EBC

Energy in Buildings and Communities Programme

Annual Report 2020

Energy in Buildings and Communities Programme

International Energy Agency

EBC Annual Report 2020

Energy in Buildings and Communities Programme

Published by AECOM Ltd on behalf of the International Energy Agency
Energy in Buildings and Communities Technology Collaboration Programme

Participating countries in EBC: Australia, Austria, Belgium, Brazil, Canada, P.R. China, Czech Republic, Denmark, Finland, France, Germany, Italy, Ireland, Japan, R. Korea, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, UK and USA.

Published by AECOM Ltd on behalf of the International Energy Agency Technology Collaboration Programme on Energy in Buildings and Communities.

Front cover image: The 'CHAMPS' modelling platform was applied in EBC Annex 68 (page 52), which highlights building complexes that can be simulated on a community scale for their combined heat, air, moisture and pollutant conditions, including an energy performance assessment.
Source: Technische Universität Dresden, Germany

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www.iea-ebc.org
essu@iea-ebc.org

Contents

EBC Executive Committee Chair's Statement

In the recent IEA analysis reported in 'Tracking Buildings 2020', the latest worldwide trends and state of affairs for the buildings sector are clearly summarized based on statistics. According to this analysis, the buildings sector energy intensity (final energy use per m2) has been decreasing continuously by 0.5% to 1% per year since 2010, but this is not enough to meet the Sustainable Development Scenario (SDS) used in the IEA's future energy and greenhouse gas emissions projections. For the SDS, at least a 2.5% annual drop in energy intensity is required, which is more than double the current rate of reduction. Although this is not good news, we should not ignore this situation.

In carrying out R&D for the buildings sector, researchers and project managers should respond to these circumstances in the scope and deliverables from their projects. Professors in universities and colleges may have to introduce some more practical technical know-how into textbooks, which may be valuable also for practitioners in industry. However, the necessary knowledge may sometimes be contained in numerous existing or newly developed industrial standards, some of which are expensive to obtain for educational purposes and protected by intellectual property rights. Unfortunately, such standards tend to be excluded from textbooks and guidelines, even though such detailed technical information is sometimes indispensable to understand the actual phenomena in buildings, and this should be shared more broadly among practitioners and future practitioners. At least it may be possible to share the qualitative information and essence contained in these standards.

In 2020, building ventilation has come into focus at a much broader scale than before due to the COVID-19 pandemic. This has revealed there are still problems to be solved for mechanical ventilation systems concerning their reliability to maintain a balance between airflows with higher energy efficiency of fan systems, even though super-energy efficient motors have already appeared in the market.

More thorough outreach of results from EBC's activities is needed, and at the same time dissemination of transparent technical know-how reflecting real performance of buildings and their services systems. These are substantial requirements for research outputs, which are expected to be produced regularly from EBC's Annexes and Working Groups.

Dr Eng Takao Sawachi
EBC Executive Committee Chair and Member for Japan

TURKEY AND BRAZIL JOIN EBC

EBC PARTICIPATION ASSISTS RAPID ACCESS TO R&D

Two additional participating countries were welcomed into the EBC Technology Collaboration Programme (TCP) in 2020: Turkey, represented by the Turkish Society of HVAC and Sanitary Engineers, and Brazil by the Ministry of Mines and Energy. The strong interest in both countries is already evident, with each promptly joining several ongoing EBC international research projects. As a key benefit common to all participating countries, they now have direct access to EBC's international research activities, allowing innovation capacity building, sharing of knowledge and best practices, support for creating the scientific basis of national policies, and also helping them to provide leadership and outreach to strengthen regional cooperation.

Turkey

The process of adapting to climate change and increasing decarbonization that the world is now adopting triggers all societies to become responsive to these circumstances and accelerates local, regional, and global initiatives to develop strategies to find solutions. Turkey, as a close follower of this process, handles all aspects of these issues. This is clearly seen in the action plans of the country set out in long-term strategies in Turkish National Programs (i.e. National Energy Efficiency Action Plan, NEEAP, 2018 - 2023).

Turkey is one of the founding countries of the International Energy Agency (IEA), and therefore Turkish authorities are involved with the relevant bodies of the IEA. As can be understood from the IEA's most recent Turkey Report, it is of primary importance to develop strategies to reduce foreign energy dependency, despite the current situation of an increasing population and high rates of energy demand, while following targets for economic growth. In recent years, in the context of enhancing energy efficiency and clean energy applications in the built environment, Turkey is aware of the importance and priority of international collaboration, as well as providing local requirements. In this sense, technology cooperation programmes have been scrutinized. The IEA Energy in Buildings and Communities programme (EBC) is an important one covering the main title of 'Energy', which is among the priority research areas in Turkey's national strategy. In addition, in the R&D activities to be carried out by Turkey, the framework of the new growth strategy of the European Union 'Green Agreement', is taken as basis, which includes basic objectives such as net zero greenhouse gas emissions by 2050 and ending the dependence of economic growth on resource use. The Scientific and Technological Research Council of Turkey (TÜBİTAK) attaches special importance to these issues within the scope of priority R&D areas and innovation issues.

The Turkish Society of HVAC and Sanitary Engineers (TTMD), in accordance with its mission and vision, is a highly recognized organization with its national and international networks. TTMD is able to gather the required stakeholders under a common umbrella ranging from research to design and implementation on the basis of engineering and architecture of the energy and environment sector. Considering that Turkey has become active in the EBC TCP since 2020 for the reasons mentioned above, TTMD has launched relevant initiatives on a national basis, and has established Turkey as one of EBC's participating countries.

Research organizations in Turkey (TÜBİTAK , universities, industrial organizations, and so on) carry out R&D activities in line with local and regional development goals. Studies that will ensure energy independence and aim at the development of energy efficiency and renewable energy technologies are conducted in research institutes of universities with university funds, R&D activities supported by industry funds, and with various research programmes carried out with the support of TÜBİTAK. Access to international funds is mostly possible within the scope of European Union calls (EU-Horizon, IPA, Newton, and so on) and / or regional development programmes. The application and research-oriented development funds offered by some countries through their embassies also support inter-institutional cooperation and contribute to regional development. In the last decade, international consortia, in which relevant Ministries are mostly beneficiaries (Ministry of Environment and Urbanization, Ministry of Energy and Natural Resources) have been able to take advantage of regional development programmes, to improve the laws, strengthen regulations and obtain best practices and activities to raise public awareness. Although these studies are extremely useful, they are still not enough. By taking part in the EBC TCP, Turkey is not only the implementer, but also the developer of current approaches, to be able to follow all stages of the process, to increase the innovation capacity, access to resources and R&D quality in cooperation, to contribute to the formation of future technologies and strategies, and aims to share acquired know-how with other communities in the region.

