EBC
Energy in Buildings and
Communities Programme

EBC NEWS

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

The Start of a New Strategy

Dear Reader

Looking back over recent years, the IEA Technology Collaboration Programme on Energy in Buildings and Communities (EBC) has been successful in its efforts: At present, there are 20 ongoing R&D projects actively engaging hundreds of researchers in the participating countries and hundreds of thousands of reports are downloaded each year produced by the previously completed R&D projects. This work is contributing to the resolution of the most important research questions needed to achieve a cost-effective transition of the built environment to very low greenhouse gas emissions. Taking into account the continuous rise in the global population, enormous challenges will have to be resolved within the next decades in terms of energy use reduction.

This work needs to be structured within an up-to-date and motivating framework. For that purpose, a new Strategic Plan for the period 2019 to 2024 for the EBC R&D programme has been adopted at our Executive Committee Meeting held in Stockholm, Sweden, in June 2018. Our focus is now on realising five of the most important strategic objectives: refurbishment of buildings, reducing the performance gap between design and operation, creating robust and affordable technologies, development of energy efficient cooling, and the creation of district level solution sets. These are supported by five strategic means for delivering the research, for example by benefitting from 'living labs' to overcome barriers to adoption of energy efficiency measures. The Strategic Plan also sets out framework conditions, including an expectation that new projects will take actions to strengthen their research impacts. The working group responsible for its delivery is convinced that the new EBC Strategic Plan forms a good basis for further success of the EBC R&D programme. This edition of EBC News provides updates on a selection of projects started under our previous strategy and gives a flavour of new projects developed under the new Strategic Plan. Further, the article on Belgium's decarbonisation plans explains how national and regional competences are assigned to support their energy policy. I hope you will enjoy reading this edition!

Rolf Moser
EBC Alternate Executive Committee Member for Switzerland and Strategy Working Group Member

Cover picture: ROKI Global Innovation Center by Tetsuo Kobori Architects, located in Hamamatsu, Shizuoka, Japan, which has a transparent roof for good daylight integrated with LED lighting and openings for a natural ventilation system.
Source: Takahiro Arai

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Building Energy Futures for Belgium

Peter Wouters

The distribution of competences for energy matters in Belgium calls for cooperation between the federal state and the Regions.

The 1980 revision of the constitution in Belgium expanded the competences of the Regions and communities for energy matters. Within this context, the federal state is responsible for those matters of which the technical and economic indivisibility of the country calls for equal treatment at the national level. Without prejudice to the regional competences for tariffs, or the security of supply, these matters are: studies on energy supply prospects; the nuclear fuel cycle; the major energy production, storage and transport infrastructure; tariffs, including pricing policy. In parallel, the Brussels Capital, Flemish and Walloon Regions are responsible, among other things, for the following policy elements: distribution and local transportation of electricity on grids of up to 70 kV; public distribution of gas; district heating distribution networks; new energy sources with the exception of nuclear energy; energy recovery by industry and other users; rational energy use.

The distribution of competences for energy matters therefore calls for cooperation between the federal state and the Regions. This was formalized in 1991 in a cooperation agreement on the coordination of energy-related activities, signed by the federal state and the three Regions, leading to the setting up of the consultative group, 'ENOVER / CONCERE'.

As of January 2016, Belgium had 11.3 million inhabitants, forming 2.2% of the total population of the European Union. Belgium is densely populated, and with an area of 30500 km² and an average density of 363 inhabitants/km² (2015), it is the third most densely populated country in Europe. Today, the Flemish Region represents 58% of the population, the Walloon Region 32% and the Brussels Capital Region 11%.

Brussels Capital Region Energy Policy

In July 2018, the Government of the Brussels Capital Region adopted its contribution to the provisional version of the 2030 National Climate and Energy Plan. This plan contains 52 measures specific to the Region, and of these 20 relate to buildings, 17 to transport, and 14 to renewable energy.

For the buildings sector, the Brussels Capital Region's Energy and Climate Plan is based primarily on a strategy to reduce the environmental impacts of existing buildings. The goal is to drive the building stock towards a high level of energy performance by 2050. For residential buildings, the objective is to arrive at an average primary energy use of 100 kWh/m²/year. For the tertiary sector, the goal is to move towards energy-neutral buildings. Decarbonizing heating and hot water solutions is a central pillar of the regional plan. The Government has already agreed that the coming decade will mark the end of the installation of coal-fired (by 2021) and oil-fired (by 2025) heating equipment. The Brussels plan also includes looking into the future of natural gas installations after 2030.

Through the combined effects of these various actions, by 2030 it is expected the Region will be able to achieve:

- a 25% reduction in its final energy use (base year 2005);
- the production of 1000 GWh of energy from renewable sources, with 600 GWh of this in cooperation with the two other Regions;
- a 35% reduction in its direct greenhouse gas emissions (base year 2005) in order to get the Region on track for 2050.

The 2030 Climate and Energy Plan for the Brussels Capital Region goes further. Indeed, the Government has agreed on the need to also advance on the indirect emissions front and on measures that contribute to improving air quality, and thus to the improvement of the health of the population.

