Energy in Buildings and Communities Programme

EBC NEWS

Issue 59 | June 2014

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

Our common ground sets a solid foundation for international collaboration

Dear Reader,

Since the lead article in this edition deals with improving the energy performance of buildings in Germany, it was absolutely clear to me that as they are a close neighbour and partner of Austria, I should emphasise the importance of international collaboration. Despite trivial rivalries between our two countries over activities such as football or skiing, there is an excellent working relationship between our innovation sectors. And between Germany, Austria, and Switzerland, there are few linguistic and cultural barriers or climatic differences in comparison with other countries. Where they exist, removing barriers to cooperation is essential to our work. The well established structure provided by EBC supports wider collaboration, not only between neighbouring countries, but also across continents and cultures. In recent times, this has been successfully put into practice with the completion of an EBC project on energy efficient communities.

Agreeing common terminology is the starting point for new EBC research to improve occupant behaviour simulation. This continues the topic of a recently concluded project that has advanced our knowledge on the analysis and evaluation methods that can be used to calculate total energy use in buildings. Two of our research studies are now examining how renovation can be improved: one is looking at optimisation in terms of cost effective energy use and carbon dioxide emissions reductions, while the other is creating a new approach to assessing the reliability of energy efficient retrofitting. Another two projects are investigating thermal performance, by improving the accuracy of building envelope measurements and by proposing novel heating, ventilation and air conditioning systems based on high temperature cooling and low temperature heating.

This newsletter gives you an insight into some of our exceptional projects. I hope you enjoy reading about the evolution of our new ideas and the interesting solutions we are developing.

Isabella Zwerger
EBC Executive Committee Member for Austria

Cover pictures - EnOB air measuring station LOBSTER at KIT Karlsruhe
Source: © fbta KIT, Karlsruhe
Foto: Moritz Karl

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Building energy efficiency research in Germany

Markus Kratz

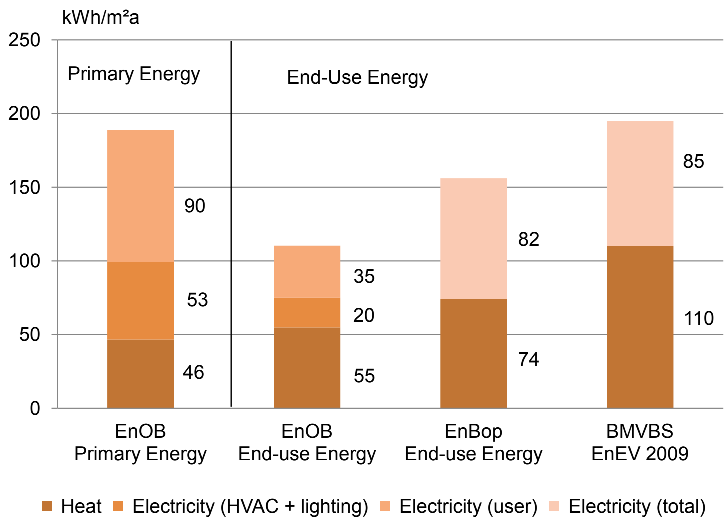
The Research for Energy Optimized Building initiative has supported the planning, construction and monitoring of ground-breaking demonstration buildings for almost 20 years. Through this experience, practical urban scale net zero-energy solutions are edging towards reality.

The 'Research for Energy Optimized Building (EnOB)' research programme has been managed by the German Federal Ministry for Economic Affairs and Energy since 1995. The objectives of this programme are to accelerate the implementation of innovative, energy efficient building technologies into practice and their scientific evaluation within a real-life context. During the EnOB initiative, more than 50 individual buildings have been monitored and evaluated for more than two years, while about a further 40 buildings are presently being planned, built or monitored. The majority of new buildings investigated have been offices or administrative buildings and form the largest group investigated. Educational buildings constitute the second largest group of demonstration buildings, serving as 'living labs' for optimized learning environments supplied with sustainable energy. The conclusions drawn from the analysis are presented below.

Demonstrating technologies

By delivering valuable results and experiences from practice, demonstration programmes are essential to implementing the outcomes from research and development (R&D) on building technologies. Systematic monitoring of high performance buildings allows a comparison of key performance indicators, as well as an evaluation of newly implemented technologies in a real building context. Demonstration buildings also

Energy consumption in EnOB office buildings



Energy consumption in 12 selected EnOB office buildings compared to consumption-based energy certificates (BMVBS EnEV 2009) and to 30 recently built modern office buildings according to an evaluation within the 'energy-oriented operation optimisation' research theme (EnBop).

serve as proofs of concept that stimulate replication at a broader scale. Further, economic benefits and occupant acceptance of new building concepts and technologies can be investigated, enhancing the scope from evaluation of energy efficiency to a more holistic view on sustainability.

