



International Energy Agency

ECBCS Annual Report 2010

Energy Conservation in Buildings & Community Systems Programme



Introduction

The drivers to substantially reduce energy use in the buildings sector are now greater than ever, with 'disruptive' changes being required to the whole industry. With this overriding goal of demand reduction, the ECBCS Programme advances the integration of technologies and processes for increased energy efficiency and conservation in community energy systems and healthy buildings, resulting in low energy-related carbon emissions. Our projects are thus investigating different aspects of how this can be achieved for the benefit of defined target audiences, including:

- **Integration of Micro-generation and Related Energy Technologies in Buildings** continues the theme of a previous ECBCS project, which has provided a sound foundation for modelling small scale co-generation systems. This work has been underpinned by extensive experimental validation to explore how such systems may be optimally applied. The target audiences for the present work include system designers and installers and energy services contracting companies, with policy and commercialisation strategy outputs of value to local to government policy makers, utilities, social housing providers, technology developers and investors.
- **Towards Net Zero Energy Solar Buildings** is investigating current net-zero, near net-zero and very low energy buildings to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. As well as establishing an international education network, the key audiences for the work are government policy makers and research funding programme managers, industry, utilities and the academic community.
- **Energy Efficient Communities** recognises that community-wide energy concepts must be based on optimized solutions in economic terms rather than necessarily introducing cutting-edge technical innovations. The project is specifically targeting local decision makers and stakeholders, who are not experts in energy planning.
- **Low Exergy Systems for High Performance Buildings and Communities:** This project, completed in the past year, has developed concepts for reducing the exergy demand in buildings and community energy systems. The outcomes are of particular benefit for energy managers, designers, and energy service companies.

- **Heat Pumping and Reversible Air conditioning** is seeking to exploit expensive air conditioning equipment as fully as possible, for example by applying exhaust air heat recovery when operating in heat pumping mode. The knowledge generated by the project is of benefit to designers, commissioning providers and building operators.
- **Energy Efficient Future Electric Lighting for Buildings:** This project, completed in the past year, has identified and helped to accelerate the widespread use of appropriate energy efficient high-quality lighting technologies and their integration with other building systems, making them the preferred choice of lighting designers, building owners, operators and users.
- **Integrating Environmentally Responsive Elements in Buildings** is exploring building integration of renewable energy and other technologies. The outcomes are of significant interest to construction product developers, architects, engineers, building contractors, owners, operators and users.

The major challenge in the coming years is renovation and refurbishment of the existing building stock to dramatically reduce energy use. ECBCS is therefore particularly active in this area, with one new project, two ongoing and one recently completed as follows:

- **Energy and Greenhouse Gas Optimized Building Renovation** is newly started and is developing accurate, understandable information and tools targeted to non-expert decision makers and real estate professionals.
- **Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost** is an ongoing project intended to help software developers, engineers, consultants and construction product developers.
- **Prefabricated Systems for Low Energy Renovation of Residential Buildings** is delivering information for building designers who focus on advanced building retrofit, energy, HVAC (heating, ventilation and air conditioning) and sustainable construction, the building industry with an interest in prefabrication of high performance energy building retrofit, apartment building owners with an interest in advanced renovation concepts, as well as a general audience.

- **Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings** has been recently completed and has produced guidance and tools for energy managers, designers and energy service companies.

Consideration about practical operation of existing and future buildings is the primary concern for a recently completed ECBCS project:

- **Cost Effective Commissioning of Existing and Low Energy Buildings:** The beneficiaries are building services commissioning providers, and also designers, building owners, and operations and maintenance personnel.

How different factors influence energy use in buildings, particularly occupant behaviour is being investigated in:

- **Total Energy Use in Buildings: Analysis and Evaluation Methods** for which the beneficiaries of the project outcomes will be policy makers, property developers, energy services contracting companies, manufacturers and designers of energy saving technologies.

In the past year, a new the **Air Infiltration and Ventilation Centre** operating period has been approved based on a very different concept than adopted in the past. A key ambition of the new AIVC is to have integrated / combined activities consisting of different activities (webinars, workshops, technical papers, and so on) resulting in high impact activities with an in depth review process. AIVC outputs include publication of the AIR newsletter, the 31st Annual AIVC Conference, development of online databases and additions to their series of reports. The main target groups for the Centre are the research community, industry including practitioners - from design to construction and maintenance - as well as policy and other decision makers.

I am also pleased to report the ECBCS Programme is continuing to improve the dissemination of knowledge generated in our research activities. During the past year, the presentation and approach to content for our website, newsletter and annual report have been further developed. The intention is that these initiatives should help to widen interest in the outcomes of ECBCS projects, not only among the project participants, but also all those concerned with energy conservation in buildings and community systems.

Dr Morad R. Atif
ECBCS Executive Committee Chair

New Research Projects

Energy and Greenhouse Gas Optimized Building Renovation

Energy and Greenhouse Gas Optimized Building Renovation

Annex 56

Project duration: 2010 - 2015

As the basis for future standards the project is developing a new methodology consisting of procedures and guidelines to enable cost effective renovation of existing buildings towards both nearly-zero energy related greenhouse gas emissions and nearly-zero energy objectives. The main objective is to provide tools, guidelines, recommendations, best-practice examples and background information for policy makers, designers, users, owners and promoters that help to cost effectively minimize greenhouse gas (GHG) emissions as well as primary non-renewable energy consumption in the existing buildings sector. Further, the integration of renewable energy production at a local and / or district or grid level is being considered.

An objective is also to develop information understandable by the target audiences enabling them to appreciate the benefits, but also the problems and risks associated with building renovation. It will also enable them to understand their roles as users, decision makers, real estate professionals or stakeholders in general. Accurate, understandable information and tools (also targeted to non-experts) must be provided so that decision-makers, including end-users, can make better decisions and choose the best options. Priority target groups must be identified and deliverables must be clearly addressed to each one of them. It is crucial for the success of the project to actively involve high level stakeholders.

The work being undertaken consists of defining the best renovation strategies from a perspective of cost-effectiveness for existing buildings of differing categories, typologies, dates of construction, construction or building characteristics, architectural restrictions, patterns of use,

“Accurate, understandable information and tools (also targeted to non-experts) must be provided so that decision-makers, including end-users, can make better decisions and choose the best options.”



climates (including buildings with heating and / or cooling needs), and so on.

Initially, the following are being defined:

- The types of buildings considered in the study (residential buildings, office buildings)
- Categories, typologies and building ages to be analysed
- The level of intervention: if just at the building level or at the block, district level or even higher
- Methodology for the intervention: keep the users / tenants in the building or move them during the works
- Objective of the intervention: keep the same tenants / users or invest in a higher standard; conservation of building value or increasing of rental revenues
- For each set of buildings it is also necessary to define target values for energy use and greenhouse gas emissions. Furthermore, the definition of a nearly-zero emissions building must be clarified at a national level.

Meetings

The 1st Project Meeting took place in Lisbon, Portugal in October 2010.

Operating Agent: Manuela Almeida, University of Minho, Portugal

Participating Countries (provisional): Austria, P.R.China, The Czech Republic, Denmark, France, Greece, Italy, The Netherlands, Norway, Portugal, Switzerland, UK

Further information:

www.ecbcs.org/annexes/annex56.htm

Completed Research Projects

Energy Efficient Future Electric Lighting for Buildings

Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings

Cost Effective Commissioning of Existing and Low Energy Buildings

Low Exergy Systems for High Performance Buildings & Communities

Project duration: 2004 - 2010

Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. At the same time the savings potential of lighting energy is high, even with existing technologies, and there are new energy efficient lighting technologies emerging onto the market. Currently more than 33 billion lamps operate worldwide, consuming more than 2650 TWh of energy annually, which is 19% of global electricity consumption. The more efficient use of lighting energy would limit the rate of increase of electric power consumption, reduce the economic and social costs resulting from constructing new generating capacity, and reduce the emissions of greenhouse gases and other pollutants. Interesting aspects of desired lighting technologies are energy savings, daylight use, individual control of light, quality of light, emissions during life cycle and total costs. The demands for the new light sources are: higher efficiency, lower environmental impact, lower costs, better light quality, longer lifetime, suitability for dimming and control.

Project objectives

The project objectives have been to:

- Identify and accelerate the use of energy efficient high-quality lighting technologies and their integration with other building systems;
- Assess and document the technical performance of existing and future lighting technologies;
- Assess and document barriers preventing the adoption of energy efficient technologies and propose means to resolve these barriers.

