessing Life Cycle Related Environmental Impacts Caused by Buildings', 'Towards Net Zero Energy Public Communities', and 'Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables'. On top of this, we have also established a new Working Group, 'HVAC Energy Calculation Methodologies for Non-residential Buildings'.

And completing their work schedules in 2016, a range of highly relevant and application-ready results have been published as outcomes from our projects: 'Evaluation of Embodied Energy and Carbon Dioxide Equivalent Emissions for Building Construction', 'Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurement', 'High Temperature Cooling and Low Temperature Heating in Buildings' .

The unprecedented number of our projects has called for new Executive Committee management approaches. To put one of these into practice, we adopted a new concept at our 80th Meeting by appointing 'Annex Advisers' to more closely connect the Committee with the work of our Operating Agents, who are in charge of leading our collaborative research projects.

While the number of EBC research projects is growing, the number of our participating countries is increasing in parallel. In the past year, the Government of Singapore has formally joined our Programme. An observer from India also attended the 80th Meeting to explore possibilities for their involvement in our programme.

With collaboration now enhanced among our participating countries, our strengthened management approach, and the ongoing engagement of our highly committed Operating Agents, I am convinced these will produce major added value for the benefit of our growing scientific network within the EBC Programme.

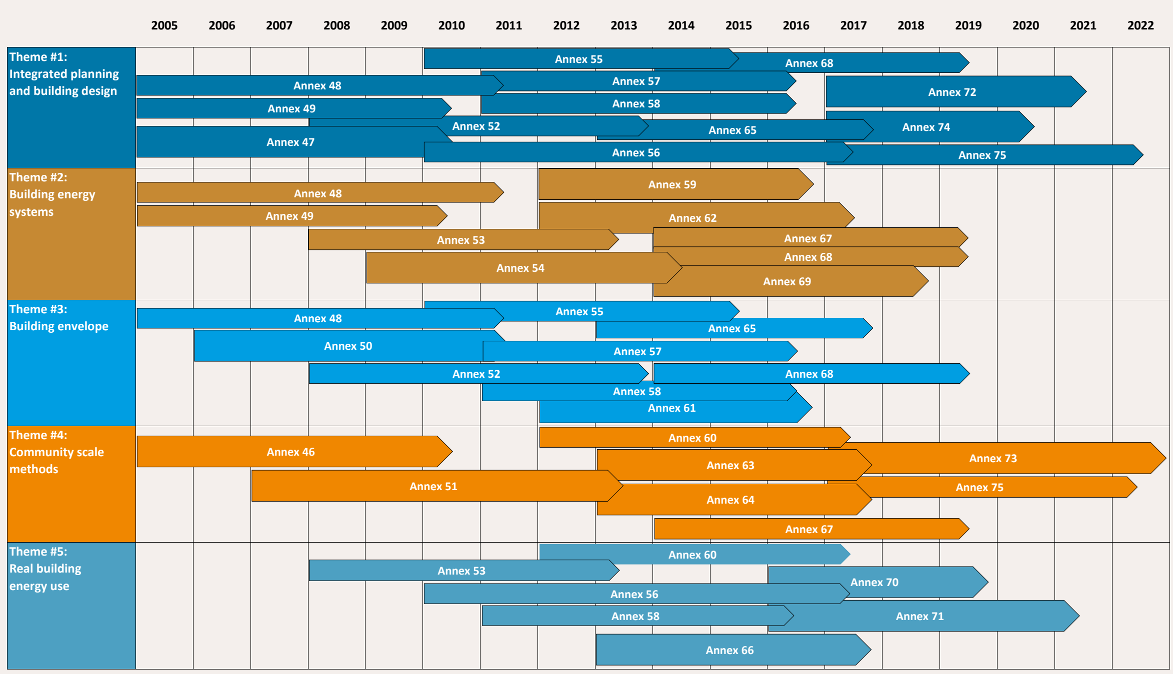
Andreas Eckmanns
EBC Executive Committee Chair

On the Way to a New Strategic Plan

The aim of the IEA EBC Technology Collaboration Programme is to carry out science based research in the field of energy use of buildings and communities. The outcomes of EBC's international collaborative research projects address the determining factors for energy use in that domain: technological aspects, policy measures, and occupant behaviour.

On the basis of its current Strategic Plan, EBC has progressively evolved over the past few years. This is reflected in the steadily increasing number of EBC's R&D projects, known as Annexes, which form the basis of the Programme. While there were around 10 ongoing Annexes in 2010, by 2016 this had increased to 16. Further advancement of the Programme is expected, with important topics gaining even more emphasis in the future, such as the increasing demand for air conditioning, especially in view of global temperature increases.

One driver for the increasing number of Annexes is that reducing energy demand in buildings continues to be of great interest for the international research community. Although many technological approaches for reducing energy use have been developed in recent years, they are still yet to be widely deployed. An important reason for this is the high investments needed to implement the required measures. Apart from technological methods



Mapping from Annexes to the Strategic Plan themes for the IEA Energy in Buildings and Communities Programme.
Source: Rolf Moser

for buildings, EBC supported research has also examined socio-economic approaches and the benefits of synergies at neighbourhood and community scales.

The frequent technical and political changes underlying energy research require regular review, with the goal of further refining EBC's strategic direction. One has to be aware that major R&D programmes such as EBC, and please excuse the analogy, show the inertia of a large petroleum transport ship: Since Annexes usually operate for 3 to 4 years, changes in the strategy only appear in the research outcomes months or even years later. For these reasons, the first steps were already taken two years ago to prepare a new Strategic Plan for the EBC Programme.

The Current Strategic Plan

The Strategic Plans for the IEA's Technology Collaboration Programmes (TCPs), including EBC, are typically renewed every five years by the IEA Committee on Energy Research and Technology (CERT). The current Strategic Plan for the EBC Programme covers the period 2014 - 2019 (www.iea-ebc.org/strategy).

The current EBC Strategic Plan was developed in 2013 in consultation with the IEA Energy End Use Working Party (EUWP) and CERT, and is based on the outcomes of an IEA Future Buildings Forum workshop. The Strategic Plan focuses on five priority technological topics and their implementation:

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

The selection of themes reflects the broad scope encompassed by the EBC Programme. While the Programme primarily works at the building level, it also deals with the large number of interfaces between different technologies in the larger spatial context of communities.

Assessment of the Current Strategic Plan

During 2016, members of the EBC Executive Committee undertook a Mid-Term Assessment of the current Strategic Plan. An initial analysis of gaps in the work programme with regard to the objectives of the Strategic Plan was discussed by the EBC Executive Committee. In this Assessment, all Annexes established since 2000 were thematically analysed and compared with the detailed topics set out in the Strategic Plan. This analysis showed a number of key findings not only on the implementation of EBC's present strategy, but also on emerging issues to inform the future strategy, as follows:

- There is good implementation of the strategy through the current Annexes, with ongoing Annexes on almost all of the many sub-topics identified in the Strategic Plan. Particularly for the recently approved Annexes, the consistency with the strategy is very good.
- Strengthening of activities was recommended within the framework of the gap analysis in the field of 'real building energy use', which has since been addressed by the approval of Annexes 70 and 71.
- In addition to technical topics, more non-technical aspects should be included in energy research for buildings and cities for the future. These include socio-economic aspects, occupant behaviour, and the motivations of building owners with regard to the renovation of their properties.
- The current strategy does not include organisational aspects of the work, such as approval criteria for new Annexes, which have an important influence on the research activities.

Outlook

The Executive Committee of the EBC Programme expressed a positive opinion about the current development of the work programme at its 80th Meeting, held in November 2016. IEA TCPs in the buildings and communities sector are important platforms for international knowledge exchange and avoiding duplication of research efforts. With the continued expansion by involving emerging economies, research findings can very quickly have impact in practice, in the case of new construction projects, as well as for renovation projects. The buildings sector remains one of the most important energy consumers in the world. Due to the needs of people in the developing nations to achieve greater health and comfort, while at the same time improving the existing building stock globally, this trend will continue for a long time.

At its 80th Meeting, the EBC Executive Committee also discussed the need to ensure that high quality research is maintained in the Programme, despite the increasing number of Annexes. In creating the future strategy, therefore, topics such as acceptance criteria for new Annexes will be discussed. A further topic to be agreed will be whether Annexes should be established mainly from proposals from the research community (i.e. 'bottom-up'), or if the Executive Committee should undertake more efforts on developing its own proposals (i.e. 'top-down'). Last, but not least, concrete recommendations for policy and decision makers as a result of the research are increasingly important. The handling of this aspect must also be considered in the development of the future strategy.

The IEA Future Buildings Forum is a regular activity run jointly with other related IEA TCPs. This is intended to identify long term energy, environmental, economic and other technical and non-technical issues, and to assess their potential effects on future building energy supply and demand. In preparation for developing the future strategy, the next Future Buildings Forum workshop should be held within 2017. As an additional important basis, EBC also intends to conduct a survey in the participating countries within the same period, in which national representatives can comment on the topics described above and introduce their national priorities into the process.

As an ambitious target and on account of the rapid evolution of the Programme, development of EBC's new strategy will be quickly progressed, with a completion goal of 2018. By this means, an up-to-date basis for the efficient management of the EBC programme will be delivered as well.

Rolf Moser and John Mayernik

New Research Projects

BUILDING ENERGY PERFORMANCE ASSESSMENT
BASED ON IN SITU MEASUREMENTS
(ANNEX 71)

ASSESSING LIFE CYCLE RELATED ENVIRONMENTAL IMPACTS
CAUSED BY BUILDINGS
(ANNEX 72)

TOWARDS NET ZERO ENERGY PUBLIC COMMUNITIES
(ANNEX 73)

ENERGY ENDEAVOUR
(ANNEX 74)

COST-EFFECTIVE BUILDING RENOVATION AT DISTRICT LEVEL
COMBINING ENERGY EFFICIENCY AND RENEWABLES
(ANNEX 75)

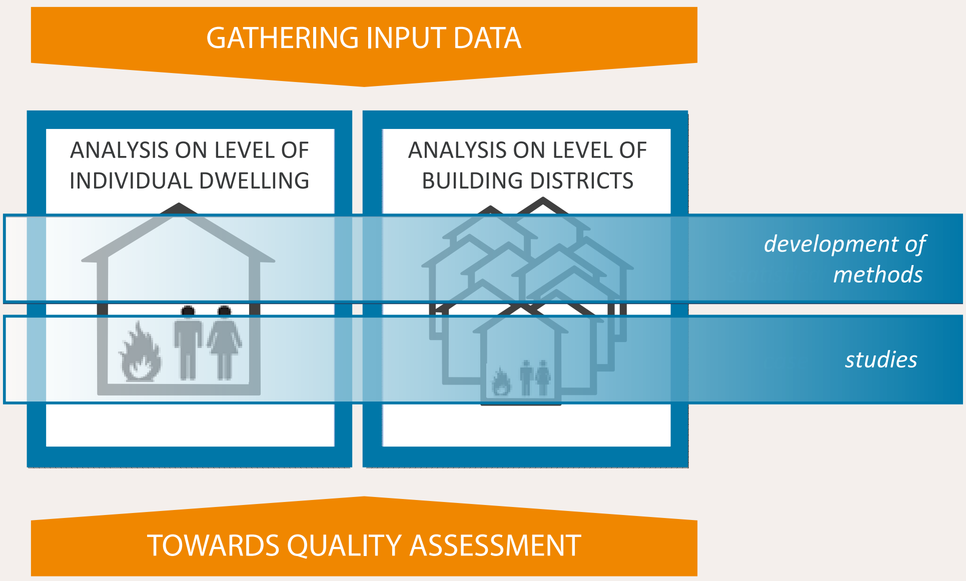
HVAC ENERGY CALCULATION METHODOLOGIES
FOR NON-RESIDENTIAL BUILDINGS
(WORKING GROUP)

Building Energy Performance Assessment Based on In-situ Measurements

ANNEX 71

Decreasing the energy use in buildings can only be achieved by an accurate characterization of the as-built energy performance of buildings. This is mainly for two reasons. First of all, despite the ever more stringent energy legislation for new and renovated buildings in many industrialised countries, monitoring the actual energy performance in many cases reveals a significant performance gap with the theoretically designed targets. Secondly, the pressing need for integration of renewables places stress on existing electricity systems, which can be remedied by using intelligent systems and smart grids that are aware of the actual status of the buildings.

This research and development project deals with the assessment of the actual building energy performance starting from in-situ measurements. It builds on the achievements of the completed EBC project Annex 58 'Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements'. That project made a first step to characterize the actual energy performance of buildings based on full scale dynamic measurements. Annex 58, however, was mainly restricted to the thermal performance of the building envelope, making use of rather intrusive tests and focusing on scale models, or test buildings. The current project aims to develop replicable methodologies embedded in a statistical and building physics framework to characterize and assess the actual energy performance of buildings in use.



The project is developing new methods to characterize the dynamic behaviour of the energy demand for design and control of district energy systems.
Source: Ruben Baetens, KU Leuven

The project is focusing on residential buildings, both on the level of individual dwellings, as well as on the level of building communities. At both levels, the development of characterisation and quality assurance methods is being explored. Characterisation methods aim to translate the (dynamic) behaviour of a building into a simplified model that can be used for instance in modelling predictive control, fault detection, and optimisation of district heating systems. Quality assurance methods aim to pinpoint some of the most relevant aspects of actual building performance, such as the overall heat loss coefficient of a building, the energy efficiency of the heating (cooling) system, airtightness and solar absorption.

Objectives

The project objectives are:

- the development of methodologies to characterize and assess the actual as-built energy performance of buildings,
- disaggregation of building energy use into its three main influencing factors: building fabric, systems and occupant behaviour,
- investigate how on-site assessment methods can be applied for quality assurance.

Deliverables

The following deliverables are planned:

- a report on reliability of input data for onsite building performance assessment,
- a report on dynamic data analysis methods to characterize and assess building energy performance, and
- guidelines to apply the methods in quality assessment procedures.

Progress

The project was formally approved at the 79th EBC Executive Committee Meeting, held in June 2016.

Meetings

The 1st preparation phase meeting was held in Leuven, Belgium in October 2016.

Project duration
2016–2021

Operating Agent
Staf Roels, KU Leuven University of Leuven, Belgium

Participating countries (provisional)
Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, UK

Further information
www.iea-ebc.org

Assessing Life Cycle Related Environmental Impacts Caused by Buildings

ANNEX 72

Investment decisions for buildings made today largely determine their environmental impacts over many future decades due to their long lifetimes. Furthermore, such decisions involve a trade-off between additional investments today and potential savings during use and at end of life - in terms of economic costs, primary energy demand, greenhouse gas emissions and other environmental impacts. Since the economic system does not fully account for external environmental effects, environmental resources are used inefficiently. Life cycle assessment (LCA) is suited to complement economic information on buildings with information on their environmental impacts. LCA helps to take measures and action to increase the resource efficiency of buildings and construction.