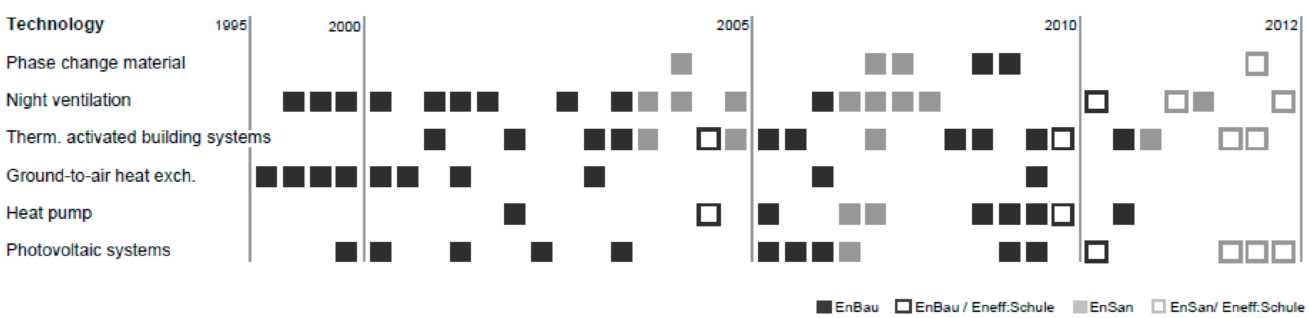
Reduced energy consumption

The level of energy consumption of EnOB buildings is significantly lower than current target values in German legislation. The average end use energy consumption (including user-related electricity consumption) of the investigated office buildings with a value of 110 kWh/(m² year) is about 45% below the reference value in the German Building Energy Saving Regulation (EnEV 2009). More than 30% of the end use energy and almost half of the primary energy consumed in the EnOB office buildings can be attributed to electricity consumption directly related to the building usage. The average emissions of greenhouse gases are about 37 kg/(m² year) CO_2-equivalent and are dominated by the 76% share related to electricity consumption. Auxiliary energy for building services systems would also have a strong influence on a building's total energy use. Therefore, careful planning, sizing and controls for all components are important to achieve high seasonal performance factors of all installed HVAC systems, for example ventilation with heat recovery or ground-coupled heat pumps.

Flexibility in energy supply and demand

A very low heating energy demand similar to the Passivhaus standard has proved to be a reliable basis for proceeding towards 'net zero-energy' or 'net-plus-energy' buildings. Highly energy efficient buildings offer maximum flexibility for different energy supply strategies, which could be either an 'all-electric' approach (for example PV with heat pumps) or combined heat and power (CHP) generation. This approach is particularly interesting for larger or existing buildings. Small scale CHP units based on biomass are still a topic of research. Exploiting low temperature sources such as waste or groundwater heat reduces the required energy quality by minimizing the exergy level. However, as mentioned above, the influence of energy saving building concepts can be partially cancelled out by end use specific electricity consumption. For this reason, not only improved efficiency, but also carbon-neutral generation of electricity are very important to achieve climate neutral buildings.
In brief, building load and energy generation profiles have to be harmonized for an overall optimization of 'green' energy use. With a highly fluctuating supply side due to an increasing share of renewable energy, the need for more flexibility on the demand side is also growing. Therefore, the interactions between buildings and the grid infrastructure such as electricity, gas and district heating becomes more important. Buildings are starting to change towards a more active role in the energy system in terms of load shifting (for example by energy storage), load management and on-site energy generation in connection with the grids. This also allows 'net zero-energy' solutions at larger urban scales (urban quarter, city, region), particularly for the existing building stock.

Technology matrix



Technology matrix with a sample of the technological approaches applied in individual EnOB demonstration buildings since 1995. The research has been funded under the following themes: "Energy-optimised new buildings" (EnBau), "Energy-oriented refurbishment" (EnSan), "Energy-efficient schools" (Eneff:Schule).

Economic evaluation

Comparisons with the German building cost index show that innovative energy concepts aligned with the current EnOB goals can be put into practice with similar construction costs to conventional buildings. Initial results on building-specific energy costs indicate they are significantly lower than those widely used in the real estate sector to estimate the anticipated energy costs during early planning phases. But, to derive reliable life-cycle costs from demonstration buildings requires much longer monitoring periods compared to energy monitoring.

