EBC

Energy in Buildings and Communities Programme

Annual Report 2013

Energy in Buildings and
Communities Programme

International Energy Agency

EBC Annual Report 2013

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Cover picture: Demonstration site in Zug, Switzerland. Prefabricated light-weight roof and wall elements used for an attic extension developed during IEA-EBC Annex 50.
Source: Mark Zimmermann, Empa

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Chair's Statement

The year 2013 was a year dominated by strategic decision making for the IEA-EBC Programme. This began at the Future Buildings Forum – held in Soesterberg, the Netherlands, in April 2013 – where the question was discussed, 'How to transform the built environment by 2035 to meet energy and environmental targets?' This was the latest in a series of workshops, originally initiated by the EBC Programme in the late 1980s and then held every five years to anticipate the new technologies and business models needed in the coming years. The internationally renowned experts and creative thinkers involved identified an enormous demand for research and development (R&D) to be conducted by the various IEA buildings-related programmes. In particular, it emerged there is still a need for new, cost effective technologies and integrated systems, as well as for increased technical capacity and knowledge on building-user-system interactions.

Together with the national priorities of the EBC Programme's member countries, these findings formed the basis for determining the strategic R&D priorities in our new five year Strategic Plan. This covers the period 2014 to 2019 and contains five priority themes for research and innovation. One of these new themes is 'real building energy use'. This states that real energy use and effectiveness of technologies for energy savings have to be based on more accurate predictions of real world energy performance of buildings and community systems. Therefore, there is a fundamental need to develop knowledge bases on building use, as well as on real (measured) energy consumption in buildings.

At its November 2013 meeting, the EBC Executive Committee approved a new project that heads in this direction, 'Annex 66: Occupant Behavior Simulation'. Among the other projects started in 2013 there are two directed at providing knowledge for smart cities, 'Annex 63: Implementation of Energy Strategies in Communities', aimed at developing implementation methods and policy instruments, and 'Annex 64: Optimized Performance of Community Energy Supply Systems with Exergy Principles', which is more technology based. Further, 'Annex 65: Long-Term Performance of Super-Insulation in Building Components and Systems' has been initiated to examine wider applications in practice of such materials.

EBC's core business is to make collaborative research happen: Our unique network of scientists, funding agencies and industry partners produces added value in research, demonstration and open innovation. Currently 281 organisations from a total of 26 member countries and several other countries participate in our projects, of which 30% of the former come from industry. On average one of our projects brings together 30 participating organisations that originate from about 15 countries. Every year our network delivers about 77 person-years of work. Through this approach each member country's research funds are highly leveraged and scientific output is correspondingly multiplied. Today, as national economies face global problems, international and trans-disciplinary collaboration are key to generating successful and sustainable solutions. EBC enables both.

This Annual Report provides you with up-to-date information about our current activities and projects. I hope you enjoy reading it.

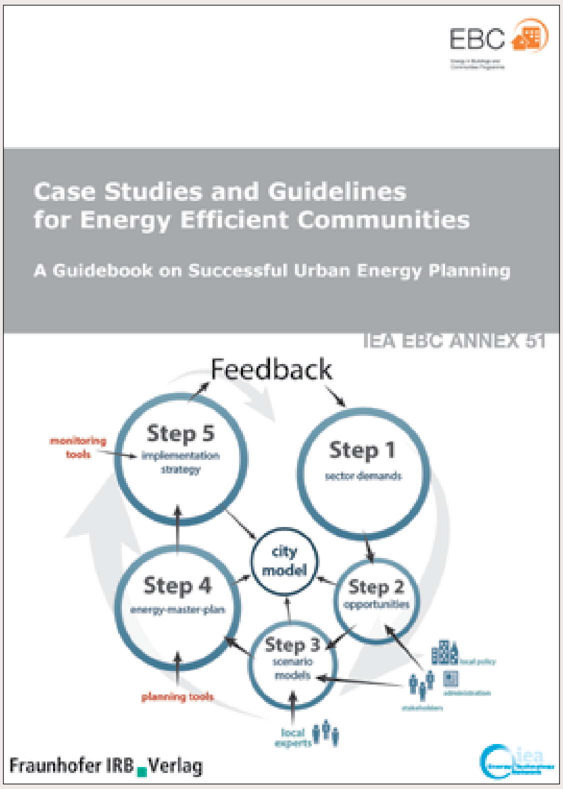
Andreas Eckmanns
EBC Executive Committee Chair

Latest Outcomes for Policy and Decision Makers

This section informs policy and decision makers about project deliverables, key findings, insights and events from the IEA-EBC Programme that may be of particular interest to their area of work. More in depth information about projects is also provided within this Annual Report.

Improving urban energy planning and delivery

A particular highlight for 2013 was the publication of the guidebook 'Case Studies and Guidelines for Energy Efficient Communities: A Guidebook on Successful Urban Energy Planning'. This guidebook is a final deliverable from the project 'Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers' (Annex 51).



The Guidebook 'Case Studies and Guidelines for Energy Efficient Communities' is a final outcome from EBC Annex 51.

Policy makers are increasingly aware of the key role that community and neighbourhood scale planning and deployment of sustainable energy can play in meeting carbon and energy reduction targets. This guidebook sets out some key lessons for successful local energy planning, based on the evaluation of over 20 case studies carried out within the 11 participating countries. Two key findings from the work are:

At a **neighbourhood scale**, the most important barrier is poor performance of the installed technologies, which often results from inadequate integration of the various system technologies employed in a specific project. In addition, insufficient monitoring equipment (which in conventional technologies is less important), makes commissioning and optimal operation of the systems difficult and requires expert knowledge. The project team identified that one solution to this would be to work more closely with experienced contractors during both the design and operation stages, as well as during installation. An example of this could be the use of a 'Design, Build and Operate' type contract, in which a significant part of the performance risk is passed to the contractor.

At the level of a **town or city**, the team found that in reality the key barriers relate more to organisational capacity and structures within local government, than to inadequate energy technologies or planning tools.

As a follow on from the second finding, the new project 'Implementation of Energy Strategies in Communities' (Annex 63) has a focus on municipal management processes and organisational models, with increased involvement of municipalities to improve learning and information exchange between them.

Ongoing EBC research into cost effective renovation: Kapfenberg case study – View of the existing (inset) and the renovated building (main picture). Source: AEE – Institute for Sustainable Technologies.

Forwarding our understanding of how to achieve zero energy buildings

If our future energy and carbon reduction targets are to be met, then new buildings will need to be as close to zero energy and carbon in use as is viable. Although it is easy to say this in theory, in practice, policy makers and regulators need to set out clear standards for what zero energy means, and, crucially, how compliance with regulatory standards will be measured. They also need to understand the costs and benefits of the technology combinations to be used and their implications for indoor air quality and building occupants. To this end, the joint project of the IEA-EBC and IEA Solar Heating and Cooling Programmes 'Towards Net Zero Energy Solar Buildings' (Annex 52 / Task 40) is nearing completion with outcomes due in early 2014.

Improving our understanding of 'real life' energy use in occupied buildings

The other completed project, 'Total Energy Use in Buildings: Analysis and Evaluation Methods' (Annex 53) has focused on improving our understanding of how to more accurately predict the 'real life' energy consumption of buildings. The project considered residential and office buildings, and placed a particular emphasis on trying to better understand the role of occupant behaviour.

This is a significant issue for policy makers for two reasons. Firstly, a better understanding of occupant behaviour by designers and clients is important to improve the operational outcomes for new buildings and so reduce the gap between design intent and actual performance. Secondly, being able to model and cater for the impact that user behaviour can have on energy efficiency interventions within existing buildings is important to the design, cost-benefit assessment and monitoring of energy efficiency programmes. The project final report has now been published, which includes:

- The results of a literature survey on the modelling of occupant behaviour on energy use in residential buildings
- Case studies looking at total energy use in 12 office buildings and the relationship of energy use to occupant behaviour

– A report on statistical methods for predicting total energy use in buildings

The new project 'Definition and Simulation of Occupant Behaviour in Buildings' (Annex 66) looks to improve how existing modelling tools address this issue.

Improving airtightness of new buildings

Building airtightness can have a major impact on the energy performance of new buildings, particularly as we move towards more highly insulated buildings. A key issue is ensuring that design standards are actually achieved in the 'as-built' building. In 2013, the Air Infiltration and Ventilation Centre (AIVC), which is Annex 5 of the Programme, produced a number of webinars and technical notes on this issue that will be valuable to policy makers who want to develop regulatory and quality assurance schemes for airtightness testing in new buildings. These included:

– Webinars on status and trends in competent tester schemes for airtightness testing in the UK, Belgium, Germany, the Czech Republic and France
– A critical review of airtightness testing, reporting and quality schemes in 10 countries

The AIVC also held its 34th Annual Conference in September 2013, focusing on the role of ventilation strategies and smart materials in climate change mitigation and adaptation in the built environment.

ESSU
This article has been prepared by Stephen Ward and Malcolm Orme, ESSU.

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New Research Projects

DEFINITION AND SIMULATION OF OCCUPANT BEHAVIOR IN BUILDINGS (ANNEX 66)

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)

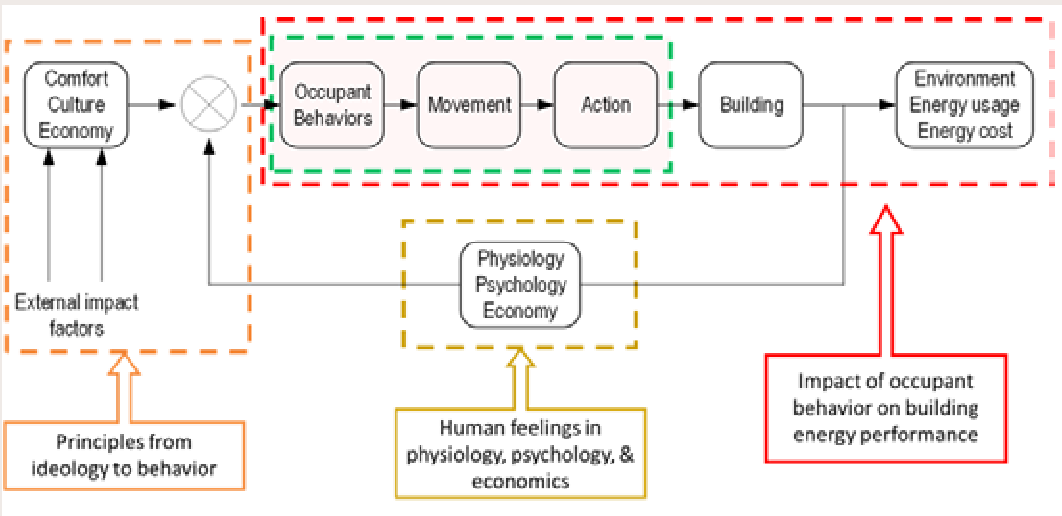
Definition and Simulation of Occupant Behavior in Buildings

ANNEX 66

Energy-related occupant behaviour in buildings is a key issue for building design optimization, energy diagnosis, performance evaluation, and building energy simulation. This is due to its significant impact on real energy use and indoor environmental quality in buildings. Examples of such behaviour include adjusting thermostats for comfort, switching lights, opening and closing windows, pulling up and down window blinds, and moving between spaces.