The project is advancing the research already conducted within EBC Annexes 56 and 57. It broadens the scope of Annex 57 by including operational impacts of buildings in use and by addressing environmental impacts in addition to primary energy demand and greenhouse gas emissions. It is the intention to cover residential, office and school buildings, hospitals and other public buildings, both new and retrofit. The overall goal is to support planning processes and decision making related to new buildings and retrofit of existing buildings to reduce the primary energy demand, greenhouse gas emissions and other environmental impacts along the entire life cycle of buildings.

The project is researching harmonization issues arising when applying life cycle assessment (LCA) approaches on buildings. It functions as a platform to exchange experiences and knowledge within partner countries and to foster the application of LCA on buildings in countries with yet little experience.

Objectives

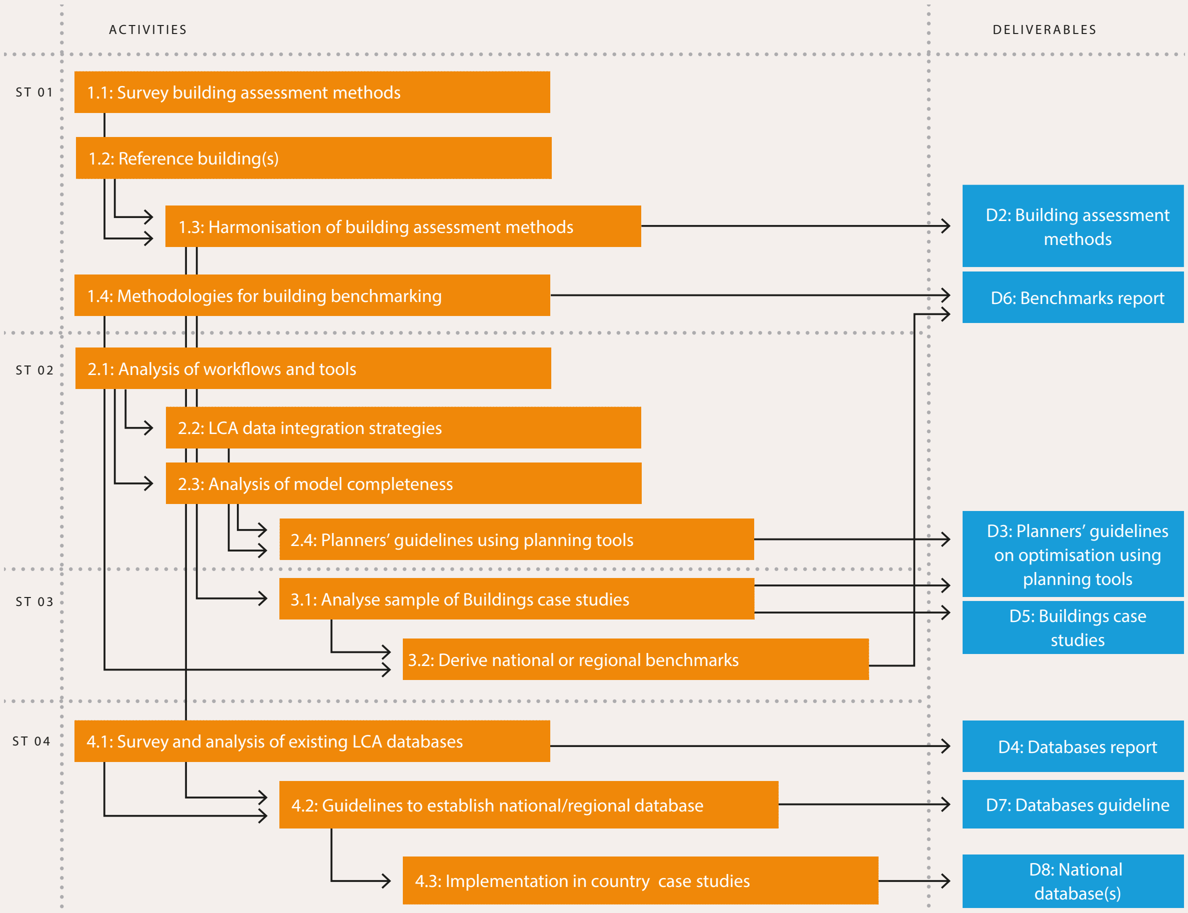
In support of the principal aim of reducing the primary energy demand, greenhouse gas emissions and other environmental impacts along the entire life cycle of buildings (construction, use and end of life), the project is working towards the following objectives:

- establish a common methodology guideline to assess the life cycle based primary energy demand, greenhouse gas emissions and environmental impacts caused by buildings;
- establish methods for the development of specific environmental benchmarks for different types of buildings;
- derive regionally differentiated guidelines and tools for building design and planning such as BIM for architects and planners;
- establish a number of case studies, focused to allow for answering some of the research issues and for deriving empirical benchmarks;
- develop national or regional databases with regionally differentiated life cycle assessment data tailored to the construction sector;
- share experiences with the setup and update of such databases.

Deliverables

The project will report on the following topics:

- harmonised guidelines on the environmental life cycle assessment of buildings,
- establishing environmental benchmarks for buildings (basics, methods, examples),
- national LCA databases used in the construction sector, including standardised characterisation of all relevant LCA databases,
- guidelines for planners on how to optimise the life cycle performance of buildings during the design process using planning tools such as BIM,



Project tasks and planned activities with links to the deliverables. The project is divided into four sub-tasks.
Source: EBC Annex 72

- building case studies using a standardised template,
- how to establish national or regional LCA databases targeted to the construction sector, and
- default publicly available, national data sets of LCA-based environmental indicators.

Progress

The project was approved at the 80th EBC Executive Committee Meeting in November 2016.

Meetings

An international workshop to develop the project was held in Zürich, Switzerland, in September 2016.

Project duration
2016 – 2021

Operating Agent
Rolf Frischknecht, treeze Ltd., Switzerland

Participating countries (provisional)
Austria, Belgium, Czech Republic, P.R. China, Denmark, Germany, Italy, Japan, R. Korea, Netherlands, New Zealand, Norway, Portugal, Singapore, Sweden, Switzerland
Observers: Brazil, Hungary, India

Further information
www.iea-ebc.org

Towards Net Zero Energy Public Communities

ANNEX 73

Until recently, most planners of public communities - for example military and university campuses - have addressed energy systems for new facilities on an individual building basis without consideration of energy sources, renewables, storage, or future energy generation needs. This situation in planning and execution of energy-related projects does not support attainment of current energy reduction goals or the minimization of costs for providing energy security. Experience gained from frontrunners shows that cost effective solutions for campuses or city districts can be achieved through a combination of energy efficiency improvements in individual buildings and advanced energy supply, distribution, and storage systems. In addition to the application of state-of-the-art technologies, this requires a clear understanding of campus or district specific energy goals, concepts for community-wide energy master planning, and business and financial models for implementations of these plans.

The project is summarizing the state-of-the-art technologies and concepts for community-wide 'near zero energy' masterplanning that consider both power and heating and cooling needs. The project is advancing the methodology of the 'near zero energy community', to enhance existing masterplanning strategies and modelling tools, and expand their application by adding standardized country-specific building data on specific building types, and information on advanced energy efficiency technologies and on their performance and cost characteristics.

The scope of the project is to develop the methodology and the decision-making process that will be transferred into computer-based modelling tools for achieving near zero energy in public communities like military garrisons, universities, housing areas, and so on. The guidelines and tools to be developed within the project will support the energy masterplanning process and will address technical, economic, social, financial, and business components presented in the way that is easy to understand and execute. The outcomes will be applicable to public communities in the participating countries.

Objectives

The project is working towards the following objectives:

- establishing energy goals and a database of energy utilization indices for representative buildings and building communities;
- developing a catalogue of building models, including mixed-use buildings, applicable to national public and private communities and military garrisons;
- collecting and analyzing best practices of energy master planning with the goal of establishing a step-by-step energy master planning process to be executed using the computerized tool;
- collecting information on the architecture of advanced central energy systems, analyzing their applicability to different building communities' needs and constraints, and evaluating these scenarios from the technical, economic, financial, and business perspective;
- dissemination and training in participating countries designed for decision makers, planners, building owners, architects, engineers, and energy managers of public-owned and operated communities .

Deliverables

To ensure that the project outcomes will be of lasting value, the final deliverables will be targeted at decision makers, community planners and energy managers, energy services companies, and industry partners, all of whom will be actively involved in their development. The major deliverables that the project will create include:

- a guide for near zero energy planning in building communities,
- an enhanced net zero planning tool,
- a book of case studies with examples of energy masterplans and near zero energy communities, and
- a report summarizing the results of several realized pilot case study projects.

Progress

The project was approved at the 80th EBC Executive Committee Meeting, held in November 2016.

Meetings

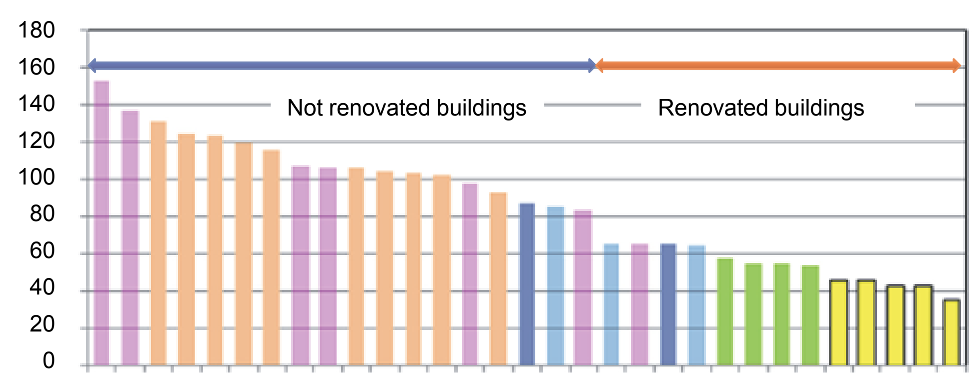
International workshops to develop the project were held in Washington, DC, USA, in September 2016, and in Frankfurt, Germany in October 2016.

Project duration
2017 – 2021

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 (provisional)
Austria, Australia, Canada, Denmark, Germany, Italy, Norway, UK, USA
Observer: Estonia, Latvia

Further information
www.iea-ebc.org



The 'Rintheim' municipal housing district, in Karlsruhe, Germany (top), with example specific heating demands in 2009 (kWh_{th}/m^2) of renovated and not renovated multi-family buildings (bottom).
Source: Volkswohnung GmbH

Energy Endeavour

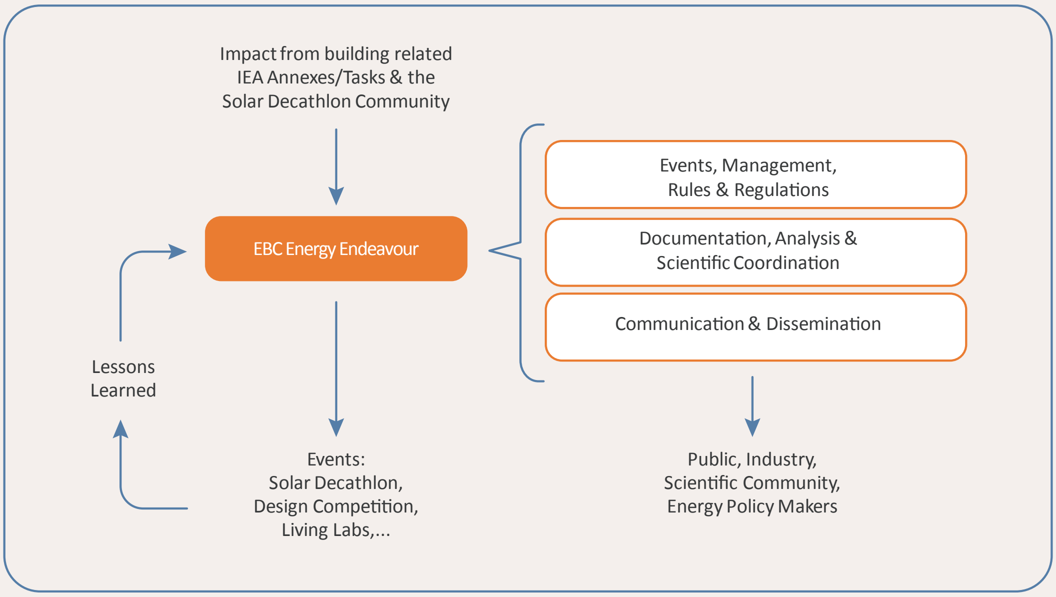
ANNEX 74

The Solar Decathlon is an international competition for student teams, based on an initiative of the U.S. Department of Energy (DOE) in 2000. In this competition, university based teams from all over the world are challenged to design, build and operate solar powered houses. Each competition's final includes 10 contestants, as a 'Decathlon'. Twelve competitions have been conducted worldwide up to 2016 gaining a great deal of experience, with new ones already being planned.

Starting with the 'Proclamation of Madrid' in 2010, a group consisting of organizers and participants of the Solar Decathlon Europe began to discuss the evolution of the competition with regard to its content and form, to go beyond the theme of solar powered habitation, and address renovation of existing buildings, building energy systems, life cycle resource optimization and possibly aspects of urban mobility. This process underlined that an authorized international platform is lacking, and is needed to link the worldwide activities and experiences as starting point for this evolution. Contrary to the competitions in the US, which are centrally managed by the DOE, the events in other places in the world have seen new organizations established for each competition. In many ways, in form, content and financially, the evolution of the existing competition formats benefits from knowledge exchange and a platform to ensure continuity of know-how, as does the creation of new competitions.

These findings form the background for creating the 'Energy Endeavour' initiative. The initiative creates the opportunity to use the lessons learned from the Solar Decathlon events worldwide for its continuous, professional evolution, as well as extending the format with new events and series of networking events under a common umbrella. The project provides the institutional and organizational framework for the Energy Endeavour initiative.

Announcement of the Energy Efficiency Award to Team Prispa, Romania, in Solar Decathlon Europe 2012, Madrid. Energy efficiency is one of the ten categories within this international solar building competition.
Source: UPM, Madrid



The proposed structure of the project and its general workflow.
Source: University Wuppertal

Objectives

The project is intended to serve as a know-how platform linking the experiences worldwide and working towards further improvement of existing competitions, as well as developing new competition formats. The project objectives are to:

- establish an international collaboration platform for competitions in the building sector,
- strengthen the IEA dissemination activities concerning buildings-related R&D,
- increase the role of competitions as test ground for innovative methods, tools and systems with a strong link to the scientific community and academia,
- raise public visibility of energy policy towards climate neutral habitation, and
- provide case studies on the building and district level.

Deliverables

The main deliverables of the project will include:

- a Web based competition knowledge platform and portal,
- a competition evolution and concept report,
- a competition management guide,
- educational material, and
- an alumni network and newsletters.

Progress

The project was approved at the 80th EBC Executive Committee Meeting, held in November 2016.

Meetings

An international workshop to develop the project was held in Zürich, Switzerland, in September 2016.