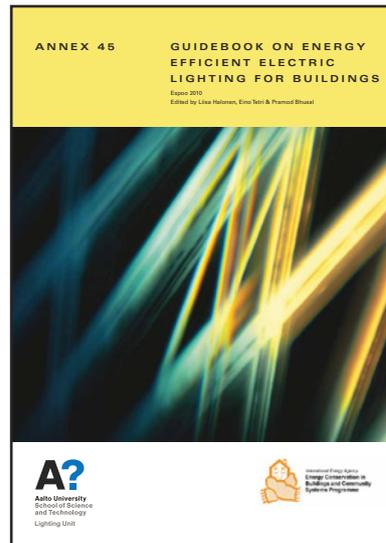
There is significant potential to improve energy efficiency of old and new lighting installations even with existing technologies. The energy efficiency of lighting installations can be improved with the following measures:

- The choice of lamps - incandescent lamps should be replaced by compact fluorescent lamps (CFLs), infrared coated tungsten halogen lamps or lighting emitting diodes (LEDs), mercury lamps by high-pressure sodium lamps, metal halide lamps, or LEDs, and ferromagnetic ballasts by electronic ballasts
- The use of controllable electronic ballasts with low losses

- The lighting design: the use of efficient luminaires and localized task lighting
- The control of light with manual dimming, presence sensors, and dimming according to daylight
- The usage of daylight
- The use of high efficiency LED-based lighting systems

The project has suggested that clear international initiatives (by the IEA, EU, CIE, IEC, CEN and other international bodies) should be taken up in order to:

- Upgrade lighting standards and recommendations
- Integrate values of lighting energy density (kWh/m², a) into building energy codes
- Monitor and regulate the quality of innovative light sources
- Pursue research into fundamental human requirements for lighting (visual and non-visual effects of light)
- Stimulate the renovation of inefficient old lighting installations by targeted measures.



The **Guidebook on Energy Efficient Electric Lighting for Buildings** is available at: www.ecbcs.org
An extended summary of this is also available.

Operating Agent: Liisa Halonen, Aalto University

Participating Countries: Australia, Austria, Belgium, Canada, China, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Poland, Sweden, Switzerland, Turkey, UK, USA

Observers: Russia and Singapore

Further information and reports:
www.ecbcs.org/annexes/annex45.htm



Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings

Annex 46

Project duration: 2005 - 2010

Older, energy inefficient buildings represent about 80% of the building stock, and 95% of the energy consumption. Therefore, this project focuses exclusively on energy retrofit in selected building categories that represent a substantial part of the non-residential building stock: office / administrative buildings, large one-story production facilities and maintenance shops. Though the focus is primarily on government buildings, many results can be applied directly to similar private sector buildings. Research has shown that many government buildings are characterised by high energy consumption. Since these buildings are constructed similarly in many countries, experience gained with retrofitting such buildings with energy saving technologies should be widely applicable – on an international scale.

Considerations of energy saving options can be based on simple tools such as the Energy Concept Adviser for Educational Buildings (developed in the ECBCS project Annex 36). A suitable tool should provide 'rules of thumb' for quick and easy estimation of required investments and potential energy savings applicable to government buildings before analysing the building construction in detail. Simple tools for analysis will encourage users to become more deeply involved in assessing the energy consumption of their facilities.

Deliverables

- Energy and Process Assessment Protocol - The document to support energy assessments at administrative / office buildings, barracks and dormitories, service buildings, and production and maintenance facilities.
- Energy Saving Technologies and Measures for Government Building Retrofits - A database of energy saving technologies and measures for government building retrofits with examples of best practices.
- Best Practice Guidelines for Innovative Energy Performance Contracts
- The 'EnERGo' IT Toolkit – An electronic interactive source book published on CD-ROM and supplemented by guidelines, best practice and case studies published as a book. A central database will include all project results and will allow users to obtain extensive information, according to their individual focus of interest: energy saving opportunities, design

inspirations, design advice, decision tools, design tools, commissioning methods, long-term monitoring systems, and measures that require no financial investment.

Progress

- The Energy and Process Assessment Protocol has been peer reviewed and amended based on the comments received.
- In addition to the electronic version of the Protocol, a print ready edition is included in the EnERGo Toolkit. Six hundred paper copies of the printed edition have been distributed internationally ASHRAE.
- The Protocol has been used for training at workshops conducted in January 2010 in Orlando, FL, USA.
- The Protocol has been adopted by the U.S. Army to help streamline energy assessments at multiple installations under its Energy Engineering Analysis Program, as well as for showcase assessments conducted under the supervision of multi-national teams in Germany, Italy, Japan, and the Republic of Korea.
- Source material for energy auditor training based on the Protocol has been published separately in CD-ROM format.
- The Best Practices Guidelines for Innovative Energy Performance Contracts, have also been incorporated into the EnERGo Toolkit.
- The terminology used in the English version of the input fields for the Toolkit and the help text for the calculation tool has been aligned with the relevant ISO / CEN standards.

Meetings

- On 28th June, 2010, a project technical session was organized as a part of the ASHRAE annual meeting in Albuquerque, NM, USA.
- A project workshop was included in the 2010 GovEnergy conference program on 14th August, 2010, Dallas, TX, USA.

Operating Agent: Alexander Zhivov

Participating Countries: Canada, Denmark, Finland, France, Germany, Italy, USA

Further information and reports:
www.ecbcs.org/annexes/annex46.htm



Cost Effective Commissioning of Existing & Low Energy Buildings

Annex 47

Project duration: 2005 - 2010

Commissioning is a cost-effective way for owners to ensure their buildings reach their full operating potential. When a building is commissioned it goes through a systematic, quality assurance process. This process, which spans the design, construction, and operation of the building and its systems, is a valuable mechanism for quality building delivery. The process is aligned with industry best-practices, and involves commissioning agents, building owners, architects, engineers and building operators. It includes:

- developing documents such as the Owner's Project Requirements;
- planning for and carrying out verification checklists and functional tests;
- developing a complete Systems Manual and training requirements;
- performing seasonal / deferred testing.

Commissioning ensures that the building meets the owner's needs, operates efficiently and lays the groundwork for training the operations and maintenance staff to maintain systems over the life of the building. The overarching benefits include reduced life cycle costs, improved occupant comfort and productivity, and cost-effective maintenance.

Twenty two organizations from ten countries have successfully completed research into the cost-effective commissioning of existing and future buildings to improve operating performance. The commissioning techniques developed through this project are intended to help transition the industry from the intuitive approach currently employed in the operation of buildings, to more systematic and structured activities focusing on achieving significant energy savings.

Key outputs of the project include:

- Methods and tools for commissioning advanced systems and low energy buildings
- Methods and tools for field application
- Information on the costs and benefits that can be used to promote the wider use of commissioning

The '**Commissioning Overview**' report can be considered as an introduction to the commissioning process. The project results also serve as a means to document information on commissioning practices in different countries and to disseminate relevant information to national practitioners.

A major barrier to market penetration is the lack of commissioning methods and tools to ensure that advanced components and systems reach their technical potential and operate energy-efficiently. So, guidelines

and tools to help overcome that barrier for both existing and future buildings have been developed.

The report, '**Commissioning Tools for Existing and Low Energy Buildings**' provides general information on the use of tools to enhance the commissioning of low energy and existing buildings. It summarizes guidelines for monitoring and the use of sensors and also presents a series of national case studies.



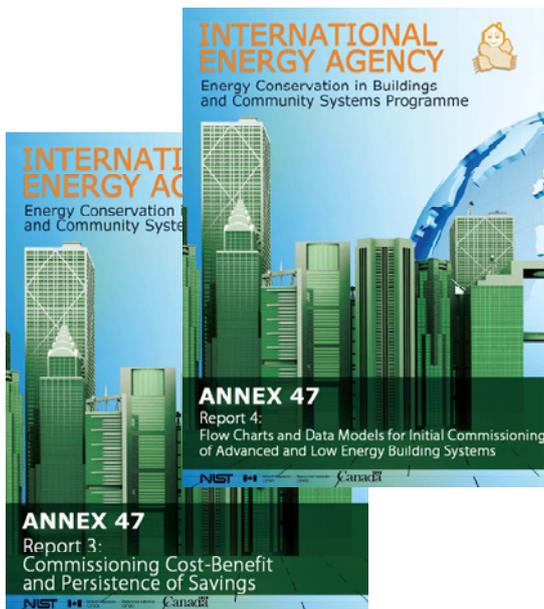
Twelve national research studies about commissioning cost-benefits and persistence have been analysed, with emphasis on cases for which the cost-benefit methodologies were available. The majority considered multiple buildings, and the sources ranged from research reports, databases and marketing literature. Key results have been obtained by forming a consensus on the evaluation methodologies for commissioning cost-benefit and persistence. These methods have been implemented in a cost-benefit and persistence database using field data. Financial and technical data was collected and analyzed from 10 new building commissioning projects and 44 existing building commissioning projects spanning

“Commissioning ensures that the building meets the owner’s needs, operates efficiently and lays the groundwork for training the operations and maintenance staff to maintain systems over the life of the building.”