For this purpose, an immediate call was made on a national basis in 2020 to ensure the active participation of Turkey in EBC, and contribution of experts and relevant organisations in the ongoing EBC Annexes was encouraged. The experts who responded to this call were assigned to the Annexes according to their expertise. In the first year that Turkey started taking part in EBC, a total of 13 experts are assigned to nine Annexes. EBC TCP can realize its local adaptation faster by following the current developments in Turkey and its region. Turkey's regional experiences, social and cultural diversity, urbanization and development experience will contribute to widen the perspectives of all EBC countries.

Brazil

The cooperation between the IEA and the Ministry of Mines and Energy of Brazil (MME) started in 2006, when MME acted as an observer in technical meetings on specific topics, such as biofuels and solar energy, as well as for the strengthening and increase of awareness on hydro power as a clean energy source. In 2011, having harmonized the concepts and negotiated the terms of participation for Brazil, MME signed the first biannual Working Plan (WP) with the IEA. Since then, five other WPs have been agreed. Regarding the IEA Technology Collaboration Programmes (TCPs), Brazil has participated in the TCP on Bioenergy since 2008, a forum coordinated by member countries of the IEA that brings together entities like MME from 24 different countries. This was followed by participation in four more TCPs: Greenhouse Gases, Oil and Gas Technologies, Hydroelectricity, and Solar Paces.

In 2020, considering the importance of promoting research and the international focus on energy efficiency of buildings, Brazil joined the EBC TCP, whose activities of research and development cover all types of buildings. Becoming an EBC participating country has shown direct alignment with the scope of the most recent 2020-2021 WP of Brazil with the IEA. In this WP, there is the commitment of the IEA in promoting and supporting cooperation opportunities with Brazil in energy technologies through the TCPs, and that considering the energy efficiency field, the IEA and Brazil would continue to collaborate with focus on: a) monitoring of energy efficiency progress, supporting the establishment of indicators and comparative analysis, b) selected sector and sub-sectors, including buildings and construction, industry and transport, and c) political support and building capacity of national authorities, as well as the search for opportunities to share experiences at a regional level.

The fields of research developed under the EBC Annexes, as well as the discussions resulting from its Working Groups including on Building Energy Codes, are considered strategic to leverage the knowledge and technologies needed to bring Brazil in line with the best international technologies and initiatives for energy efficiency in buildings. The formalization of Brazil's participation in the EBC TCP allows Brazilian researchers direct participation in its activities and research, and whose activities support technological application in practice. Therefore, between since joining in 2020 Brazil´s participation in six ongoing Annexes has already been formalized: 'EBC Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings', 'EBC Annex 77: Integrated Solutions for Daylight and Electric Lighting', 'EBC Annex 79: Occupant-centric Building Design and Operation', 'EBC Annex 80: Resilient Cooling', 'EBC Annex 82: Energy Flexible Buildings', and 'Annex 86: Energy Efficient IAQ Management in Residential Buildings'. In this way, there are now 25 Brazilian researchers, from six different Federal Universities, acting as formal members in these projects.

In conclusion, considering the research focus of the Annexes that Brazil has joined, along with the Working Groups, the importance that the engagement with the EBC TCP will have to Brazil is highlighted for the implementation of the National Strategy to advance energy efficiency in buildings. This aims to elaborate and update technical standards related to energy efficiency in buildings; carry out activities to disseminate knowledge on energy management systems and international cooperation to internalize the methodologies; development of a database of environmental performance for the construction sector using the lifecycle assessment concept on the pre-operational phase of the buildings, and the mandatory energy efficiency label for residential and non-residential buildings.

Further Information

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Dr Gülsu Ulukavak Harputlugil, EBC Member for Turkey
Dr Alexandra Albuquerque Maciel, EBC Alternate Member for Brazil

New Research Projects

ENERGY EFFICIENT INDOOR AIR QUALITY MANAGEMENT IN RESIDENTIAL BUILDINGS

(EBC ANNEX 86)

INDIRECT EVAPORATIVE COOLING

(EBC ANNEX 85)

DEMAND MANAGEMENT OF BUILDINGS IN THERMAL NETWORKS

(EBC ANNEX 84)

Energy Efficient Indoor Air Quality Management in Residential Buildings

EBC ANNEX 86

The energy performance of new and existing residential buildings needs to be radically improved to meet ambitious climate change goals while maintaining a healthy, acceptable and desirable indoor environment. While ventilation is the main strategy that is adopted for indoor air quality (IAQ management), other technologies influencing IAQ (e.g. air filtration) are available as well. However, there is no coherent assessment framework to rate and compare the performance of IAQ management strategies. This project is therefore focusing on assessing the IAQ performance and identifying the optimal solutions for maximizing energy savings while guaranteeing a high level of indoor air quality in new, renovated, and existing residential buildings.

To achieve this, the aim of the project is to gather existing scientific knowledge and data on pollution sources in buildings, investigate opportunities for applying Internet of Things (IoT) connected sensors, study current and innovative case studies of IAQ management strategies and develop road maps to ensure the continuous performance of the proposed solutions over their lifetimes.

This project will develop work carried out in the EBC project, 'Annex 68: Indoor Air Quality Design and Cont-rol in Low Energy Residential Buildings' (page 52) and will collaborate with the EBC project, 'Annex 5: Air Infiltration and Ventilation Centre' (page 48) in organizing meetings and disseminating project results.

Objectives

The main goal is to accelerate the development of better and more energy efficient IAQ management strategies to address rapidly changing expectations of residential indoor environments due to climate change and pandemic challenges. The specific objectives and scope are to:

- develop a consistent set of metrics to assess the energy performance and indoor environmental quality for an IAQ management strategy;
- propose an integrated rating method for the performance assessment and optimization of energy efficient strategies for managing the IAQ in new and existing residential buildings;
- identify or further develop tools to assist designers and managers of buildings in assessing the performance of an IAQ management strategy using the rating method;

A wordcloud generated from the project proposal text, highlighting the keywords defining the goals of the new EBC project.

Source: EBC Annex 86

- gather existing scientific knowledge and data on pollution sources in buildings to provide new standardized input data for the rating method;
- study the potential use of smart materials as an IAQ management strategy;
- develop specific IAQ management solutions for retrofitting existing buildings;
- improve the energy efficiency of the indoor air quality management strategies in operation and to improve their acceptability, control, installation quality and long-term reliability.