However, the influence of occupant behaviour is generally under-recognized or over-simplified in the design, construction, operation, and retrofit of buildings. Occupant behaviour is complex and subject to unavoidable uncertainty. So, a multi-disciplinary approach is needed to understand and properly characterise it. Having a deep understanding of occupant behaviour and being able to model and quantify its impact on use of building technologies and energy performance of buildings is crucial to design and operation of low energy buildings. Existing studies on occupant behaviour, mainly from the perspective of sociology, lack in-depth quantitative analysis.

Globally, there are over 20 groups studying occupant behaviour modelling. But until this new project was initiated, they had been doing this independently. Without this co-ordination, the various occupant behaviour models developed can be inconsistent, with a lack of consensus about common language, good experimental design and modelling methodologies. Due to the complexity and great diversity of occupant behaviour, it is a prerequisite for researchers to work together to define and simulate occupant behaviour in a consistent and standardised way.



The influencing factors on and impacts of occupant behaviour in buildings.

Objectives

The project objectives are to:

- create quantitative descriptions and classifications for energy-related occupant behaviour in buildings,
- develop effective calculation methodologies of occupant behaviour,
- implement occupant behaviour models within building energy modelling tools, and
- demonstrate occupant behaviour models in building design, evaluation and operation optimization by case studies.

Deliverables

The following project deliverables are planned:

- a standard definition and simulation methodology for occupant presence and movement models,
- a standard description of occupant action behaviour simulation, a systematic measurement approach, and a modelling and validation methodology in residential and commercial buildings,
- an occupant behaviour XML schema, 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,
- case studies and a behavioural guide that are useful to architects, engineers, building operators, and designers of controls systems.

Progress

The project was formally initiated at the 74th IEA-EBC Executive Committee Meeting, held in November 2013.

Meetings

- An international proposal development workshop took place in Paris, France, in August 2013.

Project duration
2013–2017

Operating Agents
Da Yan, Tsinghua University, China, and
Tianzhen Hong, Lawrence Berkeley National Laboratory, USA

Participating countries
Australia, Austria, Belgium, Canada, P.R. China including Hong Kong S.A.R., Denmark, Finland, France, Germany, Italy, Japan, Korea, Netherland, Norway, Poland, Spain, Sweden, UK, USA
Observers: Brazil, Hungary, Singapore

Further information
www.iea-ebc.org

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

ANNEX 65

In the buildings sector in many industrialised countries, space heating, domestic hot water and cooling account for about 80% of total household energy use. Unfortunately, most of this energy is wasted through unwanted heat losses (or gains) rather than used directly for the intended purposes. By 2050 new buildings will only contribute between 10% to 20% additional energy use in most industrialised countries. Accordingly, renovation of the existing building stock has a high priority in many countries. A jump beyond current thermal performance of building envelopes is therefore essential.

Several studies have shown that the most efficient way to curb energy use in the buildings sector (new and existing) is the reduction of the heat loss by improving the insulation of the building envelope (roof, floor, wall and windows). For example, in Europe, it appears that optimum U-values lie between 0.15 W/(m^{2}K) to 0.3 W/(m^{2}K), with an average value close to 0.2 W/(m^{2}K). Using traditional insulating materials, such as mineral wool or cellular foams, this means a required thickness of around 15 cm to 20 cm. For retrofitting, and even for new buildings in urban areas, the thickness of internal or external insulation layers becomes a major practical issue. EBC Annex 39 previously showed that vacuum insulation panel products have reached a level of quality that customers can trust for specific applications under well-defined conditions. However, there is still a need for test methods and evaluation procedures to characterize the suitability of super-insulating materials (SIMs) for wider applications in practice. So, this project is developing such procedures. In fact, overall performance and durability of SIMs must be investigated under more severe operating conditions (for instance, high or low temperatures, high humidity, or high mechanical loading). Moreover, new types of SIM are appearing on the market and their durability and applicability needs to be established on a scientific basis.

Vacuum insulation panels. Source: Porextherm.

An aerogel material. Source: Aspen Aerogel.

Objectives

The project objectives are to:

- improve knowledge and confidence of decision makers and planners regarding super-insulating materials
- provide reliable data on properties, durability and sustainability
- secure implementation techniques
- serve as a basis for future standards
- provide a clear description of the measurement procedures and the testing methods for ageing tests

Deliverables

The following project deliverables are planned as reports:

- State of the Art: Materials and Components
- Exemplary Case Studies
- Measurement Methods and Ageing Procedures: Materials and Component Scale
- Experimental and Modelling Results: Building Scale
- Recommendations for Standards
- Practical Applications: Experimental and Modelling Results
- Sustainability Aspects: life cycle costing, life cycle analysis, embodied energy
- Implementation Guidebook for Super-Insulating Materials

Progress

The project was approved as a new EBC Annex in June 2013.

Meetings

- A proposal development workshop took place in Paris, France, in April 2013.
- The 1st meeting of the preparation phase took place in Zurich, Switzerland, in September 2013.

Project duration
2013–2017

Operating Agent
Daniel Quenard, CSTB, France

Participating countries
Belgium, P.R. China, France, Germany, Greece, Italy, Japan, Korea, Norway, Spain, Switzerland, Turkey, Sweden, United Kingdom
Observer: Israel

Further information
www.iea-ebc.org

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

ANNEX 64

At the community level, different renewable energy sources are available for supplying heating and cooling energy demands for buildings. These are characterised by differing qualities, expressed as their exergy level. The higher the exergy level, the higher temperature can be produced from the energy source. For example, electricity from photovoltaics has a high exergy level and low temperature heat from renewable energy sources or from waste heat has a low exergy level. Low quality energy is particularly interesting, because low exergy ('LowEx') supply is very efficient. However, to understand how to best use this for community energy systems presents a major challenge. To solve this, the identification of potential savings and synergies by performing holistic analysis of energy flows is necessary.

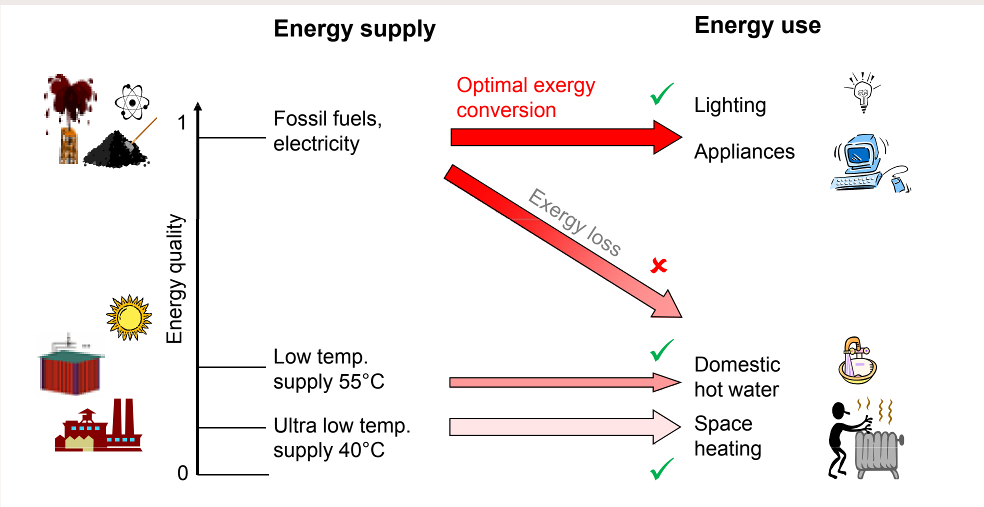
The application of exergy analysis principles is especially important, allowing the detection of the various energy quality levels available and the identification of optimal contributions to efficient supplies. From this, appropriate strategies and technologies with great potential can be derived for promoting the use of LowEx energy sources with a high share of renewable energy for heating and cooling, even of entire cities.

In the framework of this new EBC project, advanced technologies are being developed to realise the full potential of LowEx systems. The aim is to develop the necessary knowledge, tools and networks to demonstrate LowEx thinking at a community scale with the goal of finding cost effective solutions to achieving 100% renewable and GHG emissions-free energy systems.

Objectives

The project objectives are:

- increasing the overall energy and exergy efficiency of community systems,
- identification and application of promising technical LowEx solutions and practical implementation of future network management,
- identification of business models for distribution and operation,



Matching the energy quality requirements of demand with supply avoids unnecessary exergy losses.

- development of assessment methods and tools for various stages of planning, and
- knowledge transfer to community actors.

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 project was approved as a new EBC Annex in June 2013.

Meetings

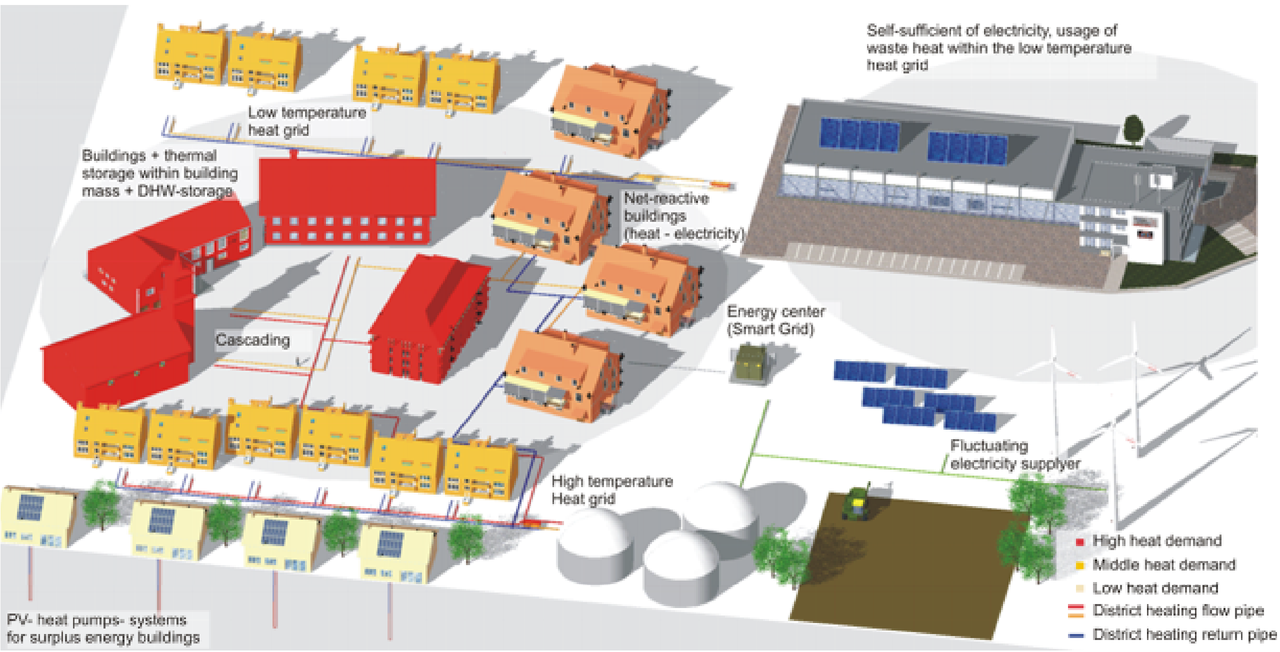
- A proposal development workshop took place in Munich, Germany in September 2012.
- The 1st meeting for the preparation phase took place in Stockholm, Sweden in September 2013.