Cost Effective Commissioning of Existing & Low Energy Buildings

Annex 47

seven countries. The results are published in the report **'Commissioning Cost Benefit and Persistence'**. This report also highlights national differences in the application of commissioning. Work on the initial commissioning of advanced and



low energy building systems has focused on the conceptual, design, construction, handover, and early operation phases of buildings to determine what can be improved for future buildings. The final and overarching recommendations will move the industry towards:

- standardizing parameters for commissioning data, users, and practices,
- finding representations that can seamlessly carry data from one phase of building delivery to the next, minimizing data loss,
- partnering with current efforts in the area of building information modelling (BIM) and developing parallel models and software applications for commissioning of advanced and low-energy buildings,
- overcoming challenges of cost, function, and payback in digital commissioning tools, and
- developing historic data records for commissioning of advanced and low-energy buildings based on pre-specified data and flow chart categories.

These findings, together with process tools developed, are presented in the report **'Flowcharts and Data Models for Initial Commissioning of Advanced and Low Energy Building Systems'**.

“Work on the initial commissioning of advanced and low energy building systems has focused on the conceptual, design, construction, handover, and early operation phases of buildings to determine what can be improved for future buildings.”

In many countries, commissioning is still an emerging activity and in all countries, advances are needed for greater formalization and standardization. The products of this research project promote best practices to advance the development of commissioning and to serve as the basis of further research in this growing field.

Recent Publications

The following reports have been published by the project:

- Commissioning Overview
- Commissioning Tools for Existing and Low energy Buildings
- Commissioning Cost-Benefit and Persistence of Savings
- Flow Charts and Data Models for Initial Commissioning of Advanced and Low Energy Building Systems

Co-Operating Agents: Daniel Choinière and Natascha Milesi-Ferretti

Participating Countries: Belgium, Canada, Czech Republic, Finland, France, Germany, Hong Kong / China, Japan, Netherlands, Norway, USA

Observer: Hungary

Further information and reports:
www.ecbcs.org/annexes/annex47.htm



Low Exergy Systems for High Performance Buildings & Communities

Annex 49

Project duration: 2005 - 2010

The main objective of this project is to develop concepts for reducing the exergy demand in buildings and community systems. Thus the related CO₂-emissions of the building stock will be reduced and supporting structures developed for sustainable and secure energy systems for this sector. Specific objectives are to:

- Use exergy analysis to develop tools, guidelines, recommendations, best-practice examples and background material for designers and decision makers in the fields of construction, energy production and government policy-making
- Develop cost-efficient energy / exergy measures for retrofit and new buildings, such as dwellings and commercial / public buildings
- Develop exergy-related performance analysis of the buildings as seen from a community level

The project is based on an integral approach which includes not only the analysis and optimisation of the exergy demand in the heating and cooling systems, but also all other processes for which energy / exergy is used within the building stock. To reach this aim, the project is working with the underlying fundamental principles, i.e. exergy analysis methodologies. These work items are aimed at development, assessment and analysis methodologies, including tool development for system design and performance analysis. On this basis, the work on exergy efficient community supply systems focuses on the development of exergy distribution, generation and storage system concepts. Within project, equal emphasis is given to generation and supply as to the use of energy / exergy. As a result, the development of exergy efficient building technology depends on the reduction of exergy demand for the heating, cooling and ventilation of buildings.

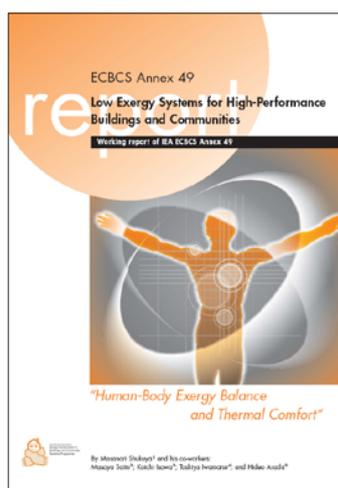
Tools for Exergy Analysis

To deploy exergy-based design approaches for buildings and community systems within design teams, the following tools are being developed:

- A simplified Excel-based tool for steady-state exergy analysis of different building heating systems. The tool is focussed at the building level and allows the combination of several building systems to be analyzed, giving an idea of their exergy performance and suitability in providing heating demands.
- Several models for the dynamic analysis of building systems have also been developed in TRANSYS code. Although compiled into a tool, the models can be combined as modules, allowing for the evaluation of a great variety of building systems.

- A simplified exergy evaluation model has been implemented into the REVIT building design environment. So an evaluation starting with a CAD drawing of a building is possible.
- A simplified tool, also Excel based, is being developed for analyzing exergy performance energy supply structures at the community level. This is intended as an aid to municipalities and decision makers involved in the community design process in the planning of optimized energy supply structures. With the help of this tool, both quantitative and qualitative views on potential improvements in such structures can be gained.
- A tool for estimating the exergy associated with thermal comfort and energy processes within the human body to give insight on the relation between the concept of exergy and thermal comfort issues.

Progress



In 2010 a working report on the “**Human-Body Exergy Balance and Thermal Comfort**” has been published to summarise the work on the relationship between exergy analysis and thermal comfort issues. The final project report is expected to be published in early 2011.

Meetings

In October 2010 the final project conference on The Future for Sustainable Built Environments with High Performance Energy Systems took place in Munich. This was a joint activity with the European COSTeXergy Action.

Operating Agent: Dietrich Schmidt, Fraunhofer-Institute for Building Physics, Department Energy Systems, Kassel

Participating Countries: Austria, Canada, Denmark, Finland, Germany, Italy, Japan, Poland, Sweden, Switzerland, Netherlands, USA

Further information and reports:
www.ecbcs.org/annexes/annex49.htm

Ongoing Research Projects

Air Infiltration & Ventilation Centre

Integrating Environmentally Responsive Elements in Buildings

Heat Pumping & Reversible Air Conditioning

Prefabricated Systems for Low Energy Renovation of Residential Buildings

Energy Efficient Communities

Towards Net Zero Energy Solar Buildings

Total Energy Use in Buildings: Analysis & Evaluation Methods

Integration of Microgeneration and Other Energy Technologies in Buildings

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

Project duration: 1979 - present

The primary objective of the ECBCS 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, and thus 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.

The popular annual conference provides an opportunity for researchers and practitioners from around the world to exchange ideas and present their latest findings. The proceedings and conference report are available at the AIVC website.

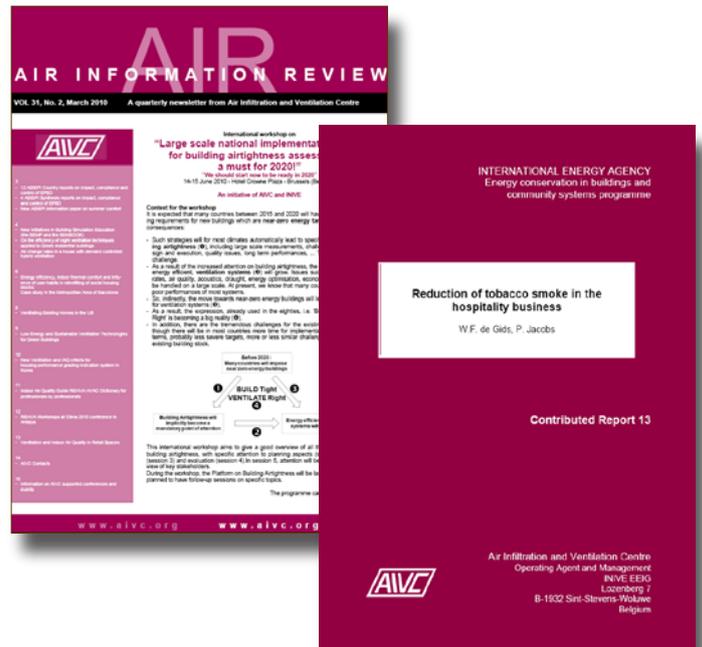
The latest operating period for the Air Infiltration and Ventilation Centre ended in May 2010. The AIVC's continuation for the period from 2011 to 2013 was approved at the November 2010 meeting of the ECBCS Executive Committee, during which time a fundamentally new approach will be implemented.

New Products in 2010

➤ New Ventilation Information Papers

VIP 34 Needs and methods for ductwork cleaning in France

VIP 33 CO₂ as indicator for the indoor air quality - General principles



VIP 32 Hybrid Ventilation

➤ Contributed Reports

CR 13 Reduction of tobacco smoke in the hospitality business

➤ AIVC Conference Proceedings

31st Annual Conference 'Low Energy and Sustainable Ventilation Technologies for Green Buildings', held 26th - 28th October 2010 in Seoul, Korea.

➤ AIVC Newsletter: 'Air Information Review'

March 2010

The website (www.aivc.org) is regularly updated.

