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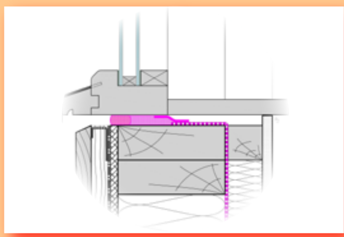

Analysis & Evaluation Methods for Buildings

Micro-Generation & Related Energy Technologies

New ECBCS Publications

- Responsive Building Elements
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France Commits to Reducing Energy Consumption & Carbon Dioxide Emissions

Towards Positive Energy Buildings

Pierre Herant, ECBCS Executive Committee Member for France

The Government of France has committed to limit national emissions of greenhouse gases to a quarter of the current level by 2050. This has been done through two laws, approved in 2009 and 2010. The buildings sector is strongly involved because energy-related carbon dioxide (CO_2) emissions from buildings account for nearly 25% of total national emissions (about 33 million tonnes). This corresponds to 43% of total energy use (70 million tonnes of oil equivalent). Improving energy efficiency in buildings to mitigate climate change has therefore become one of the main challenges in France.

Renovation of existing buildings & advanced design for new construction

France has 31 million residential buildings covering a floor area of more than two billion square metres. 20 million dwellings were built before the introduction of the first thermal regulations in 1975. These highly energy intensive dwellings represent more than 75% of the energy use of the residential sector. Commercial buildings account for more than 900 million square metres. Thermal renovation of all buildings has therefore become a national priority.

" France has commited to limit national emissions of greenhouse gases to a quarter of the current level by 2050"

Following a major consultation on energy and the environment, held in 2007 under the name 'Grenelle Environment', a goal has been set to reduce primary energy consumption in existing buildings by 38% by 2020 and to renovate 400,000 dwellings per year from 2013.

It has further been decided to reinforce the thermal regulations for all new buildings. In metropolitan France these must be 'low energy buildings' from 2012, consuming less than 50 kWh/m^2 annually for space heating, domestic hot water, lighting, ventilation and cooling. After 2020, all new buildings are planned to be 'positive energy buildings', i.e. consuming less energy than they produce. These new thermal regulations are recognised as being very demanding, both technically and financially.

The Grenelle Environment building plan

To prepare for and accompany this significant change, several research, development and demonstration (RD&D) programmes have been set up by public

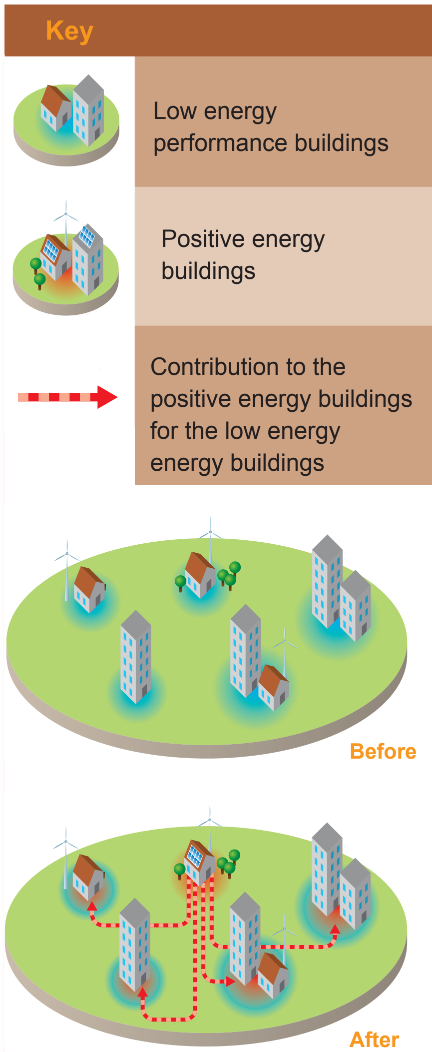

Figure 1. Changes in the buildings sector.

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Table 1. Technology options according to the spatial scale of the positive energy concept.

Spatial scale	Use and function to be satisfied	Characteristics of technological options to be mobilised
Single building	Envelope and energy management technologies	Multifunctional envelope ensuring insulation, renewable energy production (solar, photovoltaic or thermal), ventilation, energy storage, etc, and its properties (openings, solar protection, air intake, etc.) can be piloted and coordinated with an individual «smart» system to manage accumulated heat in the building
	Energy production equipment	Principally renewable energy installations (wood, solar thermal and photovoltaics, heat pump, etc.) integrated into the building.
	Storage technologies	In fully or partially autonomous buildings, individual storage capacity (stationary or mobile) adapted to occupants' needs and uses.
Clusters	Envelope and energy management technologies	Envelope improvements are still a priority, but are coordinated with an energy optimisation strategy on the scale of a group of buildings or a neighbourhood. This justifies installing devices to pool and collectively manage energy across all the buildings.
	Energy production equipment	Pooling of energy production, e.g. heat networks or low-temperature geothermal installations, and network management, in particular of power grids, to control energy demand and integrate decentralised energy production, are a top priority.
	Storage technologies	Energy is not stored on a building scale, but on the scale of several buildings. Technological options are expected to provide large-capacity storage of heat and electricity.

authorities and by the private sector. Numerous initiatives such as regulatory instruments and financial incentives have also been implemented. Training in all aspects of construction has been adapted to new technical requirements and new professions have emerged.

In 2009, the Ministry of Environment set up the 'Building Committee for the Grenelle Environment' to initiate and co-ordinate these plans and to develop them. A major part of these initiatives are being enacted, co-ordinated and implemented by the ADEME, the French public agency in charge of the governmental policy for the environment and energy management.

Stimulating innovation, research, development & demonstration

While existing technologies already enable energy performance to be considerably improved, more innovation and research are essential to contribute to reducing emissions of CO_2 in France to a quarter of their current level by 2050. Measures to stimulate, maintain and co-ordinate public and private research have been recently developed and national programmes are helping the development of breakthrough technologies. They also aim to strongly increase the use of renewable energy in buildings. Several such programmes are introduced below.

PREBAT - preparing the future of construction

The national Programme for Research and Experimentation on Energy Use in Buildings (PREBAT) was launched in France in 2004. This research, development and demonstration programme aimed to help make examples of 'positive energy buildings' widespread by 2020. With more than €62 million of public funds mobilised between 2005 and 2009 on hundreds of research projects, the first phase of PREBAT has strongly contributed to defining and implementing the new French thermal regulations applicable from 2012.