Flemish Region Energy Policy

As is the case for the other two Regions, the residential sector in the Flemish Region is characterized by a relatively old building stock, much of this pre-1970. To this end, the following long-term milestones have been set in principle by the Flemish Government:

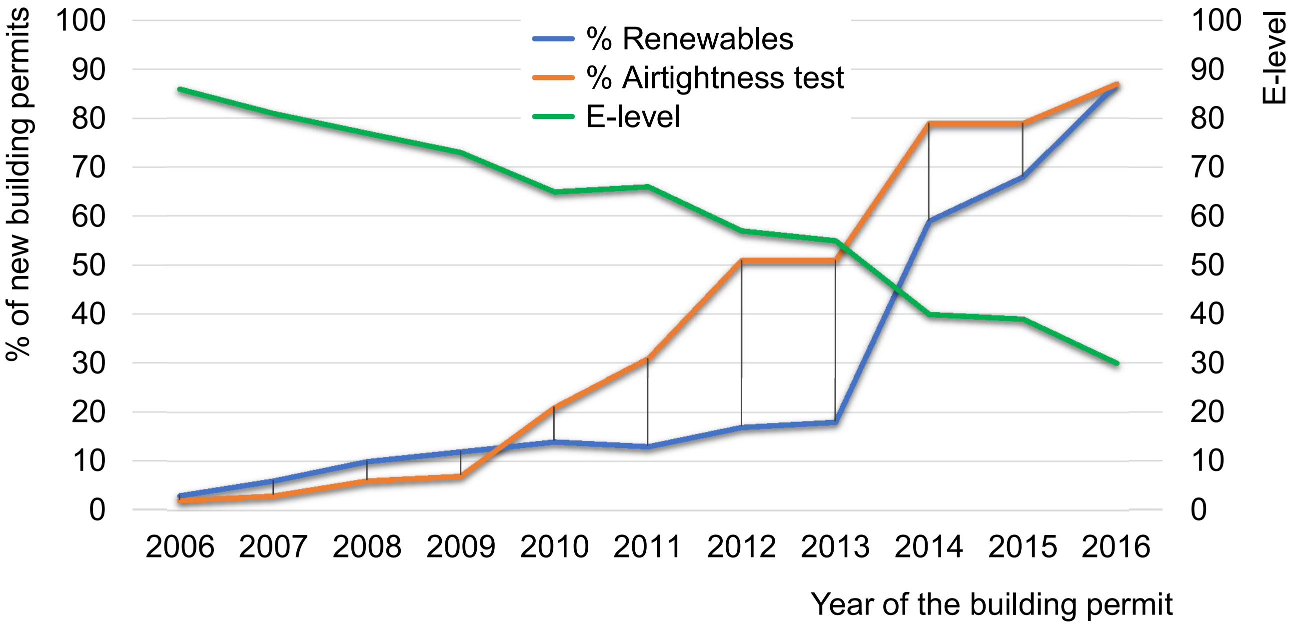
- All (existing) residential buildings must be at least as energy efficient as current high energy performance new buildings by 2050.
- Non-residential buildings must be climate neutral by 2050 at the latest.

For these reasons, additional efforts are being made to:

- Sharply increase the energy level of the building stock (residential and tertiary) including the use of demolition or replacement building where refurbishment is not financially or socially meaningful.
- Phase out the use of fossil fuels in the building stock. Paying close attention to green heating (in addition to green electricity) is crucially important to meet this objective.

Rollout is supported by various policy instruments:

- Currently, only 3% of the existing Flemish housing stock meets the energy targets for homes by 2050. Through cooperation with business, citizens, local authorities and civil society organizations, the Renovation Pact will be further elaborated with the aim to develop a framework and optimal instrument mix that will lead to increasingly thorough renovations.
- The European subsidized BE-REEL! Project has been started up. This is leading to expansion of knowledge and a learning platform, visible demonstration projects for the thorough renovation of thousands of houses, pilot projects and creation of business cases.
- To raise awareness among citizens about building energy labelling, a web application 'Benchmark tool EPC' will be developed in 2019, through which they will be able to calculate their own label and benchmark it against the Flemish housing stock.



Evolution in the Flemish Region of the energy performance level ('E-level') of new dwellings, percentage for which airtightness testing carried out and percentage of installation of renewables (PV, solar boiler and / or heat pump) according to the year of the building permit.
Source: Peter Wouters

	2020	2030	2050
Greenhouse Gas Emissions	-30% (1990 base year)	-37% non-EU Emissions Trading Scheme (2005 base year)	-80% to -95% (1990 base year)
Renewable Energy	13% gross final energy	23. 5% gross final energy	
Energy Efficiency	-21% final energy (2005 base year)	-23% final energy (2005 base year)	

Sectoral goal setting for 2050.
Source: Peter Wouters

- A first version of the 'home pass' has been launched as a step towards a digital safe with all official information for a home.
- By way of implementation of the Flemish Heating Plan, various new district heating networks are being actively deployed.
- After approval by the Flemish Government, and in principle from 2019, temporarily relaxed energy-saving zones can be established.

The draft Flemish Energy Plan 2021-2030 mentions, among other things, the following measures for residential buildings: accelerating the replacement rate of heating installations, a ban on oil-fuelled boilers starting from 2021 (for new construction and major energy renovation); no longer connecting homes to natural gas in new housing zones starting from 2021; gradual tightening of the energy performance level ('E-level') requirement for major energy-related renovations.

Walloon Region Energy Policy

Wallonia is developing a long-term vision and strategy involving all actors at local and regional level. The objectives are defined in the Climate Decree adopted in February 2014. These are specified and broken down into measures and actions in the 1st PACE (Climate and Energy Plan).

A new 2030 Climate and Energy Plan (PACE 2030) is in the process of being adopted. This will include new policies and measures to achieve the energy and climate targets set in the framework of the European Union in terms of energy and air quality. A major aspect will be the improvement of energy efficiency in buildings. In addition to this, reforms related to the gas and electricity markets, advancing the fight against energy poverty, a significant increase in the share of renewable sources, along with branch agreements for business and support for small and medium enterprises will form benefits of the Plan.

For existing buildings, the long-term renovation strategy adopted in 2017 sets ambitious targets for 2050 as follows:

- Reaching average energy performance 'Label A' for the entire residential building stock.
- For the tertiary sector, reaching energy-neutral level (zero emissions) for heating, domestic hot water, cooling and lighting.