Project duration
2013–2017

Operating Agent
Dietrich Schmidt, Fraunhofer Institute for Building Physics IBP, Kassel, Germany

Participating countries
Austria, Denmark, Finland, Germany, Japan, Sweden, Switzerland, R. Korea and USA

Further information
www.iea-ebc.org



Energy flows in community systems need to consider interactions caused by different energy demands.

Implementation of Energy Strategies in Communities

ANNEX 63

Cities consume the major part of energy production worldwide and account for a roughly equal share of global greenhouse gas (GHG) emissions. To mitigate climate change and energy shortages, a drastic reduction of both energy and GHG emissions is essential for the largescale development of more sustainable cities and communities.

In the past, research in the buildings sector has generally focused on technological innovation and improvements at the scale of the individual building. But, it is widely accepted that due to the integrated nature of our cities, including transportation and industry, to achieve the global goals more emphasis should be placed on system wide reductions of energy demand and related GHG emissions and higher shares of renewable energy. The required transition needs to refocus from optimisation of building components via single buildings to optimised solutions for whole neighbourhoods and communities.

First experiences in the development of net zero energy communities have revealed not only challenges, but also significant opportunities emerging that support net zero energy community concepts, including increased budgets for investments derived from energy savings, increased comfort and quality of life, and local production that boosts local economies. The frontrunners show that integrated approaches could be beneficial for all stakeholders, especially the end users, and the general population.

Objectives

The overall objective of this project is to give recommendations on procedures for implementation of optimised energy strategies at the community scale, in particular to:

– develop recommendations for effective translation of a city´s energy and GHG reduction goals to the community scale;
– develop recommendations for optimization of policy instruments for the integration of energy and GHG reduction goals into common urban planning processes;

The new 'Rieselfeld' district in Freiburg, Germany.
Source: SIR

Urban development in Zurich, Switzerland.
Source: SIR

- develop recommendations for stakeholder cooperation along with holistic business models;
- involvement of cities and urban planners to integrate energy planning in urban planning procedures.

Deliverables

The following deliverables are planned:

- evaluation report on energy planning with recommendations
- evaluation report on urban planning procedures, instruments and bottlenecks
- report on best practices
- manual and guidelines for integration of energy planning within urban planning
- workshop templates for dissemination within cities
- documentation on information exchange within the scientific community

Progress

The project was approved as a new EBC Annex in June 2013.

Meetings

- A proposal development workshop took place in Vienna, Austria in March 2013.
- The 1st meeting for the preparation phase took place in Freiburg, Germany in December 2013.

Project duration
2013–2017

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

Participating countries
Austria, Belgium, Canada, Denmark, Germany, France, Netherlands, Ireland, Japan, P.R.China, Sweden, Switzerland, USA

Further information
www.iea-ebc.org

Ongoing Research Projects

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TOWARDS NET ZERO ENERGY SOLAR BUILDINGS (ANNEX 53)

AIR INFILTRATION AND VENTILATION CENTRE AIVC (ANNEX 5)

Ventilative Cooling

ANNEX 62

The current trend in building energy efficiency towards nearly zero energy buildings creates a number of new challenges for building design and construction. One of the major challenges is the increased need for cooling in highly insulated and airtight buildings, which is not only required in summer and mid season periods, but can also be needed in winter, particularly in office buildings. Most of the post-occupancy studies of high performance buildings in European countries show that too high temperatures in summer are the most often reported problem, especially in residential buildings.

Ventilative cooling is the application of ventilation air flow to reduce the cooling loads in buildings. It utilizes the cooling and thermal perception potential of outdoor air. Ventilative cooling can be an attractive and energy efficient solution to reduce the cooling load and avoid overheating of both new and renovated buildings. However, before ventilative cooling is considered, internal gains from equipment and solar radiation are assumed to be reduced to a reasonable level. To address the cooling challenges of buildings, the project is focusing on development of design methods and compliance tools related to predicting, evaluating and eliminating the cooling need and the risk of overheating in buildings, and on development of new attractive energy efficient ventilative cooling solutions.

Objectives

The project objectives are to:

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

Deliverables

- Overview and state-of-the art of ventilative cooling
- Ventilative cooling source book
- Ventilative cooling case studies
- Guidelines for ventilative cooling design and operation
- Recommendations for legislation and standards

Progress

In November 2013, it was agreed to proceed with the working phase for the project, following completion of the preparation phase.

Meetings

- The 1st Project Meeting took place in Brussels, Belgium in March 2013.
- The 2nd Project Meeting took place in Athens Greece in September 2013.

Project duration
2013–2017

Operating Agent
Per Heiselberg, Aalborg University, Denmark

Participating countries
Austria, Belgium, P.R. China, Denmark, Finland, Greece, Ireland, Italy, Japan, The Netherlands, Norway, Switzerland, Sweden, United Kingdom, USA

Further information
www.iea-ebc.org

Business and Technical Concepts for Deep Energy Retrofits of Public Buildings

ANNEX 61

Know how and available funding are both crucial for the implementation of refurbishment strategies for ambitious reduction targets for energy use in government and public buildings. This combination may lead to a range of contract based 'business models' to be applied. However, recent research has shown that the performance of the 'owner directed' business model for energy retrofit projects has not kept pace with new requirements to increase the number and pace of energy retrofits to improve the efficiency of existing buildings to an adequate level. For the most part, owner directed business models lack the stimulation to meet energy efficiency targets at fixed levels of investment.

In recent years, energy savings performance contracting (ESPC) has proven to be a very successful business model overcoming the weak points of owner directed models: ESPC business models can stimulate both contracting parties to achieve high cost effectiveness in terms of the savings to investment ratio, a better life cycle cost effectiveness and a high degree of energy efficiency. With their life cycle cost orientated structure, ESPC business models generate clear additional value in comparison with owner directed models: The ESPC business model structure typically sees the Energy Service Company providing the planning, implementation and funding of the investment and the customer only paying for energy and cost savings achieved. To date, the average savings realised by ESPC projects generally vary between 25% and 40%, recouping the investment in HVAC retrofits, CHP and biomass implementations within 5 to 15 years. Nevertheless, in many countries the number of projects funded by ESPCs still does not form a significant part of the total investment budgeted by public institutions for energy retrofits. This project aims to increase the acceptance of ESPCs, and to broaden the implementation of deep energy use reduction through refurbishment of existing buildings using ESPCs and related or new business models.

Until now, ESPC has been used primarily as an instrument for retrofitting heating, ventilating, and air-conditioning (HVAC), lighting, and controls. Implementation of some individual measures (for example, building envelope insulation and improved airtightness, or cogeneration)

Renovation of barracks achieved a 45% energy use reduction through better insulation, improved airtightness, a dedicated outdoor air system, enclosed stairways with a vestibule and a covered atrium with increased usable space (Fort Polk, USA). Source: U.S. Army Corps of Engineers results in significant reductions in building heating and cooling loads or minimization of energy waste, but require significant investments with long paybacks. However, when different technologies are implemented together, or are 'bundled', they can result in significant energy use reductions, require smaller investments, and consequently have faster paybacks.

Objectives

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

Deliverables

- A guide for deep energy retrofit of buildings and communities
- Business models of deep retrofit using combined public and private funding
- Documented results of realized projects and case studies demonstrating the developed models

Progress

In June 2013, it was agreed to proceed with the working phase for the project, following completion of the preparation phase.

Meetings

- The 1st project meeting was held in Copenhagen, Denmark in March 2013.
- The 2nd project meeting was held in Darmstadt, Germany in September 2013.

Project duration
2013–2016

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

Participating countries
Austria, Australia, Belgium, Canada, Denmark, Finland, Germany, Ireland, Sweden, UK, USA
Observer: Estonia

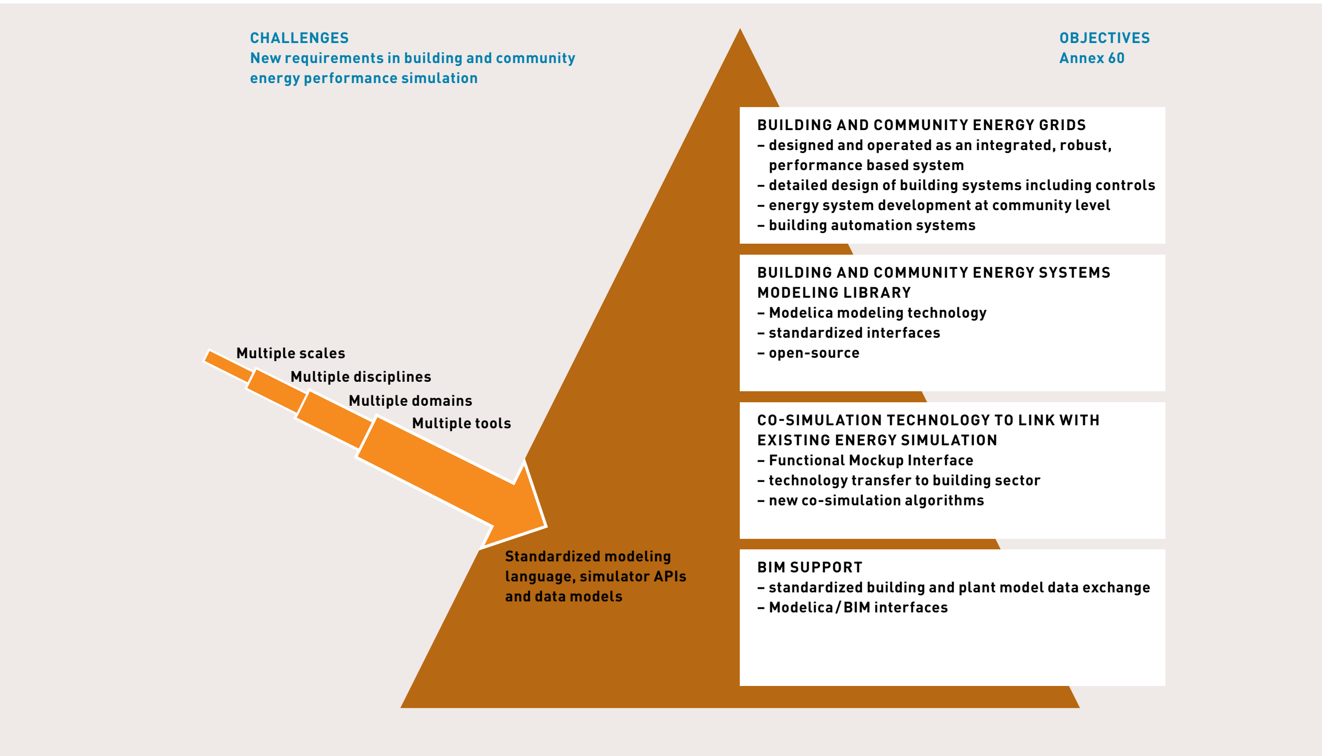
Further information
www.iea-ebc.org

New Generation Computational Tools for Building and Community Energy Systems

ANNEX 60

To reduce energy use and peak power demand, buildings and district energy systems will need to become increasingly integrated and connected with smart grids. Besides energy-relates aspects, occupant health and productivity are also issues of concern. This poses new challenges for building simulation programs to support decision making during product development, building design, commissioning and operation. This situation leads to new functional requirements on computational tools for buildings that are not addressed by existing building simulation programs. In the meantime, other engineering sectors have been making large investments in next generation computing tools for complex dynamic engineering systems.