Energy efficient technologies

An essential feature of the EnOB demonstration buildings is well-matched integration of energy efficient technologies with the architecture and the complete building concept. Thermal insulation, ventilation and the interaction between use of daylight and solar control and glare protection have a fundamental effect on the building form, floor plan and façade design.

Passive cooling can maintain thermal comfort according to the adaptive model under central-European summer conditions, if all necessary design features are incorporated, particularly avoiding high solar gains. Discharging heat stored in internal building mass by the use of natural heat sinks has been successfully demonstrated. Examples include night ventilation with ambient air, thermally activated concrete slabs or geothermal heat sinks. Geothermal heat sinks can decouple the indoor from the outdoor climate to a large extent even during very hot periods.

Proper commissioning of the buildings and energy-optimized building operation were identified as key factors to match expected and monitored performance data. Various tools have already been developed and tested in EnOB buildings to tap the huge potential energy savings by improving building operation. These include automated data processing, visualization and fault detection, as well as model based optimization.

Advanced and novel materials (capillary-active interior insulation, vacuum insulation, nanogel-plaster) allow thinner insulation layers and are the focus of current research activities. This includes prefabrication of building elements to improve quality and the installation time. As an example, large-size, prefabricated wall panels with vacuum insulation have been applied successfully in demonstration buildings. The functionality and reliability of vacuum insulation systems were tested after several years of operation. Although a significant risk remains in the construction process, the result was that there were almost no failures of elements that had been originally installed without damage – even after 10 years.

Occupant satisfaction

The monitoring of the demonstration buildings was accompanied by questionnaire-based surveys. One major finding was that the occupants' need for interacting with the indoor environment significantly influences their satisfaction with the workplace. Other parameters dominating the acceptance are privacy and the noise level in the office, which are affected by the type of office and space design. In general, standardized occupant surveys proved to be an effective measure for building operation assessment. As occupant behaviour strongly influences the energy consumption of buildings, more research is necessary to determine typical behavioural patterns for different building types. From these, improved probabilistic models can then be developed for more reliable simulation results during planning.

Further information

www.enob.info

Probabilistic Assessment of Retrofit Measures

Ongoing project: Annex 55

Carl-Eric Hagentoft

How do we design and realize robust retrofitting with low energy demand and life cycle costs, while controlling the risk of performance failure? An innovative technique looks set to accomplish them all.

Detached building in Copenhagen, Denmark
Source: Rockwool, Denmark

Social housing in Porto, Portugal
Source: Vasco Freitas

Multi-family residential buildings north of Stockholm in Sweden
Source: Johan Stein

Nowadays building energy use and durability issues are among the most important construction-related research topics in industrialised countries and the building sector generally accounts for the largest share of energy-related carbon dioxide (CO_2) emissions. In this respect, retrofit measures are of the utmost importance for upgrading the existing stock, thereby reducing energy use and CO_2 emissions. But, many building owners are only interested in the initial capital cost. Looking at actual risks in performance and the costs incurred emphasises the need for life cycle thinking. So, applicable calculation methods are required in this area.

The ongoing EBC project, 'Annex 55: Reliability of Energy Efficient Building Retrofitting-Probability Assessment of Performance and Cost', is addressing this problem by developing decision support tools and providing data for energy retrofit measures. The tools are based on probabilistic methodologies for prediction of energy use, life cycle cost and functional performance.

Case studies

During the project, three real retrofitting case studies have been analysed to show how to apply probabilistic analysis to enhance energy savings, secure performance and apply life cycle cost analysis. They are being used to better understand relevant areas in the planning, construction and operational phases.

Developed methodological and analysis techniques are also being applied to them to enhance discussion, learning and further refinement. The three case studies include:

- a detached building in Copenhagen, Denmark,
- social housing in Porto, Portugal, and
- multi-family residential buildings north of Stockholm in Sweden.

Risk management scheme

An important outcome from the project is a framework for risk assessment that describes how to analyse a specific retrofitting method that might be applied to a building. A simplified flowchart to represent this is shown in the figure below. The framework includes questions and corresponding actions to give guidance through the assessment. It sets up a number of questions that should be answered to find an acceptable solution for the retrofit measures. Some example questions are also listed below.

Retrofit measures

The project particularly focuses on the Swedish case study, in which thermal insulation was added on the cold attic floor in a multi-story building. There are clear benefits with this retrofitting method, as it is reasonably fast, convenient and inexpensive, with quite substantial heat loss reductions. However, problems with high humidity levels in cold attics have been increasing significantly over the last decade. The moist air may condense at the underlay leading to rot problems. Therefore, it is important to be able to quantify the risk involved when adding such insulation. For this purpose, several methods have been investigated. In particular, the Monte Carlo method has been thoroughly examined.