An action plan has been set up to define measures needed in the short, medium and long term to reach these ambitious targets. Among the measures adopted, the following tools are important:

- the renovation roadmap that defines the trajectory and steps to attain the long term target;
- the building passport, which is a digital notebook with all the data to be transmitted when the building owner changes,
- the unique one-stop shop supporting citizens in their renovation projects.

At the local level, municipalities are invited to develop action plans. This policy is accompanied by financial incentives. Further to this, Wallonia is involved directly, indirectly, or potentially in the EBC, SHC, Hydrogen, and ETSAP Technology Cooperation Programmes of the International Energy Agency.

Further information

www.energiesparen.be/renovatiepact
www.be-reel.be/nl
www.woningpas.vlaanderen.be/

Peter Wouters is the EBC Executive Committee Member for Belgium.

A New EBC Strategy to Tackle a Growing Challenge

Rolf Moser and Paul Ruyssevelt

The new EBC Strategic Plan sets out the objectives and means to continue to address the established challenge of reducing energy demand in developed countries and the rapidly growing challenge of emerging economies where demands for better standards of comfort and amenity must be met without massive increases in energy use and CO_2 emissions.

It is well established that buildings use approximately 40% of all energy produced globally. The buildings sector is also widely recognized as having a large potential to reduce its energy use and related carbon dioxide (CO_2) emissions at relatively low cost in comparison with other sectors. However, current investment in building energy efficiency is not on track to achieve the IEA '2 Degrees Scenario' (2DS) climate change targets. Although an increasing number of countries have implemented or improved energy efficiency policies related to buildings and appliances, progress has not offset increasing demand for better thermal comfort and ownership of energy-using products. The adoption and implementation of energy efficiency measures need to be accelerated rapidly, especially in emerging economies, such as P.R. China and India, where a window of opportunity still exists to address future building energy demand and to prevent the lock-in of inefficient, long-lived building investments. In developed countries, acceleration of deep energy renovations of existing buildings and installation of high-efficiency building construction products are critical to reaching or surpassing 2DS targets. Globally, building energy performance needs to improve from a reduction rate of 1.5% per year observed over the past decade to at least 2.5% per year required over the next decade beyond 2025.

Within the framework of the International Energy Agency (IEA) Technology Collaboration Programmes (TCPs), the Energy in Buildings and Communities (EBC) TCP has been conducting collaborative research projects among its member countries since 1977. The vision of the EBC R&D Programme is that for new buildings and communities sustainable solutions have been adopted by 2030 giving near-zero primary energy use and carbon dioxide emissions, and a wide range of reliable technical solutions have been made available for the existing building stock. Our mission is to accelerate the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development of knowledge and technologies through international collaborative research and open innovation.

The EBC Programme has responded to these expectations and pressures by creating a concrete and focused R&D strategy for its next five year operating period between 2019 and 2024. This is to support the realization of the energy savings potential of the buildings sector and to provide a scientific foundation for the transformation of the international energy economy. The strategy of the EBC Programme identifies ten high priority research themes that can be separated into two types, namely 'Objectives' and 'Means'.

Objectives - The strategic objectives are as follows:

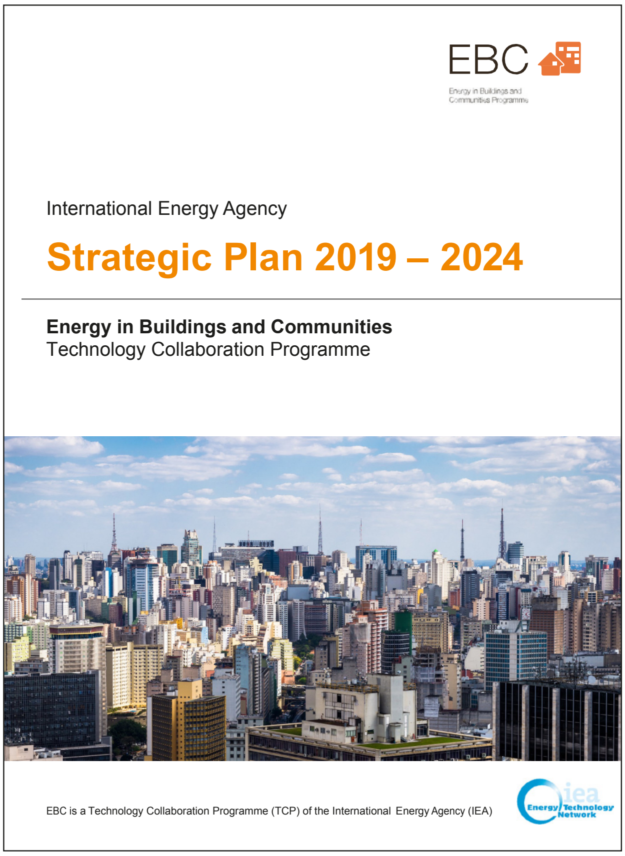
- reinforcing the technical and economic basis for refurbishment of buildings, including financing, engagement of stakeholders and promotion of co-benefits;
- improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real world operation;

- the creation of 'low tech', robust and affordable technologies;
- the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible;
- the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport implications.

Means - The strategic objectives will be achieved by the means listed below:
- the creation of tools for supporting design and construction through to operations and maintenance, including building energy standards and life cycle analysis;
- benefitting from 'living labs' to provide experience of and overcome barriers to adoption of energy efficiency measures;
- improving smart control of building services technical installations, including occupant and operator interfaces;
- addressing data issues in buildings, including non-intrusive and secure data collection;
- the development of building information modelling (BIM) as a game changer, from design and construction through to operations and maintenance.

In addition to recasting its priorities, EBC has strengthened its procedures for establishing and operating projects, known as ‘Annexes’, to ensure their relevance to the new agenda, improve the management of R&D and incorporate clear and achievable pathways to delivering tangible impact.