Meetings

A workshop on the topic of "Large scale national implementation plans for building airtightness assessment" was held in Brussels, Belgium, in June 2010.

Operating Agent: Peter Wouters, INIVE eeg

Participants: Belgium, Czech Republic, France, Greece, Japan, Republic of Korea, Netherlands, Norway, USA

Further information and reports:
www.ecbcs.org/annexes/annex5.htm

Integrating Environmentally Responsive Elements in Buildings

Annex 44

Project duration: 2004 - 2011

The building sector is identified as providing the largest potential for CO₂ emissions reductions by 2020. Many countries worldwide have set very ambitious targets for energy efficiency improvements in buildings. To successfully achieve these targets, it is necessary to identify and develop innovative building and energy technologies and solutions for the medium and long term.

These should facilitate considerable energy savings and the implementation and integration of renewable energy devices within the built environment. Rapid developments in materials science, information and sensor technology offer major opportunities for creating new intelligent building components and systems.

Responsive building concepts are design solutions that maintain an appropriate balance between optimum interior conditions and environmental performance by reacting:

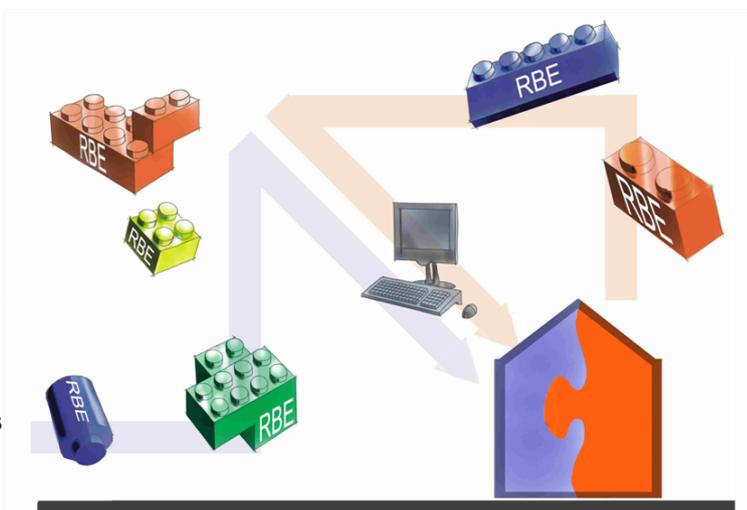
- in a controlled and holistic manner to changes in external or internal conditions, and
- to occupant intervention.

These concepts arise from an integrated multidisciplinary design process, which optimizes energy efficiency and includes integration of human factors and architectural considerations. In this respect, responsive building elements are essential technologies for the exploitation of the environmental and renewable energy resources and in the development of integrated building concepts.

The challenge is to achieve an optimum combination of responsive building elements and integration of these with the building services systems and renewable energy systems to reach an optimal environmental performance.

Environmental design and control of buildings can be divided into two very different approaches. In the usual 'exclusive' approach energy efficient building concepts are created by excluding the indoor environment from the outdoor environment through a very well insulated and air tight building construction. Acceptable indoor environmental conditions are established by automatic control of efficient mechanical systems. Alongside this,

“Responsive building concepts are design solutions that maintain an appropriate balance between optimum interior conditions and environmental performance...”



there is a growing interest for developing buildings that co-operate with nature and make use of the available environmental conditions. In this 'selective' approach, energy efficient building concepts are created by using the building form and envelope as an intermediate between the outdoor and the indoor environment.

Acceptable indoor environmental conditions are established by user control of the building envelope and the mechanical systems. It is important that the building is responsive to the fluctuations in the outdoor environment and the changing needs of the occupants, which means that the building should have the ability to dynamically adjust its physical properties and energetic performance. This capability could pertain to energy capture (as in window systems), energy transport (as air movement in cavities), and energy storage (as in building materials with high thermal storage capacity).

In a responsive building an optimum must be found between sometimes contradictory requirements such as energy use, health and comfort. From the viewpoint of human coexistence with nature the approach is to make buildings 'open' to the environment and to avoid barriers between indoors and outdoors, in which from the viewpoint of energy savings, for certain periods the approach is to exclude the buildings from the environment. The area between indoors and outdoors thereby becomes a more or less 'hybrid zone', in which the energy gains are not only rejected, but are stored, tempered, admitted or redirected, depending on the desired indoor conditions. In this respect, responsive building elements (RBE) are essential technologies for the exploitation of the environmental and renewable energy resources and in the development of responsive building concepts (RBC).

Nowadays we are able to measure and control the performance of buildings, building services and energy

Integrating Environmentally Responsive Elements in Buildings

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systems with advanced building management systems (BMS). This opens a new world of opportunities.

Buildings no longer act as rigid objects that need a large heating installation in winter and big cooling equipment during summer to “correct” the indoor climate, rather they become additional ‘living skins’ around occupants, keeping them in contact with nature, but at the same time protecting them when necessary.

The integration of responsive building elements with building services and energy-systems within responsive building concepts has a number of important advantages:

- Integration of responsive building elements with energy-systems will lead to substantial improvement in environmental and operating cost performance.
- It enhances the use and exploits the quality of energy sources (exergy) and stimulates the use of renewable and low valued energy sources (like waste heat, ambient heat, residual heat etc.)
- It will further enable and enhance the possibilities of passive and active storage of energy (‘buffering’).
- It will integrate architectural principles into energy efficient building concepts.
- Responsive building elements lead to better tuning of available technologies in relation to the building users and their behaviour.
- It enhances the development of new technologies and elements, in which multiple functions are combined in the same building element.
- It leads to a better understanding of integrated design principles among architects and engineers

With the integration of responsive building elements,

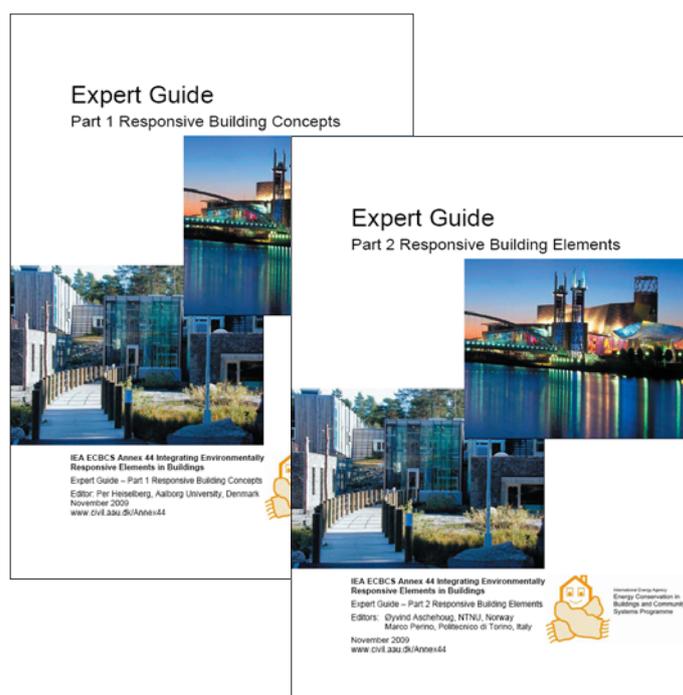
“Buildings no longer act as rigid objects..., rather they become additional ‘living skins’ around occupants keeping them in contact with nature, but at the same time protecting them when necessary.”

building services and renewable energy systems, building design completely changes from design of individual systems to integrated design of responsive building concepts. This should allow for optimal use of natural energy strategies (daylight, natural ventilation, passive cooling, etc.), as well as integration of renewable energy devices. Design teams including both architects

and engineers are formed and the building design is developed in an iterative process from the conceptual design ideas to the final detailed design. However, a number of barriers appear when the borderline between architecture and engineering is crossed; the design process contains many challenges to those who participate in the process. The main barriers to achieving an integrated design process are a lack of knowledge, information and guidelines, successful examples and expertise.

The ECBCS research project “Annex 44: Integrating Environmentally Responsive Elements in Buildings” has dealt with these issues and three major publications addressing the challenges are available from www.ecbcs.org:

- **Expert Guide. Part 1 Responsive Building Concepts**
- **Expert Guide. Part 2 Responsive Building Elements**
- **Designing with Responsive Building Element**



Operating Agent: Per Heiselberg, Aalborg University

Participating Countries: Austria, Canada, China, Denmark, France, Italy, Japan, Norway, Portugal, Sweden, Netherlands, UK, USA

Further information and reports:
www.ecbcs.org/annexes/annex44.htm

Project duration: 2005 - 2011

In many climates, office buildings are commonly equipped with a heat pump which has the function of providing cooling or air-conditioning of the internal spaces. The existence of this heat pump offers attractive, but rarely implemented, opportunities to improve the energy performance of the building and to reduce the energy-related carbon dioxide (CO₂) emissions.