Project duration
2017 – 2020

Operating Agents
Karsten Voss, University Wuppertal, Germany, and
Peter Russell, Solar Decathlon Europe Secretariat / Energy Endeavour Foundation, the Netherlands

Participating countries (provisional)
Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Switzerland, UK, USA

Further information
www.iea-ebc.org

Cost-effective Building Renovation at District Level Combining Energy Efficiency & Renewables

ANNEX 75

Buildings are a major source of greenhouse gas emissions and cost-effectively reducing their energy use and associated emissions is particularly challenging for the existing building stock, mainly because of the existence of many architectural and technical hurdles. The transformation of existing buildings into low-emission and low-energy buildings is particularly challenging in cities, where many buildings continue to rely too much on heat supply by fossil fuels. However, at the same time, there are specific opportunities to develop and take advantage of district-level solutions at urban scale. In this context, the project aims to clarify the cost-effectiveness of various approaches combining both energy efficiency measures and renewable energy measures at the district level. At this level, finding the balance between renewable energy measures and energy efficiency measures for the existing building stock is a complex task and many research questions still need to be answered, including:

- What are the cost-effective combinations between renewable energy measures and energy efficiency measures to achieve far-reaching reductions in greenhouse gas emissions and primary energy use in urban districts?
- What are the cost-effective strategies to combine district-level heating or cooling based on available environmental heat, solar energy, waste heat or natural heat sinks, with energy efficiency measures applied to building envelopes?
- How do related strategies compare in terms of cost-effectiveness and impacts with strategies that combine a decentralized switching of energy carriers to renewable energy sources with energy efficiency measures applied to building envelopes?
- Under which circumstances is it more appropriate to use available renewable energy potentials in cities at a district level, under which circumstances are decentralized renewable energy solutions more advantageous, in combination with energy efficiency measures applied to building envelopes?

Objectives

This project has the general objectives to:

- investigate cost-effective strategies for reducing greenhouse gas emissions and energy use in buildings in cities at district level, combining both energy efficiency measures and renewable energy measures;
- provide guidance to policy makers, companies working in the field of the energy transition, as well as to building owners, on how to cost-effectively transforming existing urban districts into low-energy and low-emission districts.

The specific objectives are to:

- give an overview on various existing and emerging technology options and on how challenges occurring in an urban context can be overcome;
- develop a methodology to identify cost-effective strategies for renovating urban districts, supporting decision makers in the evaluation of the efficiency, impacts, cost-effectiveness and acceptance of various solutions;
- illustrate such strategies in selected case studies and gather best-practice examples;
- give recommendations to policy makers and energy related companies on how they can influence the uptake of cost-effective combinations of energy efficiency measures and renewable energy measures in building renovation at district level.

Deliverables

The following project deliverables will be produced:

- a report on technology overview, identifying energy efficiency measures and renewable energy measures at district level in an urban context;
- a methodology report on cost-effective building renovation at district level;
- supporting tools for decision makers: identification and adaptation of tools to support the application of the methodology in generic and case-specific assessments;

An energy-renovated neighbourhood at Vesterbro in Copenhagen.
Source: Cenergia

- a report on case studies, showing cost-effective combinations of energy efficiency measures and renewable energy measures in building renovation at district level;
- a report on good practice examples, showing strategies on transforming existing urban districts into low-energy and low-emission districts;
- guidebooks containing guidelines for policy makers and energy-related companies on how to encourage the market uptake of cost-effective strategies combining energy efficiency measures and renewable energy measures and guidelines for building owners and investors about cost-effective renovation strategies, including district-based solutions;
- recommendations for subsidy programmes and for encouraging market uptake through competitions.

Progress

The project was approved at the 80th EBC Executive Committee Meeting, held in November 2016.

Meetings

An international workshop to develop the project was held in Zürich, Switzerland, in September 2016.

Project duration
2017 – 2021

Operating Agent
Manuela Almeida, University of Minho, Portugal

Participating countries (provisional)
Austria, Czech Republic, Denmark, Italy, Portugal, Spain, Sweden, Switzerland

Further information
www.iea-ebc.org

HVAC Energy Calculation Methodologies for Non-residential Buildings

WORKING GROUP

In many countries and regions, primary energy use or CO_2 emissions is used as an index representing the building energy performance, which is assessed by calculation methods. Key requirements for such calculation methods are claimed to be credibility, discrimination, repeatability and especially transparency. To be transparent, it is necessary to publish all of the logic for the calculations and all of the justifications for the input data. However, it seems that very few countries and regions have attained such an idealistic situation. The commonly faced difficulties seem to appear particularly due to the complexity and variety of non-residential buildings' functions and building services systems.

Originally, many energy calculation methods were used for calculating space heating loads to evaluate the effectiveness of building envelopes and for sizing equipment. At that time, it was not critical to convert the loads into energy use, or to compare the energy use with that needed for other purposes. On the contrary, nowadays, the energy use index is a metric that allows an evaluation of energy-saving effectiveness of various kinds of energy conservation techniques. This index has to be able to fairly evaluate the contributions of the energy conservation techniques, and requirements for the index and its calculation methods need to be explained in more depth and shared among countries and regions.

Towards 2050, the results of the calculation methods will form the guidance for design and construction practice. Reduction of the energy use in each building and the total amount of expected reductions as a whole can be quantified mainly by such energy calculation methods. The intended effects on construction practice can be better guaranteed by continuing to improve the above-mentioned key requirements for the calculation methods. If good agreement between energy use in reality and predictions is secured, the calculation methods can be applied as a core part of policies to contribute substantially to the reduction of energy use and CO_2 emissions in the buildings sector. This is why it is necessary to continue to improve the calculation methods.

Objectives

The project objectives are to:

- collect technical documents published world-wide on the calculation methodologies of energy use for HVAC systems in non-residential buildings and on their scientific basis including research works on their validation,
- analyse the collected documents and pick up characteristics of methodologies, which are appropriate for broader utilization as good practice examples, and
- identify areas in HVAC energy calculation methodologies lacking a scientific basis to suggest future R&D themes.

Deliverables

The following deliverables are planned:

- a report including the results of the analysis on national energy calculation methodologies for HVAC systems for non-residential buildings,
- a report detailing description and quoted information, and a summary report on the project findings.

Progress

The project was approved at the 79th EBC Executive Committee Meeting, held in June 2016.

Project duration
2016–2019

Operating Agent
Takao Sawachi, National Institute for Land and Infrastructure Management, Japan

Participating countries (provisional)
Canada, P.R. China, Italy, the Netherlands, Switzerland, UK, USA

Further information
www.iea-ebc.org

An experimental facility for HVAC systems, showing an air handling unit undergoing testing.
Source: Building Research Institute, Japan

Ongoing Research Projects

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

STRATEGY AND PRACTICE OF ADAPTIVE THERMAL COMFORT
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LONG-TERM PERFORMANCE OF SUPER-INSULATING MATERIALS
IN BUILDING COMPONENTS AND SYSTEMS
(ANNEX 65)

LOWEX COMMUNITIES – OPTIMISED PERFORMANCE OF
ENERGY SUPPLY SYSTEMS WITH EXERGY PRINCIPLES
(ANNEX 64)

IMPLEMENTATION OF ENERGY STRATEGIES IN COMMUNITIES
(ANNEX 63)

VENTILATIVE COOLING
(ANNEX 62)

BUSINESS AND TECHNICAL CONCEPTS FOR
DEEP ENERGY RETROFITS OF PUBLIC BUILDINGS
(ANNEX 61)

NEW GENERATION COMPUTATIONAL TOOLS
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(ANNEX 60)

COST EFFECTIVE ENERGY AND CARBON DIOXIDE EMISSIONS
OPTIMIZATION IN BUILDING RENOVATION
(ANNEX 56)

AIR INFILTRATION AND VENTILATION CENTRE AIVC
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Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale

ANNEX 70

This research and development project is an international collaboration of researchers, industry and governments worldwide who are working to develop methods for improving the empirical evidence on energy demand in the building stock. It envisions an empirically grounded and robust evidence base on energy and the building stock through established data collection, study methods and modelling techniques to better inform decision-making and policy to achieve a transition to a low carbon built environment.

The project is focusing on identifying, reviewing, evaluating and producing leading edge methods for studying and modelling the building stock including:

- data collection techniques on energy use, building features and occupant features, and building morphology;
- analysis of smart meter energy data, building systems, and occupant behaviour;
- modelling energy demand among sub-national and national building stocks.
- The work is divided into three stages as listed below:
- data user engagement (needs and provisions),
- data mechanisms and foundations, and
- building stock modelling and analysis.

Objectives

The aim of the project is to identify data user needs around energy demand in buildings and to establish best practice methods and harmonized approaches for data collection, analysis and modelling. In support of this aim, the project has the following specific objectives, which are to:

- support countries in developing realistic decarbonisation transition and develop pathways through better available empirically derived energy and buildings data;
- inform and support policymakers and industry in the development of low energy and low carbon solutions by evaluating the scope for using empirical stock building and energy use data;
- develop best practice in the methods used to collect and analyse data related to real building energy use, including building and occupant data;
- support the development of robust building stock data sets and building stock models through better analysis and data collection.

Deliverables

The results will facilitate the use of empirical energy and building stock 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. The following project deliverables are planned:

- a register of energy and building stock data among participating countries and more widely;
- a register of energy and buildings stock models;
- a data schema for energy and building stock data for developing countries;
- a series of reports on best practice and information reports on international data, models and methods;
- guidelines for energy and building stock model reporting and metrics for stock model comparisons.

Progress

In preparation for the main working phase, in 2016 the project has been initiating engagement with stakeholders of existing and prospective data users from government, academia, industry and the IEA Secretariat. The first part of the work is concentrating on defining and identifying energy and buildings stock data users who are relevant to the collection, creation, access and use of energy and buildings stock data. An appropriate survey instrument is being developed and administered to these groups. The aims are of this part of the project are to:

- identity data user needs and how best to meet them, and
- share experiences and promote best practice.

Meetings

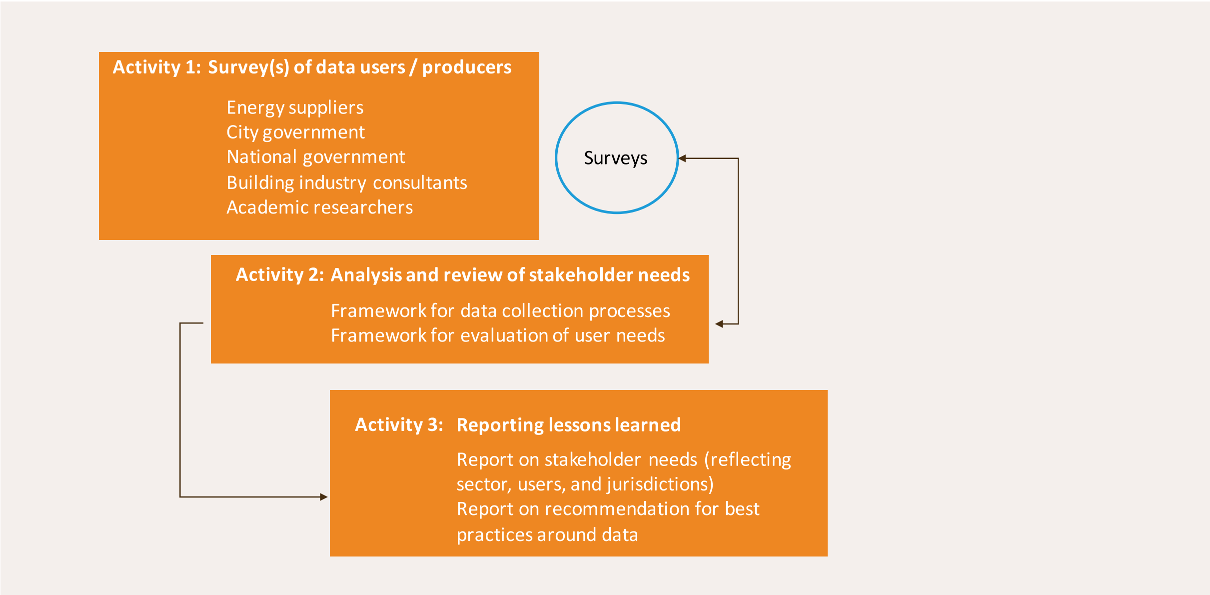
- The 1st preparation phase meeting was held in Paris, France, in May 2016
- The 2nd preparation phase meeting was held in Shanghai, P.R. China, in September 2016

Project duration
2016–2020

Operating Agent
Ian Hamilton, University College London, UK

Participating countries (provisional)
Austria, Belgium, P.R. China, Denmark, France, Germany, the Netherlands, Sweden, Switzerland, UK, USA

Further information
www.iea-ebc.org



The first part of the project is to develop the data user engagement process (needs and provisions). The focus of the first activity is to identify and map the key challenges with users on the lack of knowledge of data (existence, use, linkage, benefits) and the confidence in data quality and their models. The second activity will create a conceptual framework for the survey results to evaluate and review stakeholders' needs for energy and buildings stock data. The third activity will report on lessons learned from stakeholder engagement on the needs of energy and buildings stock data and recommendations for future engagement. Reporting will include best practice recommendations from users on data collection, reporting and access methods, which will be fed into the next stage. 'Use Cases' will also be reported to explore best practices on energy and building data uses.
Source: EBC Annex 70

Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings

ANNEX 69

It is always challenging to achieve an appropriate balance between comfortable indoor environments and energy savings for buildings. The existing evidence has indicated that close control of indoor temperatures results in high energy costs and greenhouse gas emissions, but may not always contribute to occupant comfort and health.

Adaptive thermal comfort is regarded as a significant development that can be expected to play an important role in low energy building design and operation. However, studies are still needed to fully understand the actual mechanism of the adaptive process. People living in diverse climatic regions can be expected to

The Global Thermal Comfort Database is one of the expected deliverables of the project. This already includes raw data from various sources to improve understanding of adaptive thermal comfort in buildings. (Upper) Each dot on the world map represents a location from where raw data was collected (Lower) Each slice in the pie chart shows the proportion of data contributed by each country in the database.
Source: Edward Arens and Hui Zhang

vary significantly in terms of their adaptive responses, suggesting that different building design strategies and indoor environment solutions would be appropriate. Furthermore, there are still no thermal comfort performance criteria for mixed-mode or hybrid ventilation buildings that combine HVAC systems and natural ventilation. These have emerged as one of the most common sustainable building strategies in recent years (see for example EBC Annex 35 'Hybrid Ventilation Systems').

Objectives

How to develop an analytical and quantitative description of occupants' adaptive thermal comfort in buildings is a fundamental scientific question. Answering this will inform more appropriate design strategies, evaluation approaches, and control algorithms for the indoor environment, all of which can reinforce reductions in building energy use. The specific objectives of the project are to:

- establish a worldwide database with quantitative descriptions of occupants' thermal adaptation,
- develop new or improved indoor thermal environment criteria based on the adaptive thermal comfort concept,
- propose how adaptive methods can be used in building design strategies to achieve thermal comfort with low energy use, and
- provide guidelines for developing personal thermal comfort systems based on perceived / individual control adaptation.

Deliverables

The following project deliverables are planned:

- a global thermal comfort 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

In 2016, the work of collecting thermal comfort field data from sources worldwide has been completed, and the online thermal comfort analysis tool has been updated. The review work on thermal comfort standards was progressed. Six buildings located in different participating countries have been confirmed as cases for long-term studies.