Some of the new objectives can be viewed as developments of previous EBC themes and they importantly continue a focus on critical issues such low energy and low carbon retrofit, the real performance of buildings in operation and the importance of community level solutions. However, the objectives also address critical emerging issues such as the increasing demand for space cooling in developing countries where expectations for comfort and amenity are rising rapidly as identified in the recent IEA ‘Future of Cooling’ report. In addressing such issues, the technologies sought should be robust and as simple and passive as possible, factors recognised by a specific objective in the new Strategic Plan.



EBC

Energy in Buildings and Communities Programme

International Energy Agency

Strategic Plan 2019 – 2024

Energy in Buildings and Communities
Technology Collaboration Programme

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

The new EBC Strategic Plan.

For the first time, EBC has sought to propose the means by which the various objectives might be addressed. These cover mechanisms that have been successfully employed in the past, such as the development of tools to support the design, construction and operation of buildings. However, they also address new developments in smart building controls, the increasing importance of data at both the building and building stock levels, the role that will be played by Building Information Modelling (BIM) as the construction transforms around the world. The opportunities presented to operate demonstration buildings as ‘living labs’ will be explored, in which various technologies can be tested for energy and environmental performance over time.

The new Strategic Plan sets out these objectives and means in more detail and we encourage readers to examine them closely and consider how they might benefit from the results of EBC Annexes, or even become involved in them. We would also be interested to receive feedback on the Plan.

Further information

www.iea-ebc.org

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

Completed Project: EBC Annex 64

Dietrich Schmidt and Anna Kallert

Exergy analysis supports strategic targets for communities, such as the reduction of energy utilisation and increased shares of renewable energy in our energy systems with a long-term horizon.

The building sector is causing large greenhouse gas (GHG) emissions due in part to the energy demands for heating and cooling. Commonly, fossil fuel based systems using combustion processes are used to satisfy these demands. Within this completed project, the exergy concept has been applied to help to achieve sophisticated energy system designs. Exploiting these potentials and synergies requires an overall analysis and holistic understanding of conversion processes within communities.

The objective of this research activity has been to demonstrate the advantages of exergy evaluation and the potential of 'exergy thinking' on a community level for energy and cost efficient solutions for achieving 100% renewable and GHG emission-free energy systems. The intention was to help to reach these goals by providing and collecting suitable assessment methods (for example holistic balancing methods). Furthermore, recommendations, best-practice examples and background material for designers and decision makers in the fields of building construction, energy production and supply, and policy making are provided in the final project report. Central to the work was the identification of the most promising and efficient technical solutions for practical implementation, as well as aspects of future network management and business models for distribution and operation. Aspects of transition management and policy have been considered to ensure the feasibility of practical implementation.

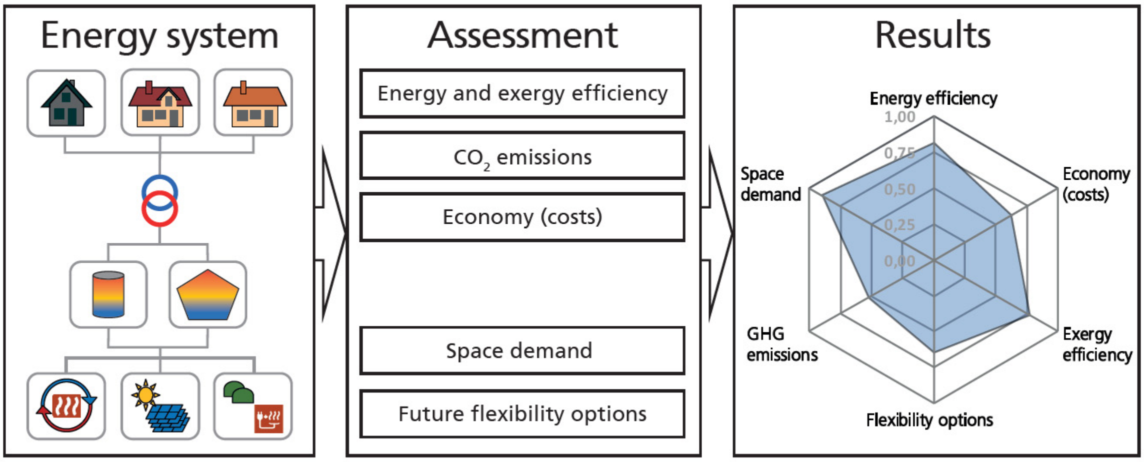
The project outcomes can also be used as a basis for future work using the models and methodologies developed, which offer the possibility of more 'sustainable' community energy systems.

Exergy thinking and analysis framework

The exergy concept can be used in the development of sustainable community energy supply systems. This can be done from the early stage of planning through to the detailed design and optimisation phase of the realisation. Firstly, by considering exergy principles in the development of the potential solutions, more favourable solutions can be obtained. In later stages of a project, exergy analysis can be used to further improve and optimize the energy systems considered. In order to evaluate the exergy performance of potential energy systems and develop this into a draft design, a simplified exergy analysis should be performed. In this way, the overall exergy efficiency can be determined, and more importantly, insight into the losses for each system component and thereby the possibilities for improvement can be obtained.

Three phases can be distinguished in the development of community energy systems: firstly, the pre-planning phase, in which ambitions are agreed and the initial options are explored for the community energy system and are roughly assessed; secondly, the design development phase, which leads to a draft design of the system; thirdly, a detailed design phase, in which refining and optimization takes place. This process then leads to a detailed design of the community energy system and can be summarised by the 10 steps below:

1. Define the system boundaries of the project.
2. Indicate the reference temperature.
3. Define the system configuration according to an 'input equals output' approach.
4. Determine energy values of all inputs and outputs.
5. Determine the exergy of all inputs and outputs, (using the quality- or exergy factor of the energy).