Cover picture: Jean-Louis Marqueze school

The Jean-Louis Marqueze School demonstration project was the first zero energy school built in France. 22 kWh/m² primary energy consumption per year is offset by renewable energy production from photovoltaic power generation, solar hot water and geothermal heat pump systems. This type of building anticipates the mandatory standards in France expected for 2020 onwards.

Location: Limeil-Brévannes, France, Val-de-Marne
Area: 3,000 m²
Cost: €8.5 million
Completion: 2007

Building clusters

Building complexes or clusters are groups of buildings, continuous or not, with varied uses or not (residential, institutional, commercial), that constitute a functional unit or neighbourhood district in terms of energy use, for pooling needs and energy production.

Positive energy buildings and building clusters

On an annual basis, positive energy buildings generate more energy on site than they use. Similarly, positive energy building clusters collectively generate more energy than they use and generated energy is shared between buildings in the cluster as needed. In both case, energy surplus to local needs can be exported.

More than 1,100 demonstration buildings with low energy consumption have been realised as part of the first phase of PREBAT. The second phase, started in 2010, has targeted even higher performance objectives with 1,000 additional demonstration buildings to be selected overall.

The way in which the public research stakeholders operate and are organised has also been redefined to increase the programme's effectiveness.

PACTE

For example, the PACTE formula (Programme of Concerted Action in Energy Technologies) set up in 2008 is particularly innovative. PACTE aims to create multidisciplinary skills clusters, with a view to making finalised, operational technical solutions for low energy consumption buildings available to the market in the short term, i.e. within three to four years. PACTE includes on-going research activities on topics including:

- innovative lighting technologies using light emitting diodes (LEDs),
- new concepts for domestic hot water equipment,
- innovative insulation technologies (using silica gels at atmospheric pressure),
- optimised efficient ventilation for heating, and
- indoor air quality and internal comfort.

Support for demonstration projects & technology platforms

As part of large scale national funding to revive French industry, nearly €1.35 billion is being invested in renewable, carbon-free energy demonstration projects, enabling development of 'breakthrough' technologies. Various calls for project proposals related to the renewable energy sector have already been launched. These demonstration projects allow companies to take a technological and financial risk between the research and commercial manufacture phases for new technologies. In particular, they can generate valuable feedback on operation and performance to guide further development before full commercialisation takes place.

" Nearly €1.35 billion is being invested in renewable, carbon-free energy demonstration projects"

In this context, a strategic road map for 'positive energy buildings' and 'building clusters' in France has been agreed by buildings experts. This has helped to refine the scope of a current call for project proposals dedicated to both existing and new buildings. The projects selected between 2011 to 2013 will enable experiments at a building clusters scale, based on low energy requirements for all energy uses and sharing of renewable energy produced on site.

Competitiveness clusters

'Competitiveness clusters' are pillars of French national policy for innovation and R&D. They bring together companies, research laboratories and higher

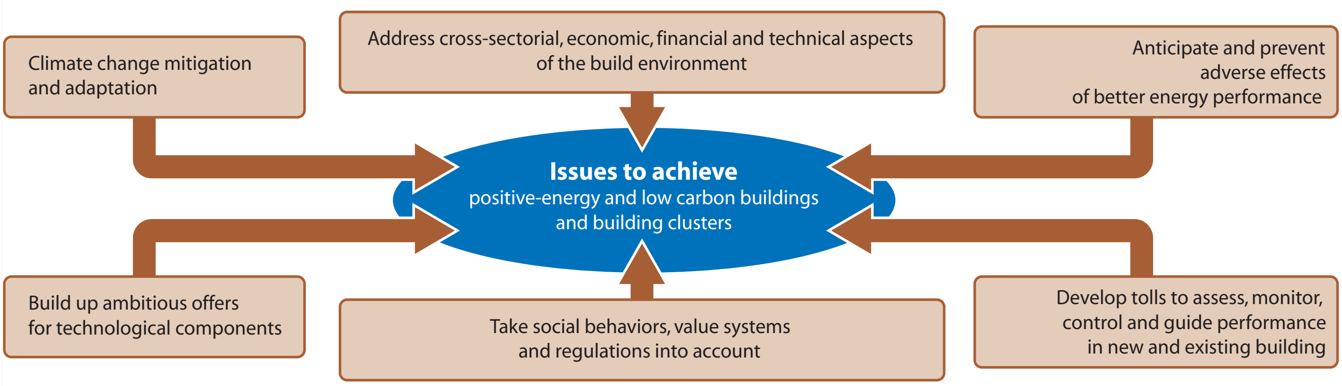


Figure 2. Issues to achieve in positive energy and low carbon buildings and building clusters.

education establishments on the same site. This concentration of knowledge helps to unite the innovation capacity of the private and public sectors in projects with high market potential. The national Government has allocated €1.5 billion to fund these clusters for the period between 2009 to 2011, and these also benefit from the support of local authorities and a special tax regime. Several of the 70 competitiveness clusters are working on energy efficiency in buildings, among them:

- Tenerdis (Rhone-Alpes region), Derbi (Languedoc - Roussillon region),
- Alsace Energivie (Alsace region), and
- Capenergies (Provence-Alpes Cote d'Azur region, Corsica, Guadeloupe, Reunion, Principality of Monaco).

Critical issues

The strategic road map for France on positive energy buildings and building clusters has identified six critical issues that need to be considered in addition to technological aspects (shown in Figure 2):

- address the objectives of climate change mitigation and adaptation policies. Mitigation policies include all actions to reduce sources of greenhouse gases and / or augment sinks to reduce them. Adaptation policies aim to organise individual corporate, institutional and government responses to current climate change and to anticipate future effects.

- build up ambitious commercial offers for component installation and maintenance in new building construction and for energy rehabilitation of existing buildings. address cross-sectoral societal, economic, financial and technical aspects of the built environment.

- take social behaviour, value systems and regulations into account.

- anticipate and prevent adverse effects of improved energy performance in buildings and building clusters.

- develop tools to assess, monitor, control, and guide performance in new and existing buildings, so as to identify and react to trends.

Further information

French Know-How in the Field of Energy Efficiency in Buildings, ADEME, 2010
www.ademe.fr

Roadmap for positive energy and low carbon buildings and building clusters

The 'Roadmap for Positive Energy and Low Carbon Buildings and Building Clusters' covers:

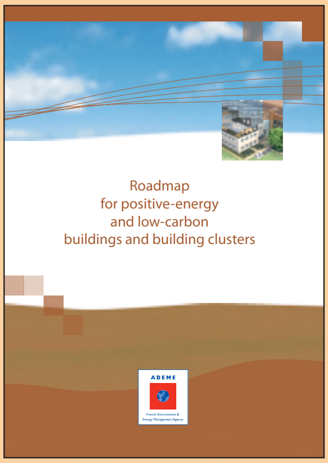
- Improved energy performance for buildings, in terms of their use, equipment, envelope and construction techniques, both individually and on the scale of groups of buildings. Pooling energy needs and collective management of energy producing and consuming equipment for a group of buildings are ways to optimise energy use. Buildings and complexes can also be a vector for energy storage, to recover waste energy, recharge electric and hybrid vehicles, and optimise energy systems on a building or multi-building scale.