Meetings

The 1st working phase meeting was held in London, UK, in April 2016.

The 2nd working phase meeting was held in Seoul, R. Korea, in October 2016.

Project duration
2015–2019

Operating Agents
Yingxin Zhu, Tsinghua University, China
Richard de Dear, the University of Sydney, Australia

Participating countries
Australia, Canada, P. R. China, Denmark, Germany, Italy, Japan, R. Korea, the Netherlands, Norway, Sweden, UK, USA
Observers: India

Further information
www.iea-ebc.org

Indoor Air Quality Design and Control in Low Energy Residential Buildings

ANNEX 68

Residential buildings must be fully optimized to become as close as possible to 'zero energy' buildings. This means that ventilation must be adjusted to just the absolute minimum necessary, while not sacrificing the quality of the indoor air. There is a need to adopt and demonstrate an integrated view about the optimization that considers the sources, sinks and transport of relevant pollutants that occur in buildings, including emissions from construction products against the effect of ventilation that dilute the pollutants.

Objectives

The key project objectives are to:

- establish performance metrics required to combine very high energy performance with good indoor air quality (IAQ);
- develop guidelines regarding design and control strategies for energy efficient buildings with good IAQ - operational parameters to consider comprise of means for ventilation and its control, thermal and moisture control and air purification strategies, and how they can optimally be combined;
- gather data on indoor pollutants and their properties pertaining to heat, air and moisture transfer;
- identify or further develop digital tools that can help building designers and managers to improve building energy performance and to provide comfortable and healthy indoor environments;
- identify and investigate relevant case studies, in which the abovementioned performance can be examined and optimized.

Deliverables

The following project deliverables are planned:

- a report on metrics for high IAQ and energy efficiency in residential buildings,
- a guidebook on design and operation for high IAQ in energy efficient residential buildings,
- a report and 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 where optimal combinations of good IAQ and low energy use have been pursued.

Progress

2016 was the first year of the working phase of the project. During this year, collection of state-of-the-art knowledge from partners and relevant stakeholders has been started, as has planning of common exercises. Work also began on gathering information on data and properties of pollutants loads, modelling tools, strategies for design and control of buildings, field measurements and case studies. The main emphasis for the first year has been on defining the metrics for combining high indoor air quality (IAQ) with energy efficiency, which has led to the completion of a draft of the first official deliverable, the report on 'metrics for high IAQ and energy efficiency in residential buildings'. This report is planned to be published in 2017, and will underpin the work in the remainder of the project.

Meetings

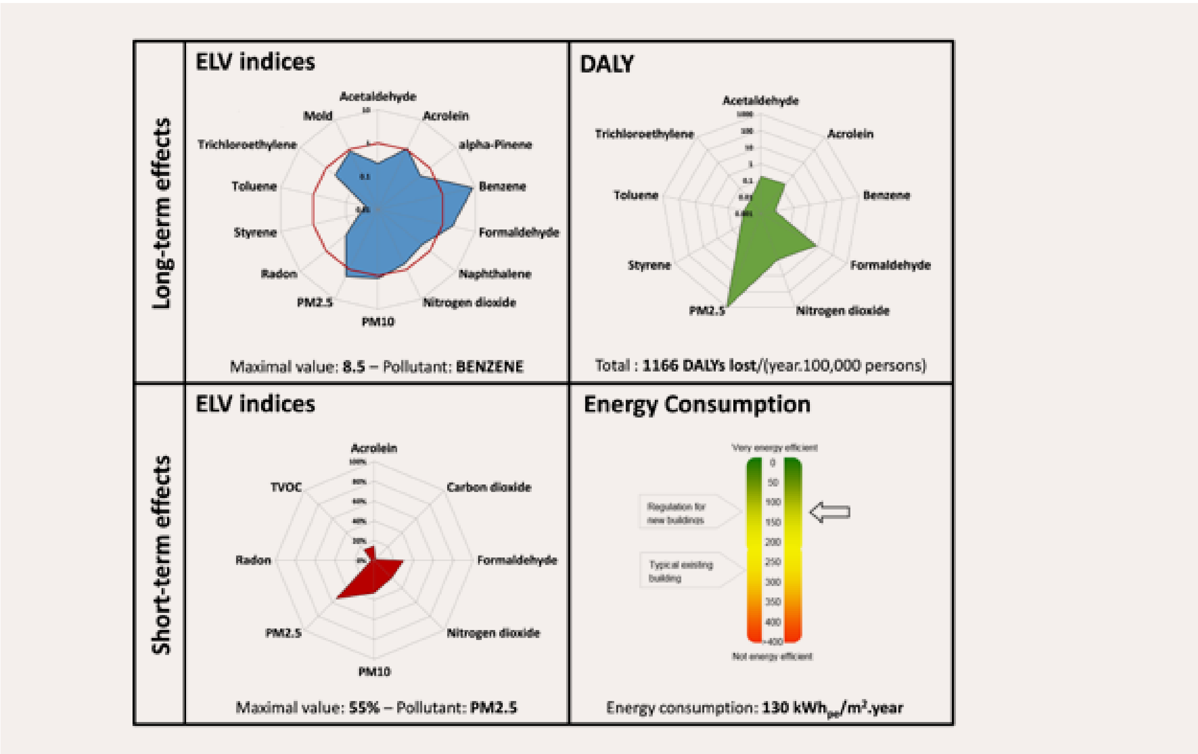
- The 1st project working meeting was held in Oslo, Norway in March 2016.
- The 2nd project working meeting was held in Syracuse, NY, USA in September 2016 - Part of this meeting was arranged as a CHAMPS (Combined Heat, Air, Moisture and Pollutant Simulation) workshop for outreach to external collaborators.
- The project was responsible for organizing workshops at the Indoor Air 2016 (Ghent, Belgium) and ASHRAE IAQ 2016 (Alexandria, VA, USA) conferences, where discussion with and input from conference participants was systematically collected for use in conjunction with the metrics work (Indoor Air 2016), and with general input for the whole project (ASHRAE IAQ 2016) respectively.

Project duration
2015–2019

Operating Agent
Carsten Rode, Technical University of Denmark, Denmark

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

Further information
www.iea-ebc.org



A schematic indoor air quality and energy dashboard for low energy residential buildings (data represented here are just for display and do not represent an actual situation).
Source: Associate professor Marc Abadie, Laboratoire des Sciences de l'Ingénieur pour l'Environnement, Université de La Rochelle, France

Energy Flexible Buildings

ANNEX 67

Due to the large deployment of fluctuating renewable energy sources foreseen, the stability of energy grids may be seriously challenged in the future. This forces a transition from generation-on-demand to consumption-on-demand. In practice, this means that energy consumption needs to become flexible. The built-in energy flexibility in buildings may, therefore, be utilized for stabilizing energy grids.

The energy flexibility of buildings is the ability to manage their 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 via load / generation control and thereby provide demand response based on the requirements of the surrounding grids.

Objectives

The project objectives are as follows:

- 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 project findings,
- 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,
- design examples on optimization of energy flexibility in buildings report, and
- a project summary report.

Progress

Several literature reviews are being carried out in the project on terminology, methodology, flexibility indicators and control possibilities to agree a common definition of the term 'energy flexibility in buildings'. Common exercises, in which the participants of the project work on a common problem with their own methods and tools in order to test different flexibility indicators, are being carried out. Simulation and modelling are utilized to test the performance of different ways of obtaining energy flexibility in single buildings and in clusters of buildings. Test facilities and real buildings are used for testing systems and controls for obtaining energy flexibility in buildings.

A number of conference paper and some journal papers have been published, while more are on the way. A study compares possible future (2030) residual loads (loads covered by power produced by fossil fuels) in fifteen countries and the requirements for grid-supportive building operation. This study has revealed that the magnitude and variability of residual load varies between countries and over the year. This is important knowledge when trying to define the amount of available flexibility.

Living Lab at NTNU, Trondheim, Norway. The living Lab is being used for investigations of energy flexibility in buildings including real occupants.
Source: Katrine Peck Sze Lim

Two other studies on market opportunities show willingness among professionals to enter the market of smart and energy flexible buildings, while a survey among 785 residential consumers in the Netherlands showed that only 3% had some knowledge about energy flexibility in buildings. However, when briefly informed, most of the respondents in the survey were willing to participate in some form of energy flexibility.

Meetings

- The 2nd working meeting was held in Trondheim, Norway, in March, 2016
- The 3rd working meeting was held in Bolzano, Italy, in October 2016
- Two Annex 67 sessions were organized at CLIMA 2016 - 12th REHVA World Congress, in Aalborg, Denmark, in May 2016
- Public Annex 67 seminar: The evolution of buildings - from the NZEB target towards energy flexibility, was held in Bolzano, Italy, in October 2016

Project duration
2014–2019

Operating Agent
Søren Østergaard Jensen, Danish Technological Institute, Denmark

Participating countries (provisional)
Austria, Belgium, Canada P.R. China, Denmark, France, Germany, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Switzerland, UK
Observer: Finland

Further information
www.iea-ebc.org

Definition and Simulation of Occupant Behavior in Buildings

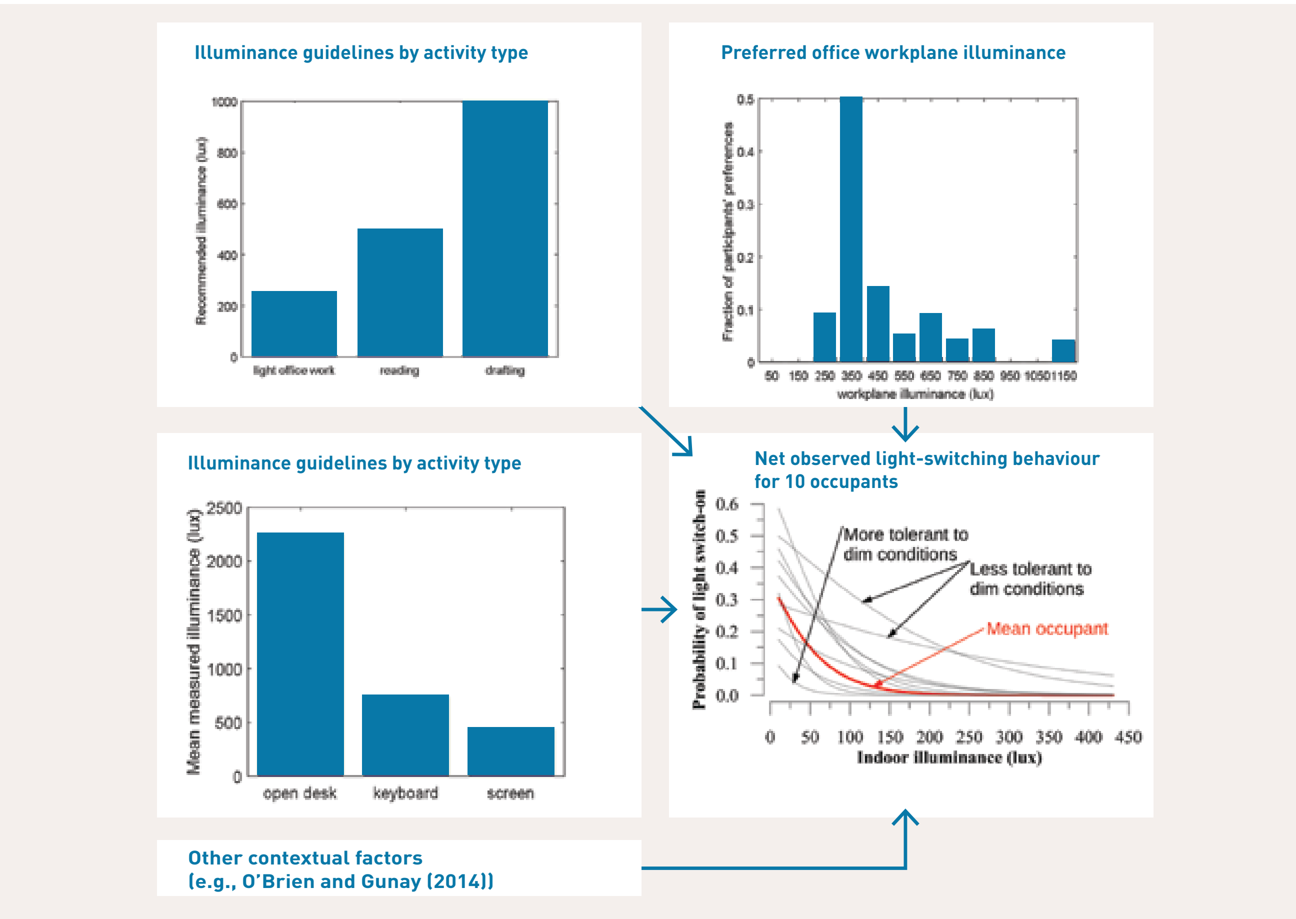
ANNEX 66

Occupant behaviour in buildings has a substantial impact on building energy use and occupant comfort. However, the behavioural dimension is much less understood than technological solutions. Delivering successful design and operation of low energy buildings are both challenging and inconsistencies between these can lead to the so-called 'performance gap'. Building performance simulations usually employ static and simplified assumptions and models, which do not capture the temporal and spatial diversity and uncertain nature of occupant behaviour in buildings, leading to inaccurate estimates of energy savings due to building technologies or design.

Objectives

This project is developing a standardized definition of occupant behaviour and is establishing a quantitative simulation methodology to model occupant behaviour in buildings, which will improve the understanding and support quantification of the influence of occupant behaviour on building performance. The project integrates the following main research activities:

- occupant behaviour monitoring and data collection,
- behaviour modelling and model evaluation,
- development of behaviour modelling tools and integrating, them with building performance simulation,



Occupant diversity for light-switching behaviours.
Source: Carleton University, Canada

- fit-for-purpose model selection and application,
- case studies of occupant behaviour in buildings, and
- integration of social science theories and practices into the occupant behaviour studies.

Deliverables

The project is producing the following deliverables based on its research activities:

- 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

The first draft of the occupancy monitoring guidebook has been completed. The objective of this book is to guide researchers who are about to embark on an occupant research campaign. It introduces fundamental aspects of developing an appropriate research and experimental design. Further, a comprehensive overview of sensors for monitoring environmental and also behavioural and action-related quantities is given.

A questionnaire survey was conducted on how the building performance simulation programs EnergyPlus, DOE-2, DeST, ESP-r, TRNSYS, IDA-ICE, COMFIE and DesignBuilder handle occupant behaviour input and models. Survey results show these programs use different approaches to model occupant behaviour, mostly limited to static and simplified inputs, lacking flexibility and interoperability in model exchange or reuse.

A collection of 16 applications, represented by case studies, were developed, organized by location, building type (residential, commercial), building size, and building life cycle stage. They are categorized by three dimensions: (1) stakeholder and problem (who and why), (2) building type, services, and provisions (what), and (3) process stage and tools (when).