The aim of this ongoing project is to transfer these developments to the buildings industry. For buildings and community energy systems, it is coordinating the currently fragmented developments on next generation computing tools based on two open, non-proprietary standards, the Modelica modelling language, and the Functional Mockup Interface (FMI). The FMI standard and co-simulation middleware allows efficient co-simulation by linking existing simulation software and the Modelica technology. Interfaces to digital Building Information Models (BIM) will allow designers to configure Modelica models from compatible CAD systems. Based on these, the project is further developing and deploying free open source contributions to existing as yet uncoordinated activities in modelling and simulation of energy systems.



Interrelationships between technical challenges and planned project outcomes. These challenges are being addressed through the use of a standardized modelling language, standardized Application Programming Interfaces and standardized data models.

The project is creating and validating tool chains that link building information models to energy modelling, building simulation to controls design tools, and design tools to operational tools. Invention and deployment of integrated energy-related systems and performance based solutions will be accelerated by extending, unifying and documenting existing Modelica libraries and by linking existing simulation tools with Modelica through the FMI standard. The technology will allow optimized design, analysis and operation of multi-domain systems as posed by building and community energy systems. It will also allow the use of models across the whole building life cycle to ensure realization and persistence of design intent. Case studies demonstrate further to urban planners and utilities the integration of buildings into a community-level energy grid. Moreover, software and case studies demonstrate how to use models to assist in the operation of buildings.

Objectives

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

Deliverables

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

Progress

In June 2013, it was agreed to proceed with the working phase for the project, following completion of the preparation phase.

Meetings

- Expert meetings were held in March and December 2013 in Aachen, Germany
- An expert meetings was held in August 2013 in Aix-les-Bains, France

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, France, Germany, Ireland, Italy, The Netherlands, Spain, Sweden, Switzerland, USA

Further information
www.iea-ebc.org

High Temperature Cooling and Low Temperature Heating in Buildings

ANNEX 59

It is important to minimise temperature differences in heating, ventilation and air conditioning (HVAC) systems, because high differences result in reduced efficiencies and therefore increased energy use. This project is thus starting from a new perspective and from this is developing a novel concept for analysing HVAC systems in buildings.

The project is focusing on temperature differences throughout HVAC systems, as well as within the indoor spaces that they serve, and on how these can be minimized in highly energy efficient buildings. Temperature differences within HVAC systems can be classified into three types, arising from:
- heat and moisture exchange,
- heat transmission through fluid media, and
- thermal mixing losses in indoor spaces due to different types of indoor terminal devices.

High temperature cooling and low temperature heating would be achieved by reducing temperature differences in heat transfer and energy transportation processes. The beneficiaries of the outcomes and deliverables will be designers and industry, such as manufacturers of chillers, radiant panels and supply air terminals. The outcomes will contribute to the further improvement of new HVAC terminal devices.

Objectives

The main project objectives are to:
- Establish a methodology for analysing HVAC systems from the perspective of reducing mixing and transfer losses.
- Propose novel designs for indoor terminals and novel flow paths for outdoor air handling equipment.
- 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.

Deliverables

- A guide book on a new analysis method for HVAC systems
- Novel designs for indoor terminals in high temperature cooling and low temperature heating systems
- Novel flow paths for outdoor air handling equipment and their application in high temperature cooling and low temperature heating systems
- A design guide for high temperature cooling and low temperature heating systems with applications
- Real-time test results for high temperature cooling and low temperature heating systems in typical office buildings under different climatic conditions

Progress

In 2013 the following work has been performed:

- Development of an analysis method based on entransy theory and temperature-heat diagrams including temperature affects on heating and cooling source efficiency;
- Consideration of systems combined with natural ventilation, thermally activated building elements and diffuse ceiling supply systems, dynamic performance of radiant floors (with direct solar radiation), the idea of operative temperature and equivalent temperature (dry heat loss); comparison of terminals: radiant panels, chilled beams;
- Unmatched characteristics in air handling processes applied to solid and liquid desiccant dehumidification;
- Creation of a reference building model and a reference system as the working platform for deep investigations of HVAC system losses;
- All participants have reached a consensus on several important issues:
  (1) the technical route to studying losses in HVAC systems,
  (2) focus on several typical conditions of HVAC systems,
  (3) how to select typical conditions,
  (4) the dynamic performance of radiant floors, especially with direct solar radiation, and
  (5) the collection of case study buildings with measurements.
- A workshop was organized in ISHVAC 2013 (the International Symposium on Heating, Ventilation and Air Conditioning) to present the latest project results;
- Three papers have been published in Energy, and Energy and Buildings.

Meetings

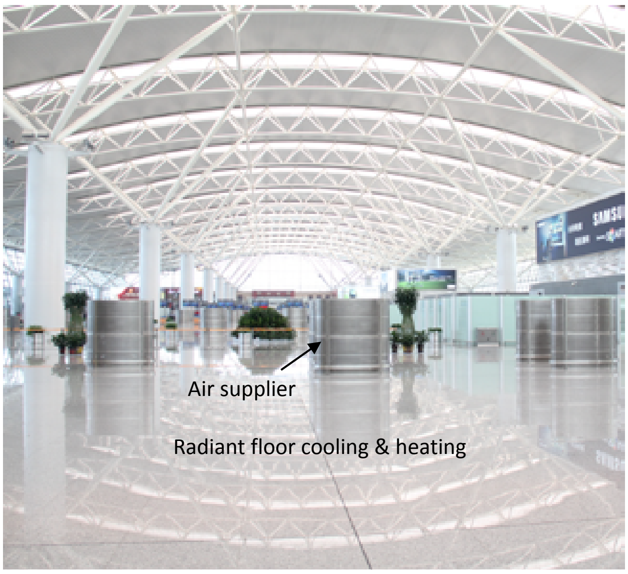
- The 3rd project meeting was held in Liège, Belgium in April 2013.
- The 4th project meeting was held in Beijing, China in October 2013.

Project duration
2012–2015

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

Participating countries
Belgium, P.R. China, Denmark, Finland, Italy, Japan, USA

Further information
www.iea-ebc.org



A case study building with a large enclosure.
Source: Tsinghua University

Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurement

ANNEX 58

To reduce the energy use of buildings and communities, many industrialised countries have imposed stringent requirements for new developments. In most cases, evaluation and labelling of the energy performance of buildings are carried out at the design phase. Several studies have showed, however, that the actual performance after construction may deviate significantly from this theoretically designed performance. As a result, there is a growing interest in full scale testing of components and whole buildings to characterise their actual thermal performance and energy efficiency. This full scale testing approach is not only of interest to study building (component) performance under actual conditions, but is also a valuable and necessary tool to deduce simplified models for advanced components and systems to integrate them into building energy simulation models. The same is true to identify suitable models to describe the thermal dynamics of whole buildings including their energy systems e.g. when optimising energy grids for building and communities.

It is clear that quantifying the actual performance of buildings, verifying calculation models and integrating new advanced energy solutions for nearly zero or positive energy buildings can only be effectively realised by in situ testing and dynamic data analysis. But, practice shows that the outcome of many on site activities can be questioned in terms of accuracy and reliability. Full scale testing requires high quality during all stages of research, starting with the test environment, such as test cells or real buildings, accuracy of sensors and correct installation, data acquisition software, and so on. It is crucial that the experimental setup (for example test layout or imposed boundary conditions for testing) is correctly designed, and produces reliable data. These outputs can then be used in dynamic data analysis based on advanced statistical methods to provide a characteristic with reliable accuracy intervals and final use of the results. If the required quality is not achieved at any of the stages, the results become inconclusive or useless. This project is therefore developing the necessary knowledge, tools and networks to achieve reliable in situ dynamic testing and data analysis methods that can be used to characterise the actual energy performance of building components and whole buildings.

Objectives

The project objectives are to:

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

Deliverables

The expected project outcomes are:

- A report on the state of the art of full scale testing and dynamic data analysis, including a survey of existing full scale test facilities for the benefit of the building industry, engineers and consultants
- Guidance on how to perform reliable full scale dynamic testing, intended for the building industry and building research community
- A description of the methodology to perform dynamic data analysis and performance characterisation, intended for the building research and associated communities
- A summary report (white paper) on full scale dynamic testing and data analysis to characterise building energy performance, intended for the building research and associated communities
- A few, well-documented dynamic data sets that can be used for developing dynamic data analysis procedures and for validation purposes, aimed at software developers and the building research community
- A synthesis report, demonstrating the applications of the developed framework, intended for building designers and industry, government and other authorities

Progress

The following activities took place in 2013:

- The survey of full scale test facilities was completed.
- A scale model of a building (a 'round robin' test box) was built and in situ characterisation under real climatic conditions was performed on the test box in Belgium and Spain.
- A first concept was developed for a decision tree to guide and optimise full scale testing.
- Common exercises on dynamic data analysis and performance characterisation were run.
- A network of excellence on full scale testing and dynamic data analysis was set up in close collaboration with the Dynastee network.

Meetings

In 2013, two experts meetings took place in:

- Munich, Germany, in April 2013.
- Hong-Kong, China, in October 2013.

Project duration
2011–2015

Operating Agent
Staf Roels, University of Leuven, Belgium

Participating countries
Austria, Belgium, P.R. China, Czech Republic, Denmark, Finland, France, Germany, Italy, The Netherlands, Norway, Spain, United Kingdom, USA

Further information
www.iea-ebc.org

Detailed and well-documented full scale experiment in the twin test houses at Fraunhofer IBP, Holzkirchen performed in the project to validate common building energy simulation models and to develop 'grey box' models for the thermal characterization of buildings. Source: Fraunhofer IBP

Evaluation of Embodied Energy and Carbon Dioxide Emissions for Building Construction

ANNEX 57

The total energy used by a building during its whole life cycle includes both embodied and operational energy. Embodied energy is 'embedded' in construction materials during all production processes, on-site construction, renovation and demolition and final disposal, while operational energy is used for supplying services within a building. The accuracy of operational energy use and related carbon dioxide (CO_2) emissions prediction methodologies have been improved in recent years, resulting in more energy efficient building designs. As operational energy use is so reduced, the embodied energy and CO_2 emissions become proportionally more significant. For this reason, the project is investigating methods for evaluating embodied energy and CO_2 emissions of buildings and to develop guidelines to further practitioners' understanding. The intention is to assist them to find better design and construction solutions for buildings with less embodied energy and CO_2 emissions.