- Reduced carbon content (the amount of CO_2 emitted over the entire life span of the building) and more broadly lower energy, environmental and health impacts for building components, design and construction. The objective is to achieve the smallest carbon footprint possible, renewable or natural-origin materials, minimum energy consumption during the life of the building, including demolition, deconstruction and recycling, as the case may be.

- The robust and reproducible nature of technological and organisational options, with optimal cost and quality criteria.

- The circular economy, optimising energy and materials flows to bring industrial ecosystems closer to the cyclical functioning of natural ecosystems, applied at the building or building cluster scale to:

  – develop new design approaches integrating options to reclaim, salvage and recycle components at the end of their useful life;



  – enhance management of primary and secondary (dismantled and recycled) resources.

- Socioeconomic issues related to the emergence and large-scale deployment of positive-energy and low-carbon buildings and clusters. The roadmaps look at property management, legal, financial and social aspects as well as trends in the value systems associated with energy pooling, the acceptability of automated systems, requalification and re-attribution of building functions, among others.

Micro-Generation & Related Energy Technologies in Buildings

How Small Scale Technologies Can Contribute to Sustainable Building Energy Supplies

ECBCS Project Update

Evgueniy Entchev, CanmetENERGY Research Centre, Canada

Peter Tzscheutschler, Technical University of Munich, Germany

The market penetration of energy micro-generation technologies is increasing globally. At present photovoltaic systems are the most prominent of these with millions of installations on buildings in many countries.

What is micro-generation?

Micro-generation comprises of technologies to generate energy by small scale systems of up to around ten kilowatts, such as photovoltaic systems or micro-wind turbines. The combined production of heat and power (CHP) in a single small scale process is called micro-cogeneration (µCHP). This can be extended to micro-trigeneration if cooling is produced in addition.

Challenges of future building energy supplies

Many countries have defined ambitious targets in terms of greenhouse gas emission reductions, energy savings and energy supplies from renewable resources. In the buildings sector efforts are being made to reduce the energy demands for space heating and cooling by improving the building envelope as well as the application of advanced building services systems with higher efficiencies and using renewable energy.

The management of energy flows within buildings and the ability to store thermal or electrical energy will have a major importance in the future, when fluctuating renewable energy generation patterns are unlikely to be well matched with users' demand profiles.

Micro-generation technologies can contribute to meeting buildings sector targets. State of the art combined heat and power systems are highly efficient due to use of otherwise waste heat from electricity generation. The integration of thermal buffer storage allows temporary decoupling of electricity and heat demand. Furthermore, modern advanced control systems will enable micro-generation technologies to act as active components in future smart grids.

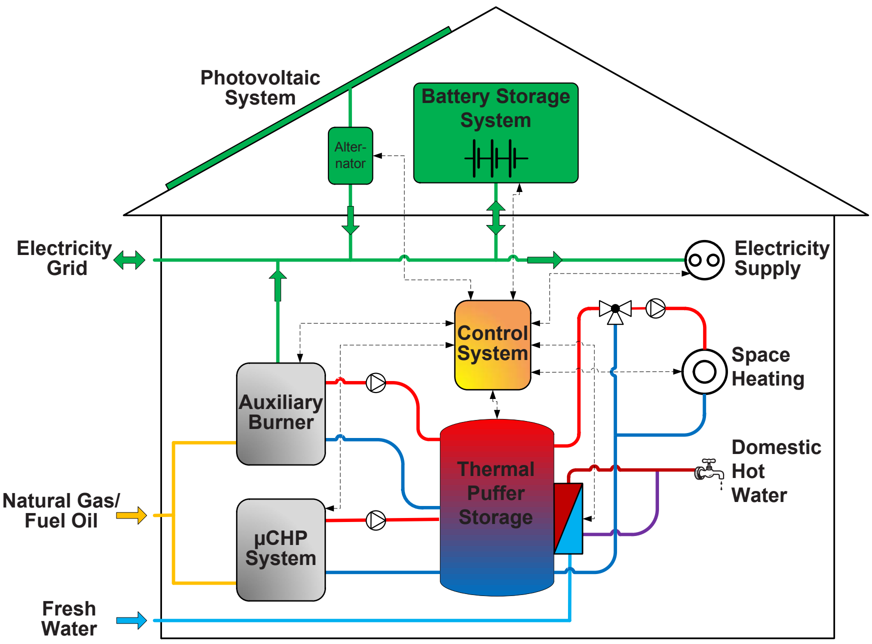


Figure 1. Schematic of micro-generation technologies in a building.

Micro-generation systems

Figure 1 shows a schematic of a building with micro-generation technologies implemented. The main components in this example are:

- micro-cogeneration unit (µCHP) to produce heat and electricity with high efficiency,
- thermal buffer storage, used for the decoupling of heat and electricity and to increase µCHP runtime,
- auxiliary burner for thermal peak load coverage,
- electricity generation system, such as photovoltaic system or micro-wind turbine,
- battery storage system to save surplus electricity and cover peak load (for example a second life battery reused from an electric vehicle),
- electrical grid connection for surplus feed in and peak load coverage,
- advanced control system for optimal operation of the components.

A thermally or electrically driven cooling system can be added to the configuration shown in Figure 1 if cooling is required.

Technical developments

District heat and power plants using conventional combustion engines (ICE) at the scale of several hundred kilowatts are widely implemented. In the range of µCHP, ICE co-generators with 1 kW to 5 kW electrical and up to about 12 kW thermal output have been on the market for about a decade (see Figure 2). Systems using Stirling engines with about 1 kW electrical output are new to the market. These small systems are also suitable for single family houses.

The advantages of fuel cells are a high electrical efficiency, no moving parts in the process and thereby low maintenance requirements. The high power to heat ratio of fuel cells correlates well with the requirements of future low energy buildings, with low heat demand but still significant electricity consumption.

Much development work on fuel cell µCHP has been carried out in Japan, where the first systems were introduced on the market. Meanwhile fuel cell µCHP systems are now also available in Europe and North America. However prices of these systems are still very high.

Currently, µCHP systems are mainly fuelled with natural gas, LPG or fuel oil. Systems running on renewable resources as vegetable oil, biogas or wood pellets have already been realised, but are not yet commercially available. Aside from the development of micro-generation components, a particular focus must be on advanced control systems.