Meetings

- 3rd Experts Meeting in the Working Phase took place in Vienna, Austria, in March / April, 2016
- 4th Experts Meeting in the Working Phase took place in Ottawa, Canada in August 2016

Project duration
2013–2017

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

Participating countries
Australia, Austria, Canada, P.R. China, Denmark, Germany, Italy, R. Korea, the Netherlands, New Zealand, Norway, Spain, UK, USA
Observer: Poland

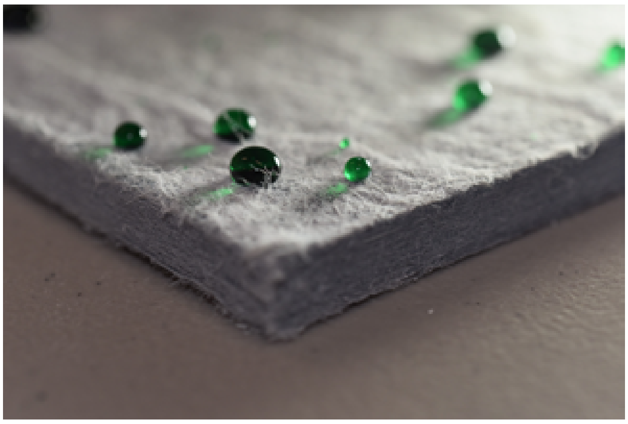
Further information
www.iea-ebc.org

Long-term Performance of Super-insulating Materials in Building Components and Systems

ANNEX 65

In cold and temperate climates, thermal insulation of building envelopes is largely applied to lighten the heating energy burden in buildings. By doing so, a reduction of around 70% to 90% of the heating demand can be achieved in new energy efficient buildings compared with the typical existing stock. It is also used to reduce cooling demand.

At present, a large number of types of so-called 'traditional insulating materials'. Traditional insulating materials are available on the market, from which it could be concluded that further research on insulating materials is unnecessary. But, this is mistaken because traditional insulating materials are still unable to fulfil certain requirements to be met in existing and even in new buildings. For example, when high performance internal thermal insulation is required, a thick traditional insulating material layer would need to be applied, which reduces living space. In new buildings, thin walls are advantageous to provide large indoor spaces for occupants while limiting the overall footprint. By working on 'super-insulating materials' (SIMs), the project is providing solutions to overcome such challenges. SIMs generally have thermal conductivities around half to eight times lower than traditional insulating materials, with lower values providing better levels of insulation.



Hydrophobic aerogel fibre mat.
Source: ASPEN AEROGEL

SIMs can nowadays be considered as mature technologies and two main types of materials are now available on the market: vacuum insulation panels (VIPs) and advanced porous materials, such as aerogel or porous silica. For specific applications under well-defined conditions, both VIPs and advanced porous materials have reached a reliable level of quality. However, there is still a need for test methods and evaluation procedures to characterize the suitability of SIMs in more severe conditions.

Objectives

SIMs are anticipated to greatly contribute to increasing energy efficiency in buildings by reducing heating and cooling needs, especially for retrofitting. The project is therefore helping to bring this about by:

- making reliable data available about the initial and lifetime performance of SIMs,
- developing robust handling and construction techniques for SIMs, and
- demonstrating the sustainability of SIMs through life cycle assessment (LCA).

Deliverables and Outcomes

The following deliverables are being prepared:

- a state-of-the-art and case studies report,
- a report about scientific Information for standardization bodies dealing with hygro-thermo-mechanical properties and ageing,
- guidelines for design, installation and inspection with a special focus on retrofitting, and
- a report on sustainability aspects (LCA, life cycle cost, embodied energy).

A two-level methodology has been established in the project for:

- characterisation at the material scale to compare the methods applied worldwide to measure the thermal performance of SIMs and to simulate their ageing, and
- an investigation of the temperature and humidity conditions the SIMs must experience on site, at the wall scale.

The project has also proposed a methodology to carry out LCA of SIMs, although supporting data from industry is currently lacking. This methodology is ready for future application as the necessary data become available.

Progress

In 2016, a first draft of the state-of-the-art report has been completed. A review has been conducted of the available methods for materials characterization, along with an analysis of the modelling methods to describe heat, moisture and air transfer through nano-structured materials and films.

A large campaign of measurements has been carried out to evaluate and compare the expertise of different laboratories worldwide and the analysis of results is underway. Surprisingly, on the one hand, measurements of the initial performance of SIMs from the different laboratories show low discrepancies; on the other hand, the measurement results after ageing were widely distributed.

A design methodology has been developed in the project for SIMs at the wall scale, based on heat and moisture simulations, to evaluate the level of risk depending on the wall design and the indoor climate conditions and climatic conditions for typical walls. This methodology is a good step towards installation of SIMs in walls. It has been found that in some cases, the design of the wall should be modified and some additional layers should be specified to protect SIMs against temperature and humidity extremes. Further, a detailed model of heat, air and moisture transfer in SIMs has been developed and is being compared with a simpler linear model.

The methodology for LCA of SIMs is ready, but manufacturers need to be convinced to provide input data to complete the LCA analysis.

Meetings

- The 3rd Plenary Meeting took place in Torino, Italy, in February 2016.
- The 4th Plenary Meeting took place in Göteborg, Sweden, in September 2016.
- A special session about the project was organised during the Sustainability in Energy and Buildings conference, organized in Torino, Italy, in September 2016.

Project duration
2013–2017

Operating Agent
Daniel Quenard, CSTB, France

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

Further information
www.iea-ebc.org

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

ANNEX 64

Energy systems in communities encompass a broad variety of building energy demand and supply technologies and system configurations. To increase the share of renewables and to steer communities towards minimised CO_2-emissions, various optimisation indicators play important roles. In traditional community energy planning these are mostly energy-based indicators, CO_2 emissions and costs. This project is focusing on low exergy (LowEx) communities and aims to improve energy conversion chains at the community scale, using exergy analysis as the primary evaluation mode.

The project is considering available methods for energy and exergy assessment, as well as the added value of aiming for so-called 'LowEx communities'. The approaches taken include sophisticated evaluation and optimisation models, which are evaluated through practical case study applications. The principal reason to exploit the exergy approach is that it provides critical insight into how the maximum potential of energy resources can be used, resulting in a reduced need for high quality energy sources. This will eventually lead to a targeted use of energy sources, both fossil fuels and renewable, and delivering a good match between the energy quality levels of the demand and the supply sides. The community level offers the most appropriate application scale for this approach, since many low exergy resources can be exploited within the system boundary.

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

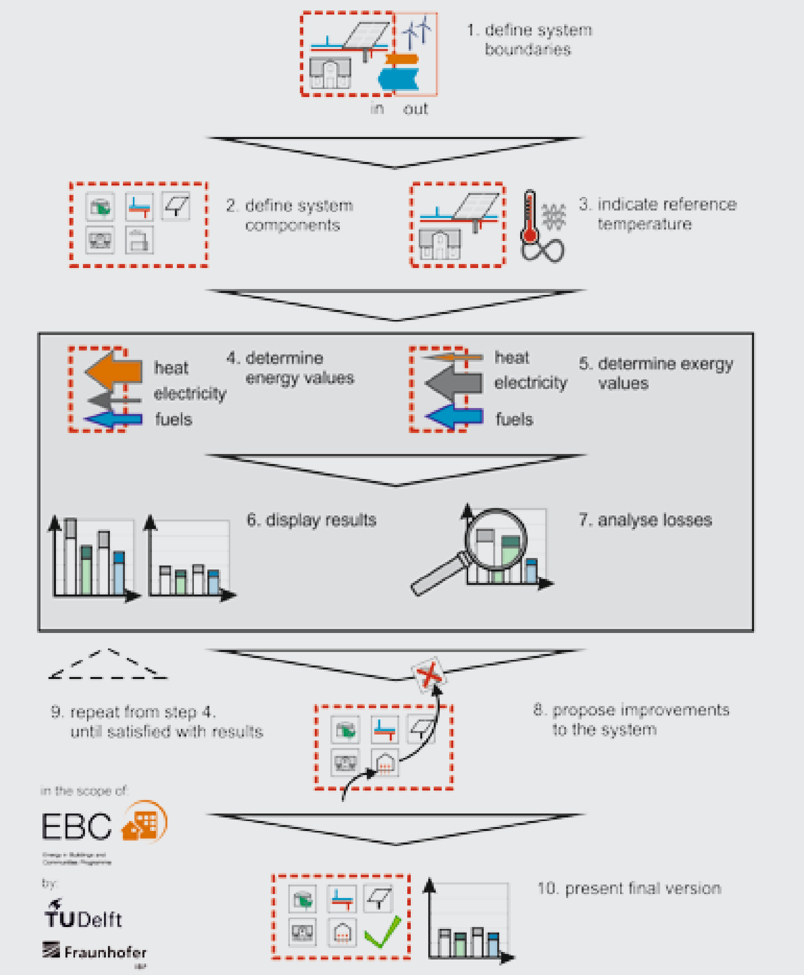
The broad variety of approaches to the optimisation of community energy systems is reflected in the case studies being examined in the project. A central point of discussion is the utilisation of temporally surplus electricity from renewable sources for heating purposes. In the 'LavEx Samfund' case study, the Technical University of Denmark and Danfoss have been working together on a method for how to use direct electricity for space heating purposes in off-peak hours (generally 00:00 - 06:00), when the electricity production from wind power can exceed typical electricity consumption. In this case, the use of surplus renewable electricity wins the argument in an overall exergy evaluation, while the exergy efficiency in subordinate systems can still be optimised.

An overall definition of the aims and targets for low exergy community planning has been developed within the project as follows: "A LowEx community is a community for which the energy system is designed in such a way that exergy destruction is minimized, or that all exergy destruction is justified for other reasons (for example, for socio-economic or other sustainability reasons)". This emphasises the fact that exergy analysis does not lead to conclusions on renewability, storability, or availability aspects, and these also need to be integrated within general decision making frameworks.

The project has been developing several models and tools to optimise the exergy performance of systems based on the specific demands of the case studies or other optimisation tasks. The models range from exergy-based ventilation controls to methodologies for the assessment of temperature reduction potentials in district heating networks including demand side management and cascading. The exergy analysis method has proven its value in the reduction of exergy losses and destruction caused by inefficient conversion processes and would mostly be used to optimise heat-driven processes within a community energy system. The complexity of exergy modelling demands a clear understanding of system boundaries and reference environments. To give planners and modellers alike a better idea about the most important influencing factors and aspects to consider when setting up an exergy model, a ten-step approach to guide them towards exergy efficient community energy systems has been created. The final project guidebook will lead the reader through this ten-step planning approach to modelling different solutions aided by case study examples.

Meetings

- The 4th meeting for the working phase took place in Aalborg, Denmark in May 2016.
- The 5th meeting for the working phase took place in Princeton, USA, in October 2016.
- During a topical session at CLIMA 2016 - the 12th REHVA World Congress was held in Aalborg, Denmark in May 2016, the project was presented in depth and discussed with a broad audience to help to ensure the practicability and relevance of the final outcomes.



The approach for creating comparable and meaningful exergy analysis results can be summarised in ten steps.
Source: EBC Annex 64

Project duration
2013–2017

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

Participating countries
Austria, Denmark, Germany, Italy, the Netherlands, Sweden, USA
Observer: Turkey

Further information
www.iea-ebc.org

Implementation of Energy Strategies in Communities

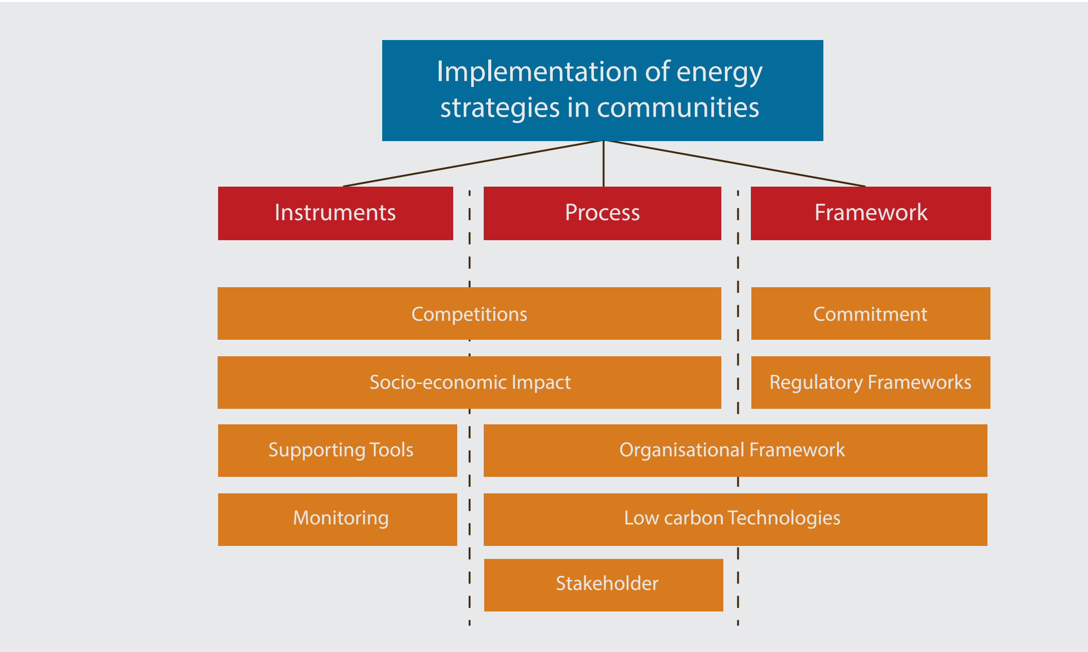
ANNEX 63

Cities are major contributors to global CO_2 emissions. To exacerbate this, most cities are still growing. This implies drastic reductions in their energy demands and related CO_2 emissions are essential. However, this transition of urban areas needs high investments in buildings, energy and transportation infrastructure that only can be generated when additional benefits are considered. To be successful and effective, a close link between energy and urban planning is essential, but this is not yet obligatory. Integrated planning processes have to deal with a high level of complexity regarding multiple issues, multiple stakeholder-groups, conflicting interests and a lack of instruments for implementation. Within the project, recommendations are being created on procedures for implementation of optimized energy strategies at the scale of communities in urban development. The project outcomes will primarily serve the needs of decision makers within urban and energy planning departments.

Objectives

The general goal of the project can be described as 'to put energy into urban planning processes'. The following specific goals are intended to support this:

- development of recommendations for implementation of optimized energy strategies;
- effective translation of a city's energy and CO_2 reduction goals to the community scale;
- optimization of policy instruments for the integration of energy and CO_2 reduction goals into common urban planning processes;
- development of new techniques for stakeholder cooperation along with holistic business models involving a wide range of stakeholders;
- division of methods for the monitoring and evaluation of both energy-related building criteria and the effectiveness of policy instruments;



How measures are clustered according to the tasks required for urban energy planning.
Source: SIR, 2016

- involvement of cities and urban planners in order to integrate energy planning in urban planning procedures, creating a win-win situation for cities, citizens, economy and the environment.