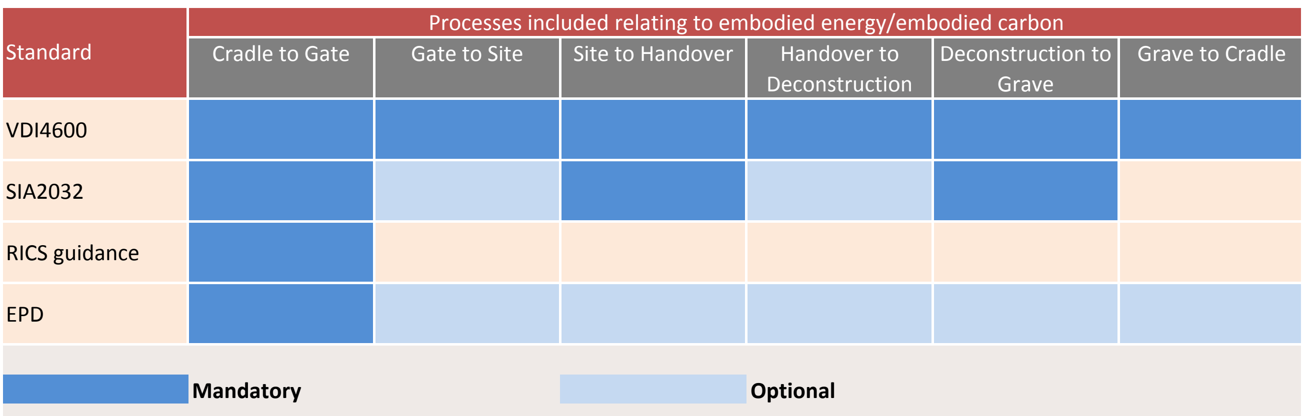
Objectives

The project objectives are to:

- Collect existing research results concerning embodied energy and CO_2 emissions due to building construction, analyze and then summarize them to present the state of the art.
- Develop guidelines for methods for evaluating embodied energy and CO_2 emissions resulting from building construction.
- Develop guidelines for measures to design and construct buildings with less embodied energy and CO_2 emissions.

Deliverables

- A report on the state of the art for embodied energy and CO_2 emissions resulting from building construction
- Evaluation method guidelines for evaluating embodied energy and CO_2 emissions caused by building construction
- Design and construction method guidelines for buildings with low embodied energy and CO_2 emissions
- Project summary report outlining the technical outputs from Annex 57



Relationship between various standards and the included processes related to embodied energy and embodied carbon.
Source: Karlsruher Institut für Technologie

Progress

During 2013, the following work has been undertaken:

- The key concepts were clarified based on existing references to refine the scope of the project.
- A literature survey covering more than 200 references was completed to inform the research objectives. The references were classified according to country, study topics, study results and case study subjects. The findings were compiled mainly in terms of how to construct databases and evaluation methods for recycled materials.
- Databases and calculation methods in participating countries were compiled in addition to the data that characterize their attributes. A simplified calculation method was developed. Calculation methods for the effects of chlorofluorocarbons (CFCs) were summarized. Specific consumption and carbon intensities of major construction materials were compiled. Tentative calculations were performed to make sure that input-output tables for countries worldwide could be used.
- Templates for case studies of low embodied energy buildings were developed. Global warming impact caused by CFCs used for thermal insulation or refrigeration, reduced amount of embodied energy when long-lasting buildings were constructed, and other factors were tentatively calculated.
- As part of dissemination efforts, seminars and joint workshops with Annex 56 were held at the SB 13 Graz Conference.

Meetings

- The 4th expert meeting took place in Munich, Germany in April 2013.
- The 5th expert meeting took place in Graz, Austria in September 2013.

Comparison of embodied CO_2 of building materials between Japan and Country A (embodied energy and CO_2 vary depending on the country).

Project duration
2011–2015

Operating Agent
Tatsuo Oka, Utsunomiya University, Japan

Participating countries
Australia, Austria, China, Czech Republic, Denmark, Finland, Germany, Japan, Republic of Korea, The Netherlands, Norway, Poland, Portugal, Sweden, Switzerland, UK
Observer: Brazil

Further information
www.iea-ebc.org

Cost Effective Energy and Carbon Dioxide Emissions Optimization in Building Renovation

ANNEX 56

In recent years, various standards and regulations for energy consumption in buildings have emerged that specify greatly improved levels of energy efficiency in comparison with earlier requirements. However, these mainly focus on new buildings and they do not respond effectively to the numerous technical, functional and economic constraints of the existing stock. It is common that requirements for existing buildings, which are generally targeted at energy efficiency measures, result in expensive processes and complex procedures, seldom accepted by occupants, owners or developers. These procedures can be simplified if onsite generation of renewable energy is considered during the renovation process, potentially reducing the amount of work needed for energy efficiency measures.

Effectively, within the overall objective of slowing down climate change by reducing carbon dioxide (CO_2) emissions, renewable energy supply measures can sometimes be at least as cost effective as energy efficiency measures, if not more so. Therefore, in existing buildings, the most cost-effective renovation solution is often a combination of energy efficiency and renewable energy supply measures. So, it is important to investigate where the balance point lies between these two types of measures from a cost-benefit perspective.

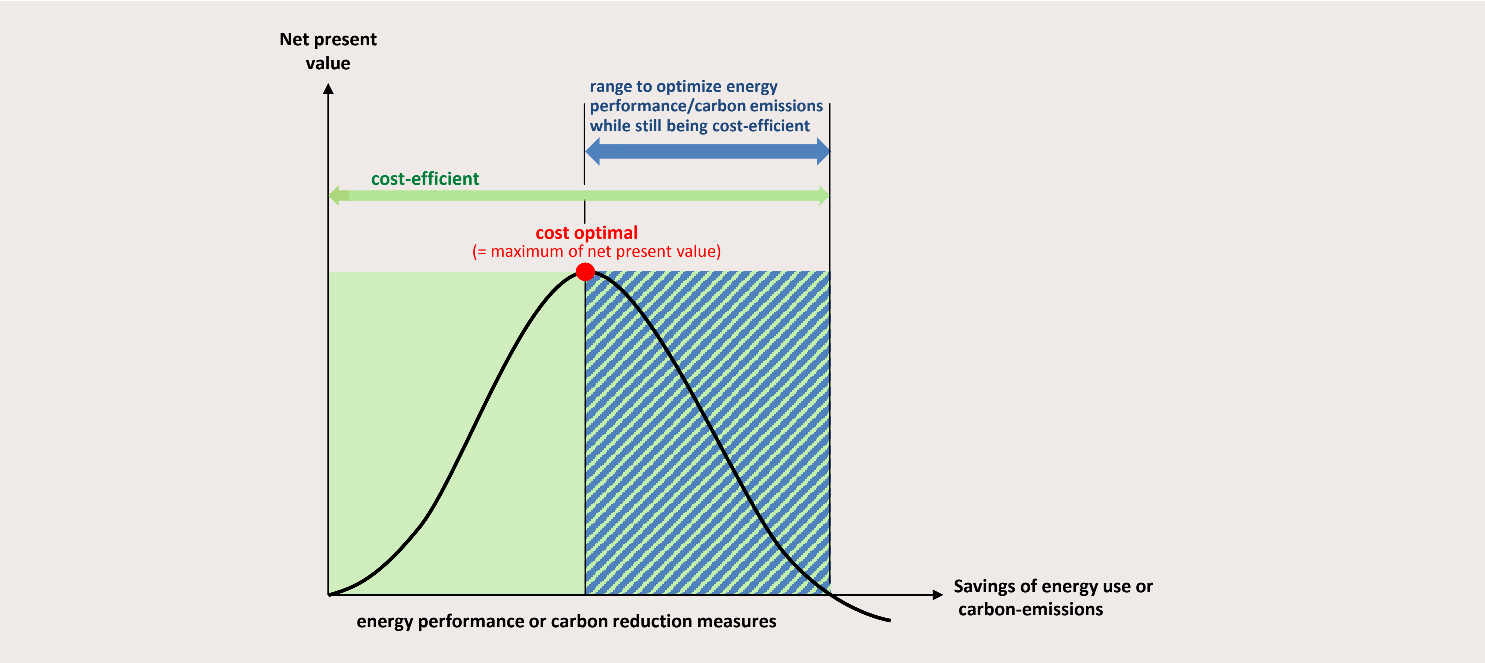
This involves determining how the best performance (in terms of less energy use, reduced CO_2 emissions and other benefits) would be achieved with the least effort (in terms of financial investment, depth and duration of interventions and disturbance of occupants). Therefore, a new methodology for energy and CO_2 emissions optimized building renovation is being developed to be used by interested private entities helping them in their renovation decisions, as well as by governmental agencies for the definition of regulations and their implementation.

Kapfenberg case study – View of the finished renovation (left part of building) and still in renovation (right part of building).
Source: AEE – Institute for Sustainable Technologies

Objectives

The project objectives are to:

- define a methodology for establishing cost optimized targets for energy consumption and CO_2 emissions in building renovation,
- clarify the relationship between CO_2 emissions and energy targets and their eventual hierarchy,
- determine cost effective combinations of energy efficiency and renewable energy supply measures,
- highlight additional benefits achieved in the renovation process,
- develop 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.



Global cost curve for renovation measures, starting from the current situation (requirements in force) towards lower primary energy consumption or carbon dioxide emissions. Source: econcept AG

Deliverables

The following deliverables are planned:

- 'Methodology for Cost Efficient Energy and Carbon Emissions Optimized Building Renovation' report,
- 'Integration of Embodied Energy and LCIA into the Assessment of Renovation Measures' report,
- 'Added Values of Building Renovation: Integration into Assessment and Promotion of Renovation Measures' report,
- supporting tools for decision makers,
- 'Shining Examples' brochure,
- 'Detailed Case Studies' report, and
- 'Renovation Guidebook', including a summary for policy makers.

Progress

During 2013, the following main activities were carried out:

- Results were produced to demonstrate the viability of the developed methodology, based on different packages of energy renovation measures to be applied in single and multi-family typical buildings in the participating countries.
- Further development of the methodology was made regarding the integration of life cycle assessment (LCA) and co-benefits.
- Data were collected about real buildings to be documented in the 'Detailed Case Studies'.
- The 'Shining Examples' brochure was completed, with the objective of demonstrating examples of building renovation to motivate and inspire a general, non-technical audience.

Meetings

- The 4th meeting of the working phase took place in Copenhagen, Denmark in March 2013.
- The 5th meeting for the working phase took place in Graz, Austria in September 2013.