Using state-of the-art computational programs for predicting the temperature and moisture levels in the attic, the risk levels for mould growth and other moisture related damage can be estimated. An important input for these calculations is the somewhat random nature of material properties, airtightness, workmanship and weather. The total economic value of the retrofit measures can then be evaluated based on investment cost, the reduced heat loss, as well as the exemplified moisture related mould growth damage.

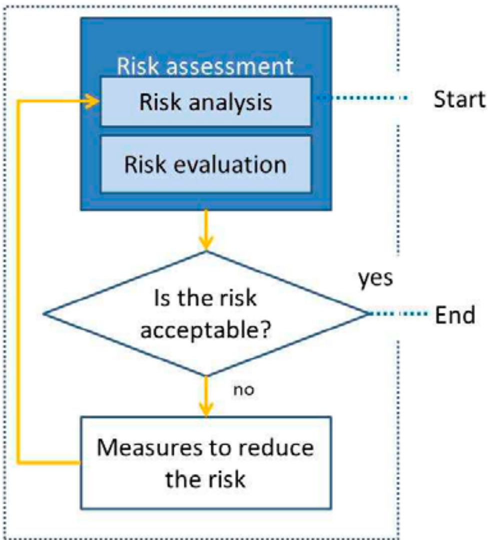
Project outcomes

The project has contributed new methods and tools for integrated evaluation and optimization of retrofitting measures, including energy efficiency, life cycle cost and durability. The main deliverables, available later in the year, are 'Guidelines for Practitioners' and 'Probability Based Assessment of Energy Retrofitting Measures' (tools, assessment schemes and case studies). It has demonstrated the benefits of the renewal of the existing building stock and how to achieve reliable solutions to decision makers, designers and practitioners.

Further information

www.iea-ebc.org

The framework for risk assessment: a simplified flowchart



Example questions used in the framework are shown below.

The first set of questions relates to the scope of the assessment that can be defined by asking:

- What is to be retrofitted?
- What is the aim of the retrofit?
- Desired values and consequences?
- What are the renovation strategies?

The risk analysis includes questions such as:

- What is known about the chosen renovation strategies?
- What can cause deviations?
- What are the qualifications and quantifications of the deviations?

Questions on the risk evaluations include:

- How well does the renovation strategy meet the purpose of the renovation?
- Are there any limitations with the recommended renovation?

Energy and Carbon Emissions Optimisation in Renovation

Ongoing project: Annex 56

Manuela Almeida

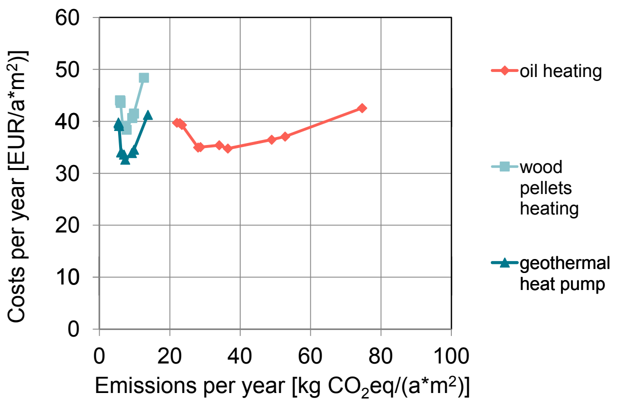
Initial results from residential building renovation case studies have shed light on optimal balances between energy efficiency measures and renewable energy supplies to minimise annual costs.

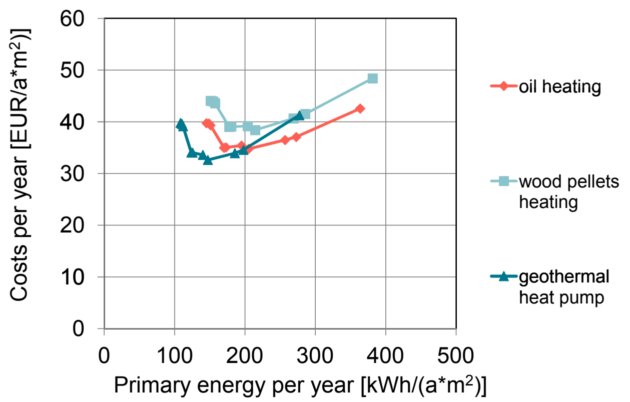
The existing residential building stock in most industrialised countries is a key area for large scale actions for energy demand and related carbon dioxide (CO_2) emissions reductions. Indeed, not only is the buildings sector a major energy consumer, but at present there is also a low replacement rate of the existing stock by new, efficient buildings.