Smart local generation

Micro-cogeneration systems are also known as 'power generating heating systems'. This indicates how they are operated today: in heating-led mode, similarly to conventional heating appliances. However, it is doubtful this will be the appropriate operation strategy for future building energy supply systems based on flexible consumers (with demand site management and demand response), local generators such as photovoltaic systems and higher shares of renewable generation in the electricity grid.

Figure 2. Test facilities for micro-cogeneration systems.

Together with building energy management, thermal and optional electrical storage capacities, micro-generation offers possibilities to align electric power generation and consumption locally, but in an interconnected smart grid environment. Therefore, self-sufficiency of single buildings is not the goal for the development of micro-generation systems.

ECBCS research

The ECBCS research project 'Annex 54: Integration of Microgeneration and other Energy Technologies in Buildings' has focused on micro-cogeneration systems with a capacity of up to around 10 kW electrical and 25 kW heat output. Building integrated photovoltaic systems, micro-wind turbines or additional provision of cooling energy (trigeneration) have been also considered. In addition, thermal and electrical storage systems have been investigated.

The project objective is to update information on the state of the art, technical efficiencies and financial aspects of these technologies. Analyses of micro-cogeneration and associated technologies are thus being performed and their impacts on building energy supply for different building types in various climatic regions are being evaluated by:

- modelling and simulating µCHP units and complete systems, including 'balance of plant' components;
- field testing and laboratory experiments;
- measurement, analysis and synthesis of demand patterns for space heating (and cooling), domestic hot water and electricity demand;
- performance assessment studies;
- evaluation of new control algorithms to optimise performance against both local energy needs and wider heat and power networks.

It is expected that energy consumption and energy supply of buildings will change substantially within the coming decades. Micro-generation technologies will play an important role to make these change more sustainable.

Further information

For further information, please see:
www.ecbcs.org/annexes/annex54.htm

Total Energy Use in Buildings – Analysis & Evaluation Methods

ECBCS Project Update

Hiroshi Yoshino, Tohoku University, Japan

One of the most significant barriers for achieving substantial improvement of building energy efficiency is a lack of knowledge about the factors determining total energy use. Well known factors of direct influence are:

- climatic conditions,
- building envelope, and
- building services performance,

but energy use also depends on: operation and maintenance, occupant behaviour and indoor environmental conditions.

The ultimate outcome of the ECBCS project 'Annex 53: Total Energy Use in Buildings - Analysis and Evaluation Methods' will be improved understanding and strengthening of the knowledge required for robust prediction of total energy use in buildings, thus enabling more accurate assessment of energy-saving measures, policies and techniques. With this objective, the project is studying how occupant behaviour influences building energy consumption, and hence how this may be applied to the building energy field. Applications of building energy analysis will then be more closely aligned with reality.

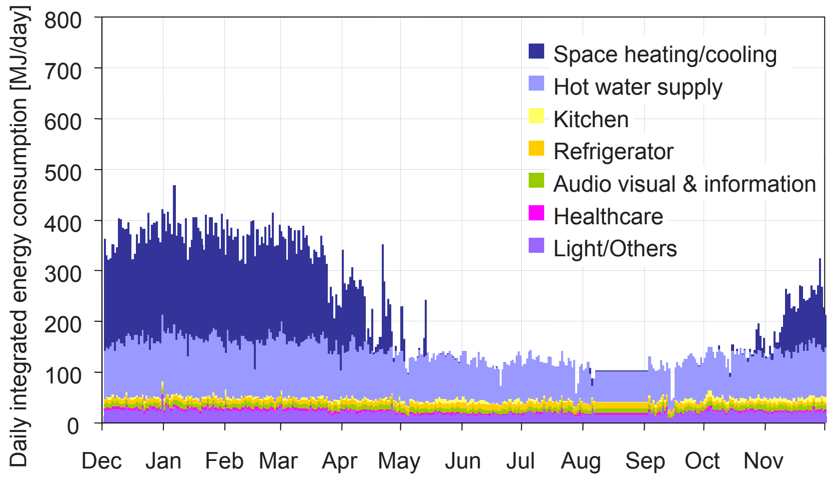


Figure 1. Example of annual energy consumption by end use.

The specific project goals are, with respect to energy use, to develop and demonstrate:

- the approach to describe occupant behaviour quantitatively,
- new methodologies to analyze total building energy use and to then investigate the factors that influence total energy use,
- methodologies and techniques for monitoring total building energy use,
- how monitored data can be used to provide indicators of building energy performance,
- methodologies to predict total energy use in buildings and to assess the impacts of energy saving policies and techniques including the influence of occupant behaviour.

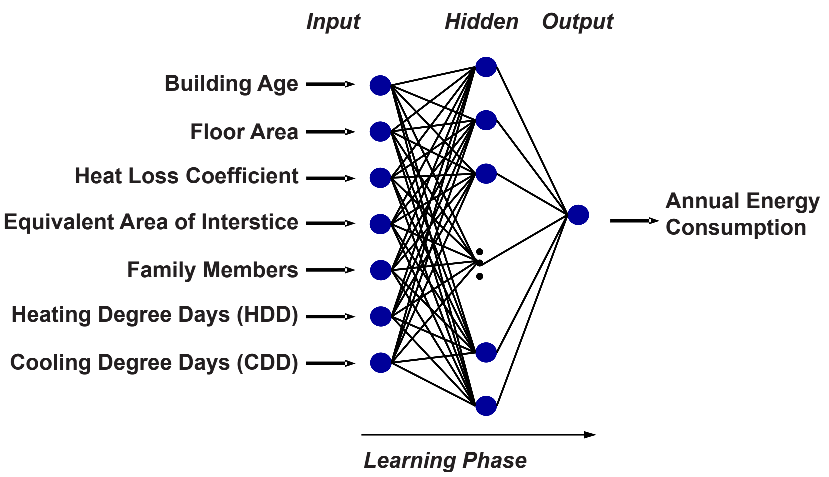


Figure 2. Neural network for prediction of annual energy.

Five distinct research topics have been established in the project:

- definitions and reporting,
- case studies and data collection,
- statistical analysis,
- energy performance evaluation, and
- occupant behaviour analysis.

Definitions & reporting

The purpose of this topic is to agree consistent definitions related to building energy use terminology, the six categories of influencing factors of energy use, and energy performance indicators. These will become the fundamental basis underpinning our understanding of energy use in buildings.

Table 1. Typology database and categories of influential factors defined in each database.