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

In 2016, analyses of national political frameworks in the areas of urban and energy planning in the participating countries were almost finished and resulted in a detailed list of 88 categorized measures. These include a short description of each measure, the entry points in urban and energy planning and the effectiveness, motivation and distribution of the measure. In general, planning in most countries follow a similar pattern in which overall responsibility for environmental issues lies with the senior levels of government, who in turn passed the requisite level of responsibility for implementation down to lower levels of government or to the municipalities themselves. It emerged that planning practices often fail when linking energy issues and development of urban form. It is noticeable that voluntary measures dominate (Effectiveness: Enable, Engage), while there is a lack of mandatory instruments (Effectiveness: Enforce). In addition, 22 best practice examples were collected and conceptualised to show how innovative approaches can work.

Based on all of this information, a set of recommendations is currently under development in collaboration with 18 cities involved in this project. National workshops held in five cities have showed that every urban and energy planning process has its strengths and weakness and the opportunities and risks for optimisation differ. The experts involved have summarized the key findings in nine clusters:

- target setting and commitment,
- implementation of low carbon technologies,
- regulatory frameworks,
- criteria in urban design competitions,
- supporting tools for information and decision making,
- stakeholder engagement,
- inclusion of social-economic impact,
- organisational frameworks, and
- monitoring.

Based on these clusters development of strategic guidance for the transferability of relevant elements in different processes has been started. Selected results will be used for delivering specific stakeholder support materials.

Meetings

- The 4th project meeting took place in May 2016 in Biel, Switzerland.
- The 5th project meeting took place in October 2016 in Leiden, the Netherlands.

Project duration

2014–2017

Operating Agent

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

Participating countries

Austria, Canada, Denmark, France, Germany, Ireland, Japan, the Netherlands, Norway, Switzerland, USA

Further information

www.iea-ebc.org

Ventilative Cooling

ANNEX 62

In many industrialised countries, overheating in buildings is emerging as a common challenge at the design stage and during operation. It is a significant problem that compromises the health and wellbeing of occupants. Ventilative cooling, which uses natural or mechanical ventilation strategies to cool indoor spaces, could be a solution to overcome this.

A qualitative survey conducted among the countries participating in this project has revealed that in many of them energy performance calculations do not explicitly consider ventilative cooling as an option for achieving cooling energy performance. Therefore, the appropriate treatment of ventilation requirements for ventilative cooling and its effect on cooling energy demand reduction is unclear and available tools used for such calculations might not be well suited to model its impact. Secondly, no specific key performance indicators focused on ventilative cooling performance are available yet. This is also a major barrier for application and further development of the technology as it makes it difficult to evaluate and compare the ventilative cooling performance and other technologies for cooling and ventilation. For this technology to be widely applied in building design and operation, this situation needs to be resolved, with recommendations and guidance ultimately developed on minimum requirements for ventilative cooling performance prediction in energy compliance tools.

Objectives

The overall 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

An overview and state-of-the-art report on ventilative cooling has previously been published. The following further project deliverables are planned:

- a ventilative cooling source book,
- ventilative cooling case studies,
- guidelines for ventilative cooling design, and
- recommendations for legislation and standards.

Progress

Two key research activities completed during the last year have been to investigate:

- modelling approaches and assumptions related to ventilative cooling in energy compliance tools, and
- the applicability for performance evaluation of ventilative cooling in the design and compliance phases of existing key performance indicators to either identify which of these can be used or adapted, or to show the need for new indicators.

To develop recommendations and guidance on minimum requirements for ventilative cooling performance prediction in energy compliance tools, the predicted cooling need reduction and thermal comfort improvement have been compared between a national energy compliance tool calculation and a dynamic simulation tool calculation based on a common reference building.
Individual modelling approaches and assumptions made in compliance tool calculations of ventilative cooling have been investigated. The results of tool comparisons carried out in six different countries have been analysed and evaluated according to the modelling approach of each

The gym and canteen at Saviese primary school in St-Germain, Switzerland, equipped with demand controled natural ventilation and a ventilative cooling system. The monitoring results show that four groups of openings, placed at the right positions and controlled with a simple BMS system, offer excellent indoor air quality and summer comfort without the presence of a single fan or duct. Source: Dominique Uldry

country before any new or updated recommendations and guidance were developed. The work illustrates the very different modelling approaches for predicting ventilative cooling impact on cooling need reduction and thermal comfort improvements in energy compliance tools in the investigated countries. The results clearly identify the minimum modelling requirements needed and the importance of using correct assumptions in achieving satisfactory predictions of ventilative cooling performance.

In the work on identifying and developing useful key performance indicators for ventilative cooling, four different categories of indicators have been identified, such as system and component boundary conditions and risk indicators. Examples of developed system indicators tested in the project include:

- The cooling requirements reduction (CRR), which is defined as the percentage of cooling requirements saved in a ventilative cooling scenario compared to a reference scenario.
- The ventilative cooling seasonal energy efficiency ratio, which is defined as the cooling requirement saving divided by the electrical consumption of the ventilation system.
- Ventilative cooling advantage (ADV_{VC}), which is defined as the benefit of the ventilative cooling, i.e. the cooling energy difference divided by the energy needed for ventilation.
- Percentage outside the range (POR), which is defined as the number or the percentage of hours of occupation when the — actual or simulated — PMV or indoor operative temperatures are outside a specified comfort range related to the chosen comfort category.
- Degree-hours criterion (DhC), which is defined as time during which the actual operative temperature exceeds the specified comfort range during occupied hours weighted by a factor that depends on the difference between actual or calculated operative temperature at a certain hour, and the lower or upper limit of a specified comfort range.

A large number of other key performance indicators in all four categories have also been tested in the project. To evaluate the performance of compliance tools and to estimate and evaluate the applicability of the identified and developed key performance indicators, a common reference case has been used. This has been based on the design of the Saviese primary school, located in St-Germain (Switzerland). This design is a three-storey combined school / office building that is modified to fulfil building regulations in each of the countries.

Meetings

- The 5th Expert Meeting took place in Cork, Ireland in April 2016 in April 2016.
- The 6th Expert Meeting took place in Vienna, Austria in October 2016.

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
Observer: Finland

Further information
www.iea-ebc.org

Business and Technical Concepts for Deep Energy Retrofits of Public Buildings

ANNEX 61

To meet ambitious energy reduction targets in many industrialised countries, both the number of building refurbishments and the actual energy savings achieved in each instance, must be dramatically increased in the near future. Energy use reductions typically achieved in 'business as usual' situations vary between 10% and 20% including heat and electricity. This research project is working towards cost effective technical and business concepts for deep energy retrofits (DER) aiming at reductions of at least 50% against the projected energy baseline.

Cost-effectiveness is the major criterion in the decision-making process in the public sector, with the criteria most frequently used being dynamic cash flows and net present value. The evaluation of DER projects shows, however, that cost-effectiveness is still a major challenge that has to be solved for each retrofit project in terms of its costs and its benefits.

Deep Energy Retrofit Forum discussions - In September 2016, the DER Forum hosted by the Federal Facilities Council of the National Academies of Sciences, Engineering, and Medicine in partnership with EBC Annex 61, US Army Corps of Engineers, GSA, ASHRAE and the US Department of Energy (FEMP) was convened with the attendance of more than 100 high level experts from the USA, Canada and Europe.
Source: EBC Annex 61

In order to minimise the investment costs, highly effective bundles of DER measures are identified by an energy modelling process. Within the modelling, the technical specifications of the major components of the bundles are defined, such as building envelope, ventilation with heat recovery, lighting design, building automation and other high performance equipment.

Objectives

The project is aiming to:

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

Deliverables and Outcomes

The following project deliverables are being prepared for publication:

- A prescriptive guide to achieving significant energy use reductions with major renovation projects report,
- Advanced DER business models report, and
- Documented results of several realized projects and case studies demonstrating whole or a part of the developed models for DER.

The ways in which a deep energy retrofit project are financed and implemented (i.e. the business model) are closely interdependent with the cost-effectiveness. First of all, existing grant programmes can significantly reduce the overall demand for funding. In many European countries and in the USA, loan programmes create incentives for renovations that go beyond the national minimum requirements. Usually, grant programmes take into account the incremental costs needed to reduce energy demands.

A major approach to improve the cost-effectiveness of DER is to combine major renovation projects to deliver minimum energy requirements that already have allocated funding sources ('seed money') with a DER project. By only referring to the marginal investment costs necessary to improve from minimum requirements to a DER, the cost-effectiveness may become attractive for public building owners. In case that sufficient seed money is unavailable, cost-effectiveness can only be achieved by considering energy savings and additional life cycle cost savings.

Within this project, the scope of existing and well proven energy performance contracting business schemes has been advanced towards a 'DER energy performance contracting' business model. By providing performance guarantees, the energy and non-energy related cost savings become reliable and accountable. Because the remuneration of an energy services company is related to the energy savings and life cycle cost achieved in practice, this advanced DER energy performance contracting business model may provide a cost-neutral financing scheme for a public building owner. In fact, the DER energy performance contracting business model has been successfully implemented in public buildings in the USA and Germany.

Progress

The project moved into its reporting phase in 2016. The official project deliverables, 'Deep Energy Retrofit – A Prescriptive Guide to Achieve Significant Energy Use Reduction with Major Renovation Projects' report, 'Deep Energy Retrofit Business Models' guideline, and the 'Deep Energy Retrofit Case Studies' report have been prepared and are due to be published in 2017.

Meetings

- 6th Experts meeting, April 2016, Darmstadt, Germany
- 7th Experts meeting, September 2016, Washington, DC, USA

Project duration
2012–2017

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

The core research problem that has been solved within this project is the coordinated development, application and demonstration of new generation computational tools for building and community energy systems that:
- are based on open standards, and
- allow buildings and energy grids to be designed and operated as integrated, robust, and performance based systems.

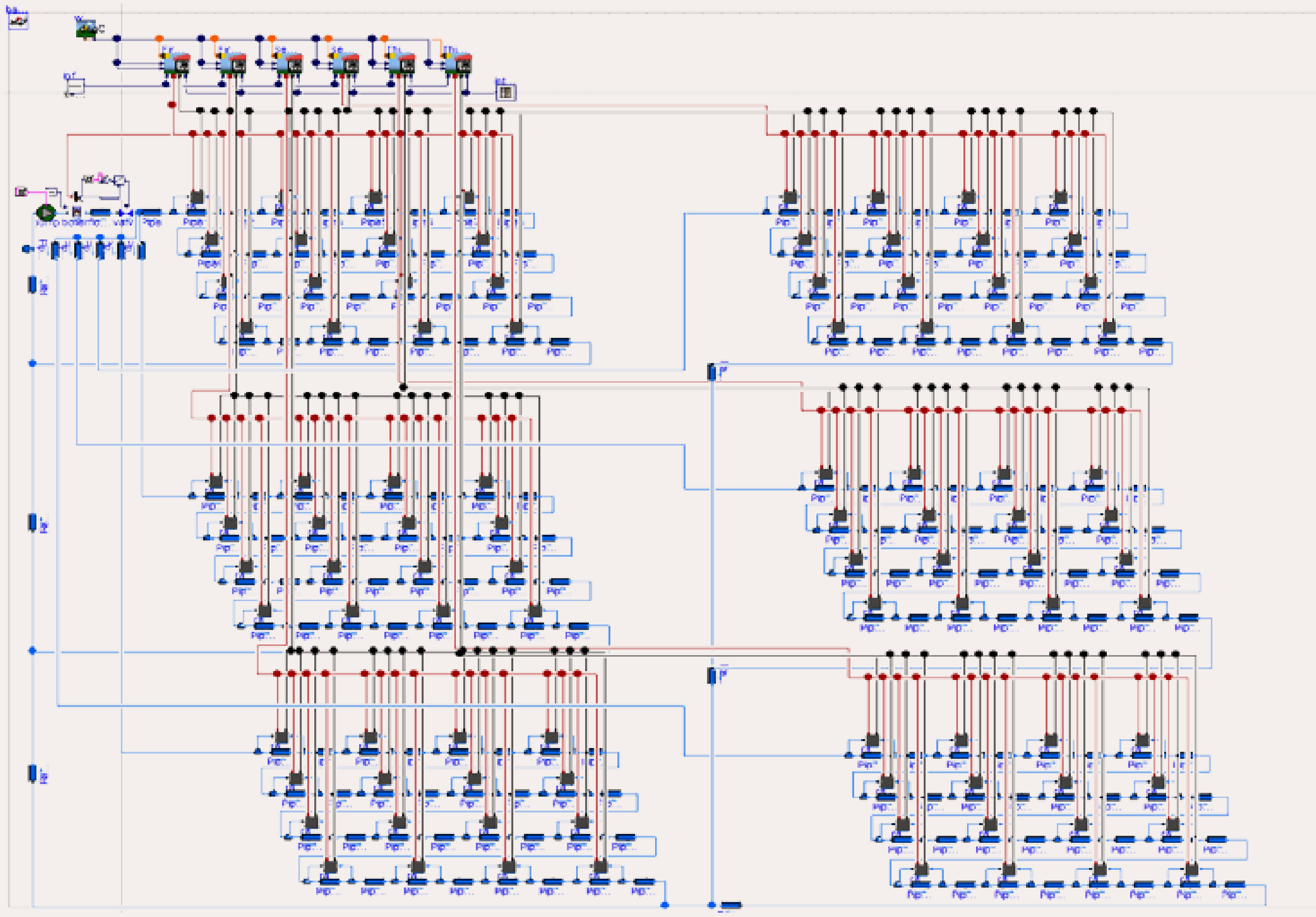
Building and community energy simulation is faced with several challenges that lead to structural changes being required in the methods, tool developments and application of these tools. For building simulation programs to fully support decision making during product development, building design, commissioning and operation, these challenges arise due to:
- the design and operation of zero energy buildings and communities,
- shifting the energy supply with the increased use of variable renewable energy resources, a sector-wise coupling of electricity and heat at both the demand and supply sides, at various time scales from fast power regulation requirements to daily and seasonal energy storage, and
- the increasingly integrated building delivery process, supported by digital planning tools, such as Building Information Modelling (BIM).

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

Deliverables and Outcomes
The following project deliverables are being produced:
- validated and documented models that can be used within multiple freely available 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 to 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
After four years of intensive collaboration by a large international team consisting of 42 organisations from 16 countries, the project entered its final phase with emphasis on reporting and dissemination. In 2016, the freely available open-source 'Annex 60 Modelica Library' has been extended to a total of more than 300 models and functions and more than 260 examples. This Library has been successfully integrated into the four Modelica libraries that are distributed by the participants: Lawrence Berkeley National Laboratory, USA, Berlin University of the Arts, Germany, KU Leuven, Belgium and RWTH Aachen University, Germany. Work has continued on increasing numerical robustness and progress has been made in revising the models. Concerning co-simulation and model exchange, new simulation environments have been developed to import and export Functional Mockup Units.

For the BIM to Modelica transformation, progress has been achieved in further advancing the tool chain and testing it according to the project use cases. A BIM Model View Definition was developed for advanced building energy performance simulation. Further progress was made in validation and demonstration. For building systems, emphasis was placed on refining simulation scenarios for optimal design and control. For the design of district energy systems, work concentrated on the definition of the 'Annex 60 Neighbourhood Case' as a common exercise and district simulation benchmark.



An object-oriented Modelica simulation model using the EBC Annex 60 framework technology.
Source: RWTH Aachen University

To continue this successful collaboration framework, the research, development and dissemination activities will be advanced within International Building Performance Simulation Association (IBPSA) Project 1, "BIM / GIS and Modelica framework for building and community energy system design and operation", which is planned to start in 2017.