Substituting a boiler with a heat pump may save more than 50% of primary energy, if electricity is produced by a modern gas-steam power plant (and even more if a part of that electricity is produced from a renewable source). 'Heat pumping' is probably today one of the quickest and

“Substituting a boiler with a heat pump may save more than 50% of primary energy, if electricity is produced by a modern gas-steam power plant”

safest solutions to save energy and to reduce carbon dioxide emissions. This project is promoting the best heat pumping techniques applicable to air conditioning for commercial buildings. The specific focus is the integration of these techniques inside the whole air conditioning system. The project has investigated two options based upon the use of heat pumps, not only to provide cooling, but to also to meet, at least partially, the heating demand: heat recovery at the condenser and reversibility of the machine.

The project has addressed both new building projects and retrofit of existing cases. Indeed, the retrofit of an existing building and even more, the design of a new one, should take all possibilities of heat pumping into consideration as soon as possible. Based upon a number of case studies, the research work conducted in this project has identified a number of constraints and obstacles to the application of this strategy.

This research project has examined in detail the problems raised when moving to a more systematic use of heat pumps for providing both heating and cooling to office buildings. While not all problems have been solved, the project has successfully delivers a set of tools, design methodology and practical illustrations that will help



designers, commissioning agents and building operators to pay more attention to these new options and in that way to reduce the environmental impact of buildings.

Deliverables

- Analysis of building heating and cooling demand for the purpose of assessing the reversibility and heat recovery potentials
- Review of heat recovery and heat pumping solutions
- A reference book for simulation tools
- Design Handbook for Reversible Heat Pump Systems with and without Heat Recovery
- Overview of Case Studies and Demonstrations of Heat Pump systems for Tertiary buildings

Meetings

The 8th Experts' Meeting took place in Paris in February 2010.

Co-Operating Agents: Philippe Andre and Jean Lebrun, Université de Liège

Participating Countries: Belgium, China, France, Germany, Italy, Switzerland

Further information and reports:
www.ecbcs.org/annexes/annex48.htm



Prefabricated Systems for Low Energy Renovation of Residential Buildings

Annex 50

Project duration: 2006 - 2011

Energy conservation is largely dominated by existing buildings. In most industrialized countries new buildings will only contribute 10% - 20% additional energy consumption by 2050 whereas more than 80% will be influenced by the existing building stock. If building renovation continues at the current rate and with the present common policy, we will need between 100 and 400 years to improve the building stock to the energy level of today's new construction.

Currently, most building renovations address isolated building components, such as roofs, façades or heating systems. This often results in inefficient, and in the end expensive solutions, without an appropriate long-term energy reduction. Optimal results cannot be achieved by single renovation measures and new problems can arise, including local condensation or overheating. Currently, most building renovations are neither cost effective nor energy effective. This project aims to standardise and prefabricate building retrofits for efficiency and quality. The objective is the development and demonstration of an innovative whole building renovation concept for typical apartment buildings.

Project objectives

- Investigate and promote cost effective low energy renovation strategies for existing apartment buildings
- Establish optimised renovation solutions that will reduce the energy consumption by a factor of 5 to 10 i.e. to less than 30 - 50 kWh/(m²·year)
- Achieve standardisation of construction details suitable for prefabrication at lower costs.

The focus is on typical apartment blocks, which represent approximately 40% of the residential European dwelling stock. One of the novel aspects of the project is the integration of a ventilation system into the façade construction. Innovative solutions have been studied to integrate conduits into the insulation layer and to apply vacuum insulation to compensate locally for the additional thermal loss. This concept avoids extensive construction work inside the building and makes it possible for the building to be inhabited during refurbishment. A special area of the project is dealing with advanced geometrics using laser scanning to obtain an accurate three-dimensional picture of existing buildings.



Progress

The final reports will be published in 2011.

- **'Retrofit Strategies Design Guide'** documents typical solutions for whole building renovations, including prefabricated roofs with integrated HVAC components and for advanced facade renovation. An electronic tool, the 'Retrofit Advisor' has also been developed that allows an evaluation of suitable renovation strategies. These serve building owners and planners wishing to develop appropriate retrofit strategies and the guidance describes 10 important design steps that have to be considered if prefabricated renovation modules will be used.
- The **'Retrofit Simulation'** report documents achievable energy savings.
- The **'Retrofit Module Design Guide'** is for system evaluation, design, construction process and quality assurance for prefabricated whole building renovation concepts. Four types of Renovation modules have been developed and documented. The concepts presented have been developed by national teams from Austria, France, Portugal and Switzerland. They have considered the specific needs and possibilities for each country and the implications of applying different construction materials.
- **'Building Renovation Case Studies'** provides information about national case studies. Four demonstration projects in Austria and Switzerland with a total of eight buildings have been completed and documented. A full demonstration project in the Netherlands is further two planned demonstration sites in Sweden and Switzerland are being documented as such.
- A **'Project Summary Report'** is being developed for a broad audience, demonstrating the potential of prefabricated retrofit.

Meetings

- The 7th and 8th working meetings were held in Malmö, Sweden and Zurich, Switzerland respectively.
- The results have been presented at a large construction fair in Basel, Switzerland (Swissbau '10).

Operating Agent: Mark Zimmermann, EMPA

Participating Countries: Austria, The Czech Republic, France, Netherlands, Portugal, Sweden, Switzerland

Further information and reports:
www.ecbcs.org/annexes/annex50.htm

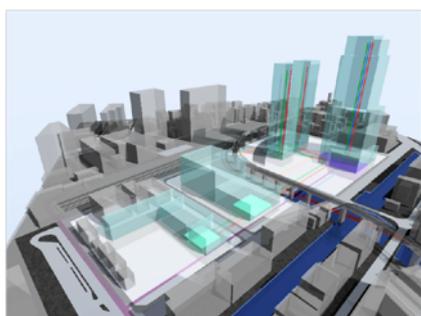
Energy Efficient Communities Case Studies and Strategic Guidance for Urban Decision Makers

Annex 51

Project duration: 2007 - 2012

Energy planning for community level systems is of increasing political importance in a number of industrialised countries. A strong increase of interest in sustainability issues is apparent in municipal administrations as a result of both national and local political pressure. Consequently ambitious targets for the reduction of energy-related carbon dioxide (CO₂) emissions are often set by communities, but with only a limited understanding of the means to achieve them. Often the appropriate technology exists, but difficulties are caused by insufficiencies in:

- know-how for strategic planning,
- management ability during the implementation process, and
- availability of tools and instruments for decision making, planning and monitoring.



This project is providing practical guidance for urban planners, decision makers and stakeholders on how to achieve ambitious energy and CO₂ reduction targets on a

local and urban scale. Addressing small units such as neighbourhoods or quarters, as well as whole towns or cities, the project is generating the necessary knowledge and means to be able to define reasonable goals in terms of energy efficiency, energy conservation and greenhouse gas abatement at the community level.

Local decision makers and stakeholders are the primary audiences addressed by this project, rather than energy planners. Hence the legal frameworks and different approaches found within the participating countries are being considered according to their comparable suitability to enable innovative approaches for successful urban energy policies.

Research Areas

- Existing organisational models, implementation instruments and planning tools for local administrations and developers are being assessed in a state of the art review.
- Case studies on energy planning and implementation strategies for neighbourhoods, quarters and municipal areas. This involves both refurbishment of existing building stock and planning and development of new 'green' settlements.

- Case studies on the preparation of integrated energy and CO₂ abatement concepts for towns or cities and corresponding implementation strategies.
- Instruments for a successful community energy policy: to include the preparation of a guidebook to successful urban energy planning, a community energy concept adviser and dissemination activities.

Deliverables

- The '**Guidebook to Successful Urban Energy Planning**' is aimed at decision makers in urban administrations, developers and urban planners. The document is based on the findings of the state of the art review, and an evaluation of the case studies, and presented in a way that users will be able to apply the guidebook directly to their own work.
- The '**District Energy Concept Adviser**' is a computer-based tool to support municipal administrations and urban planners faced with evaluating and monitoring.

Progress

- Evaluation of case studies on energy planning and implementation strategies for neighbourhoods, quarters and municipal areas is underway.
- Work on the District Energy Concept Adviser (D-ECA) is ongoing with a first working version expected during 2011.
- The Guidebook to Successful Urban Energy Planning is being drafted.
- A website for the project has been set up providing information on the project objectives, participants and periodic newsletters. In addition, papers and presentations made during the course of the project are provided for download.

Meetings

- A Web meeting was convened April 2010 (replacing a planned project meeting)
- In November 2010, a full project meeting took place in Tokyo, Japan

Operating Agent: Reinhard Jank, Volkswohnung GmbH

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

Further information:

www.ecbcs.org/annexes/annex51.htm

Project duration: 2008 - 2013

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions. Energy use and emissions include both direct, on site use of fossil-fuels and indirect use from electricity, district heating / cooling systems and embodied energy in construction materials. Several industrialised countries have adopted a vision of so-called 'net zero energy buildings' as long-term goal of their energy policies. However, what is missing is a clear definition and international agreement on the measures of building performance that could inform 'zero energy' building policies, programmes and industry adoption around the world.