Project duration
2010–2015

Operating Agent
Manuela Almeida, University of Minho, Portugal

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

Further information
www.iea-ebc.org

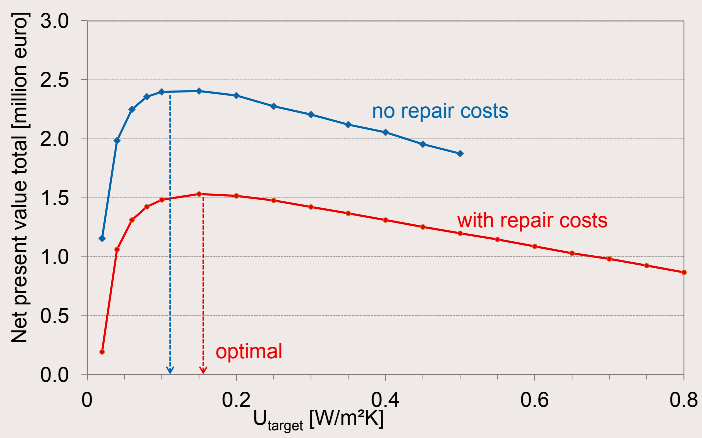
Reliability of Energy Efficient Building Retrofitting – Probability Assessment of Performance and Cost

ANNEX 55

Nowadays, building energy use and durability issues are some of the most important topics in industrialised countries. Even though considerable progress has been achieved concerning new buildings (low energy, passive houses, zero energy) and advanced building services, the buildings sector still generally accounts for the largest share of energy-related carbon dioxide (CO_2) emissions. While in many industrialised countries, new buildings are constructed every year corresponding to approximately 1% of the existing building stock, commonly more than 50% of the building stock dates from before the first energy crisis in the 1970s. Hence, a large potential for energy savings and consequently CO_2 emissions reduction is presently available in the existing building stock.

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

The project is improving methods and tools for integrated evaluation and optimization of retrofitting measures, including energy efficiency, life cycle cost and durability. It will demonstrate to decision makers, designers and practitioners the benefits of the renewal of the existing building stock and how to create reliable solutions.



Calculation of the whole life costs for retrofitting a cluster of 237 dwellings has shown that a different optimal thermal transmittance for the retrofit emerges when repair costs for remedial work are included.

Objectives

The objectives are to provide decision support data and to develop tools for energy retrofitting measures, focussing on residential building envelopes. These tools are being based on probabilistic methodologies. Specifically, the project will:

- develop and validate probabilistic methods and tools for prediction of energy use, lifecycle cost and functional performance,
- apply and demonstrate probabilistic methodologies on real life case studies, and
- create guidelines for practitioners, including assessment of common retrofitting techniques.

Deliverables

The deliverables from the project will be:

- a methodology for probability based assessment of energy retrofitting measures,
- analyses of case studies to show how to apply probability analyses to enhance energy savings, secure performance and apply cost analyses, and
- a report and electronic database for stochastic inputs, validation data, and guidelines for practitioners.

Progress

During 2013, the following activities have taken place:

- The collection of stochastic data was finalized.
- Various probabilistic methods for performance and cost were established.
- The framework for the risk assessment was established.
- Development of the guidelines for how to use the framework for risk assessment in practice was progressed.
- Reporting of frequently used retrofitting technologies in different countries was completed, including benefits and risks.

Meetings

In 2013, two experts meetings took place:
Curitiba, Brazil, in April 2013.
Lund, Sweden, in November 2013.

Project duration
2010–2014

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

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

Further information
www.iea-ebc.org

Integration of Micro-Generation and Related Energy Technologies in Buildings

ANNEX 54

Microgeneration consists of technologies for providing energy for single buildings. Small scale systems of up to around ten kilowatts are used. The combined production of heat and power (CHP) in a single small scale process is called micro-cogeneration (μCHP). This can be extended to a micro-trigeneration system, if cooling power is also produced. Microgeneration also consists of technologies for small scale electricity generation, such as photovoltaic or micro-wind turbines.

Activities within this project have encompassed complete building integrated systems, also including thermal and electrical energy storage, chillers, balance of plant components such as pumps and heat exchangers and advanced control strategies. The effects of microgeneration on power distribution systems have been analysed with a focus on the building level for single and multiple residences, along with small commercial premises.

Research Area

The following areas of research have been investigated:

- Field tests and laboratory measurements of microgeneration systems to derive performance parameters and input data for simulation models.
- Development of technical models for different microgeneration technologies, such as cogenerators with combustion engines, fuel cells or Stirling engines, photovoltaic systems, thermal and electrical storage and balance of plant components. The models have been validated using data from laboratory and field measurements.
- Simulations have been used to develop an extensive library of performance assessment studies covering different combinations of technology types, performance in different countries and with different end users. Simulation work initially concentrated on improving and optimising the performance of basic, but realistic micro-generation systems. Subsequent work featured a wider range of system components, system functions and end users.
- Dissemination strategies for the mass deployment of microgeneration-related technologies have been investigated. This activity was informed by a regulatory and market review, along with data emerging from technical analyses and performance assessment studies.

Progress

The following activities took place in 2013:

- The extension of existing models to simulate complete micro-generation systems has been completed.
- National performance assessment studies of micro generation technologies were completed.
- Country specific data such as standards, regulations, energy-related and economic parameters were collected and analysed.
- The 3rd International Conference on 'Microgeneration and related Technologies' took place April 2013 in Naples, Italy, which was organised and supported by the project participants.

Outcomes

- Component and system models have been developed and implemented in building simulation tools, including TRNSYS and ESPr
- Performance assessment studies of microgeneration systems have shown that energy-related CO_2 emissions reductions in the range of 5% to 20% can be reached using cogeneration systems and up to 40% if renewable energy resources are integrated additionally.
- Storage systems, thermal storage in particular, are important components to increase system performance and to decouple the supply from the demand side.
- Most applications are not yet economically viable without support, such as investment grants or feed-in tariffs. However, some niche applications are now already economically viable without subsidies.

A micro cogeneration unit in a field test. Source: TUM

Meetings

- The 7th expert meeting was held in Rome, Italy in April 2013.
- The 8th expert meeting was held in Munich, Germany in September 2013.

Project duration
2009–2014

Operating Agents
Evgueniy Entchev, Natural Resources Canada, Canada, and Peter Tzscheutschler, Technische Universität München (TUM), Germany

Participating countries
Belgium, Canada, Denmark, Germany, Italy, Japan, Republic of Korea, The Netherlands, UK, USA

Further information
www.iea-ebc.org

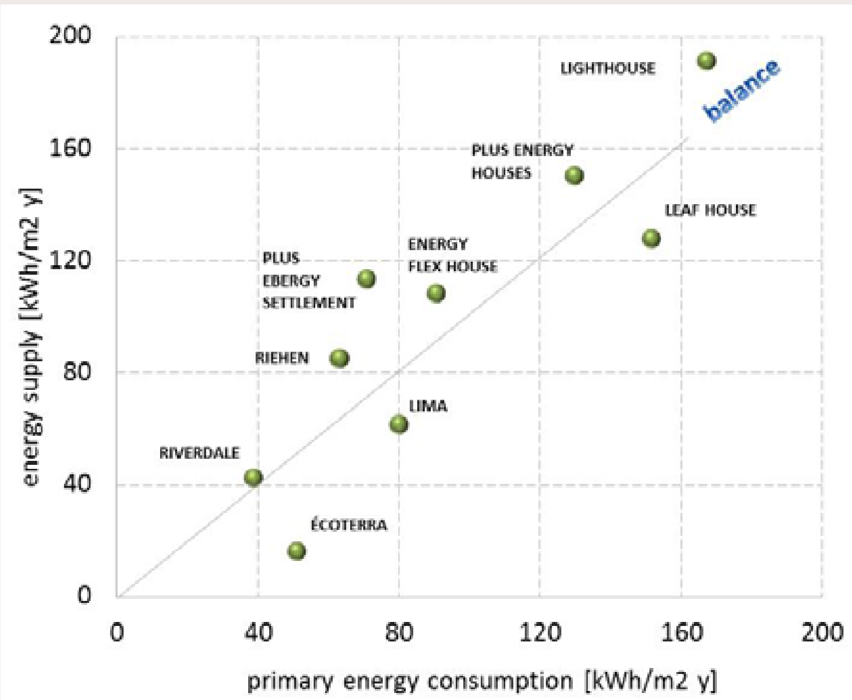
Towards Net Zero Energy Solar Buildings

ANNEX 52

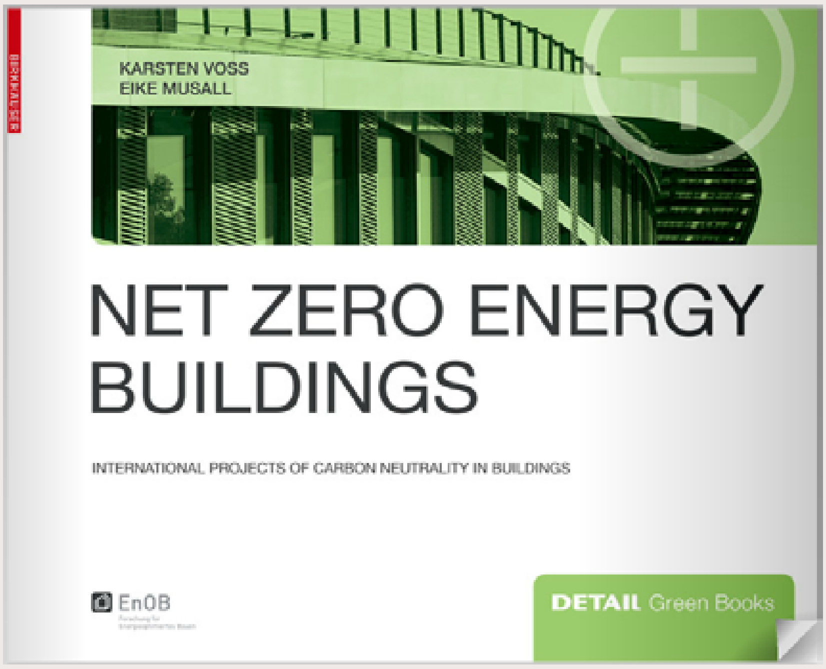
The project has successfully studied current net zero, near net zero and very low energy buildings and is now close to completion. Over the past five years it has developed a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. This was achieved primarily by documenting and proposing practical net zero energy building (NZEB) demonstration projects, with convincing architectural quality. These exemplars, supported by a sourcebook, guidelines and tools, are viewed as essential for industry adoption.

The project has investigated the cost effective equalisation of the small annual energy needs of such buildings through building integrated heating and cooling systems, power generation and interactions with utilities. It has learnt from recent industry experiences with net zero and low energy solar buildings and the most recent developments in whole building integrated design and operation. This joint international research and demonstration activity has addressed concerns of comparability of performance calculations between building types and communities for different climates. Further, it has produced solution sets intended for broad industry adoption.

The scope has included major building types (residential and non-residential), new and existing buildings in various climatic zones represented by the participating countries. The work has linked to national activities and



Primary energy consumption and energy supply for the case studies.



Cover of Net Zero Energy Buildings, International Projects of Carbon Neutrality in Buildings edited by Karsten Voss and Eike Musall, 2nd edition published in November 2012.
Source: www.enob.info

has focused on individual buildings, clusters of buildings and neighbourhoods. It has been based on analysis of existing examples, leading to the development of innovative solutions to be incorporated into national demonstration buildings.

Objectives

- establish an internationally agreed understanding of NZEBs, based on a common methodology,
- identify and refine design approaches and tools to support industry adoption,
- develop and test innovative, whole building net zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration, and
- support knowledge transfer and market adoption of NZEBs at a national and international level.

Progress

- Development was completed on the NZEB Definition Evaluation Tool (Microsoft Excel based).
- Volumes 2 and 3 of the Source Book on net zero energy buildings were completed.