Meetings

In 2016, two expert meetings were held, the first in May 2016 in Miami, Florida, USA and the second in October 2016 in Porticcio, France. The second meeting was followed by a five day workshop sponsored by IBPSA-France, during which 65 participants were trained by experts from Annex 60 in Modelica for building and district energy system simulation.

Several special scientific tracks at national and international conferences were organized in order to disseminate and promote results of the project. Invited presentations about the work were held at the IBPSA-USA / ASHRAE SimBuild conference in Salt Lake City, Utah, the IBPSA-England BSO conference in Newcastle, UK, the IBPSA-Germany's BauSim conference in Dresden, Germany, and the Modelica North America Users' Group meeting in Troy, Michigan, all in 2016. Also, an invited presentation about the project was given at the international conference of the European Energy Research Alliance (EERA) in November 2016 in Birmingham, UK.

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

Cost Effective Energy and Carbon Dioxide Emissions Optimization in Building Renovation

ANNEX 56

Considering the intensive use of energy in buildings, this sector has become an important target for reducing carbon dioxide (CO_2) emissions, and use of energy and resources. However, most current regulations in industrialised countries are focused mainly on new buildings and do not account for the multiple technical, functional and economic constraints that have to be faced in the renovation of existing buildings. Thus, a new methodology has been created in this project to be used in the decision making process for energy-related building renovation, which allows a cost-effective balance to be found between energy use, CO_2 emissions and overall added value.

Objectives

The project objectives are to:

- define a methodology for establishing cost optimized targets for energy use 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 and Outcomes

Aside from a dedicated website and bi-annual newsletters, the project is producing the following reports:

- 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 Life Cycle Assessment into the Assessment of Renovation Measures and Demonstration of the Relevance of Life Cycle Assessment 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, and
- Renovation Guidebook for Professional Owners.

In 2016, the project has been concluding its reporting phase, with most of the reports completed and being used as a basis for the two final deliverables, namely the Renovation Guidebooks targeted for Policy Makers and for Professional Owners. The preparation of the Renovation Guidebooks has been the major focus of the project during 2016. These rely on the major findings included in the various other project reports and deliver recommendations for the two selected target groups. Some of the main conclusions for residential buildings are as follows:

- The cost optimal level does not lead to nearly zero energy or nearly zero emissions levels. So, to reach this target it is essential to go a step further and explore the full potential of the cost-effective energy-related renovation measures.
- Despite the use of renewable energy sources that must be encouraged, building renovation should always integrate improvements on the building envelope in order to assure comfort and prevent damage resulting from problems relating to building physics.

Project case studies (from left to right and up-down, before and after renovation) (1) Multifamily building in Kapfenberg, Austria, (2) Elementary school Kaminky 5, Brno, Czech Republic, (3) Multifamily building in the Traneparken complex, Hvalsø, Denmark (4) Multifamily building in Lourdes neighbourhood, Tudela, Spain, (5) Multifamily building in Rainha Dona Leonor neighbourhood, Porto, Portugal (6) Multifamily building Back Röd, Gothenburg, Sweden.
Source: EBC Annex 56

- When the target is to reduce the CO_2 emissions at the least cost, it is advisable to use renewable energy sources.
- It is better and more cost-effective to improve the energy performance of several elements of the envelope, rather than to maximize the performance of just one at high cost.
- In order to benefit from the synergies between energy-related measures and technical systems, it is advisable to combine renewable energy systems with conservation measures on the buildings envelope.
- The inclusion of embodied energy in materials in the assessment of the buildings energy performance has an increasing impact as the zero energy targets become more relevant. However, this impact in a renovation process plays a much smaller role than in the case of construction of new buildings.

Progress

During 2016, all of the above reports have been approved ready for publication, except for the Renovation Guidebooks for Policy Makers and for Professional Owners, which are being finalised for publication during 2017.

Meetings

While no project meetings were held during 2016, it was represented at the CLIMA 2016 - 12th REHVA World Congress, with the presentation of two papers and the co-organization of a workshop dedicated to 'Cost-effective Deep Renovation of Buildings'. A further important event in the promotion of the project findings was the SE4All Energy Efficiency Accelerators Platform Webinar 'Renovating Buildings with Cost-Effective Reductions in Energy and Carbon Emissions – Findings from IEA EBC Annex 56' that took place in November 2016.

Meetings

No meetings have been held during 2016.

Project duration
2010–2017

Operating Agent
Manuela Almeida, University of Minho, Portugal

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

Further information
www.iea-ebc.org

Air Infiltration and Ventilation Centre

ANNEX 5

Adequate ventilation provision is vital in providing acceptable indoor air quality. The goal of the 'Air Infiltration and Ventilation Centre' (AIVC) is to provide reference information on ventilation and infiltration in buildings, given that these mechanisms typically represent between 25% to over 50% of a building's total space heating (or cooling) needs. Inaugurated in 1979 with a focus on infiltration losses, its scope now expands to energy and indoor air quality impacts of all ventilation strategies in new and existing buildings.

The latest project publication – Technical Note 68 on Residential Ventilation and Health, published in 2016.
Source: EBC Annex 5

Objectives

- Identify emerging issues on ventilation and infiltration in new and renovated buildings;
- Help better design, implement, hand-over and maintain ventilation systems;
- Provide discussion platforms, including conferences, workshops and webinars.

Deliverables

- Events: annual conference, 1 to 2 workshops per year on specific topics, 1 to 2 webinars per year;
- Publications: conference and workshop proceedings, technical notes and contributed reports (1 per year), biannual newsletter.

Progress

In 2016, the AIVC focused its work on three projects, the 37th Annual Conference, and supporting discussions and dissemination for EBC Annex 62 on Ventilative Cooling and EBC Annex 68 on Indoor Air Quality Design and Control in Low Energy Residential Buildings. The three projects have been progressed as follows:

- Residential Ventilation and Health: This project resulted in the publication of Technical Note 68 after review by experts and with the support of the Indoor Environmental Quality Alliance (www.ieq-ga.net). It has benefited from contributions of several authors and many structured discussions held during specific sessions at AIVC events, including feedback from the audience by using a voting system with prepared multiple-choice questions.
- Residential Cooker Hoods: Several topical sessions were also organised concerning the second project to discuss challenges regarding cooker hoods, from performance characterization to practical implementation and actual use.

– Competent Tester Schemes for Building Airtightness Testing: Regarding this project, AIVC has pursued its efforts on the quality of building airtightness measurements in collaboration with TightVent, which is an information platform aiming at raising awareness on the building and ductwork airtightness.

During the CLIMA 2016 - 12th REHVA World Congress, held in Aalborg, Denmark, the AIVC has co-organised three specific sessions, one on building and ductwork airtightness, a second one on ventilative cooling in collaboration with EBC Annex 62, a third one on the '2020 Agenda for Ventilation and Air Infiltration'. In all of these sessions, contributors gave overviews of the status and challenges which served as basis for discussions on perspectives for future work, not only in R&D, but also in legislation, standards, dissemination, and so on.

The 37th AIVC Annual Conference was held in Alexandria, Virginia, USA, in collaboration with ASHRAE's IAQ triannual conference. 176 delegates from 21 countries attended the conference. EBC Annex 68 convened a dedicated session to discuss their approach and findings with a wider audience. This conference had a clear focus on indoor air quality, and confirmed the relevance of future research topics identified by the AIVC, including indoor air quality (IAQ) metrics, air cleaning, cooker hoods, and measurement methods.

Given the challenges faced by many countries to contain the energy losses by ventilation and infiltration, while providing a good indoor environmental quality, the Executive Committee of the IEA Energy in Buildings and Communities Programme approved the continuation of the AIVC for the period 2017-2021 at its 80th Meeting in November 2016.

Meetings

The AIVC board met twice in 2016:

– Aalborg, Denmark on 25th May, 2016, and
– Alexandria, Virginia, USA on the 14th September, 2016.

AIVC Newsletter

March 2016
September 2016

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: Finland, Poland

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

Completed Research Projects

EVALUATION OF EMBODIED ENERGY AND CARBON DIOXIDE EQUIVALENT EMISSIONS FOR BUILDING CONSTRUCTION (ANNEX 57)

RELIABLE BUILDING ENERGY PERFORMANCE CHARACTERISATION BASED ON FULL SCALE DYNAMIC MEASUREMENT (ANNEX 58)

HIGH TEMPERATURE COOLING AND LOW TEMPERATURE HEATING IN BUILDINGS (ANNEX 59)

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

ANNEX 57

The evaluation of energy use by buildings is becoming increasingly accurate, and has in many industrialised countries has led to the design of more energy efficient building envelopes and systems, driven by more demanding standards and regulations. However, the fraction of the total life cycle energy use and CO_2 emissions caused by other life cycle stages, the embodied impacts, is significant, and growing. Energy use and CO_2 emissions due to building construction and civil engineering works currently account for about 20% of global impacts, varying from typically 5% to 10% for industrialised countries and 10% to 30% in developing countries.

The reduction of embodied energy and CO_2 emissions from buildings has the potential to decrease these values considerably. However, while this is increasingly recognized, current calculation approaches and methods vary greatly depending on the country and evaluator, and resulting in widely differing results. Over the last five years, this major international research project has addressed this issue, with researchers from 18 countries working together to develop a detailed understanding of the multiple calculation methods and their interpretations. The project has also used the knowledge developed to present the information in a set of clear guidelines so that various practitioners can include this in their decision-making. The aim of the research has been the global reduction of embodied energy (EE) and equivalent CO_2 emissions (EC_{eq}) from buildings. The project objectives were 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}.

Achievements

The design of a building is based on a vast range of requirements and principles, of which reducing whole life cycle EE-EC_{eq} will only ever be part. However, the potential to significantly reduce the EE-EC_{eq} from buildings, through a wide range of different measures, has been clearly demonstrated through the work of the project. As the main project outcomes, the reports and guidelines have been based on analysis and documentation of more than 80 case studies, which have been classified according to the measures applied to reduce EE-EC_{eq}.

The project has recommended that calculations of EE-EC_{eq} should be conducted as standard for all buildings, just as in more recent years the operational impacts have been routinely calculated. The development of policy instruments, possibly including regulation, to encourage this should be a priority for all Governments. However, R&D challenges remain and work needed in the future includes the creation of practical measures to reduce EE-EC_{eq}, technology transfer to developing countries, integrated technologies and calculation methodologies related to embodied energy and greenhouse gas emissions within building assessment tools and combining impacts of construction and operation of buildings.

Publications

The following project deliverables have been 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.

Meetings

- The 10th Expert Meeting took place in Prague, Czech Republic in June 2016, and the 11th Expert Meeting took place in Tokyo, Japan in October 2016.
- During 2016, the project outcomes were explained at dedicated EBC Annex 57 sessions at the CESB16 conference, held in Prague, the Czech Republic, at the CLIMA2016 conference in Aalborg, Denmark, and at a workshop in Tokyo, Japan.

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

Further information
www.iea-ebc.org

Scenario	Standard	Resilient
Reference period (years)	50	100
EG (kg-CO_2/m^2 year)	7.9	4.8
EC (kg-CO_2/m^2 year)	89	60

Measures to reduce embodied greenhouse gases (EG) and embodied CO_2 emissions (EC) by prolongation of building life.
Source: © Henning Larsen Architects

Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements

ANNEX 58

The rise of living standards in many countries, the scarcity of natural resources and the awareness of climate change have resulted in international pressure to significantly reduce the energy use of buildings and communities. In many industrialised countries, increasingly stringent requirements have been imposed by energy performance legislation. For the most part, meeting requirements for and labelling of the energy performance of buildings is carried out during the design phase by calculating theoretical energy use. Several studies showed however that the actual performance after construction of buildings may deviate significantly from the theoretically designed performance.

This recently completed international research project has narrowed the gap between designed and realized energy performance by developing quality procedures for on-site assessment. Methods for full scale testing and data analysis have been developed and their applicability evaluated to achieve reliable as-built performance characterisation of building components and whole buildings. Substantial effort was given in the project to the determination of the actual overall heat loss coefficient of a building starting from static and dynamic on-site measurements.

Achievements

To achieve the main objective of the project, the following tasks have been successfully carried out:

- Inventory of the state-of-the-art on full scale testing and dynamic data analysis,
- Development of a decision tree on how to measure the actual thermal performance of building components and whole buildings in-situ,

The IDEE house at Limelette, Belgium, a full-scale experimental building that has been used as a test case to develop and evaluate methodologies to characterise the overall heat loss coefficient based on static and dynamic measurement campaigns.
Source: BBRI, Belgium

- Analysis and development of dynamic data analysis tools that can be used to characterize building components and whole buildings starting from full scale dynamic data tests,
- Undertake a detailed empirical validation exercise on a full-scale building to provide datasets suitable for assessing detailed simulation programs used in predicting building thermal performance,
- Illustrate the applicability of full scale dynamic testing with respect to energy conservation in buildings and communities,
- Set-up a network of excellence on full scale testing and dynamic data analysis for knowledge exchange and guidelines on testing.

Publications

As official publications of the project, a final summary report has been published, together with seven supporting documents that explain the underlying work in depth. These publications are as follows:

- Project Summary Report: Reliable Building Energy Performance Characterization Based on Full Scale Dynamic Measurements,
- Inventory of Full Scale Test Facilities for Evaluation of Building Energy Performances Report,
- Overview of Methods to Analyse Dynamic Data Report
- Logic and Use of the Decision Tree for Optimizing Full Scale Dynamic Testing Report,
- Thermal Performance Characterization Based on Full Scale Testing: Physical Guidelines And Description of the Common Exercises Report,
- Thermal Performance Characterisation using Time Series Data: Statistical Guidelines Report,
- Empirical Validation of Common Building Energy Simulation Models Based on In-situ Dynamic Data Report,
- Towards a Characterisation of Buildings Based on In-situ Testing and Smart Meter Readings and Potential for Application in Smart Grids Report.

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

High Temperature Cooling and Low Temperature Heating in Buildings

ANNEX 59

This recently completed international research project provides a fresh perspective and introduces a novel concept for optimizing heating, ventilation, and air conditioning (HVAC) systems in buildings. The direction taken is based on a deep understanding of HVAC systems and aims to avoid unnecessary energy losses due to offset of cooling with heating, dehumidification with humidification, mixing of cold and hot fluids, and transfer losses due to unnecessary or inappropriate heat exchange. High temperature cooling and low temperature heating are achieved by reducing temperature differences in heat transfer and energy transportation processes.

The project was organized around the concept of reducing mixture losses and transfer losses, and was arranged in response to the current inefficiencies of HVAC systems. The scope of the project included major commercial building types, such as offices, those with large internal spaces, and so on. The ultimate goal was to create new concepts for analyzing HVAC systems based on reducing mixture and transfer losses and to then apply these to high temperature cooling and low temperature heating systems.