The objective of the project is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. A primary means of achieving this objective is to document and propose practical net zero energy building (NZEB) demonstration projects, with convincing architectural quality. These exemplars and the supporting sourcebook, guidelines and tools are viewed as keys to industry adoption.

The project aims to equalize their small annual energy needs, cost-effectively, through building integrated heating / cooling systems, power generation and interactions with utilities. It is building upon recent industry experiences with net-zero and low energy solar buildings and the most recent developments in whole building integrated design and operation. The joint international research and demonstration activity will address concerns of comparability of performance calculations between building types and communities for different climates in participating countries. The goal is solution sets that are attractive for broad industry adoption.

The scope includes major building types (residential and non-residential), new and existing, for the climatic zones represented by the participating countries. The work will be linked to national activities and will focus on individual buildings, clusters of buildings and neighbourhoods. The work will be based on analysis of existing examples that leads to the development of innovative solutions to be incorporated into national demonstration buildings.

Research objectives

- To establish an internationally agreed understanding on NZEBs based on a common methodology.
- To identify and refine design approaches and tools to support industry adoption.
- To 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
- To support knowledge transfer and market adoption of NZEBs on a national and international level.

Progress

- Planning for a post graduate summer workshop on net-zero energy solar buildings (theory, modelling and design).
- Negotiations underway for publication of Volume 1 of the Source Book (German-language, to be followed by an English edition).
- Drafting of Volume 2 of the Source book in progress.
- Continuing to strengthen links to industry by participating in the Buildings and Appliances Task Force of the Asia-Pacific Partnership "Net-Zero Energy Homes" project.
- Project website launched and publicity brochure published.

Meetings

- The 3rd Experts Group Meeting was held in Ile de la Reunion, France in May, 2010.
- The 4th Experts Group Meeting was held in Graz, Austria in September, 2010.

Operating Agent: Josef Ayoub, CanmetENERGY, Natural Resources Canada

Participating Countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Republic of Korea, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, USA

Further information:

www.ecbcs.org/annexes/annex52.htm



Total Energy Use in Buildings: Analysis & Evaluation Methods

Annex 53

Project duration: 2008 - 2012

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 the designed and the real total energy use in buildings. The reasons for these discrepancies are generally poorly understood, and 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, and
- the indoor environmental quality provided.

Current research focuses mainly 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 as great as or greater than the former three ones. Detailed comparative analysis on building energy data, concerning the six factors mentioned above, would provide essential guidance in identifying energy saving potentials and opportunities.

The project is working to improve understanding of how the six factors combine to influence building energy use, with particular emphasis placed on occupant behaviour. It also aims to improve the treatment of these factors within the building energy field, and to more closely relate this to the real world. Hence, the intention is to have 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.

Deliverables

- Scientific ways (statistical and analytical models) to handle occupant behaviour for estimation of total energy use.
- Demonstration of case studies used as fundamental data sources as well as benchmarks for further studies of total energy use.
- Demonstrations of total energy use measurement and data collection technologies.

Progress

- Definition and reporting - A comprehensive set of definitions has been agreed and drafts of the three level databases produced.



- Case Studies and Data Collection - The cases to be examined under a variety of occupant behaviour patterns have been selected. The state-of-the-art for new technologies for measurement and on-line data collection is being reviewed and analyzed. Collection of typical case studies of different kinds of buildings in different countries has been completed.
- Statistical Analysis - Review and analysis of available databases is finished. The databases for total energy use in large building samples at global, national, regional level have been selected, as well as energy use in individual buildings. Development of statistical analyses for total energy use in large building samples and individual buildings are ongoing.
- Energy Performance Evaluation - Review and development of analytical models are being conducted with some models already showing good agreement with measured data and so can be used for evaluating the influencing factors. By simulation it has already been found that changes in lifestyle are then seen to have a large energy saving potential, while the energy saving effect of envelope insulation is less distinct.

Meetings

- The 1st Experts Meeting was held in Vienna, Austria in April 2010
- The 2nd Experts Meeting was held in Rhodes, Greece in September 2010

Operating Agent: Hiroshi Yoshino, Tohoku University, Japan

Participating Countries: Austria, Belgium, China, Denmark, Finland, France, Italy, Japan, Netherlands, Norway, Portugal, Spain, USA

Further information:
www.ecbcs.org/annexes/annex53.htm

Integration of Microgeneration and Other Energy Technologies in Buildings

Annex 54

Project duration: 2009 - 2013

Given the rapidly increasing numbers of micro-cogeneration installations around the world there is the pressing need for further research to enable informed choices to be made on where and when the installation of micro-cogeneration is appropriate.

The previous ECBCS project, 'Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems' proved to be highly successful in terms of its research achievements. This project continues that work, although the focus of the current work is shifted from model development and experimentation towards a more expansive analysis of micro-cogeneration and associated technologies.

The scope of activities is encompassing:

- multi-source micro-cogeneration systems, polygeneration systems (i.e. integrated heating / cooling / power generation systems) and renewable hybrid systems (collectively termed micro-generation);
- the integration of micro-generation, energy storage and demand side management technologies at a local level (integrated systems);
- customised and optimum control strategies for integrated systems;
- the analysis of integrated systems performance when serving single and multiple residences along with small commercial premises; and
- analysis of the wider effects of micro-generation on the power distribution system.

Research areas

- Simulation studies of integrated micro-generation systems operating in many different situations are being undertaken to create an extensive portfolio of performance studies; these studies will include 'optimised' systems demonstrating the potential of the technologies.
- Technical development work is being undertaken to support the simulation studies: this includes updating of the earlier project model portfolio; where appropriate, the development of new models (including battery storage and demand side management) is being undertaken using data from field trials and laboratory tests on up-to-date devices and systems.
- Dissemination strategies for the mass deployment of micro-generation-related technologies are being investigated; this activity is being informed by a regulatory and market review along with data emerging from the technical analysis.

Expected Outcomes

- An update of occupant related domestic hot water and electric load profiles.
- Component models and their implementation in building simulation tools.
- Review of best practice in the operation and control of integrated micro-generation systems.
- Control algorithms to maximize the performance and value of micro-generation.
- Experimental data sets for the calibration and validation of device models.
- Performance assessment methodologies.
- Country-specific studies on the performance of a range of micro-generation systems.
- Studies of the viability of micro-generation systems in different operational context and of the impacts of micro-generation on the wider community and the potential benefits, in particular for the electricity network.
- An investigation of interactions between technical performance and commercialization / regulatory approaches for micro-generation.
- Compilation of case studies of the introduction of micro-generation technologies.

Progress

- A literature review is underway to populate the Buildings Thermal and Electric Load Profiles database.
- Existing models for generating building load profiles are being examined.
- Collection and population of a database with country specific performance studies using the developed methodology is ongoing.
- Country specific national and international standards and regulations in the field of microgeneration are being collated and analyzed.

Meetings

- The 1st Experts Meeting was held in Munich, Germany in February 2010
- The 2nd Experts Meeting was held Maryland, USA in November, 2010, along with a workshop.

Operating Agent: Evgueniy Entchev

Participating Countries: Belgium, Canada, P.R.China, Denmark, Finland, Germany, Italy, Japan, Netherlands, UK, USA

Further information:
www.ecbcs.org/annexes/annex54.htm

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

Annex 55

Project duration: 2010 - 2014

Nowadays energy 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 so on) and advanced building services, the building sector still accounts for the largest share of energy-related carbon dioxide (CO₂) emissions (including emissions associated with electricity use in buildings). While in many industrialised countries, new buildings are constructed every year corresponding to approximately 1% of the existing building stock, often 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 a large reduction of greenhouse gas emissions - is presently available in the existing building stock.

Retrofit measures are therefore of utmost importance for upgrading the building stock. Many consumers are only interested in the first cost and it is rare that life-cycle thinking is required. Looking at actual risks that are taken, both in performance and in cost, highlights the need for life cycle thinking and supports the demand for applicable methods in this area. Probability assessment in life-cycle costing of solutions supports sound decision making relating to investments. Customer relationships are based on future expectations and confidence: This will be supported by proper probability assessments.

The project is contributing towards the dissemination of improved 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 end users the benefits of the renewal of the existing building stock and how to make reliable solutions. Probability assessment supports the development of robust solutions without surprises. The mission is to answer the following question:

How do we design and realize robust retrofitting with low energy demand and life cycle costs, while controlling risk levels for performance failure?