Exergy based assessment process for energy systems in communities.
Source: Anna Kallert, Fraunhofer IEE

6. Display exergy values in a clear way.
7. Analyse losses.
8. Propose improvements (to reduce losses).
9. Repeat step from Step 4, until satisfied with the results.
10. Present the final version including final performance (describing improvements and justifying remaining exergy losses).

LowEx supply technologies

Further to the planning approach, the most promising and efficient supply technologies have been identified allowing a flexible supply to meet different demands with the maximal share of low-valued local and renewable energy sources. The technological considerations include both demand- and supply-side aspects. Hence, the requirements for efficient buildings and appropriate occupant behaviour are discussed in the final report. Furthermore, different supply solutions and storage technologies, which serve as interfaces for community supply, are compared. Subsequently, different decentralised supply technologies (for example heat pumps, or solar thermal collectors) and centralised supply options (thermal grids at different temperature levels) are also described. As part of the supply solutions, the significance of the considered options in the context of a demand-adapted community supply is also explored. Approaches for the exergetic assessment of the respective system component are also discussed.

Case studies across scales

Different case studies, at different scales (building, district and city) and from different countries have been presented as part of the project work. The examples consider the heat and electricity domains in one system in a way that makes calculations, comparisons (between systems taken with similar assumptions) and interpretations more consistent and useful compared to an energy-based approach. From the different case studies, the following conclusions have been drawn:

- Buildings destroy more input exergy than they lose and produce, with about 84% to 93% of exergy consumed by buildings destroyed by irreversibilities.
- Exergy-based control is suitable to achieve efficient building operation. Using dynamic simulation models, the exergy analysis can be fully automatized and used for model-based control.
- Exergy analyses based on annual measurements show that ultra-low temperature district heating systems with local electric boosters have higher exergy efficiencies compared to existing district heating systems.
- A low energy demand can be achieved by high buildings standard and low thermal losses from the network, a high share of energy produced from renewables and good exergy efficiency, compared to traditional thermal systems.
- Old heat generation systems can be significantly improved in terms of exergy input and efficiency by replacing part of the heat production from fossil fuels by heat production from low-exergy sources.
- Lowering supply and / or return temperatures increases the exergy efficiency of district heating networks and consequently the whole system.
- The low-exergy approach allows identifying the component or configuration of the system on which to focus to implement and improve low-temperature district heating networks, so reducing energy use from fossil fuels, with lower overall exergy input.

Further information

www.iea-ebc.org

Energy Flexible Buildings

Current Project: EBC Annex 67

Søren Østergaard Jensen, Anna Marszal-Pomianowska and Rune Grønborg Junker

The energy flexibility of a building is its ability to manage its energy demand and generation according to local climate conditions, occupant needs and grid requirements. Such energy flexibility is expected to play a major role in future energy networks based entirely on renewable energy sources.

Substantial and unprecedented reductions in greenhouse gas emissions are required if the worst effects of climate change are to be avoided. A major paradigmatic shift is therefore needed in the way energy is provided and used. Significant reductions in greenhouse gas emissions can be achieved by reducing the energy demand by improving the energy efficiency, and then covering the remaining energy demand by renewable energy sources (RES). However, applying flexibility to the energy use can be just as important as energy efficiency improvements. Energy flexibility is necessary due to the large-scale integration of decentralized energy conversion systems based on renewable primary energy resources, which is a key component of the national and international roadmaps to a transition towards sustainable energy systems in which the reduction of fuel poverty and energy-related greenhouse gas emissions are top priorities.

A paradigm shift is, thus, required away from existing systems, in which energy supply typically follows demand, to systems in which the demand side considers the available supply. Taking this into consideration, flexible energy systems should play an important part in holistic solutions. Flexible energy systems overcome the traditional centralized production, transport and distribution oriented approach, by integrating decentralized storage and demand response into the energy market. In this context, strategies to ensure the security and reliability of energy supply involve simultaneous coordination of distributed energy resources, energy storage and flexible schedulable loads connected to smart distribution networks (electrical as well as thermal grids).

Buildings can provide energy flexibility

Buildings have the potential to offer significant flexibility services to energy systems by intelligent control of their thermal and electrical energy loads. More specifically, a large part of a building's energy demand may be shifted in time and may therefore significantly contribute to increasing flexibility of the demand in the energy system. In particular, the thermal part of the energy demand, for example space heating or cooling, ventilation, domestic hot water, and also hot water for washing machines, dishwashers and heat to tumble dryers, can be shifted. Additionally, the demand from other devices such as electric vehicles, pool pumps, cold display cases in supermarkets, and so

Building reference	Wind Penalty	Solar Penalty	Ramp Penalty
Building 1	11.8%	4.4%	6.0%
Building 2	3.6%	14.5%	10.0%
Building 3	1.0%	5.0%	18.4%

The Energy Flexibility Savings Index (EFSI) in percentage savings for the three buildings in the example opposite when situated in the three example grids also shown. These show that the building with the large time constant is best suited for a grid with much wind power, with an EFSI of 11.8 % compared to 4.4% and 6.0% for the two other buildings. The reason is there is often either wind present, or nearly no wind for several contiguous days, so energy needs to be stored for several days. Building 3, with the fast reaction, is best suited for a grid with short peak problems, while Building 2, with a medium time constant, best supports the grid with daily swings in the amount of RES (solar power).

on, can also be controlled to provide energy flexibility. All buildings have thermal mass embedded in their construction elements, which makes it possible to store a certain amount of heat and thereby postpone heating or cooling from periods with low RES in the networks to periods with excess RES in the networks without jeopardizing the comfort of the occupants. Additionally, many buildings may also contain different kinds of discrete storage (for example hot water tanks and storage heaters) that can potentially contribute to their energy flexibility. A simple example of a discrete storage system is the domestic hot water tank, which can be pre-heated during periods of high RES power. From these examples, it is evident that the type and amount of flexibility that can be offered will vary among buildings. Therefore, a key challenge is to establish a uniform framework that describes how flexibility can be offered in terms of quantity and quality.