Meetings

- The 9th Meeting was held in Copenhagen, Denmark, in May 2013.
- The 10th Meeting was held in Montreal, Quebec, Canada, in October 2013.

Project duration
2008–2014

Operating Agent
Josef Ayoub, CanmetENERGY, Natural Resources Canada, Canada

Participating countries
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, R. Korea, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, United Kingdom, USA

Further information
www.iea-ebc.org
www.iea-shc.org

Air Infiltration and Ventilation Centre AIVC

ANNEX 5

The primary objective of the EBC information centre, 'Air Infiltration and Ventilation Centre' (AIVC), is to be the international centre on research and development in the fields of air infiltration and ventilation. Thus, the specific objective is to provide a high quality international technical and information forum covering the areas of ventilation and air infiltration in the built environment with respect to efficient energy use, good indoor air quality and thermal comfort. The mission of AIVC is to be the reference portal for information on ventilation in buildings to improve the wellbeing of people through development and dissemination of ventilation knowledge.

Since the beginning of 2011, the AIVC has been operating with a new approach, which has been unanimously approved by the EBC Executive Committee in June 2013 for prolongation for the period through to 2016. A key ambition of the new AIVC is to convene integrated and combined activities (called 'projects'), resulting in different information tools, for example webinars, workshops, position papers, technical papers, and so on. These are supported by a review process and result in an increased information dissemination impact. The projects initiated since 2011 are:

- Quality of methods for measuring ventilation and infiltration in buildings
- Competent tester schemes for building airtightness testing
- Ventilation and health
- Improving the quality of residential ventilation systems
- Ventilative cooling – use of natural or mechanical ventilation strategies to cool indoor spaces, resulting in the launch of EBC Annex 62
- Testing, reporting and quality schemes for building airtightness
- Philosophy for setting building airtightness requirements
- Development and applications of building air leakage databases

For the current focus, with projects and events in relation to airtightness and ventilative cooling, AIVC is joining forces with the two information platforms TightVent Europe and venticool. TightVent is focusing on airtightness of buildings and ductwork and was launched in January 2011. Venticool is focusing on ventilative cooling and was launched in September 2012. TightVent Europe's and venticool's main goals are to:

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

In 2013, the 34th AIVC Annual Conference, held in Athens, Greece, has again provided an opportunity for over 170 researchers and practitioners from around the world to exchange ideas and to present their latest findings. The theme for the conference was 'Energy conservation technologies for mitigation and adaptation in the built environment: the role of ventilation strategies and smart materials'. The very positive evaluation of the event by participants – 96% rated the conference as meeting their expectations well or extremely well – shows the quality of the programme and organization.

Given the converging interests of AIVC, TightVent Europe and venticool, the AIVC Board and the Steering Committees of both platforms have agreed to collaborate among other things on:

- the organization of the 2014 conference, which will be held in Poznan (Poland) on the theme of 'Ventilation and airtightness in transforming the building stock to high performance', and
- the joint management of seven of the projects mentioned above.

NEW PRODUCTS

Website

In October 2013, AIVC has launched its new website which is database driven with 'Web 2.0' functionalities. It includes a powerful search engine for the bibliographic database AIRBASE with over 18000 references and 5000 pdf documents.

Technical Notes

Technical Note 66: 'Building air leakage databases in energy conservation policies: analysis of selected initiatives in 4 European countries and the USA'

Technical Note 67: 'Building airtightness: a critical review of testing, reporting and quality schemes in 10 countries'

AIVC Conference Proceedings

34th Annual Conference, 'Energy conservation technologies for mitigation and adaptation in the built environment: the role of ventilation strategies and smart materials', held 25th – 26th September 2013, Athens, Greece.

Contributed reports

Contributed report 14: 'Methods and techniques for airtight buildings'

Contributed report 15: 'Development and evaluation of a new test method for portable air cleaners'

AIVC Newsletter

February 2013

September 2013

WEBINARS

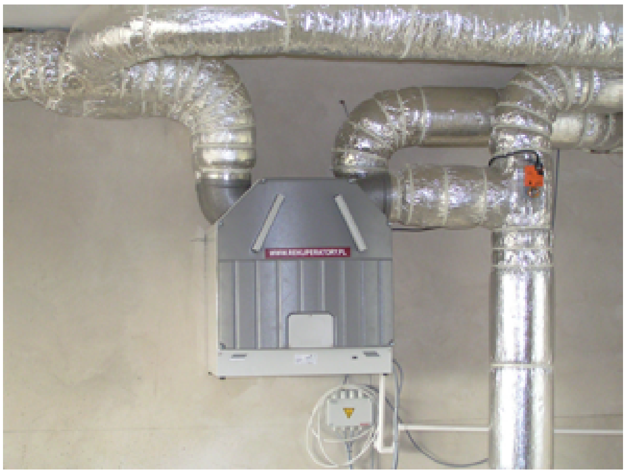
- Airtightness testing part 1: status and trends in competent tester schemes in United Kingdom and Belgium, held in November 2013.
- Airtightness testing part 2: status and trends in competent tester schemes in Germany, the Czech Republic and France, held in November 2013.
- Recordings of 20 presentations from the AIVC 2013 conference, held in September 2013.

Project duration
1979–present

Operating Agent
Peter Wouters, INIVE eeig, Belgium

Participating countries
Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, Japan, Republic of Korea, The Netherlands, New Zealand, Norway, Portugal, Sweden, USA

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



A ventilation heat exchanger. Source: Rekuperatory.pl, Poland

Completed Research Projects

TOTAL ENERGY USE IN BUILDINGS –
ANALYSIS AND EVALUATION METHODS (ANNEX 53)

ENERGY EFFICIENT COMMUNITIES: CASE STUDIES AND STRATEGIC
GUIDANCE FOR URBAN DECISION MAKERS (ANNEX 51)

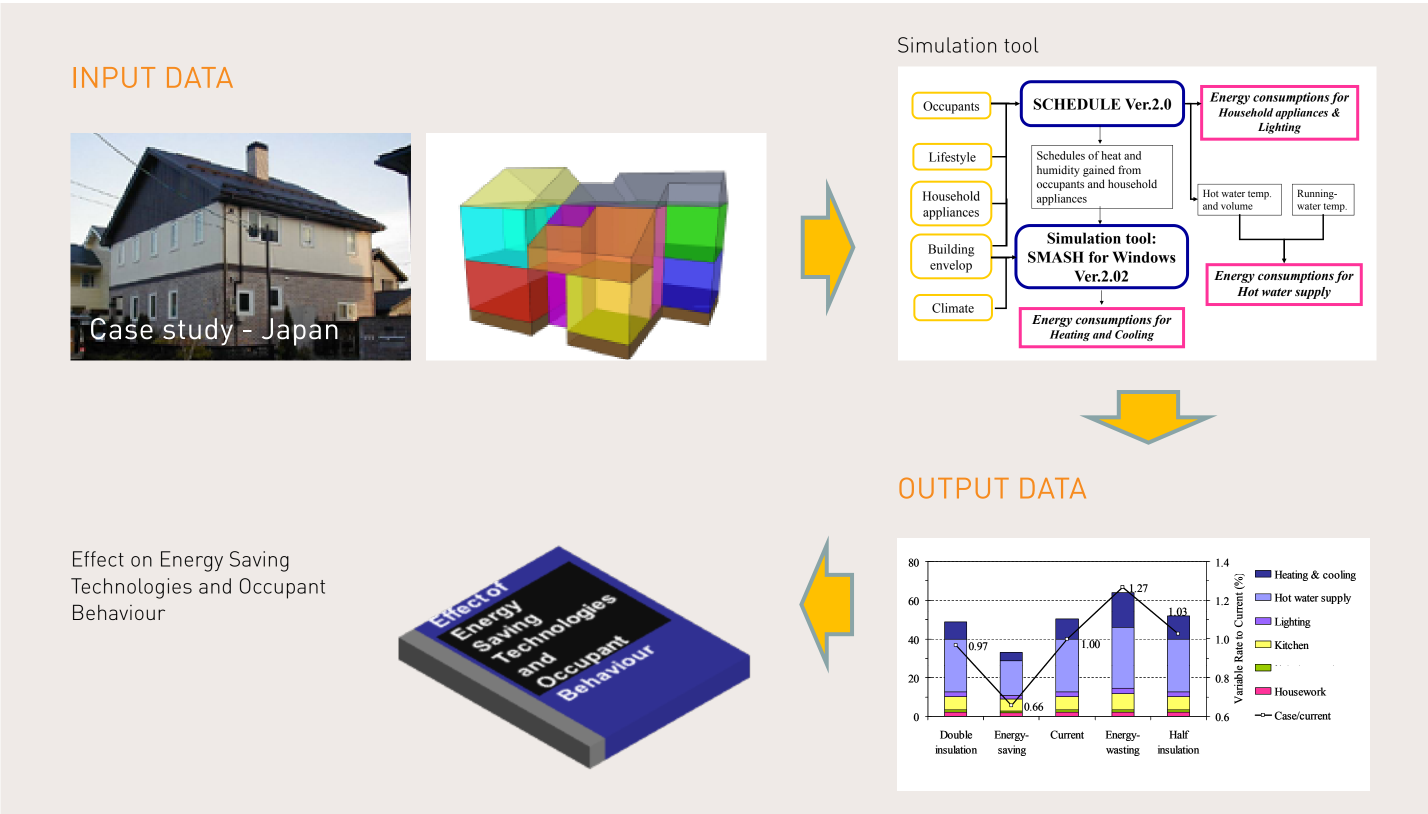
Total Energy Use in Buildings – Analysis and Evaluation Methods

ANNEX 53

One of the most significant barriers for achieving a substantial improvement of building energy efficiency is a lack of knowledge about the factors determining energy use. In fact, there is often a significant discrepancy between designed and real total energy use in buildings. The reasons for this are generally poorly understood, but are believed to often have more to do with the role of human behaviour than the building design. In fact, building energy use is mainly influenced by six factors:

- Climate
- Building envelope
- Building services and energy systems
- Building operation and maintenance
- Occupants' activities and behaviour
- Indoor environmental quality

In the past, much research focused on the first three factors (climate, building envelope, building services and energy systems). However, the latter three factors related to human behaviour can have an influence at least as significant as the three former ones. Detailed comparative analysis of building energy data covering all six factors would provide essential guidance in identifying energy saving potentials and opportunities. This recently completed project has advanced the understanding of how these six factors combine to influence building energy use, with particular emphasis placed on occupant behaviour.



The analytical approach taken by the project.

Achievements

The project has greatly improved the treatment of the influencing factors within the building energy field and has more closely related this to the real world. Hence, it has given a better understanding of how to robustly predict total energy use in buildings, so enabling the improved assessment of energy saving measures, policies and techniques. The scope has covered office and residential buildings. Several distinct areas of research have been carried out covering:

- A literature review and a state of the art review: These were incorporated into the Final Report.
- Definitions and energy reporting: These included terminology, indicators and influencing factors for energy use. Definitions were developed for energy boundaries, building energy use terms and conversion factors. Moreover, definitions were developed of the influencing factors and energy performance indicators at three levels of complexity for residential and office buildings, with two case studies used to expound the definitions.
- Case studies and data collection: Case studies were completed including collation of material for four building types for use in simulations.
- Statistical analysis and energy performance evaluation: Guidance has been developed on how to apply statistical and analytical methods as predictive models for total energy use.
- For residential buildings, the particular aspects of occupant behaviour considered relate to use of: heating, cooling, ventilation and windows, domestic hot water, appliances and electric lighting, and cooking.
- The classification of energy-related occupant behaviour in office buildings was on three different levels, namely: individual occupant or manager, zone or office, and the whole building. At each level, occupant and management behaviour is taken into account with respect to electric lighting, equipment, natural or mechanical ventilation, and heating and domestic hot water systems.