The scope of the project is to develop and provide decision support data and tools for energy retrofitting measures. The tools are being based on probabilistic methodologies for prediction of energy use, life cycle cost and functional performance. The objectives are to:

- Develop and validate probabilistic methods and tools for energy use, life cycle cost and hygrothermal performance
- Apply and demonstrate probabilistic methodologies on real life case studies

- Create guidelines for practitioners including assessment of common retrofitting techniques

Deliverables

- Report and electronic database for stochastic input and validation data
- 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.
- Guidelines for Practitioners.

Progress

- Six different retrofitting approaches from six different countries have been selected for the Case studies.
- Common exercises on stochastic data collection are running on material properties and climate data.
- A common exercise on the development of both qualitative and quantitative probabilistic methods applied to the Danish case study is ongoing.
- A survey is taking place to list frequently used retrofitting building technologies and associated benefits and risks in the different countries.
- Invited lecturers from other disciplines have presented to the project team to share and adapt new methodologies.
- The project website is operational.
- The first project newsletter has been published.

Meetings

In 2010 two Experts' Meetings took place:

- Holzkirchen, Germany in April 2010
- Copenhagen, Denmark in October 2010



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

Participating Countries (provisional): Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA

Observers: Brazil, Slovakia, Estonia

Further information:
www.ecbcs.org/annexes/annex55.htm

ECBCS & the IEA

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster co-operation 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 co-operation 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/textbase/techno/framework_text.pdf



This framework provides uncomplicated, common rules for participation in research programmes, known as 'Implementing Agreements', and simplifies international co-operation 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

In recognition of the significance of energy use in buildings, in 1977 the International Energy Agency established an Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS). The function of ECBCS 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 ECBCS 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.

About ECBCS

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 carbon dioxide production. 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, the International Energy Agency has established an Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS). The function of ECBCS 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 ECBCS 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 Energy Conservation in Buildings and Community Systems (ECBCS) 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 International Energy Agency (IEA).

The principal objective of the ECBCS 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 ECBCS programme are:

ECBCS & the IEA

- To support the development of generic energy conservation technologies within international collaboration;
- To support technology transfer to industry and to other end-users by the dissemination of information through demonstration projects and case studies;
- To contribute to the development of design methods, test methods, measuring techniques, and evaluation/assessment methods encouraging their use for standardisation;
- To ensure acceptable indoor air quality through energy efficient ventilation techniques and strategies;
- To 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 Green House Gas emissions;
- “Whole Building” performance approach;
- Sustainability;
- The impact of energy measures on indoor health, comfort and usability;
- The exploitation of innovation and information technology’
- Integrating changes in lifestyles, work and business environment.

Mission Statement

The mission of the IEA Energy Conservation in Buildings and Community Systems Programme is as follows:

“To facilitate and accelerate the introduction of energy- conservation and environmentally sustainable technologies into healthy buildings and community systems, through innovation and research in decision-making, building assemblies and systems, and commercialisation”

Nature of ECBCS Activities

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

b. Formal co-ordination through cost shared activities:
ECBCS currently supports one cost shared project, Annex 5, the Air Infiltration and Ventilation Centre (AIVC). In recent times, Annex 5 has sub-contracted 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 co-ordination or initiation of activities by participants: Many organizations and groups take part in the activities of ECBCS including government bodies, universities, non-profit making research institutes and industry.

d. Information exchange: Information about associated activities is exchanged through the ECBCS and through individual Annexes. The ECBCS website (www.ecbcs.org), for example, provides links to associated research organizations. Participants in each Annex 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 ECBCS Newsletter, which, for example, carries regular reports of energy policy development and research activities taking place in various countries.

ECBCS Participating Countries

- Australia
- Austria
- Belgium
- Canada
- P.R. China
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Italy
- Japan
- Republic of Korea
- New Zealand
- The Netherlands
- Norway
- Poland
- Portugal
- Spain
- Sweden
- Switzerland
- Turkey
- United Kingdom
- United States of America

ECBCS & the IEA

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 building 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. The duty of the chairs of the Executive Committees is to keep the others informed about their activities, seeking areas of common interest.

Collaboration with IEA Building-Related Implementing Agreements

The ECBCS Programme continues to co-ordinate its research activities, including Annexes and strategic planning, with all BRIA's (Building-Related Implementing Agreements) through collaborative Annexes 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 Conservation in Buildings and Community Systems (ECBCS)
- Energy Conservation through Energy Storage (ECES)
- Heat Pumping Technologies (HPT)
- Photovoltaic Power Systems (PVPS)
- Solar Heating and Cooling (SHC)

Beyond the BCG meetings, ECBCS meets with representatives of all building-related IA's at Future Buildings Forum (FBF) Think Tanks and Workshops. It is planned that the outcome from the Future Buildings Forum Think Tank will be used strategically by the various IEA buildings related Implementing Agreements to help in the development of their work programmes over the next five years.

Proposals for new research projects are discussed in co-ordination with these other programmes to pool expertise and to avoid duplication of research. Co-ordination with SHC is particularly strong and joint meetings are held between the programmes every two years. Both ECBCS and the Solar Heating and Cooling (SHC) programmes focus primarily on buildings and communities.

Collaboration with the IEA Solar Heating and Cooling Programme

While there are several IEA programs that are related to the building sector, the ECBCS and the Solar Heating

and Cooling (SHC) programmes focus primarily on buildings and communities. Synergy between these two pro-



grammes occurs 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 greenhouse gas emissions. The areas of responsibility of the two programs were reviewed and agreed. ECBCS 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 every two years. At these meetings matters of common interest are discussed, including planned new tasks, program 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 program, 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:

- ECBCS programme - to facilitate and accelerate the introduction of energy- conservation and environmentally sustainable technologies into healthy buildings and community systems, through innovation and research in decision-making, building assemblies and systems, and commercialization
- SHC programme - to facilitate an environmentally sustainable future through the greater use of solar designs and technologies.

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;

ECBCS & the IEA

- Enhancing building standards;
- Interaction with developing countries.
- The other objectives are different. The ECBCS 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 building sector and are committed to continue their coordinated approach to reducing the use of purchased energy in building sector markets.

Non-IEA Activities

A further way in which ideas are progressed and duplication is avoided is through co-operation with other building related activities. Links are maintained with other international bodies including:

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

The collage features several factsheets with the following titles and descriptions:

- Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings (Annex 46):** Research has previously shown that many existing government buildings are characterized by high energy use. In fact, older, energy inefficient buildings represent about 80% of the building stock, but about 50% of the energy use. So the part of the stock should be improved. Since government buildings use renovated regularly in many countries, experience gained with retrofitting such buildings with energy saving technologies should be widely applicable on an international scale.
- Future Electric for Buildings (Annex 45):** The fact that energy saving measures are seldom applied when government buildings are established reveals that in many cases, decision makers simply lack knowledge of the many energy saving measures available to them, and of the efficiencies and return on investment that such measures can yield. The current decision making process needs to be improved to confront the challenges of increasing energy costs and climate change, and to avoid locking in long-term commitment to energy inefficiency by adopting sub-optimal retrofits.
- Energy Systems for High Buildings & Communities (Annex 49):** The project "Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings" intends to improve the decision making process for energy retrofitting of government non-residential buildings, e.g. office / administrative buildings, courtyards / barracks, service buildings and production and maintenance facilities. Through the focus on government buildings, many results can be applied to similar private sector buildings. Collectively these building types represent a substantial part of the non-residential building stock.
- Let Zero Energy Solar Buildings (Annex 52 / Task 40):** The main objective of the ECBCS information center "Air Infiltration and Ventilation Centre" (AIVC) is to be the international centre on research and development in the fields of air infiltration and ventilation, and thus 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.
- Air Infiltration and Ventilation Centre (Annex 5):** The primary objective of the ECBCS information center "Air Infiltration and Ventilation Centre" (AIVC) is to be the international centre on research and development in the fields of air infiltration and ventilation, and thus 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 collage features several factsheets with the following titles and descriptions:

- Rating Environmentally Elements in Buildings (Annex 44):** The primary objective of the ECBCS information center "Air Infiltration and Ventilation Centre" (AIVC) is to be the international centre on research and development in the fields of air infiltration and ventilation, and thus 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.
- Efficient Communities (Annex 51):** The primary objective of the ECBCS information center "Air Infiltration and Ventilation Centre" (AIVC) is to be the international centre on research and development in the fields of air infiltration and ventilation, and thus 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.
- Reversible Air Conditioning (Annex 48):** The primary objective of the ECBCS information center "Air Infiltration and Ventilation Centre" (AIVC) is to be the international centre on research and development in the fields of air infiltration and ventilation, and thus 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.