Database Typology	Categories of influencing factors			
	I	II	III	+(optional)
Simple	1. Climate			
	2. Building envelope			
	3. Building services and systems			
Intermediate	1. (Outdoor) Climate	4. Operation and maintenance	6. Occupants' activities and behaviour	7. Social and economical aspects
	2. Building envelope	5. Indoor thermal environment		
	3. Building service and systems			
Complex	1. (Outdoor) Climate	4. Operation and maintenance	6. Occupants' activities and behaviour	7. Social and economical aspects
	2. Building envelope	5. Indoor thermal environment		
	3. Building service and systems			

Three levels of database have been defined to serve different purposes, including case studies, statistical or simulation studies. These range from simple to complex in structure. Table 1 shows the three database typologies and the categories of influencing factors covered. The different databases include a number of categories of influencing factors. Specific items are also defined for each category of influencing factor. For example, the 'simple' database structure includes three categories of influencing factor:

- climate,
- building envelope, and
- building services and systems.

Both the 'intermediate' and 'complex' databases cover all influencing factors, but these need to be defined in more detail in the latter than in the former. The three levels of database definitions have been tested and refined by using real case studies of office and residential buildings.

Case studies & data collection

Collection, review and selection of case studies, with documentation and analysis of their energy use data are critical aspects of the research. About 30 case studies will be collected in total from different countries, within the following four building categories:

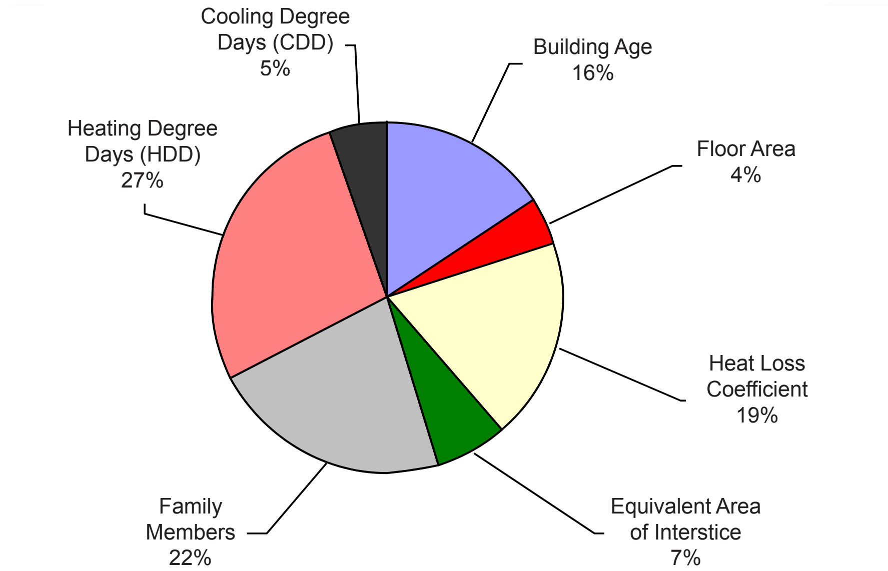


Figure 3. Importance of neural network input layers to prediction of annual energy consumption.

- Office buildings - (i) large-scale and high-rise, (ii) small-scale,
- Residential buildings - (iii) single family houses, (iv) multi-family apartments.

As an example, detailed energy data for a single residential building in Japan are shown in Figure 1. The annual energy profiles for the various end uses give essential information to understand the consumption patterns of this household. In addition, the case study buildings are being used for statistical analysis and energy performance evaluations.

Statistical analysis

The research is focusing on prediction methods and identification of the main factors relevant to total energy use. So, for this reason statistical analysis is being applied alongside development of the case studies. In fact, this needs to be undertaken not only for global, national and regional total building energy use as is most common at present, but also for total energy use in individual buildings.

A literature review has been completed on existing statistical analysis and prediction techniques for building energy consumption. All project partners have contributed their national expertise to this review, from which the following key items have been identified:

- database typology,
- adopted method of investigation,

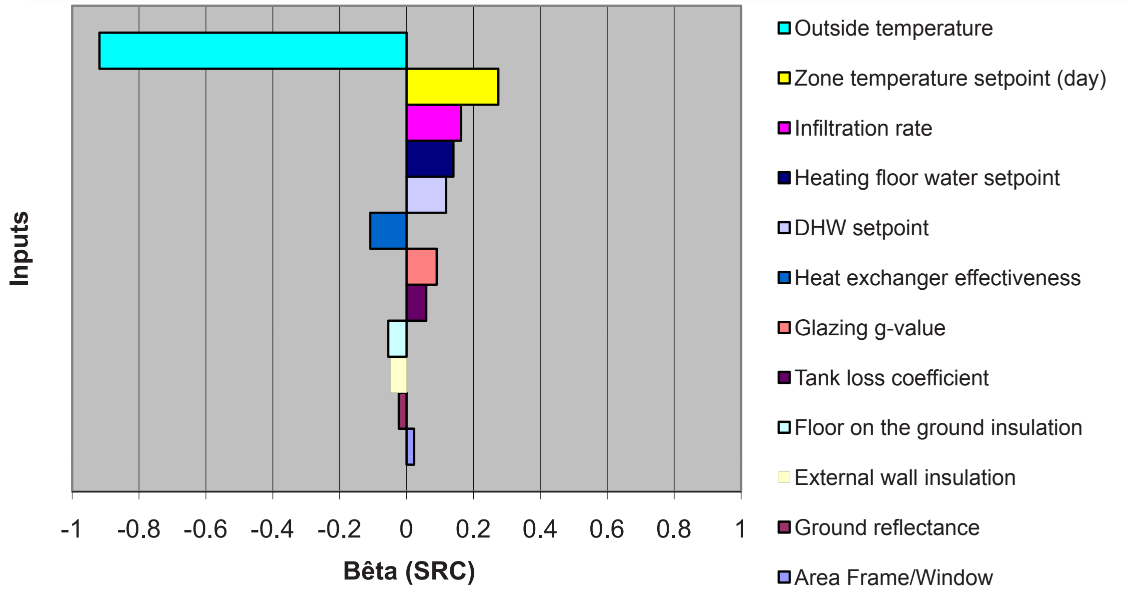


Figure 4. Result of sensitivity testing on the total energy consumption.

- subject of the analysis, and
- main goal of the analysis.

Further to the above, a database of 80 residential buildings developed in Japan has been used to apply and evaluate different analytical models.

Figures 2 and 3 shows a neural network model applied and the results of statistical analysis respectively. It can be seen from this analysis that main parameters influencing the total energy use are:

- heating degree days (HDD),
- family members, and
- heat loss coefficient.