It is possible to reduce energy and CO_2 emissions within the buildings sector by applying energy efficiency (and conservation) measures and by using renewable energy sources. The topic of the current EBC research project, 'Annex 56: Cost-Effective Energy and CO_2 Emissions Optimization in Building Renovation', is how to find optimal balances between these two approaches. The project is looking at how to combine them to achieve the best results for renovations defined in terms of reductions in energy use, CO_2 emissions and consumed resources, along with comfort improvement and overall added value achieved. It is considering how these can be achieved with the least effort in terms of financial investment, depth and duration of the intervention, and disturbance to occupants.

Initial optimisation results

The findings of the initial optimisation are now available from the project for packages of renovation works on residential buildings for annualised life cycle costs, CO_2 emissions and primary energy use. The renovation packages include various measures on the building envelope in combination with the installation of alternative heating systems. Some examples are presented in the figures below. Each point on a curve represents a specific renovation package, and each curve represents a different heating system. The point on the 'oil heating' curve with the highest value for CO_2





Comparisons of the cost effectiveness of energy efficient renovation measures for different heating systems based on CO_2 emissions and primary energy use for a single-family house in Switzerland.

emissions, or with the highest value for primary energy use, forms the reference case. As more measures are added to the renovation packages, CO_2 emissions and primary energy use both decrease while costs only decrease until a certain level is reached - the cost optimal level - after which they start to rise again. All the renovation packages with costs below the reference case are still cost effective, even those above the cost optimal level.

From the results of evaluations of case study buildings located in Austria, Denmark, Norway, Portugal, Spain, Sweden and Switzerland, the following preliminary conclusions have been drawn:

– The number of building elements renovated is more important for the energy performance of the building than the efficiency level of individual elements.
– The cost optimal levels for energy efficiency measures with conventional heating systems tend to be similar to those for renewable energy systems (RES), such as ground source heat pumps or biomass wood pellet boilers.
– Synergies are achieved by combining RES with energy efficiency measures.
– Installing RES reduces CO_2 emissions more significantly than energy efficiency measures.

Shining Examples

It is important to promote good examples and good practice already implemented, as well as to pinpoint existing and emerging efficient technologies with potential to be successfully applied. Nine case studies in six countries were identified to be successfully completed national demonstration projects. This brochure termed 'Shining Examples' is now available for download.

An example of these is a residential building from Kapefenberg in Austria, shown below. The findings from an analysis of these case studies are:

– The main barriers associated with the renovation process were of an administrative nature, for example delays caused by poor project leadership, or were related to financial issues.
– All of the Shining Examples confirm that the opportunity for optimised renovation is created by the need for maintenance or routine renovation. Renovation should allow for the actions, products and services necessary to guarantee the normal use, safety, legal function and aesthetics of the existing building and, if necessary, for upgrading it to current functional needs.
– Not only did all renovation projects achieve better energy performance, but also improved the indoor climate, comfort and aesthetics. These benefits, if clearly communicated to building owners, managers and occupants can help to overcome some of the barriers they are currently experiencing.
– The average primary energy savings calculated for all of the analysed case studies was more than 70%.

Further information

www.iea-ebc.org

The residential building in Kapfenberg, Austria, before (left) and after the renovation process (right).

Real Thermal Performance of Buildings

Ongoing project: Annex 58

Staf Roels

The accuracy and reliability of building envelope performance measurements have lately come under scrutiny. Can taking turns in testing make for more truthful thermal assessments?

Several recent studies have shown that real thermal building envelope performance after construction may deviate significantly from the theoretical design. Consequently, there is growing interest in full scale on-site testing to evaluate as-built thermal performance. However, experience has shown that the outcome of many on-site testing activities can be questioned in terms of accuracy and reliability. Additionally, their applicability to different climatic regions is not well established. The focus of nearly all full scale testing is on the assessment of components and buildings, but often overlooking the need for reliable assessment methods and quality assurance.

So to address these issues, the goal of the EBC research project, 'Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements', is to develop the necessary knowledge, tools and research networks to achieve reliable on-site dynamic testing and data analysis methods. These can then be used to characterise the actual energy performance of components and of whole buildings. In a first simple trial, a series of 'round robin' physical experiments are being performed on a test box by separate teams. In round robin experiments, the partner organisations in different countries each take turns to perform full scale testing under real world climatic conditions.