Publications

As official publications from the project, a final report has been published, together with six supporting documents that explain the underlying work in depth. The publications are:

Final Report: Total Energy Use in Buildings Analysis and Evaluation Methods
Volume I: Definition of Terms
Volume II: Occupant Behavior and Modelling
Volume III: Case Study Buildings
Volume IV: Data Collection Systems for the Management of Building Energy Systems
Volume V: Statistical Analysis and Prediction Methods
Volume VI: Energy Performance Analysis

Meetings

- 7th project meeting, held in Turin, Italy, in February 2013.

Project duration
2008 – 2013

Operating Agent
Hiroshi Yoshino, Tohoku University, Japan

Participating countries
Austria, Belgium, Canada, P.R. China, Denmark, Finland, France, Germany, Italy, Japan, The Netherlands, Norway, Portugal, Spain, USA

Further information
www.iea-ebc.org

Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers

ANNEX 51

This recently completed project has successfully delivered practical guidance for urban planners, decision makers and stakeholders on how to achieve ambitious energy and related carbon dioxide reduction targets at local and urban scales. It has addressed small units, such as neighbourhoods or quarters, as well as whole towns or cities. The project has generated the necessary knowledge and means to be able to define reasonable goals in terms of energy efficiency, energy conservation and CO_2 abatement at the community level.

While current methods and tools useful for local energy planning form part of a number of case studies, which are of interest to both urban and energy system planners, the primary audiences for this project are local decision makers and stakeholders. Hence, the legal frameworks and different approaches found within the participating countries have been considered according to their comparative suitability to enable innovative approaches for successful urban energy policies.

Achievements

The aim of the project was to describe both an 'integrated approach' to develop municipal energy master plans and neighbourhood scale energy action plans, based on experiences from realistic case studies. In most towns and cities, earlier practical experiences of implementing such local energy plans have typically only been very moderately successful. So, the goal was to address municipal decision makers and urban planners by providing them with information on the state-of-the-art of urban energy planning methods and to derive recommendations for strategies and organizational structures that encourage successful implementation. The project has achieved its objectives in the following ways:

– Existing organisational models, implementation instruments and planning tools for local administrations and developers were assessed in a 'state of the art' review.

Aerial view of the Ludwigsburg city centre covered by the Ludwigsburg Case Study, Germany.
Source: Municipality of Ludwigsburg

- Case studies were produced on energy planning and implementation strategies for neighbourhoods, quarters and municipal areas. These include both refurbishment of existing building stock and planning and development for new 'green' settlements.
- Case studies were documented on the preparation of integrated energy and CO_2 abatement concepts for towns or cities and corresponding implementation strategies.
- Instruments for a successful community energy policy were explained, including an overview of legal instruments at the level of urban planning found to be useful within the participating countries, as part of the means of implementing a policy.

Publications

Two key deliverables have resulted from the project. These are:

- The 'Guidebook to Successful Urban Energy Planning', which is aimed at decision makers in urban administrations, developers and urban planners. This is based on the findings of the state of the art review, an evaluation of the case studies, and is presented in such in a way that users will be able to apply it directly to their own work.
- The 'District Energy Concept Adviser', which is an electronic tool to support municipal administrations and urban planners faced with the task of developing and comparing options for integrated energy systems for neighbourhoods, either for new developments or for retrofit projects.

Project duration
2007 – 2013

Operating Agent
Reinhard Jank, Volkswohnung GmbH, Germany

Participating Countries
Austria, Canada, Denmark, Finland, France, Germany, Japan, The Netherlands, Sweden, Switzerland, USA

Further information
www.iea-ebc.org

The District Energy Concept Adviser comprises of a set of individual supporting tools. The very heart of the software is a tool for the energy assessment of districts which uses archetypes and other pre-set configurations to allow for simple and quick data input mapping all of the buildings in a district. Source: www.annex51.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 eight IEA member countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D). The current framework for international energy technology RD&D cooperation was approved by the IEA's Governing Board in 2003. More information about the energy technology RD&D framework can be found at: www.iea.org/techinitiatives.

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

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

ABOUT EBC

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

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

OBJECTIVES AND STRATEGY

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

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

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

- The environmental impacts of fossil fuels;
- Business process 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
Finland
France
Germany
Greece
Italy
Ireland
Japan
Republic of Korea
New Zealand
The Netherlands
Norway
Poland
Portugal
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States of America

COORDINATION WITH OTHER BODIES

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

COLLABORATION WITH IEA BUILDING-RELATED IMPLEMENTING AGREEMENTS

The EBC Programme continues to coordinate its research activities, including Annexes and strategic planning, with all IEA Building-Related Implementing Agreements through collaborative projects and through the BCG (Buildings Coordination Group), constituted by the IEA Energy End Use Working Party (EUWP) Vice Chair for Buildings and the Executive Committee Chairs of the following IEA research programmes:

– District Heating And Cooling (DHC)
– Demand Side Management (DSM)
– Energy in Buildings and Communities (EBC)
– Energy Conservation through Energy Storage (ECES)
– Heat Pumping Technologies (HPT)
– Photovoltaic Power Systems (PVPS)
– Solar Heating and Cooling (SHC)
– Energy Efficient Electrical Equipment (4E)

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

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

COLLABORATION WITH THE IEA SOLAR HEATING AND COOLING PROGRAMME

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

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

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

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

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

- Technology development via international collaboration;
- Information dissemination to target audiences;
- Enhancing building standards;
- Interaction with developing countries.

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

NON-IEA ACTIVITIES

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

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

Recent Publications

Air Infiltration & Ventilation Centre (AIVC) – Annex 5

Database

AIRBASE – bibliographical database, containing over 18,000 records on air infiltration, ventilation and related areas, Web based, updated every 3 months

Technical Notes

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

AIVC Conference Proceedings

2013 Greece - Energy conservation technologies for mitigation and adaptation in the built environment: the role of ventilation strategies and smart materials

Integrating Environmentally Responsive Elements in Buildings – Annex 44

- Project Summary Report, Per Heiselberg, 2012
- Designing with Responsive Building Elements, Ad van der Aa, Per Heiselberg, Marco Perino, 2011

Energy-Efficient Future Electric Lighting for Buildings – Annex 45

- Project Summary Report, Liisa Halonen, Eino Tetri, and Pramod Bhusal, 2012

Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) – Annex 46

- EnERGo IT-Toolkit, 2011

Cost Effective Commissioning of Existing and Low Energy Buildings – Annex 47

- Commissioning Overview, Edited by Chloé Legris, Natascha Milesi Ferretti and Daniel Choinière, 2010
- Flow Charts and Data Models for Initial Commissioning of Advanced and Low Energy Building Systems, Edited by Ömer Akin, Natascha Milesi Ferretti, Daniel Choiniere and David Claridge, 2010
- Commissioning Tools for Existing and Low energy Buildings, Edited by Christian Neumann, Harunori Yoshida, Daniel Choinière and Natascha Milesi Ferretti, 2010
- Commissioning Cost-Benefit and Persistence of Savings, Edited by Hannah Friedman, David Claridge, Daniel Choinière and Natascha Milesi Ferretti, 2010

Heat Pumping and Reversible Air Conditioning – Annex 48

- Analysis of Building Heating and Cooling Demands in the Purpose of Assessing the Reversibility and Heat Recovery Potentials, Edited by Pascal Stabat, Philippe Andre, Stéphane Bertagnolio, Marcello Caciolo, Pierre Yves Franck, Corinne Rogiest, Laurent Sarrade, 2011
- Analysis of Building Heating and Cooling Demands in the Purpose of Assessing the Reversibility and Heat Recovery Potentials: Annexes, Edited by Pascal Stabat, 2011
- Review of Heat Recovery and Heat Pumping Solutions, Edited by Stéphane Bertagnolio, Pascal Stabat, Marcello Caciolo, David Corgier, 2011
- Simulation tools: Reference Book, Edited by Stéphane Bertagnolio, Samuel Gendebien, Benjamin Soccal, Pascal Stabat, 2011
- Design Handbook for Reversible Heat Pump Systems with and without Heat Recovery, Edited by Wolfram Stephan, Arno Dentel, Thomas Dippel, Madjid Madjidi, Jörg Schmid, Bing Gu, Philippe Andre, 2011
- Overview of Cases Studies and Demonstrations of Heat Pump Systems for Tertiary Buildings, Edited by Marco Masoero, Chiara Silvi, Jacopo Tonolio, 2011

Low Exergy Systems for High Performance Buildings and Communities – Annex 49

- Exergy Assessment Guidebook for the Built Environment, Summary Report, 2011
- Detailed Exergy Assessment Guidebook for the Built Environment, Guidebook, 2011

Prefabricated Systems for Low Energy Renovation of Residential Buildings – Annex 50

- Project Summary Report, Mark Zimmermann, 2012
- Retrofit Strategies Design Guide, Peter Schwehr, Robert Fischer, Sonja Geier, 2011
- Retrofit Module Design Guide, René L. Kobler, Armin Binz, Gregor Steinke, Karl Höfler, Sonja Geier, Johann Aschauer, Stéphane Cousin, Paul Delouche, François Radelet, Bertrand Ruot, Laurent Reynier, Pierre Gobin, Thierry Duforestel, Gérard Senior, Xavier Boulanger, Pedro Silva, Manuela Almeida, 2011
- Building Renovation Case Studies, Reto Miloni, Nadja Grischott, Mark Zimmermann, Chiel Boonstra, Sonja Geier, Karl Höfler, David Venus, 2011

Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers – Annex 51

- Case Studies and Guidelines for Energy Efficient Communities, A Guidebook on Successful Urban Energy Planning, Publisher: Fraunhofer IRB Verlag, Stuttgart 2013
- District Energy Concept Adviser, March 2013

Towards Net Zero Energy Solar Buildings – Annex 52

- Evaluation tool for net zero energy buildings: application on office building, March 2013
- Net Zero Energy Buildings: International Projects of Carbon Neutrality in Buildings, Karsten Voss and Eike Musall, Detail, Germany, 2011

Total Energy Use in Buildings – Analysis and Evaluation Methods – Annex 53

- Final Report: Total Energy Use in Buildings Analysis and Evaluation Methods, November 2013
- Volume I: Definition of Terms, November 2013
- Volume II: Occupant Behavior and Modelling, November 2013
- Volume III: Case Study Buildings, November 2013
- Volume IV: Data Collection Systems for the Management of Building Energy Systems, November 2013
- Volume V: Statistical Analysis and Prediction Methods, November 2013
- Volume VI: Energy Performance Analysis, November 2013

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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

EBC is a programme of the International Energy Agency (IEA)