Based on these studies, statistical prediction models will be developed to assess the impacts of energy saving techniques and occupant behaviour on total energy use.

Energy performance evaluation

The final important aspect to the project is the analysis by specific methods of the relationships between influencing factors for building energy use. For that purpose, information for simulations and sensitivity analysis has been prepared. For example, a typology of buildings and HVAC systems was devised and a number of simulation models have then been adapted and developed.

Figure 4 shows the results of sensitivity analysis using a case study residential building in Belgium. It is clear that the strongest influencing factor in this example is outdoor temperature, followed by indoor temperature, infiltration rate and so on. A methodology manual for analysis of the effects of the six factors on building energy use is under preparation.

Definitions & evaluations of occupant behaviour

Taking into account occupant behaviour is essential to properly evaluate total energy use in buildings. The findings of the literature review have been used as a basis for definitions and evaluations of occupant behaviour. Many investigations in the literature focus on relationships between energy-related behaviour and mainly physical factors influencing this behaviour, such as outdoor temperature and solar radiation.

However, in reality, there is no direct relation for instance between window opening and outdoor temperature. An occupant decides whether to open or close a window, but this decision is based on a number of influencing factors (presented schematically in Figure 5) that can be divided into:

- physical and environmental aspects,
- human biological aspects,
- psychological aspects, and
- interactions between occupants.

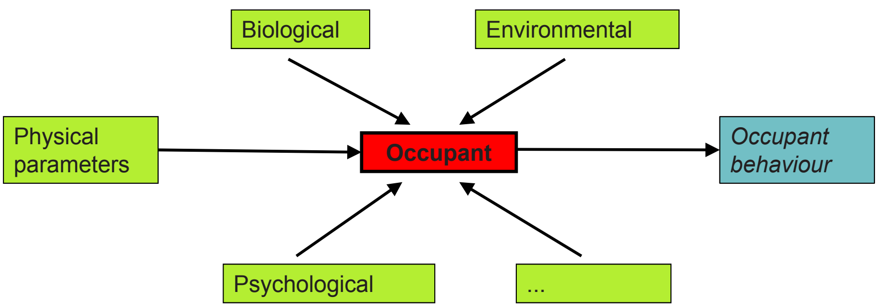


Figure 5. Relation between occupants and their environment.

Further information

For further information, please see:
www.ecbcs.org/annexes/annex53.htm

Air Infiltration & Ventilation Centre (AIVC) - A New Approach

ECBCS Information Centre Update

Rémi Carrié, INIVE EEIG, Belgium

Inaugurated in 1979, the Air Infiltration and Ventilation Centre (AIVC) is now operating with a novel approach that was approved at the end of 2010. A key ambition of the new AIVC is to have integrated / combined activities (called 'projects') resulting in different information tools, for example webinars, workshops, position papers, technical papers, and so on. These will be supported by an in depth review process and an increased impact of the dissemination of information.

The AIVC Board (which replaces the previous AIVC Steering Group) is in charge of the overall policy and of approval of the projects and of their key deliverables. The following projects have been initiated:

- Development and applications of air leakage databases
- Quality systems for airtightness requirements
- Philosophy for building airtightness requirements
- How tight and insulated should ducts be?
- Night ventilation for passive cooling

Within those projects, AIVC will play a key role in organizing or encouraging efforts in a consistent manner. AIVC will make use of its global network of renowned specialists and will create synergies between national initiatives. For instance, on the subject of air leakage databases, a group of experts from Canada, the Czech Republic, France, Germany, Greece, UK and USA has recently agreed that the following three major AIVC deliverables will be produced:

- a standardized format for presenting fan pressurization tests results,
- a position paper on the need for structured air leakage databases, and
- an overview of existing air leakage databases.

In addition, the experts have agreed to convene workshops on this topic at the AIVC conferences in 2011 and 2012.

In general, the anticipated publications, conferences, webinars that will be organized or facilitated by the AIVC are expected to fall under this project-oriented approach. This allows the active involvement of a wide range of experts in each project.

The AIVC annual conference has for over 30 years been a major event for scientists and specialists in the field of ventilation and infiltration. This year's conference, held in Brussels on 12^{th} and 13^{th} October 2011, had the theme 'Towards Optimal Airtightness Performance'. The programme included two parallel tracks, with one focusing on airtightness related issues and the other one addressing ventilation issues in general. The conference consisted of a mixture of well-prepared workshops, presentations both received by invitation and from an earlier call for papers.

For both the expected projects and the events in relation to airtightness, AIVC is joining forces with TightVent Europe, which is a newly-launched platform that focuses on airtightness of buildings and ductwork. TightVent Europe's main goals are to:

- raise awareness of airtightness issues, which are experiencing a revived interest with the recent trend towards nearly zero-energy buildings
- provide appropriate support tools and knowledge transfer to ease market transformation
- Given the converging interests of both bodies, the AIVC Board and the TightVent Europe Steering Committee have agreed to collaborate among other things on:
- the organization of the next conference which will be a joint AIVC-TightVent event
- the overall scientific approach of TightVent and the involvement of AIVC experts for scientific review of publications
- the joint organization of four of the projects mentioned above.

Source: SINTEF
Source (cover inset): CETE de Lyon

Becoming involved & further information

To discuss potential involvement in AIVC projects, please contact the AIVC: info@aivc.org