Deliverables

The deliverables to be produced in the project are provisionally as follows:

- a literature list for energy efficient IAQ management,
- an open database with source data for the rating of IAQ management strategies,
- an overview report on methods and tools for the rating of IAQ management strategies, and
- a collection of case studies and demonstrations of energy efficient IAQ management strategies.

Progress

A one-year preparation phase for the project was approved at the June 2020 EBC Executive Committee Meeting. During 2020, the workplan was developed for the project tasks.

Meetings

- A preparatory workshop was held online in May 2020.

Project duration
2020–2025

Operating Agents
Jelle Laverge, Ghent University, Belgium

Participating countries (provisional)
Australia, Austria, Belgium, Brazil, Canada, P.R. China, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, UK, USA
Observers: Chile

Further information
www.iea-ebc.org

Indirect Evaporative Cooling

EBC ANNEX 85

Building energy use accounts for almost one-third of total energy use at present. Over 10% of the building energy use is used for air conditioning and indoor thermal comfort in hot seasons. Changing the air conditioning mode is one essential solution to meet the cooling demand without increasing power consumption and CO_2 emission. Although over 85% of cooling worldwide is achieved by mechanical refrigeration, more than 40% of the cooling can be provided by evaporative cooling in particular in dry climate zones.

The main types of evaporative cooling technologies are:

- direct evaporative cooling (DEC) to produce cooling air or cooling water, and
- indirect evaporative cooling (IEC) to produce cooling air or cooling water.

This project is studying the feasibility of IEC technologies and providing a roadmap for using these technologies in various dry climate zones. The following project tasks are included:

- a definition and field study,
- a feasibility study of IEC technologies,
- a study of fundamentals, and
- creation of a simulation tool and guidelines.

Objectives

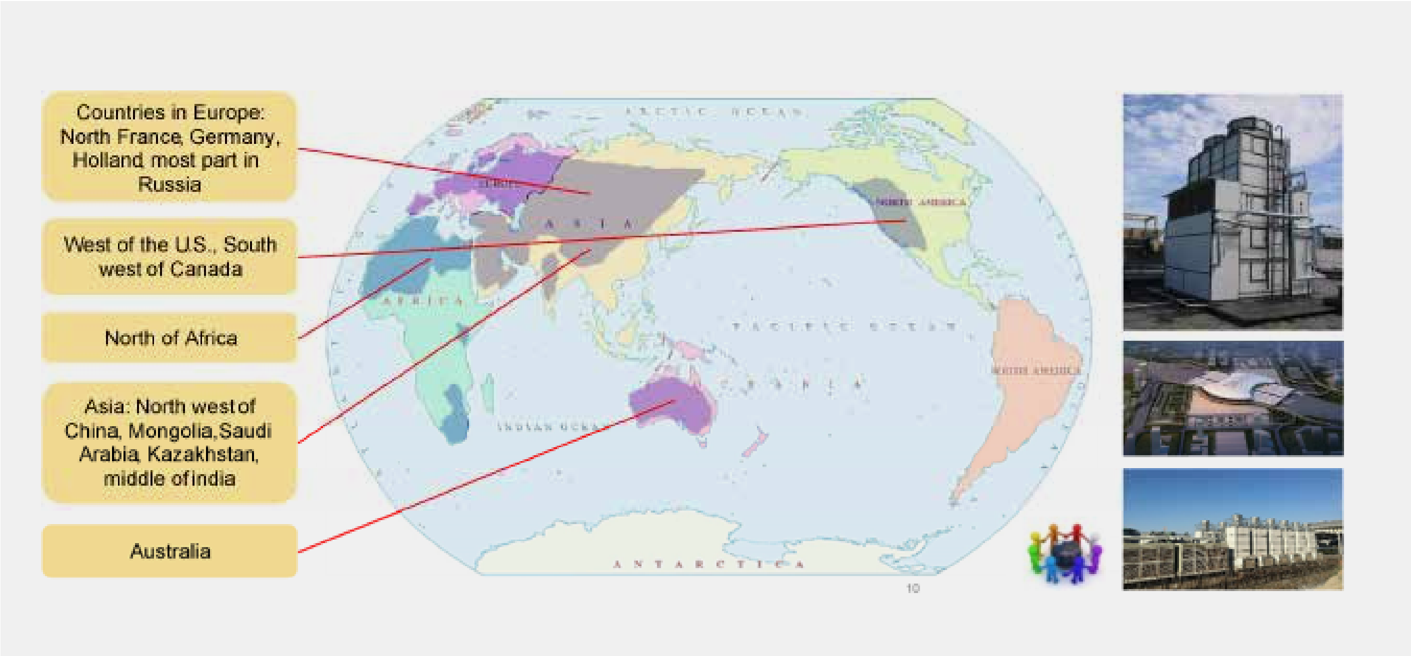
The aim of the project is to advance international co-operation on the development of IEC technologies. It is focusing on discovering the current challenges of using these technologies and reaching a scientifically-based and applicable roadmap for applying IEC in various dry climate zones. The project objectives are to:

- investigate IEC and conventional cooling systems to gather information on the equipment and maintenance costs, space requirements, environmental impacts and limitations of using IEC widely;
- carry out field testing of existing IEC systems in various climate zones to build a field test database;
- develop a general theoretical analysis method of IEC processes to guide the design of various IEC systems;
- evaluate water and electricity consumption of IEC processes;
- model IEC systems and create a tool to simulate different types of buildings under various dry climate zones;
- develop a guide for designing IEC systems for different types of buildings under various dry climates and water resource conditions.

Deliverables

The planned deliverables of the project include:

- a book, provisionally entitled: The Indirect Evaporative Cooling Source Book,
- a collection of case studies and feasibility analysis of indirect evaporative cooling technologies worldwide;
- reports on fundamental analysis results through thermal analysis and optimization;
- design guidelines for indirect evaporative cooling technologies;
- a simulation tool for various types of IEC technologies for different types of buildings and dry climate zones.



Climate regions potentially suitable for using indirect evaporative cooling technology.
Source: Building Energy Research Center, Tsinghua University / Map source: m.onegreen.net

Progress

The project one-year preparation phase started in July 2020. The first preparation-phase workshop was held online in September 2020. Five presentations were given by the representatives from the participating countries to share the present research and application of IEC technologies in several countries and climate zones.

The second preparation-phase workshop was held online in December 2020. The participation and leadership of each project task was discussed. During the workshop the content of each task was further refined and the method to reach the planned outcomes was agreed.
Between the preparation phase workshops, several online discussions were arranged with the researchers from each participating country to find out their research interests, expertise, and potential role in each task.

Meetings

The following meetings were held in 2020:

- The proposal development workshop was held in April 2020 to develop the project proposal.
- The first preparation phase workshop took place in September 2020.
- The second preparation phase workshop took place in December 2020.