Example project results

The actual energy flexibility potential depends on the type of building, the types of energy service systems in the building, the control possibilities, the climate, the time of day and year, the acceptance of occupants, operators and owners of the building, the state of the storage, and so on. The actual useful energy flexibility is further determined by the needs of the surrounding energy networks for which the building can provide flexibility services.

In contrast to energy use, for example, the amount of available energy flexibility cannot be expressed by means of a single number. So, the project has developed a methodology including key parameters for the characterization of energy flexibility. The flexibility of a building can be described by a dynamic flexibility function (FF), which describes how the building reacts to a penalty signal that may for instance be a price signal, the greenhouse gas emissions characteristics of the grid, or the amount of grid RES. The FF can be used to investigate how a building may support a specific grid. Based on the FF for a building and a dynamic penalty signal, it is possible to further calculate an 'Energy Flexibility Savings Index' (EFSI).

Further information

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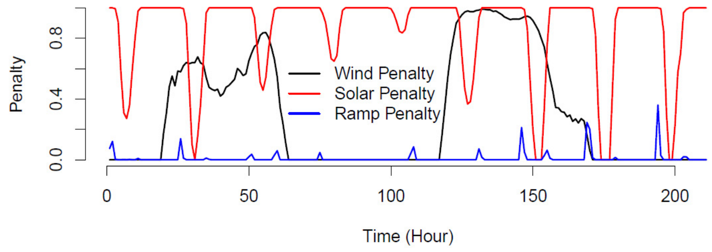
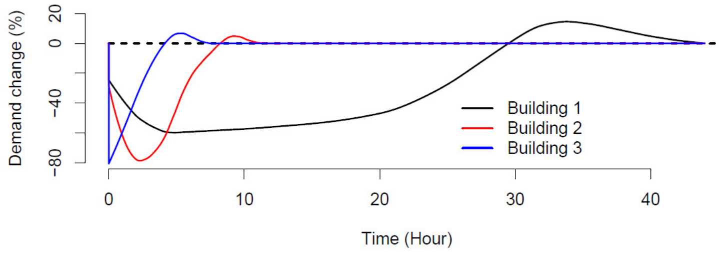
Penalty signals and flexibility functions



'Wind Penalty' and 'Solar Penalty' signals in Denmark during 2017, with a 'Ramp Penalty' signal based on demands in Norway during the same period. This illustrates three different types of grid: one with large amount of wind power, one with much solar power, and one with large peaks (ramps) in the morning and afternoon. These are examples of dynamic penalty signals, in which a penalty of '1' means that there is little or no wind or solar power in the grid, or that there are ramping (peak) problems.
Source: www.sciencedirect.com/science/article/pii/S030626191830730X



Example flexibility functions for three different buildings: Building 1 has a large time constant (for example a low energy building), Building 3 has a very low time constant (for example a poorly insulated building with electrical resistance heating), while Building 2 has a medium time constant.
Source: www.sciencedirect.com/science/article/pii/S030626191830730X

HVAC Energy Calculations in Building Codes

Current Project: EBC Working Group

Takao Sawachi

National building energy codes and regulations set their own methods for calculating energy use of buildings. By better matching energy use calculated before construction with actual use after occupation, it becomes more likely that the energy performance of the buildings sector will achieve the targeted CO_2 emissions reductions.

Before starting building construction and occupation, there are many uncertain or undecided parameters that are relevant to energy calculations for non-residential buildings. However, one reason why we calculate energy use based on building energy codes and regulations is to provide confidence that the influence of many design parameters can be quantified by using our existing knowledge together with the calculation logic. Such parameters include, for example, thermal transmittance of parts of the building envelope, energy efficiencies of heat generators, and so on. Through this current EBC Working Group, 'HVAC Energy Calculation Methodologies for Non-residential Buildings', five national calculation methodologies (four from Europe and one from Japan) have been analysed by referring

	Switzerland **SIA 2044**	**Japan** **Web-program**
(a) Grouping of cold generators	Chiller (electrically driven)	Air / water cooled heat pump / chiller / refrigerator, packaged air-conditioner
(b) Main input parameters and relevant standard(s)	$\eta_{COP,C}$ (energy efficiency for cooling) and temperatures of cold and cooling water, which are measured at four different partial load ratios.	The rated energy efficiency of cold generator, which is measured according to the test standard of the cold generator, (see (e)) thermal need dealt with by the cold generator and outdoor temperature at the time. The following characteristics of each cold generator are assumed: 1) relationship between the maximum output (capacity of the generator) and outdoor (or cooling water) temperature, 2) relationship between the maximum input (energy use) and outdoor (or cooling water) temperature, and 3) relationship between input (energy use) ratio and part load ratio.
(c) Core logic for calculating energy use by the generators	Based on EN 16798-13, a function of $\eta_{COP'C}$ (energy efficiency) with temperature conditions and partial load ratio as independent variables is determined by the regression analysis. By using the regression function, $\eta_{COP,C}$ (energy efficiency) can be determined for any part load ratio and temperature conditions.	The part load ratio is calculated as the ratio of the cooling energy need dealt with by the cold generator divided by the maximum output under the outdoor (or cooling water) temperature. By using the relationship between the part load ratio and the input (energy use) ratio, and the relationship between the maximum input (energy use) ratio and the outdoor (or cooling water) temperature, the input (energy use) at the time can be calculated.
(d) Standard calculation	EN 16798-13	-
(e) Standard equipment	ARI, ESEER	e.g., JIS B 8613 for water chilling units, JIS B 8621 for turbo centrifugal water chillers