- CIB: This organization, sponsored by individual groups, has its main area of interaction in sponsored workshops, conferences and publications. ECBCS has a formal memorandum of understanding with CIB to assist in the dissemination of results and avoidance of duplication of effort. The Secretariat of CIB periodically attends ECBCS ExCo meetings.
- EC: A certain level of co-operation exists between the European Commission and ECBCS. The EC Framework Program sponsors research, primarily within the European Union. IA's provide opportunity for a wider range of country participation and hence a broader knowledge base. There is, however, much cross-pollination of ideas between the IEA and EU.
- International Standards Organization: This group sets standards that can be adopted by individual countries or communities. ISO interacts with ECBCS and its information for developing standards is drawn from many sources including output from IEA activities.

Publications

Air Infiltration and Ventilation Centre

➤ Technical Notes

TN 65 Recommendations on Specific Fan Power and Fan System Efficiency 2009

TN 64 Ventilation in Korea 2008

TN 63 Ventilation in the Czech Republic 2008

➤ Contributed Reports

CR 12 Indoor air quality in French dwellings 2009

CR 11 Air Leakage of U.S. Homes: Model Prediction 2008

CR 10 Ventilation Behavior and Household Characteristics in New California Houses 2008

➤ Newsletters

AIR newsletter (published every 3 months)

➤ Annual AIVC Conference Proceedings

2009 Germany – Berlin, Trends in High Performance Buildings and the role of Ventilation

2008 Japan – Kyoto, Advanced building ventilation and environmental technology for addressing climate change issues

➤ Ventilation Information Papers

VIP 31 Humidity Controlled Exhaust Ventilation in Moderate Climate 2009

VIP 30 An overview of national trends related to innovative ventilation systems 2008

VIP 29 An overview of national trends in envelope and ductwork airtightness 2008

VIP 28 IAQ and ventilation efficiency with respect to pollutants inside automobiles 2008

VIP 27 Trends in the Czech building ventilation market and drivers for changes 2008

VIP 26 Trends in the Korean building ventilation market and drivers for changes 2008

VIP 25 Trends in the Japanese building ventilation market and drivers for changes 2008

VIP 24 Trends in the Polish building ventilation market and drivers for changes 2008

VIP 23 Trends in the Brazilian building ventilation market and drivers for changes 2008

VIP 22 Trends in the US building ventilation market and drivers for changes 2008

VIP 21 Trends in the Norwegian building ventilation market and drivers for changes 2008

VIP 20 Trends and drivers in the Finnish ventilation and AC market 2008

VIP 19 Trends in the French building ventilation market and drivers for changes 2008

VIP 18 Trends in the Belgian building ventilation market and drivers for changes 2008

VIP 17 Trends in the building ventilation market in England and drivers for change 2008

VIP 16 Air quality in passenger aircraft 2008

VIP 15 Report of the 2nd European BlowerDoor Symposium 2008

Computer-Aided Evaluation of HVAC System Performance

➤ Technical Synthesis Report: Computer-Aided Evaluation of HVAC System Performance

➤ Demonstrating Automated Fault Detection and Diagnosis Methods in Real Buildings

Design of Energy Efficient Hybrid Ventilation (HYBVENT)

➤ Technical Synthesis Report: Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings (HybVent)

➤ Hybrid Ventilation: State of the Art Report

➤ Principles of Hybrid Ventilation

Retrofitting of Educational Buildings

➤ Technical Synthesis Report: Retrofitting in Educational Buildings - Energy Concept Adviser for Technical Retrofit Measures

➤ Case Study Reports

➤ Energy Concept Adviser

➤ KULU – a tool for commissioning

➤ State of the Art Overview: Questionnaire Evaluations

➤ Overview of Retrofitting Measures

➤ Calculation Tools for the Energy Concept Adviser

➤ Energy Audit Procedures

Low Exergy Systems for Heating and Cooling of Buildings (LowEx)

➤ Technical Synthesis Report: Low Exergy Systems for Heating and Cooling of Buildings

➤ Heating and Cooling with Focus on Increased Energy Efficiency and Improved Comfort – Guidebook to IEA ECBCS Annex 37 Low Exergy Systems for Heating and Cooling of Buildings

➤ Guidebook Summary Report

➤ Introduction to the Concept of Exergy - for a Better Understanding of Low-Temperature-Heating and High-Temperature-Cooling Systems

➤ Analysis Tool for the Exergy Chain (Excel Tool)

Solar Sustainable Housing

➤ Sustainable Solar Housing (2 volumes)

➤ Bioclimatic Housing: Innovative Designs for Warm Climates

➤ The Environmental Brief: Pathways for Green Design

➤ Business Opportunities in Sustainable Housing:

Publications

- A Marketing Guide Based on Houses in Ten Countries
- Exemplary Sustainable Solar Houses - a set of 40 Brochures

High Performance Insulation Systems

- Vacuum Insulation Panels: Study on VIP Components and Panels for Service Life Prediction of VIP in Building Applications
- Vacuum Insulation in the Building Sector: Systems and Applications
- Vacuum Insulation: Panel Properties and Building Applications - Summary
- High Performance Thermal Insulation Systems - Vacuum Insulated Products (VIP): Proceedings of the International Conference and Workshop
- Building Commissioning to Improve Energy Performance

Commissioning Tools for Improved Energy Performance

- Final Report
- Toolkit CD

Whole Building Heat, Air and Moisture Response (MOIST-ENG)

- Final Report Volume 1: Modelling Principles and Common Exercises
- Final Report Volume 2: Experimental Analysis of Moisture Buffering
- Final Report Volume 3: Boundary Conditions and Whole Building HAM Analysis
- Final Report Volume 4: Applications: Indoor Environment, Energy, Durability

The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (COGEN-SIM)

- Review of Residential Cogeneration Technologies
- Methodologies for the Performance Assessment of Residential Cogeneration Systems
- Review of Existing Residential Cogeneration Systems
- Performance Assessments and Evaluations
- Residential Cogeneration Systems: A Review of the Current Technologies



- European and Canadian non-HVAC Electric and DHW Load Profiles for Use in Simulating the Performance of Residential Cogeneration Systems
- Specifications for Modelling Fuel Cell and Combustion-Based Residential Cogeneration Devices within Whole-Building Simulation Programs

Testing and Validation of Building Energy Simulation Tools

- In-Depth Diagnostic Cases for Ground Coupled Heat Transfer Related to Slab-on-Grade Construction
- Final Task Management Report - Testing and Validation of Building Energy Simulation Tools
- Empirical Validations of Shading / Daylighting / Load Interactions in Building Energy Simulation Tools
- Double Skin Facades: A Literature Review
- Empirical Validation of Building Simulation Software: Modelling of Double Facades

Integrating Environmentally Responsive Elements in Buildings

- Responsive Building Elements, Integrated Building Concepts and Environmental Performance Assessment Methods: State of the Art Review

Low Exergy Systems for High Performance Buildings and Communities

- Midterm Report

These publications are available for free download at the ECBCS website:

www.ecbcs.org

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Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings

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Towards Net Zero Energy Solar Buildings (NZEBS)

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Total Energy Use in Buildings: Analysis & Evaluation Methods

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Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost

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Past Projects

- Load Energy Determination of Buildings
- Ekistics and Advanced Community Energy Systems
- Energy Conservation in Residential Buildings
- Glasgow Commercial Building Monitoring
- Energy Systems and Design of Communities
- Local Government Energy Planning
- Inhabitants Behaviour with Regard to Ventilation
- Minimum Ventilation Rates
- Building HVAC System Simulation
- Energy Auditing
- Windows and Fenestration
- Energy Management in Hospitals
- Condensation and Energy
- Energy Efficiency in Schools
- BEMS 1- User Interfaces and System Integration
- BEMS 2- Evaluation and Emulation Techniques
- Demand Controlled Ventilation Systems
- Low Slope Roof Systems
- Air Flow Patterns within Buildings
- Thermal Modelling
- Energy Efficient Communities
- Multi Zone Air Flow Modelling (COMIS)
- Heat, Air and Moisture Transfer in Envelopes
- Real time HEVAC Simulation
- Energy Efficient Ventilation of Large Enclosures
- Evaluation and Demonstration of Domestic Ventilation Systems
- Low Energy Cooling Systems
- Daylight in Buildings
- Bringing Simulation to Application
- Energy-Related Environmental Impact of Buildings
- Integral Building Envelope Performance Assessment
- Advanced Local Energy Planning
- Computer-Aided Evaluation of HVAC System Performance
- Design of Energy Efficient Hybrid Ventilation
- Retrofitting of Educational Buildings
- Low Exergy Systems for Heating and Cooling of Buildings
- Solar Sustainable Housing
- High Performance Insulation Systems
- Building Commissioning to Improve Energy Performance
- Whole Building Heat, Air and Moisture Response
- The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems
- Testing and Validation of Building Energy Simulation Tools

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Published by AECOM Ltd, AECOM House, 63-77 Victoria Street, St Albans, Hertfordshire, AL1 3ER, United Kingdom

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