Project duration
2020–2025

Operating Agents
Xiaoyun Xie, Building Energy Research Center, Tsinghua University, P.R. China

Participating countries (provisional)
Australia, Belgium, P.R. China, Denmark, France, Turkey, USA
Observer: Egypt

Further information
www.iea-ebc.org

Demand Management of Buildings in Thermal Networks

EBC ANNEX 84

Buildings are capable of offering flexibility to the power grid by smart control of heat pumps, electric vehicles (EVs), or white goods. There is a significant share of buildings, where heating and / or cooling demands are met by energy from a district heating / cooling network (DHC Net). DHC Nets and their potential for flexible and sustainable heating and cooling supply is considered as the strategic component of roadmaps towards low-carbon future and gas-free neighbourhoods.

However, meeting the milestones on decarbonisation roadmaps will not be feasible solely by technology development. This must be accompanied by engagement of occupants, customers, and users, since they are the ones to choose, use and communicate about new technological and user-friendly solutions. Therefore, buildings and customers should not anymore be simply considered as a simple demand-side variable. They should be viewed as communities that are capable of delivering technical solutions (e.g. different ways of storage) and systemic interventions (e.g. advanced control, pre-loading of buildings) and / or co-creating sustainable business cases for DHC Net development, and thus speeding up the process towards carbon-free societies.

There is a lack of previous projects that directly investigated which social and technological challenges at the demand side must be overcome in order to fruitfully harvest the energy flexibility potential offered by buildings to enhance the operation of DHC Nets. In that way, a viable and successful transition towards low-carbon future could be achieved.

Objectives

The overall project aim is to provide comprehensive knowledge and tools for successful activation of the demand management of buildings in DHC Nets. The project is investigating social, technological and management challenges, and how these can be overcome for various building typologies, climate zones and local conditions, as well as how digitalisation of heating demand (real-time data from smart meters) can speed up the activation process.

The specific objectives of the project are to:

- map partners / actors involved in the energy chain in DHC Nets for different building typologies, network configurations and local legal frameworks;
- provide recommendations for collaboration models / instruments that are viable and beneficial for all partners;
- evaluate and provide design solutions for new and existing building heating and cooling substations and installations for successful demand management;
- develop methods and tools to utilize smart heat meter data for real-time data modelling of DHC Nets;
- provide knowledge from and drive adaptation and visualization of project results through case studies.

Deliverables

The planned deliverables from this project include:

- comprehensive knowledge about the actors involved in the demand response of building in thermal networks,
- design guidelines for new and existing DHC substations and heating / cooling installations with specification of minimum technological requirements for enabling demand management beneficial for buildings and DHC Nets,
- a method to derive new dynamic building characteristics from real-time data from smart heat meters used for DHC Nets real-time modelling, and
- case studies of demand management at either single technology, building, or DHC community level.

Progress

During 2020, the project proposal was developed by gathering the inputs and contributions during an online workshop. A one-year preparation phase for the project was approved at the June 2020 EBC Executive Committee Meeting. The development of the work plan and further clarification of the deliverables and outputs were discussed during the first preparation workshop.

Meetings

In 2020, the following online meetings took place:

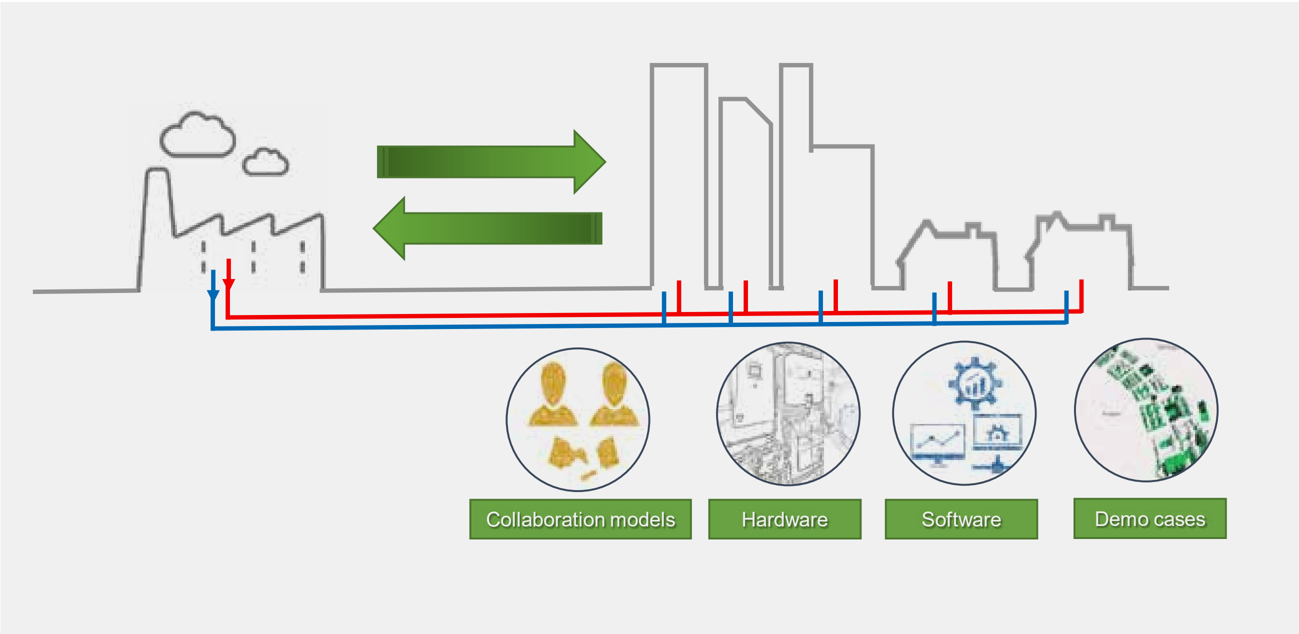
– The 2nd development workshop took place in May 2020,
– The 1st preparation workshop was held in September 2020.