National hourly calculation methodologies for energy use by cold generators for space cooling.
Source: EBC Working Group: HVAC Energy Calculation Methodologies for Non-residential Buildings

	Italy **UNI / TS11300-3**	**Germany** **DIN V 18599-7**	**UK** **National Calculation Methodology: SBEM**
(a) Grouping of cold generators	Compressor type, or absorption type	Electrical compressor type, absorption type, or gas engine compressor	Air / water cooled chiller, remote condenser chiller, heat pump (electric / gas / oil)
(b) Main input parameters and relevant standard(s)	Compressor type: EER_{100} (Energy Efficiency Ratio at 100% partial load ratio), EER_{75}, EER_{50}, EER_{25} (EN 14825), correction coefficients, η_1 for temperature conditions. If EERs at partial loads are not available, EER_{100} can represent. Absorption type: GUE (rated Gas Utilization Efficiency, EN 12309), correction coefficients, Cd (degradation coefficient) for partial loads.	Compressor type: EER or ζ (heat ratio) at rated condition, generator type, refrigerant, control of generator and cooling tower, specifications on connected AHU and heat recovery unit, room type serviced by the cold generator Gas engine compressor: Values of EER and PLV_{av} (average Part-Load Value) are fixed.	Nominal electrical power in kW for chillers. Qualification for the ETL (Energy Technology List) for a government scheme called ECA (Enhanced Capital Allowance), which determines default values of SEER. If only the full load efficiency (EER_{100}) measured according to EN 14511 is available, SEER = EER_{100}. If the full and half (50%) load EERs are known, SEER is the average of the EERs. If the part load EERs are known at four points, SEER is the average of the four EERs. For application in an office, SEER = $0.03 \times EER_{100} + 0.33 \times EER_{75} + 0.41 \times EER_{50} + 0.23 \times EER_{25}$.
(c) Core logic for calculating energy use by the generators	Compression type: Using EER values corrected by η_1, the energy efficiency at the monthly averaged partial load factor is obtained by interpolation. Absorption type: Multiplying GUE with C_d, the efficiency is obtained.	Energy use = Cooling energy need x EER x PLV_{av}. The PLVav can be determined by referring to specifications of the HVAC system listed above. The tables for PLV_{av} are given in the Appendix B of DIN V 18599-7. This method is known as characteristic value method.	The cooling energy use for each cold generator (C_e) is calculated by the equation: $C_e = C_d$ / SSEER, where C_d is the addition of the cooling demand of all zones serviced by the cold generator, and SSEER (system seasonal energy efficiency ratio) is the ratio of the total cooling demand in spaces served by the cold generator divided by the energy use into the cold generator. The SSEER can be calculated from SEER and heat loss through pipework and duct work as well as duct leakage.
(d) Standard calculation	-	-	EN 15243
(e) Standard equipment	EN 14511, EN 14825, EN 12309	EN 14511, EN 14825	EN 14511

National monthly calculation methodologies for energy use by cold generators for space cooling.
Source: EBC Working Group: HVAC Energy Calculation Methodologies for Non-residential Buildings

to documents describing the logic underpinning the calculations. A summary is given below of a key analysis that has already been completed in the project on cold generators such as chillers and heat pumps.

Effect of partial loads on cold generator efficiency

The project has revealed the key characteristics of five national calculation methodologies for cold generators for space cooling, with monthly methodologies adopted by three countries (Italy, Germany, UK) and hourly methodologies for two countries (Switzerland and Japan). In fact, this technological area spans two industries, which are buildings and HVAC products, and requires additional practical and academic studies for each of them. The HVAC product industry has already developed so-called seasonal or annual efficiencies of cold (and heat) generators, for instance 'SEER', 'SCOP' (EN 14825) and 'APF' (ISO 16358-3). Naturally, such indices need to be made with fixed assumptions about the building and climatic condition(s) that are relevant to the building if a certain product is going to be installed. The maximum possible cooling (or heating) need may be assumed to be equal to the rated (maximum) capacity of the cold (heat) generators, even though this can differ considerably from reality.

An important point for study in future research is how we can improve the utilization of energy efficiencies of cold generators at partial load conditions within energy calculations and at different cold supply temperatures. At the same time, research is needed on how the cost for testing can be reduced for manufacturers. This example analysis has only been provided for calculation methodologies for energy use for cold generators. Analyses are on-going in the project on heat generators, as well as on air and water transport systems.

Further information

www.iea-ebc.org

EBC International Projects

New Projects

EBC Working Group: Buildings Energy Codes

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Buildings have lifetimes measured in decades if not centuries, so it is fitting that most IEA member countries use building energy efficiency codes (regulations) to target the many decisions that cannot readily be upgraded at some future point as new technologies emerge. Building energy codes continue to significantly evolve, and they are facing not only the familiar issue of compliance, but also new challenges such as finding faster and easier methods to check compliance with code, greater reliability in evaluating compliance, incorporating efficiency into major retrofits of older buildings, or meeting ambitious policy objectives (for example net zero energy or carbon). The EBC Programme has recently identified energy codes as a priority theme and so has authorized the creation this Working Group dedicated to considering energy codes in EBC R&D projects and helping to leverage codes to advance efficiency in buildings and communities. It is carrying out the following activities:

- defining methods to enable comparisons among building codes (including between prescriptive and performance-based codes);
- developing long-term targets and roadmaps to support code development, adoption, monitoring, and evaluation;
- exploring how to make codes more relevant for existing building stock;
- sharing building best practices (existing and emerging alike).