Round robin experiments

A round robin experimental approach has been devised to examine the effectiveness of different on-site testing and data analysis methods. The test box used has exterior dimensions of 120 cm x 120 cm x 120 cm. The floor, roof and wall components of the box are all identical and of 12 cm thickness, apart from a window in one side. A non-conducting frame ensures that the test box is not subject to thermal influences from the ground. This box, assembled by one of the participants, can be regarded as a scale model of a building, with fabric properties unknown to all other participants. The measured data obtained are distributed to all participants, who then have to try to determine the thermal performance of the test box's fabric.

At the various test sites, a range of different experiments are performed, including periods with free floating temperatures, heating to constant inside temperature, and dynamically imposed heating sequences. During these experiments, heat fluxes (i.e. heat flow rates per unit area) on all internal surfaces, internal and external surface temperatures, indoor air temperature and delivered heating energy within the box are recorded. Additionally, an outdoor weather station comprehensively measures relevant climatic boundary conditions. During winter 2012, the test box was deployed in Limelette, Belgium. It was subsequently transferred to Spain, where it was tested under the summer conditions of Almeria, Spain. It has recently been situated in Bilbao, Spain for winter testing.

Characterising thermal performance

Based on the data measured during the physical experiments, a range of different analysis methods are being applied by the teams to attempt to characterise the thermal performance of the test box. The methods vary from a simple averaging approach to advanced dynamic techniques as follows:

- An averaging method: This is the simplest technique used to estimate the steady state (i.e. assumed constant) thermal resistance of building elements from in situ surface temperature and heat flux measurements. It assumes that the average heat flow rate and temperatures over a sufficiently long period of time will give a reliable estimate of the true values. Consequently, this method is expected to be useful, for example, for interpreting the data collected during the winter conditions in Belgium, but not for the summer data from Spain.
- Co-heating: A data analysis method to determine steady state properties of a building based on linear regression is known as the co-heating test, which requires results from heating to constant inside temperature. By fitting an assumed linear relationship between the heat input and indoor to outdoor temperature difference, the overall heat loss coefficient can be determined. Applying multiple linear regression extends this concept to provide valuable information on the solar transmittance.
- State space modelling: State space ('grey box') models are based on a combination of prior physical knowledge and statistical relationships and identify the previously unknown thermal parameters of the system using dynamic data analysis. Generally a 'forward selection' approach is used: First of all a very simple model is fitted, which is then extended step by step until no improvement is found compared to the previous model and all relevant physical phenomena have been incorporated.

Next project steps

The objective of the round robin experiments is to perform well-controlled comparative testing and data analysis for determining building thermal performance. This work is exploring how different techniques can be applied to characterise the performance of the test box ranging from (quasi-) steady state techniques to dynamic characterisation. After this has been concluded, the next step for this research project is to investigate how these methods can be best applied to determine the thermal performance of real buildings. Particular attention is being paid to the possibilities for and limitations of grey box models informed by measured dynamic thermal behaviour of buildings in use, for both summer and winter conditions.

Further information

www.iea-ebc.org

Test box at the measuring sites: (left) during winter at Limelette, Belgium (right) during summer at Almeria, Spain.

Rethinking HVAC systems

Ongoing Project: Annex 59

Yi Jiang

An innovative concept for HVAC system analysis and design is producing more efficient cooling and heating systems by reducing mixing and transfer losses.

The purpose of building heating, ventilation and air conditioning (HVAC) systems is to maintain the quality of the indoor climate, including meeting required levels of air temperature, humidity and indoor air quality. But, conventional systems have not always been developed with energy efficiency as a priority. In fact, they can include inefficient processes that use more energy than is necessary to produce the desired environmental conditions. However, since the temperatures of heating and cooling sources directly influence HVAC system energy use, high temperature cooling and low temperature heating (HTC and LTH) systems have the potential to improve energy efficiency.

One of the aims of the ongoing EBC project 'Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings' is to develop novel systems with fully utilized sources of heat and cold, high efficiency transportation and appropriate indoor terminals. Specifically, it is considering how to avoid unnecessary offset of cooling and heating, dehumidification and humidification, mixing losses of cold and hot fluids, or unnecessary or inappropriate transfer losses due to heat exchange. The project is evaluating HVAC systems in buildings from a new angle and is intended to provide a new perspective to their design. This will be principally for the benefit of building owners, designers and equipment manufacturers. The scope includes suitable systems for major commercial buildings, such as offices, buildings containing large enclosures, and so on.