Project duration
2020–2025

Operating Agents
Anna Marszal-Pomianowska, Aalborg University, Denmark

Participating countries (provisional)
Austria, Belgium, P.R. China, Denmark, Italy, R. Korea, the Netherlands, Singapore, Spain, Sweden, Turkey, UK

Further information
www.iea-ebc.org



The scope of the project and key research topics, including collaboration models, hardware and software and case studies.
Source: Anna Marszal-Pomianowska, Aalborg University

Ongoing Research Projects

BUILDING ENERGY CODES

(EBC WORKING GROUP)

POSITIVE ENERGY DISTRICTS
(EBC ANNEX 83)

ENERGY FLEXIBLE BUILDINGS
TOWARDS RESILIENT LOW CARBON ENERGY SYSTEMS

(EBC ANNEX 82)

DATA-DRIVEN SMART BUILDINGS

(EBC ANNEX 81)

DATA-DRIVEN SMART BUILDINGS

(EBC ANNEX 81) RESILIENT COOLING OF BUILDINGS

(EBC ANNEX 80)

OCCUPANT-CENTRIC BUILDING DESIGN AND OPERATION
(EBC ANNEX 79)

SUPPLEMENTING VENTILATION WITH GAS-PHASE AIR CLEANING,
IMPLEMENTATION AND ENERGY IMPLICATIONS

(EBC ANNEX 78)

ASSESSING LIFE CYCLE RELATED ENVIRONMENTAL IMPACTS
CAUSED BY BUILDINGS

(EBC ANNEX 77 – SHC TASK 61)

CITIES AND COMMUNITIES
(EBC WORKING GROUP)

DEEP RENOVATION OF HISTORIC BUILDINGS
TOWARDS LOWEST POSSIBLE ENERGY DEMAND AND CO_2 EMISSION
(EBC ANNEX 76 – SHC TASK 59)

COST-EFFECTIVE BUILDING RENOVATION AT DISTRICT LEVEL
COMBINING ENERGY EFFICIENCY AND RENEWABLES
(EBC ANNEX 75)

COMPETITION AND LIVING LAB PLATFORM
(EBC ANNEX 74)

TOWARDS NET ZERO ENERGY RESILIENT PUBLIC COMMUNITIES
(EBC ANNEX 73)

ASSESSING LIFE CYCLE RELATED ENVIRONMENTAL IMPACTS
CAUSED BY BUILDINGS
(EBC ANNEX 72)

BUILDING ENERGY PERFORMANCE ASSESSMENT
BASED ON IN SITU MEASUREMENTS
(EBC ANNEX 71)

BUILDING ENERGY EPIDEMIOLOGY:
ANALYSIS OF REAL BUILDING ENERGY USE AT SCALE
(EBC ANNEX 70)

STRATEGY AND PRACTICE OF ADAPTIVE THERMAL COMFORT
IN LOW ENERGY BUILDINGS
(EBC ANNEX 69)

AIR INFILTRATION AND VENTILATION CENTRE - AIVC
(EBC ANNEX 5)

Building Energy Codes

EBC WORKING GROUP

It is widely recognized and well documented that building energy codes, also known as building energy standards, are an effective policy tool for improving the energy efficiency of residential and non-residential buildings. However, even in jurisdictions with extensive history in this area, building energy codes are facing key issues such as:

– a need for faster and easier methods to check the compliance of buildings with codes;
– the need to meet ambitious policy objectives such as zero net energy construction standards;
– the challenge of integrating various distributed energy resources including solar, electric vehicles, and grid-interactive and flexible technologies.

Against this backdrop, the EBC Working Group on Building Energy Codes (BECWG) was formally launched in 2019. The creation of a Working Group dedicated to the consideration of building energy codes in EBC Annexes and the integration of Annex results into building codes can leverage this impactful tool for use in collaboratively advancing energy efficiency in buildings and communities.

Objectives

The project objectives are to:

– enhance understanding of impactful options and practices regarding building energy codes across different countries;
– provide methods for cross-national comparisons that lead to meaningful information sharing;
– foster collaboration on building energy code issues that leads to enhanced building energy code programmes by incorporating new technologies, practices and issues.

Deliverables

The project is undertaking three major umbrella activities to achieve these objectives, which are listed below:

– Activity 1: Exchange on Building Energy Code Practices – This activity involves several opportunities for countries to exchange information on their building energy code systems, including a quarterly webinar series, as well as meetings associated with EBC Executive Committee meetings to better coordinate and share research progress. One recurring meeting is the new Annual Building Energy Code Symposium.
– Activity 2: Comparative Analysis – As part of this activity, the project is developing a survey and reports around various topics of interest. Examples of topics include an overview comparing building energy codes in project participating countries and defining methods and terminology; building energy codes in existing buildings; building energy code compliance best practices, including means of assessing code compliance post construction; case studies of how new technologies impact and are integrated into national codes.
– Activity 3: Dissemination – Through the use of multiple communication platforms (for example the EBC website, conference papers, journals), the project is working on disseminating the analysis and knowledge obtained back to the wider community and collaborating with a diverse group of stakeholders to encourage improvements and innovation in practices.

The project is collaborating closely with the International Code Council, ASHRAE and European Union activities.

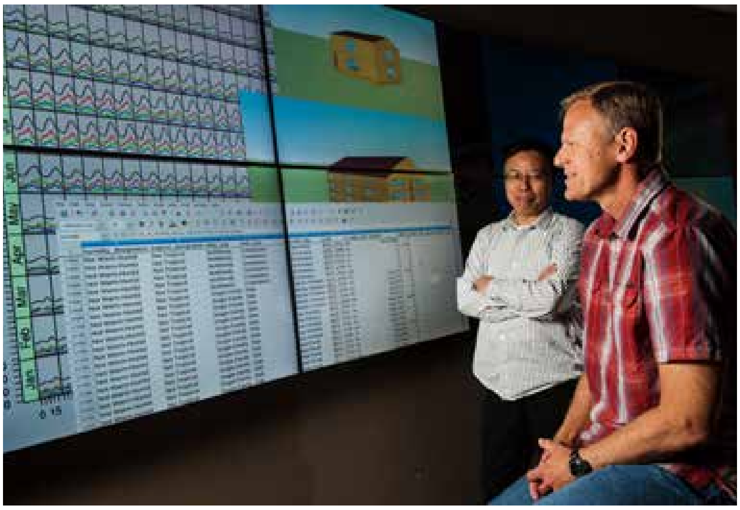
Progress

The project hosted four webinars in 2020 on the following topics:

– building energy issues and the COVID-19 response;
– towards net or nearly zero energy buildings;
– energy codes for existing buildings;
– building code virtual diagnostics and inspections.

Researchers use computer simulations to conduct studies on energy usage in large buildings. Many countries are switching to performance-based codes which rely on building energy simulation software to simulate energy use in a designed building that is compared either to a reference building or to a specified requirement. These codes require more training and analytical understanding to demonstrate code compliance via whole-building simulation.

Source: Andrea Starr, Pacific Northwest National Laboratory, 2019



A researcher demonstrates how advanced building controls in energy-using equipment such as heating and cooling systems can reduce energy use and improve building operations. Many jurisdictions are implementing new code requirements related to building controls.