Further information

www.iea-ebc.org

EBC Working Group: International Building Materials Database

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This EBC Working Group is bringing together a global network of regional data aggregators (RDAs) to support an online International Building Materials Database that can be used by national rating programmes and product specifiers. The RDAs are intended to collect and curate data and information for building materials that impact energy use in buildings. Key objectives of the work include: (1) improve the sustainability of buildings by having accurate information on product performance; (2) ensure global consistency by coordinating global efforts and resources to reduce redundant activity or inconsistent data; (3) enable funding to manage the database on behalf of the RDAs' countries or regions. The first component of the effort is the International Glazing and Shading Database (IGSDB), which has been developed through the Lawrence Berkeley National Laboratory (LBNL). The IGSDB is supported through the U.S. DOE as a cloud-based database hosted by LBNL. However, moving forward, while LBNL will continue to host the database, RDAs are responsible for managing it. The second component is to determine what additional products and material specifications should be included in the database beyond those already covered.

Further information

www.iea-ebc.org

EBC International Projects

Current Projects

Annex 5: Air Infiltration and Ventilation Centre
The AIVC carries out integrated, high impact dissemination activities, such as delivering webinars, workshops and technical reports.
Contact: Dr Peter Wouters
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Annex 63: Implementation of Energy Strategies in Communities is developing robust approaches for implementing community-scale optimized energy strategies.
Contact: Helmut Strasser
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Annex 64: Optimised Performance of Energy Supply Systems with Exergy Principles is covering the improvement of energy conversion chains on a community scale, using an exergy basis as the primary indicator.
Contact: Dr Dietrich Schmidt
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Annex 65: Long-term Performance of Super-Insulating Materials is investigating potential long term benefits and risks of newly developed super- insulating materials and systems and to provide guidelines for their optimal design and use.
Contact: Daniel Quenard
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Annex 67: Energy Flexible Buildings is investigating how energy flexibility can provide generating capacity for energy grids, and is identifying critical aspects and possible solutions to manage such flexibility.
Contact: Søren Østergaard Jensen
sdj@teknologisk.dk

Annex 68: Design and Operational Strategies for High Indoor Air Quality in Low Energy Buildings focuses on design options and operational strategies suitable for good energy performance, such as demand controlled ventilation, improvement of the fabric by using low pollutant emitting products.
Contact: Prof Carsten Rode
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Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings is studying the underlying mechanism of adaptive thermal comfort, and is applying and evaluating the thermal adaptation concept to reduce energy use through design and control strategies.
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zhuyx@tsinghua.edu.cn,
richard.dedear@sydney.edu.au

Annex 70: Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale is focusing on developing best practice methods for collecting, accessing, analyzing and developing models with empirical data of energy demand in buildings and communities.
Contact: Dr Ian Hamilton
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Annex 71: Building Energy Performance Assessment Based on In-situ Measurements is advancing in-use monitoring to obtain reliable quality checks of routine building construction practice to guarantee that designed performance is obtained on site.
Contact: Prof Staf Roels
staf.roels@bwk.kuleuven.be

Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings is based on previous EBC research based on life cycle assessment to include in-use operational impacts and addresses environmental impacts in addition to primary energy demand and greenhouse gas emissions.
Contact: Rolf Frischknecht
frischknecht@treeze.ch

Annex 73: Towards Net Zero Energy Resilient Public Communities is advancing 'near zero energy communities', to enhance existing masterplanning strategies and modelling tools, and expand their application with standardized country-specific building data on specific building types.
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Annex 74: Competition and Living Lab Platform is benefitting from the lessons learned from the Solar Decathlon events worldwide, and is extending the format with new competitions and a series of networking events under a common umbrella.
Contacts: Prof Karsten Voss, Prof Sergio Vega,
kvoss@uni-wuppertal.de,
sergio.vega@sdeurope.org

Annex 75: Cost-effective Building Renovation Strategies at District Level is examining the cost-effectiveness of methods combining energy efficiency and renewable energy measures at the district level.
Contact: Dr Manuela Almeida
malmeida@civil.uminho.pt

Annex 76 / SHC Task 59: Deep Renovation of Historic Buildings is examining conservation compatible energy retrofit approaches and solutions, which allow the preservation of historic and aesthetic values while increasing comfort, lowering energy bills and minimizing environmental impacts.
Contact: Dr Alexandra Troi
Alexandra.Troi@eurac.edu

Annex 77 / SHC Task 61: Integrated Solutions for Daylighting and Electric Lighting is fostering the integration of daylight and electric lighting solutions with the benefits of higher occupant satisfaction and energy savings.
Contact: Dr-Ing Jan de Boer
jan.deboer@ibp.fraunhofer.de

Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications is examining the possible energy benefits and indoor air quality implications of using gas phase air cleaners.
Contacts: Prof Bjarne Olesen, Dr Pawel Wargocki, bwo@byg.dtu.dk, paw@byg.dtu.dk

Annex 79: Occupant-centric Building Design and Operation is advancing comfort-related occupant behaviour in buildings and its impact on building energy performance. Contacts: Dr Liam O'Brien, Prof Andreas Wagner,
liamobrien@cunet.carleton.ca, wagner@kit.edu

Annex 80: Resilient Cooling for Residential and Small Commercial Buildings is investigating relevant applications for nearly zero energy buildings and is encompassing both active and passive cooling technologies and systems.
Contact: Dr Peter Holzer
peter.holzer@building-research.at

Working Group: HVAC Energy Calculation Methodologies for Non-residential Buildings is analysing national energy calculation methodologies with the intent of securing good agreement between their results and energy use in reality.
Contact: Dr Takao Sawachi
tsawachi@kenken.go.jp

Working Group: Cities and Communities is integrating the decision-making issues encountered by energy planners within cities and associated stakeholder groups into the R&D being carried out by the IEA Technology Collaboration Programmes.
Contact: Helmut Strasser
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Energy in Buildings and
Communities Programme

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