For further information, please see: www.aivc.org and www.tightvent.eu

ECBCS Recent Publications

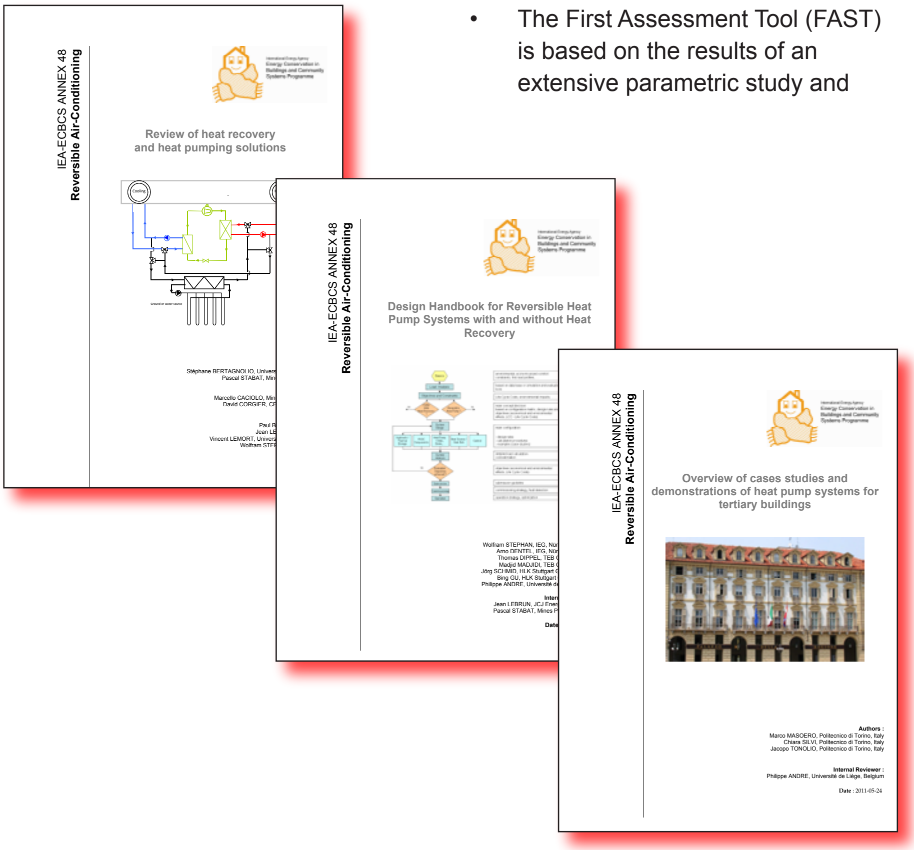
Heat pumping & reversible air conditioning

Analysis of Building Heating and Cooling Demands in the Purpose of Assessing the Reversibility and Heat Recovery Potentials

Edited by Pascal Stabat, Philippe Andre, Stéphane Bertagnolio, Marcello Caciolo, Pierre Yves Franck, Corinne Rogiest, Laurent Sarrade, Université de Liège, 2011

This report focuses on the issue of determining the heating and cooling demands of buildings in order to analyse the potential of energy savings obtained by the selection of a reversibility or recovery-based heat pumping solution. It is aimed at building and HVAC designers as well as at researchers in the field.

The scope of the study is limited to office buildings and health care institutions in Europe.



Review of Heat Recovery and Heat Pumping Solutions

Edited by Stéphane Bertagnolio, Pascal Stabat, Marcello Caciolo, David Corgier, Université de Liège, 2011

This report presents a survey of the technical solutions available to achieve reversibility or recovery-based heat pumping solution. The document describes the different typologies of vapour compression systems that can be used in office and heath care buildings for both heat and cold production, through reversibility and heat recovery. The document is in two parts: the first presents an overview of the solutions and the second is a catalogue of description sheets.

Simulation tools: Reference Book

Edited by Stéphane Bertagnolio, Samuel Gendebien, Benjamin Soccal, Pascal Stabat, Université de Liège, 2011

This report forms a reference and user guides for the tools developed in the project. Two tools are available:

- The First Assessment Tool (FAST) is based on the results of an extensive parametric study and aims to help practitioners and decision makers in identifying the appropriateness of using a reversible heat pump solution.
- An energy and economic assessment tool for the selected heat pump systems.

Design Handbook for Reversible Heat Pump Systems with and without Heat Recovery

Edited by Wolfram Stephan, Arno Dentel, Thomas Dippel, Madjid Madjidi, Jörg Schmid, Bing Gu, Philippe Andre, Université de Liège, 2011

The main goals of this design handbook are:

- to help designers and decision makers to preserving future possibilities in not making new mistakes, rather to optimise whole HVAC and heat pump systems
- to document the basic design procedures for reversibility and heat recovery technologies, their components and typical HVAC systems
- to identify most important design rules for each system type
- to document the design steps in reference to selected case studies
- to distribute calculation tools for load analysis and life cycle calculation (LCC).

Overview of Cases Studies and Demonstrations of Heat Pump Systems for Tertiary Buildings

Edited by Marco Masoero, Chiara Silvi, Jacopo Tonolio, Université de Liège, 2011

A summary report gives a general overview of the different case studies and presents some commissioning related issues.

Further information
Publications are available from:
www.ecbcs.org/annexes/annex48.htm

Low exergy systems for high-performance buildings & communities

Exergy Assessment Guidebook for the Built Environment

Edited by Herena Torio, Dietrich Schmidt, Fraunhofer Verlag, 2011

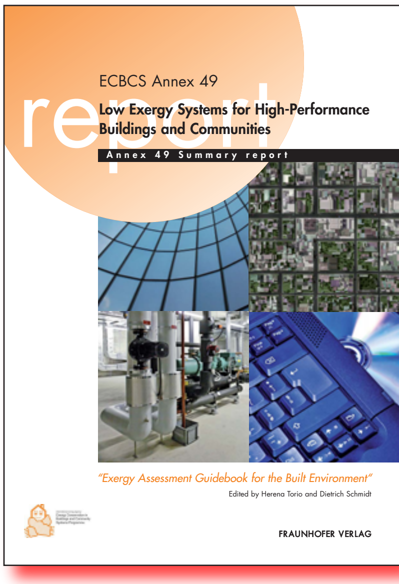
This report is a shortened version of the full final report of ECBCS Annex 49. (Both the full and shortened versions of the Guidebook are available on CD-ROM and to also freely download.)

This report presents a summary of the methodology and models behind complex dynamic exergy simulations which have been developed within the project.

Chapter 2 gives a brief description of the first unified methodology for performing dynamic exergy analysis on building systems. Some fundamental concepts and the thermodynamic background of the exergy approach are highlighted. Detailed equations for analysis of several building systems can be found in the full version of the report, as well as an extended version of the thermodynamic background of exergy analysis.

In chapter 3 the tools developed within the project are introduced. A brief description of the main features, calculation approach and usability of each tool are also given. Chapter 4 highlights and summarizes the main strategies for exergy oriented design of buildings and community systems.

Chapter 5 presents the main parameters developed for characterising exergy performance of any building or community system. Based on these parameters, an initial discussion and a basis for setting prenormative proposals that include the exergy concept are also included.



Chapters 6 and 7 show the main building and community systems case studies analyzed.

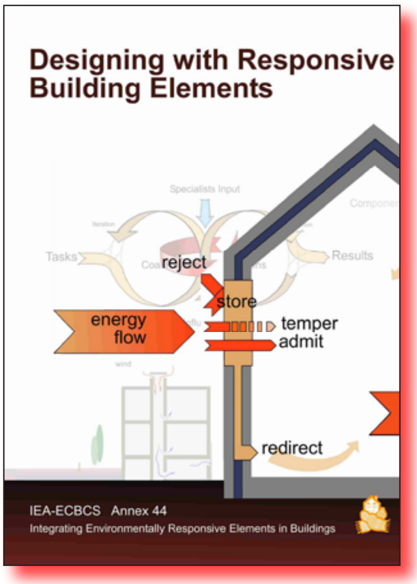
Further information
Publications are available from:
www.ecbcs.org/annexes/annex49.htm

ECBCS Facts at Your Fingertips
www.ecbcs.org

Integrating environmentally responsive elements in buildings

Designing with Responsive Building Elements

Edited by Ad van der Aa, Per Heiselberg, Marco Perino, Aalborg University, 2011



This document aims to address, highlight and illustrate the main ideas and principles of responsive building elements and integrated design for those interested in this field.