The EBC Annex 59 project workshop held during the CLIMA 2016 - 12th REHVA World Congress. During this workshop, presentations were given on similarities and distinctions between exergy and entransy analyses in air-conditioning systems, an experimentally based analysis of HVAC indoor terminal units, the equivalent thermal resistance in periodic heat transfer processes, experiences in Italy and for newly built office buildings towards net zero energy buildings, a performance evaluation and experimental study on a heat recovery device, and the effects of floor covering resistance of a radiant floor on system energy and exergy performance.
Source: Tang Haida, Tsinghua University

The specific objectives were 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.

Achievements

The final project reports have been published. These cover different aspects for achieving 'high temperature cooling and low temperature heating' systems in buildings, including basic theory, key devices, system analysis, and so on. By way of example, the research has unified and clarified the methodology for optimizing HVAC systems. It has investigated parameters (entransy, exergy, and so on) and their application ranges. The aim of this part of the project was to rethink handling processes in air-conditioning systems. Heat transfer processes rather than heat-work transmission processes should be examined to improve the energy performance of air-conditioning systems. The associated report emphasizes the novel theoretical analysis about the air-conditioning systems. This also includes a simplified overview of current systems and development history.

Publications

The following project deliverables have been produced:

- Guide book on a new analysis method for HVAC systems,
- Report on demand and novel design of indoor terminals in high temperature cooling and low temperature heating systems,
- Report on novel flow paths of outdoor air handling equipment and their application in high temperature cooling and low temperature heating systems,
- Design guide for high temperature cooling and low temperature heating systems,
- Report on applications and real-time tests of high temperature cooling and low temperature heating systems in typical office buildings with different climate conditions,
- Project summary report.

Meetings

In 2016, an open forum about the project was held during CLIMA 2016 - 12th REHVA World Congress, held in Aalborg, Denmark. Eight presentations were given concerning high temperature cooling and low temperature heating systems.

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

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 nine 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/tcp

This framework provides uncomplicated, common rules for participation in RD&D programmes, known as Technology Collaboration Programmes, and simplifies international cooperation between national entities, business and industry. The IEA Technology Collaboration Programmes (TCPs) are established by 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 TCPs. There are numerous advantages to international energy technology RD&D collaboration through the TCPs, 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 a Technology Collaboration Programme 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 created as annexes to the 'Implementing Agreement' on which the EBC TCP is established. 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 Technology Collaboration Programme 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
Singapore
Spain
Sweden
Switzerland
UK
USA

COORDINATION WITH OTHER BODIES

In order to achieve high efficiency in the EBC Technology Collaboration Programme (TCP) and to eliminate duplication of work it is important to collaborate with other IEA buildings-related TCPs. 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 BUILDINGS-RELATED TECHNOLOGY COLLABORATION PROGRAMMES

The EBC Programme continues to coordinate its research activities, including Annexes and strategic planning, with all IEA buildings-related TCPs 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 Technology Collaboration 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 buildings-related TCPs 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 Technology Collaboration Programmes 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 TCPs 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 TCP.

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 68 Residential Ventilation and Health, 2016

AIVC Conference Proceedings

IAQ 2016 USA - Defining Indoor Air Quality: Policy, Standards and Best Practices
Co-Organized by ASHRAE and AIVC
September 12 – 14, 2016
Alexandria, VA

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

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

Evaluation of Embodied Energy and CO2 Equivalent Emissions for Building Construction – Annex 57

– Summary Report
– Overview Report
– Basics, Actors and Concepts
– Literature Review
– Evaluating the Embodied Energy and the Embodied GHG in Building and Construction: Methods and Guidelines
– Recommendations for the Reduction of Embodied Greenhouse Gases and – Embodied Energy from Buildings
– Guidelines for Designers and Consultants Parts 1 and 2
– Guidelines for Construction Products Manufacturers
– Guidelines for Policy Makers
– Guidelines for Education
– Case Study Report

Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements – Annex 58

–Inventory of full scale test facilities for evaluation of building energy performances, Arnold Janssens, KU Leuven, Belgium 2016
–Overview of methods to analyse dynamic data, Arnold Janssens, KU Leuven, Belgium 2016
– Logic and use of the Decision Tree for optimizing full scale dynamic testing, Aitor Erkoreka, Chris Gorse, Martin Fletcher, Koldobika Martin, KU Leuven, Belgium 2016
– Thermal performance characterization based on full scale testing - description of the common exercises and physical guidelines, Maria Jose Jimenez, KU Leuven, Belgium 2016
– Thermal performance characterisation using time series data – statistical guidelines, Henrik Madsen, Peder Bacher, Geert Bauwens, An-Heleen Deconinck, Glenn Reynders, Staf Roels, Eline Himpe, Guillaume Lethé, KU Leuven, Belgium 2016
– Empirical validation of common building energy simulation models based on in situ dynamic data, Paul Strachan, Katalin Svehla, Matthias Kersken, Ingo Heusler, KU Leuven, Belgium 2016
– Towards a characterisation of buildings based on in situ testing and smart meter readings and potential for applications in smart grids, Dirk Saelens, Glenn Reynders, KU Leuven, Belgium 2016

Ventilative Cooling – Annex 62

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

EBC Executive Commitee Members

CHAIR
Andreas Eckmanns (Switzerland)

VICE CHAIR
Dr Takao Sawachi (Japan)

AUSTRALIA
Stanford Harrison
Department of the Environment and Energy
Stanford.Harrison@environment.gov.au

AUSTRIA
Isabella Zwerger
Austrian Federal Ministry of Transport, Innovation and Technology
Isabella.Zwerger@bmvit.gv.at

BELGIUM
Dr Peter Wouters
Belgian Building Research Institute (CSTC – WTCB)
peter.wouters@bbri.be

CANADA
Gilles Jean
Natural Resources Canada
gilles.jean@canada.ca

P.R. CHINA
Prof Yi Jiang
Tsinghua University
jiangyi@tsinghua.edu.cn

CZECH REPUBLIC
Magdalena Vyslychová
Ministry of Industry and Trade
vyslychova@mpo.cz

DENMARK
Prof Per Heiselberg
Aalborg University
ph@civil.aau.dk

FRANCE
Nicolas Doré
Agence de l'Environment et de la Maitrise de l'Energie
nicolas.dore@ademe.fr

GERMANY
Katja Riess
Forschungszentrum Juelich
k.riess@fz-juelich.de

IRELAND
Prof J Owen Lewis
j.owen.lewis@gmail.com

ITALY
Michele Zinzi
ENEA - UTEE ERT
michele.zinzi@enea.it

JAPAN
Dr Takao Sawachi (Vice Chair)
Building Research Institute
tsawachi@kenken.go.jp

REPUBLIC OF KOREA
Dr Seung-eon Lee
Korea Institute of Construction Technology
selee2@kict.re.kr

NETHERLANDS
Daniël van Rijn
Netherlands Enterprise Agency
daniel.vanrijn@rvo.nl

NEW ZEALAND
Michael Donn
Victoria University of Wellington
michael.donn@vuw.ac.nz

NORWAY
Eline Skard
Department for Energy and Petroleum, Norges Forskningsrad
eska@rcn.no

PORTUGAL
João Mariz Graça
Direção-Geral de Energia e Geologia
joao.graca@dgeg.pt

SINGAPORE
Tan Tian Chong
Building and Construction Authority
TAN_Tian_Chong@bca.gov.sg

SPAIN
Francisco Rodriguez Pérez-Curiel
Tecnalia Research & Innovation
francisco.rodriguez@tecnalia.com

SWEDEN
Conny Rolén
Formas
conny.rolen@formas.se

SWITZERLAND
Andreas Eckmanns (Chair)
Bundesamt für Energie BFE
andreas.eckmanns@bfe.admin.ch

UK
Prof Paul Ruyssevelt
University College London
p.ruyssevelt@ucl.ac.uk

USA
David Nemtzow
US Department of Energy
David.Nemtzow@ee.doe.gov

EBC Operating Agents

Air Infiltration and Ventilation Centre (AIVC) – Annex 5
Dr Peter Wouters
INIVE EEIG, Belgium
info@aivc.org

Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation – Annex 56
Dr Manuela Almeida
University of Minho, Portugal
malmeida@civil.uminho.pt

Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction – Annex 57
Prof Tatsuo Oka
Utsunomiya University, Japan
okatatsuo@e-mail.jp

High Temperature Cooling and Low Temperature Heating in Buildings – Annex 59
Prof Yi Jiang
Tsinghua University, P.R. China
jiangyi@tsinghua.edu.cn

New Generation Computational Tools for Building and Community Energy Systems – Annex 60
Dr Michael Wetter
Lawrence Berkeley National Laboratory, USA
mwetter@lbl.gov

Christoph van Treeck
RWTH Aachen University, Germany
treeck@e3d.rwth-aachen.de

Business and Technical Concepts for Deep Energy Retrofit of Public Buildings – Annex 61
Dr Alexander M. Zhivov
Energy Branch US Army Corps of Engineers, USA
Alexander.M.Zhivov@erdc.usace.army.mil

Rüdiger Lohse
KEA-Climate protection and energy agency of Baden-Württemberg GmbH, Germany
ruediger.lohse@kea-bw.de

Ventilative Cooling – Annex 62
Prof Per Heiselberg
Aalborg University, Denmark
ph@civil.aau.dk

Implementation of Energy Strategies in Communities – Annex 63
Helmut Strasser
Salzburg Institute for Regional Planning and Housing, Austria
helmut.strasser@salzburg.gv.at

LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles - Annex 64
Dr Dietrich Schmidt
Fraunhofer Institute for Building Physics, Germany
dietrich.schmidt@ibp.fraunhofer.de

Long-term Performance of Super-insulating Materials in Building Components and Systems – Annex 65
Daniel Quenard
Centre Scientifique et Technique du Bâtiment, France
daniel.quenard@cstb.fr

Definition and Simulation of Occupant Behavior in Buildings – Annex 66
Dr Da Yan
Tsinghua University, P.R. China
yanda@tsinghua.edu.cn

Dr Tianzhen Hong
Lawrence Berkeley National Laboratory, USA
thong@lbl.gov

Energy Flexible Buildings – Annex 67
Søren Østergaard Jensen
Danish Technological Institute, Denmark
sdj@teknologisk.dk

Design and Operational Strategies for High IAQ in Low Energy Buildings – Annex 68
Prof Carsten Rode
Technical University of Denmark, Denmark
car@byg.dtu.dk

Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings – Annex 69
Prof Yingxin Zhu
Tsinghua University, P.R. China
zhuyx@tsinghua.edu.cn

Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale – Annex 70
Dr Ian Hamilton
University College London, UK
i.hamilton@ucl.ac.uk

Building Energy Performance Assessment Based on In-situ Measurements – Annex 71
Prof Staf Roels
University of Leuven, Belgium
staf.roels@bwk.kuleuven.be

Assessing Life Cycle Related Environmental Impacts Caused by Buildings – Annex 72
Rolf Frischknecht
treeze Ltd., Switzerland
frischknecht@treeze.ch

Towards Net Zero Energy Public Communities – Annex 73
Dr Alexander M. Zhivov
Energy Branch US Army Corps of Engineers, USA
Alexander.M.Zhivov@erdc.usace.army.mil

Rüdiger Lohse
KEA-Climate protection and energy agency of Baden-Württemberg GmbH, Germany
ruediger.lohse@kea-bw.de

Energy Endeavour – Annex 74
Prof. Karsten Voss
University Wuppertal, Germany
kvoss@uni-wuppertal.de

Peter Russell
Solar Decathlon Europe Secretariat / Energy Endeavour Foundation, the Netherlands
peter.russell@solardecathlon.eu

EBC Operating Agents

Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables – Annex 75

Dr Manuela Almeida
University of Minho, Portugal
malmeida@civil.uminho.pt

HVAC Energy Calculation Methodologies for Non-residential Buildings Working Group

Prof Tatsuo Oka
Utsunomiya University, Japan
okatatsuo@e-mail.jp

EBC Executive Committee Support and Services Unit (ESSU)

Malcolm Orme
essu@iea-ebc.org

IEA Secretariat

Brian Dean
brian.dean@iea.org

Past Projects

Annex 1 Load Energy Determination ofBuildings
Annex 2 Ekistics and Advanced Community Energy Systems
Annex 3 Energy Conservation in Residential Buildings
Annex 4 Glasgow Commercial Building Monitoring
Annex 6 Energy Systems and Design of Communities
Annex 7 Local Government Energy Planning
Annex 8 Inhabitants Behaviour with Regard to Ventilation
Annex 9 Minimum Ventilation Rates
Annex 10 Building HVAC System Simulation
Annex 11 Energy Auditing
Annex 12 Windows and Fenestration
Annex 13 Energy Management in Hospitals
Annex 14 Condensation and Energy
Annex 15 Energy Efficiency in Schools
Annex 16 BEMS 1-User Interfaces and System Integration
Annex 17 BEMS 2-Evaluation and Emulation Techniques
Annex 18 Demand Controlled Ventilation Systems
Annex 19 Low Slope Roof Systems
Annex 20 Air Flow Patterns within Buildings
Annex 21 Thermal Modelling
Annex 22 Energy Efficient Communities
Annex 23 Multi Zone Air Flow Modelling (COMIS)
Annex 24 Heat, Air and Moisture Transfer in Envelopes
Annex 25 Real time HEVAC Simulation
Annex 26 Energy Efficient Ventilation of Large Enclosures
Annex 27 Evaluation and Demonstration of Domestic Ventilation Systems
Annex 28 Low Energy Cooling Systems
Annex 29 Daylight in Buildings
Annex 30 Bringing Simulation to Application
Annex 31 Energy-Related Environmental Impact of Buildings
Annex 32 Integral Building Envelope Performance Assessment
Annex 33 Advanced Local Energy Planning
Annex 34 Computer-Aided Evaluation of HVAC System Performance
Annex 35 Design of Energy Efficient Hybrid Ventilation (HYBVENT)
Annex 36 Retrofitting of Educational Buildings
Annex 37 Low Exergy Systems for Heating and Cooling of Buildings (LowEx)
Annex 38 Solar Sustainable Housing
Annex 39 High Performance Insulation Systems
Annex 40 Building Commissioning to Improve Energy Performance
Annex 41 Whole Building Heat, Air and Moisture Response (MOIST-ENG)
Annex 42 The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM)
Annex 43 Testing and Validation of Building Energy Simulation Tools
Annex 44 Integrating Environmentally Responsive Elements in Buildings
Annex 45 Energy Efficient Electric Lighting for Buildings
Annex 46 Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)
Annex 47 Cost-Effective Commissioning for Existing and Low Energy Buildings
Annex 48 Heat Pumping and Reversible Air Conditioning
Annex 49 Low Exergy Systems for High Performance Buildings and Communities
Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings
Annex 51 Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers
Annex 52 Towards Net Zero Energy Solar Buildings (NZEBs)
Annex 53 Total Energy Use in Buildings – Analysis and Evaluation Methods
Annex 54 Integration of Microgeneration and Other Energy Technologies in Buildings
Annex 55 Reliability of Energy Efficient Building Retrofitting – Probability Assessment of Performance and Cost
Annex 57 Evaluation of Embodied Energy and Carbon Dioxide Equivalent Emissions for Building Construction
Annex 58 Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurement
Annex 59 High Temperature Cooling and Low Temperature Heating in Buildings

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