Minimising temperature differences

This project introduces a new concept for analysis and design of HVAC systems. This involves redesigning conventional systems by reducing mixture and transfer losses to produce HTC and LTH systems. It is important to minimise temperature differences in HVAC systems, because high differences result in reduced efficiencies and therefore in increased energy use. It is focusing on temperature differences throughout the systems and within the indoor spaces that they serve, and on how these can be minimized in highly energy efficient buildings. Temperature differences within HVAC systems can be classified into three types, arising from:

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

In particular, reduced temperature differences can be achieved by:

- proper design of heat exchange processes, including moisture,
- minimization of mixture losses through appropriate arrangement of indoor terminals, and
- efficient heat transmission from source to fluid media and then to occupied spaces.

Initial results

A number of findings have emerged from the work already completed, including:

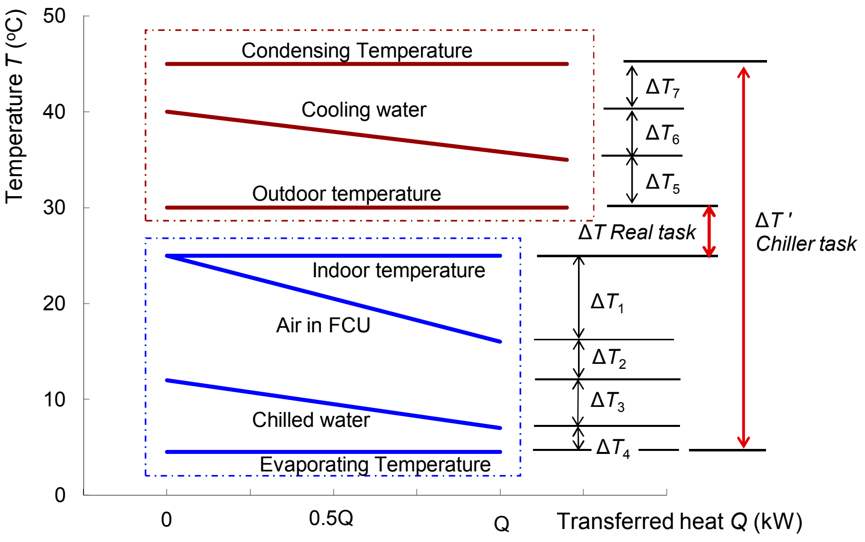
- Separate temperature and humdity controls is the basic requirement for HTC and LTH systems, since the requirements for heating or cooling sources differ for air temperature and humidity levels.

- Outdoor air handling equipments, especially for treatment of humidity level, is the main components in HTC and LTH systems.
- Low quality sources can be used efficiently by applying liquid or solid desiccant dehumidification.
- Based on proper humidity treatment, indoor temperature can be controlled by indoor terminals with high temperature cooling sources and low temperature heating sources.
- Radiant terminals, for example underfloor heating and cooling and radiant panels are well suited for HTC and LTH systems. Static and dynamic performance of radiant terminals is planned to be further examined, especially in combination with direct solar radiation.

Further information

www.iea-ebc.org

Temperature differences arising from heat exchange and transfer in a conventional HVAC system



Energy consumption
ΔT : Compressor
ΔT_1: FCU Fan
ΔT_3: Chilled water pump
ΔT_6: Cooling water pump

Heat and mass transfer area
ΔT_2: FCU
ΔT_4: Evaporator
ΔT_5: Condenser
ΔT_7: Cooling tower

The schematic diagram (above left) shows an illustrative relationship between temperature and transferred heat in a conventional HVAC system, with the sources of the temperature differences also explained (above right).

When the difference between the indoor temperature and outdoor wet bulb temperature (ΔT) is only 2 K, the condenser to evaporator temperature difference in the chiller (ΔT') is 32 K under typical summer conditions. The temperature changes mainly during the heat transportation process from the cooling or heating sources to the indoor space, and from the condenser to the outdoor environment.

In this conventional HVAC system, air is dehumidified by cooling it to condense moisture, which requires the cooling source's temperature be lower than the indoor dew point temperature and much lower than that required to simply cool the indoor space. The coupled treatment of cooling and dehumidification results in an increase in temperature difference in the system. In addition, losses due to temperature differences arise inside the conditioned indoor space, due to variations between the constant supply air conditions and varying levels of internal heat and moisture gains.