The main driving force for responsive building elements and integrated building concepts is the growing need and awareness for energy savings in the built environment together with increasing requirements for better health and indoor air quality in buildings.

Nowadays, the construction industry is in the early phases of a revolution to reinvent the design process that was used before the introduction of HVAC equipment. Increasingly, it becomes apparent that the design process needs to be an integrated and joined-up effort between architects and engineers. 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 may be due to lack of:

- knowledge,
- information and guidelines,
- successful examples, and
- expertise.

These barriers can hopefully be reduced by the contents of this document, within which general information about responsive building elements, responsive building concepts, their design considerations and the principles are described. In addition, for detailed information, reference is made to the design guides mentioned.

Further information
Publications are available from:
www.ecbcs.org/annexes/annex44.htm

ECBCS International Projects

5 Air Infiltration & Ventilation Centre

www.aivc.org

The AIVC carries out integrated, high impact activities with an in depth review process, such as delivering webinars, workshops and technical papers. The main target groups for the Centre are the research community and industry including practitioners from design through to construction and maintenance, as well as policy and other decision makers.
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44 Integrating Environmentally Responsive Elements in Buildings

www.ecbcs.org/annexes/annex44.htm

The building integration of environmentally responsive components, renewable energy generators and other technologies is an approach intended to transform the way in which buildings are designed and operated. The project outcomes are of significant interest to construction product developers, architects, engineers, building contractors, owners and operators.
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45 Energy-Efficient Future Electric Lighting for Buildings

www.ecbcs.org/annexes/annex45.htm

Recent major advances have expanded the available options for energy efficient, high-quality lighting technologies. These technologies have been identified, their appropriate applications evaluated and their proper integration with other building systems considered, to encourage their widespread adoption by lighting designers, building contractors, owners and operators.
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46 Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings

www.ecbcs.org/annexes/annex46.htm

A simplified toolkit has been developed for evaluating the potential for energy savings when refurbishing government buildings (offices, warehouses, industrial buildings, or dormitory accommodation). This is supported by guidance, case studies and an extensive database of energy savings measures and is intended to be used by energy managers, designers and energy service companies.
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47 Cost Effective Commissioning of Existing & Low Energy Buildings

www.ecbcs.org/annexes/annex47.htm

The improved operation of existing and future buildings in practice is the primary concern of this completed project. Not only have tools been developed to support the commissioning process, but also the business case has been strengthened by cost-benefit analysis and recognition of the persistence of savings. The beneficiaries of the work are building services commissioning providers, and also designers, building owners, and operations and maintenance personnel.
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48 Heat Pumping & Reversible Air Conditioning

www.ecbcs.org/annexes/annex48.htm

When installed, high cost air conditioning systems should be exploited as fully as possible, by allowing them to operate reversibly as required, either in heat pumping or in air cooling modes. Exhaust air heat recovery can also be applied during heat pumping. The knowledge and guidance generated by the project is targetted at designers and is also of relevance to building operators and owners.
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49 Low Exergy Systems for High-Performance Buildings & Communities

www.ecbcs.org/annexes/annex49.htm

This project has developed concepts for reducing the exergy demand (a measure of energy quality) in buildings and community energy systems. The guidance produced is of particular benefit for designers and presents an approach that evaluates how exergy is lost in energy generation, transmission and end use. This permits low exergy sources to be selected to meet heating and cooling demands.
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50 Prefabricated Systems for Low Energy Renovation of Residential Buildings

www.ecbcs.org/annexes/annex50.htm

An advanced design, manufacturing and construction approach has been created to allow existing buildings to be retrofitted using prefabricated external facade units, which are designed to upgrade the building fabric energy performance and accomodate new heating, ventilation and air conditioning systems. Crucially, the building occupants can remain in place during the renovation works. The project has focused on the needs of designers, the building industry and apartment building owners.
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51 Energy Efficient Communities

www.ecbcs.org/annexes/annex51.htm

Community-wide energy system 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. Guidance, case studies and a decision making tool are being produced to assist in implementing robust based approaches.
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52 Towards Net Zero Energy Solar Buildings (NZEBs)

www.ecbcs.org/annexes/annex52.htm

There is now a strong interest in net-zero, near net-zero and very low energy buildings. The project is achieving a common understanding of these concepts and are delivering a harmonized international definitions framework, tools, innovative solutions and industry guidelines. The key audiences for the work are government policy makers and research funding programme managers, industry, utilities and the academic community.
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53 Total Energy Use in Buildings: Analysis & Evaluation Methods

www.ecbcs.org/annexes/annex53.htm

Knowledge of the influence of different factors on energy use in buildings is essential to accurately assess short- and long-term energy saving measures, policies and technologies. This includes an improved treatment of how occupant behaviour can be addressed. The beneficiaries of the work are policy makers, energy services contracting companies, manufacturers and designers.
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54 Integration of Micro-generation & Related Energy Technologies in Buildings

www.ecbcs.org/annexes/annex54.htm

A sound foundation for modelling small scale co-generation systems underpinned by extensive experimental validation has been established to explore how such systems may be optimally applied. The target audiences include system designers and installers and energy services contracting companies, with outputs also of value to local to government policy makers, utilities, social housing providers, technology developers and investors.

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

www.ecbcs.org/annexes/annex55.htm

When retrofitting existing buildings, it is vital to ensure anticipated energy benefits are realized in practice. The project is providing decision support data and tools for energy retrofitting measures for software developers, engineers, consultants and construction product developers. These tools are based on probabilistic methods for prediction of energy use, life cycle cost and hygrothermal performance.

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56 Energy & Greenhouse Gas Optimised Renovation

www.ecbcs.org/annexes/annex56.htm

Current standards for new build are generally unsuited to the numerous constraints imposed by existing buildings. It is therefore urgent to agree new standards to respond to these constraints and to develop good practice guides that integrate appropriate, applicable and cost effective technologies. To assist this process, the project is delivering accurate, understandable information and tools targeted to non-expert decision makers and real estate professionals.

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International Energy Agency
Energy Conservation in Buildings and Community Systems Programme