EBC International Projects

New and Completed Projects

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Annex 66: Definition and Simulation of Occupant Behavior in Buildings (new)

Despite the enormous impact of occupant behavior on building performance, this factor is often not given the same recognition as building envelopes, lighting, and heating, cooling, and ventilation during design, construction, and operation of buildings. This subject will be investigated by this newly approved project with the objectives to:

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

Annex 51: Energy Efficient Communities (completed)

Contact: Reinhard Jank
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This recently completed project has successfully delivered practical guidance for urban planners, decision makers and stakeholders on how to achieve ambitious energy and CO_2 reduction targets at local and urban scales. It has addressed small units, such as neighbourhoods or quarters, as well as whole towns or cities. The project has generated the necessary knowledge and means to be able to define reasonable goals in terms of energy efficiency, energy conservation and CO_2 abatement at the community level. The project deliverables are the 'Guidebook to Successful Urban Energy Planning' is aimed at decision makers in urban administrations, developers and urban planners and the 'District Energy Concept Adviser' - an electronic tool to support municipal administrations and urban planners faced with the task of developing and comparing options for integrated energy systems for neighbourhoods, either for new developments or for retrofit projects (see www.iea-ebc.org for how to get deliverables).

Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (completed)

Contact: Hiroshi Yoshino
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Improving the understanding of how various factors influence the total energy use in buildings, and developing analysis and evaluation methods to support this were the main goals of this recently completed project. Fifteen countries were involved in this project and more than 100 researchers participated. The final report on 'Total Energy Use in Buildings, Analysis and Evaluation Methods' has been published on www.iea-ebc.org together with six supporting documents that explain the underlying work in detail. The supporting documents cover the following topics:

- definition of terms,
- occupant behaviours and modelling,
- case study buildings,
- data collection systems for the management of building energy system,
- statistical analysis and prediction method, and
- energy performance analysis.

EBC International Projects

Current Projects

Annex 5 Air Infiltration and Ventilation Centre

The AIVC carries out integrated, high impact dissemination activities with an in depth review process, such as delivering webinars, workshops and technical papers.
Contact: Dr Peter Wouters
aivc@bbri.be

Annex 52 Towards Net Zero Energy Solar Buildings (NZEBs)

The project is achieving a common understanding of net-zero, near net-zero and very low energy buildings concepts and is delivering a harmonized international definitions framework, tools, innovative solutions and industry guidelines.
Contact: Josef Ayoub
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Annex 54 Integration of Micro-generation and Related Energy Technologies in Buildings

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.
Contact: Dr Evgueniy Entchev
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Annex 55 Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost

The project is providing decision support data and tools concerning energy retrofitting measures for software developers, engineers, consultants and construction product developers.
Contact: Dr Carl-Eric Hagentoft
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Annex 56 Cost-Effective Energy and CO_2 Emission Optimization in Building Renovation

The project is delivering accurate, understandable information and tools targeted to non-expert decision makers and real estate professionals.
Contact: Dr Manuela Almeida
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Annex 57 Evaluation of Embodied Energy and CO_2 Emissions for Building Construction

The project is developing guidelines to improve understanding of evaluation methods, with the goal of finding better design and construction solutions with reduced embodied energy and related CO_2 emissions.
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Annex 58 Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements

The project is developing the necessary knowledge, tools and networks to achieve reliable in-situ dynamic testing and data analysis methods that can be used to characterise the actual energy performance of building components and whole buildings.
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Annex 59 High Temperature Cooling and Low Temperature Heating in Buildings

The project aim is to improve current HVAC systems, by examining how to achieve high temperature cooling and low temperature heating by reducing temperature differences in heat transfer and energy transport processes.
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Annex 60 New Generation Computational Tools for Building and Community Energy Systems

The project is developing and demonstrating new generation computational tools for building and community energy systems based on the non-proprietary Modelica modelling language and Functional Mockup Interface standards.
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Annex 61 Business and Technical Concepts for Deep Energy Retrofit of Public Buildings

The project aims to develop and demonstrate innovative bundles of measures for deep retrofit of typical public buildings to and achieve energy savings of at least 50%.
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Annex 62 Ventilative Cooling

This project is addressing the challenges and making recommendations through development of design methods and tools related to cooling demand and risk of overheating in buildings and through the development of new energy efficient ventilative cooling solutions.
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Annex 63 Implementation of Energy Strategies in Communities

This project is focusing on development of methods for implementation of optimized energy strategies at the scale of communities.
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Annex 64 LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles

This project is covering the improvement of energy conversion chains on a community scale, using an exergy basis as the primary indicator.
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Annex 65 Long-Term Performance of Super-Insulating Materials in Building Components and Systems

This project is investigating potential long term benefits and risks of newly developed super insulation materials and systems and to provide guidelines for their optimal design and use.
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Energy in Buildings and Communities Programme

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