Source: Pacific Northwest National Laboratory, 2020

The second Annual Symposium took place online in November 2020. The project held a working group business meeting followed by technical presentations on several topics including integrating research and technology breakthroughs in codes and adapting / expanding code coverage in places with hot climates. The project also held the second event of the symposium in collaboration with the U.S. National Energy Codes Conference in November 2020.

During 2020, a proceedings paper entitled 'Codes Around the Globe: A Cross-national Comparison of Building Energy Codes' was produced for the 21st biennial Summer Study of the American Council for an Energy-Efficient Economy that took place in August 2020. Further, work on two reports was started on codes for existing buildings and code compliance best practices.

Meredydd Evans (BECWG Operating Agent / Pacific Northwest National Laboratory) and Michael Donn (EBC BECWG Co-Chair / Victoria University of Wellington) begun serving as Guest Editors for the special issue of the journal Atmosphere on 'Building Energy Codes and Greenhouse Gas Mitigation.' They invited researchers to contribute original research articles, as well as review articles.

The project launched an e-newsletter series beginning in July 2020 and the Working Group webpage on the EBC website in April 2020.

Meetings

The following meetings were held in 2020:

- The EBC Building Energy Codes Working Group Annual Symposium was held in November 2020.
- A webinar on 'Energy Codes Around the World: A Joint U.S. National Energy Codes Conference and EBC BECWG Session' took place in November 2020.

Project duration

2019–2022

Operating Agents

David Nemtzow, Department of Energy, USA
Michael Donn, Victoria University of Wellington, New Zealand
Meredydd Evans, Pacific Northwest National Laboratory, USA

Participating countries

Australia, Brazil, Canada, P.R. China, Ireland, Italy, Japan, New Zealand, Portugal, Singapore, Sweden, UK, USA

Further information

www.iea-ebc.org

Positive Energy Districts

EBC ANNEX 83

The basic principle of a positive energy district (PED) is to create a district within the city that is capable of producing more energy than it consumes, flexible enough to respond to the energy market situation, and in addition to this, contribute to improving the quality of life and wellbeing of the residents. PEDs should also support minimizing their impacts on the connected centralized energy networks by offering options for increasing onsite load-matching and self-consumption, technologies for short and long term storage, and providing energy flexibility with smart control. PEDs can include all types of buildings present in the city environment and they are not isolated from the energy grid. In the research community, the PED is a rising concept for shaping cities in the near future into carbon neutral communities. Reaching the goal of a PED requires firstly improving energy efficiency, secondly cascading local energy flows by making use of any surpluses, and thirdly using low-carbon energy production to cover the remaining energy use. Smart control and energy flexibility are needed to locally match demand with production as far as practical, and also to minimize the burdens and maximize the usefulness of a PED on the grid at large.

At a global level, the need for energy efficiency and an increased share of renewable energy sources is evident as is the crucial role of cities due to the rapid urbanization rate. As a consequence of this, the research work related to PEDs has accelerated in recent years. A common shared definition, as well as technological approaches and methodological issues related to PEDs are still unclear in their development and a global scientific discussion is needed. A common platform is required to facilitate such collaboration and this is provided by this project with the ultimate aim of generating opportunities for creating such interdisciplinary solutions.

Objectives

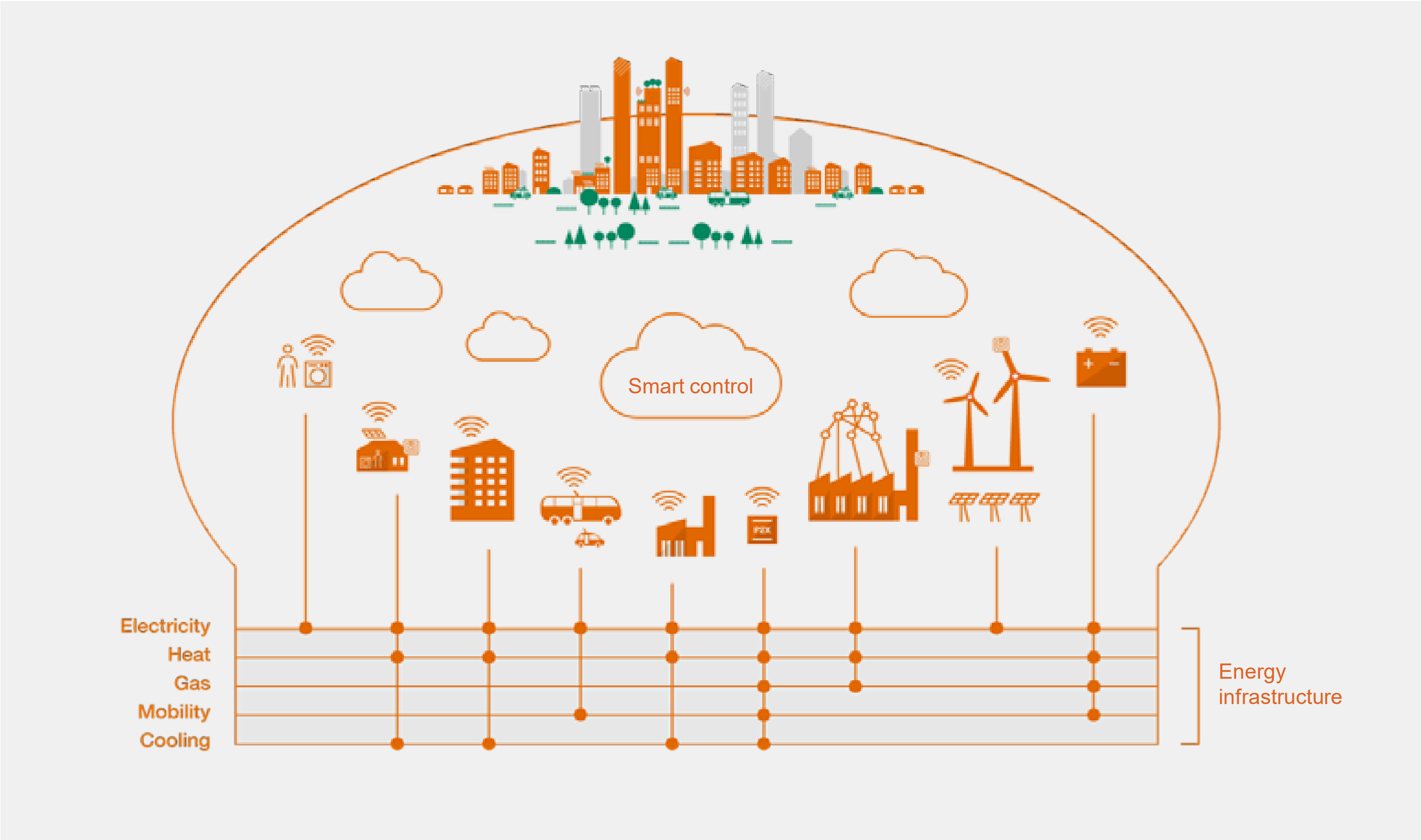
Through the EBC programme, the project is enhancing international co-operation on PED development. The main objectives and scope are as follows:

- Map the relevant city, industry, research, and governmental (local, regional, national) stakeholders and their needs and roles to inform the specific project objectives. The main purpose is to ensure the involvement of the principal stakeholders in the development of relevant definitions and recommendations.
- Create a shared in-depth definition of a positive energy district by means of a multi-stakeholder governance model. So far, international activities have developed generalized definitions that leave many questions open.
- Develop the required information and guidance for implementing the necessary technical solutions (at building, district and infrastructure levels) that can be replicated and ultimately scaled up to the city level, giving emphasis to the interaction of flexible assets at the district level and also economic and social issues such as acceptability.
- Explore novel technical and service opportunities related to monitoring solutions, big data, data management, smart control and digitalisation technologies as enablers of PEDs.
- Develop the required information and guidance for the planning and implementation of PEDs, including both technical and urban planning. This includes economic, social and environmental impact assessments for various alternative development paths.

Deliverables

The planned main project outcomes are as follows:

- definitions and key concepts for positive energy districts,
- methods, tools and technologies for realizing positive energy districts,
- governance principles and impact assessment for positive energy districts, and
- case studies on positive energy districts and related technologies.



Local energy needs in a positive energy district are minimized by improving energy efficiency, using renewable energy production and smart control. Smart control and energy flexibility are needed to match demand with energy production and storage.

Source: VTT Technical Research Centre of Finland Ltd.

Progress

The project entered its working phase in November 2020. During 2020, the project plan was developed and the participants' contributions gathered using an online platform and in online workshops. The plan describes the need, aims, approaches and planned outcomes of the project. The first activities included development of data gathering from potential case areas and planning a workshop for collaborating with other EBC Annexes, projects and initiatives.

Meetings

Two online workshops were held in March and October 2020 to develop the project plan.

Project duration
2019 – 2024

Operating Agents
Pekka Tuominen and Francesco Reda, VTT Technical Research Centre of Finland Ltd., Finland

Participating countries
Australia, Austria, Belgium, Canada, P.R. China, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK

Further information
www.iea-ebc.org

Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems

EBC ANNEX 82

In many countries, the share of renewable energy sources is increasing in parallel with an extensive electrification of the energy demand. The electrification of the demand emanates from, for instance, the replacement of internal combustion engines cars with electric vehicles (EVs), or replacement of fossil fuel heating systems with energy efficient heat pumps. These changes, on both the demand and supply sides, impose new challenges to the management of energy systems. System operators must now design solutions to counter the increased variability and limited control of the energy supply, as well as increased load variations over the day. Energy system electrification also threatens to exceed already strained limits in peak demand and stability.

A paradigm shift is the movement from using traditional systems, in which energy supply follows demand, to systems where the demand side considers available supply. Therefore, flexible energy systems, where demand is responsive to supply, should play an important part in a holistic solution. Such responsive systems are expected to replace the traditional generation and distributon systems, resulting in a fully integrated and bidirectional network capable of seamlessly incorporating distributed storage and demand response. In this context, strategies to ensure the security and reliability of the energy supply involve simultaneous coordination of distributed energy resources, energy storage and flexible loads, connected to smart electrical and thermal distribution networks.

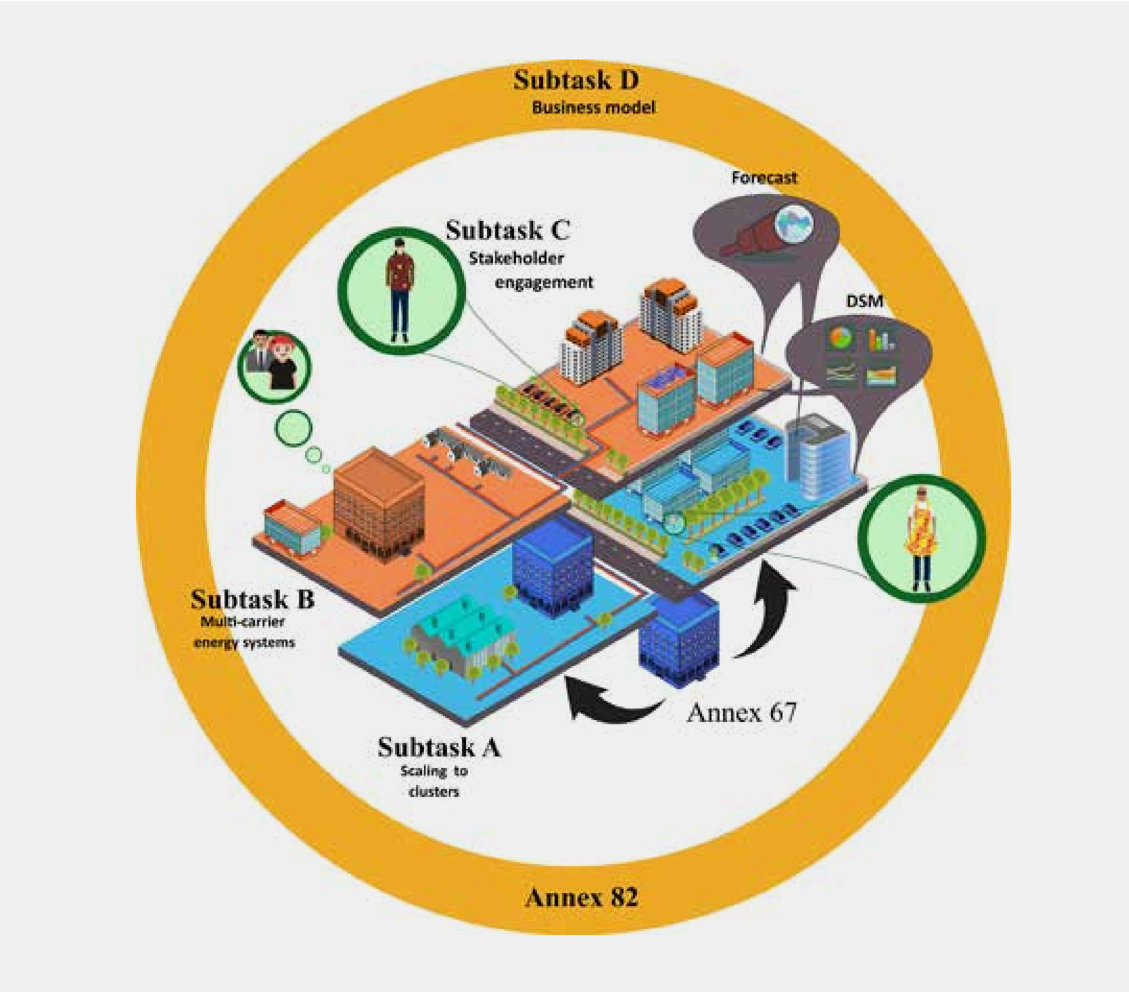
The aim of this project is to extend the findings from the completed EBC project, 'Annex 67: Energy Flexible Buildings' (see page 54). That project has revealed areas where further work is needed to ensure that energy flexibility from buildings would actually be an asset for future energy networks. The areas identified are listed below:

- scaling from single buildings to clusters of buildings (aggregation);
- energy flexibility and resilience in multi-carrier energy systems (electricity, district heating / cooling and gases);
- acceptance / engagement of the stakeholders;
- business models.

Objectives

The project objectives are as follows:

- demonstration and further development of the project characterization and labelling methods to help them become commonly accepted;
- investigation of aggregation of energy flexibility from clusters of buildings both physically connected and commercially connected (not necessarily physically connected) via an aggregator;
- investigation of the aggregated potential of energy flexibility services from buildings and clusters of buildings located in different multi-carrier energy systems;
- demonstration of energy flexibility in clusters of buildings through simulations, experiments and field studies;
- mapping the barriers, motivations and acceptance of stakeholders associated with the introduction of energy flexibility measures in buildings and clusters of buildings;
- investigation of how to include the views of stake-holders in the development of feasible technical solutions;
- investigation and development of business models for energy flexibility services for energy networks;
- recommendations to policy makers and government entities involved in the shaping of future energy systems.



The structure and background of EBC Annex 82.
Source: Jean-Nicolas Louis, University of Oulu, Finland

Deliverables

The planned deliverables from this project include:

- a summary of the project findings,
- a collection of case studies,
- recommendations for policy makers and government entities,
- a project summary report.

Progress

In 2020, the project legal text and workplan were developed and refined during two preparation workshops. Although the working phase did not start in 2020, discussions on the literature review were initiated. It was decided to include common exercises on selected research questions related to the method of characterization of energy flexibility previously developed in EBC Annex 67.

Meetings

The following meetings were held online in 2020:

- The 1st preparation workshop took place in April 2020.
- The 2nd preparation workshop took place in September 2020.

Project duration
2019–2024

Operating Agent
Søren Østergaard Jensen, Danish Technological Institute, Denmark

Participating countries
Austria, Belgium, Canada, P.R. China, Denmark, Finland, France, Germany, Ireland, the Netherlands, Portugal, Spain, Switzerland, UK, USA

Further information
www.iea-ebc.org

Data-Driven Smart Buildings

EBC ANNEX 81

Digital technology has energy saving potential through advanced control and operation of building heating, ventilation and air-conditioning (HVAC) systems. Emerging digital technologies include:
- the Internet of Things (IoT),
- artificial intelligence (AI) and data analytics, and
- sharing business models.

Despite the energy saving potential of digitalisation, progress towards digitalization of the building services industry has been slow, and has not reached its full potential. The project is examining how data-driven approaches can optimize energy use by HVAC equipment, including data-driven control strategies and fault diagnostics. It is also investigating barriers and solutions for accessing building services data, so that energy efficiency software solutions can be scaled. The research is considering a range of issues and opportunities including:
- the applicability of open data concepts for driving innovation and competition,
- data management standards and semantic web technologies for enhancing device interoperability, software portability and data reusability,
- development and implementation of energy efficiency solutions using data-driven approaches, such as model predictive control (MPC) and fault detection and diagnosis,
- federation of data and implementation of data-driven applications across individual buildings, precincts and electricity networks, and
- data-driven approaches for benchmarking building operation underpinning energy efficiency policies, programs and business models.

The project is planning to host one or more competitions to help stimulate global innovation in the field of predictive maintenance and optimisation, consistent with the objectives of the Mission Innovation Affordable Heating and Cooling Innovation Challenge.

Objectives

The project objectives are to:
- provide knowledge, standards, protocols and procedures for low-cost high-quality data capture, sharing and utilization in buildings;
- develop a methodology for control-oriented building modelling that facilitates testing, developing and assessing the impacts of alternative energy efficient building HVAC control strategies in a digital environment;
- develop building energy efficiency (and related) software applications that can be used and ideally commercialized for reducing energy use in buildings;
- drive adoption of project results through case studies, business model innovation and results dissemination.

Deliverables

The planned deliverables from this project include:
- a proposal for governments to lead by example in the use of data-driven smart building solutions in their own buildings, and particularly to adopt the HVAC data-sharing principles and processes developed in this project;
- a report on functional-requirements for a 'minimum viable product' Open Data Platform that could support low transaction cost data-sharing amongst an ecosystem of building services innovators;
- an online repository of exemplar data sets for building analytics research;
- data-driven control-oriented building models suitable for model predictive control in different building typologies and scenarios;
- a software repository, containing prototype software implementations and application descriptions for energy saving HVAC services;
- a grand challenge / hackathon style competition for incentivizing innovators to develop data-driven applications.

Pacific Northwest National Laboratory (PNNL) has developed a new deep model predictive control (MPC) method that adapts by learning from new data and is generic enough that it can be used with any type of building.

Source: Composite image by Shannon Colson, Pacific Northwest National Laboratory

Progress

The project working phase started in June 2020. Work commenced on the production of a range of state-of-the-art reports relating to data governance, digital data platforms, and data formats and schemas. The aim of these reports is to better understand the commercial landscape for managing data between industry stakeholders, and to identify opportunities for streamlining data exchange and software as a service innovation.

Surveys were issued calling for MPC test cases and case study examples of smart building implementations, from which a number of examples were identified. Data collection from these examples was used to establish benchmarking capability for testing the efficacy of MPC algorithms. The case study examples are being further used to understand and disseminate information on the techno-economic challenges associated with the adoption of digital technologies. These support development of policy-relevant recommendations.

Preparation has commenced for potentially hosting one or more data-driven challenges, utilising the Kaggle data-science online community platform. The challenges will adopt a format similar to the ASHRAE Great Energy Predictor Competition, where 3,600 teams competed using machine learning techniques trained on over 20 million data points from almost 1,500 buildings. A range of new data-driven challenges are being considered.

A LinkedIn Group was established for day-to-day communication of activities, events, and findings in the field of data-driven smart buildings.

Meetings

The following meetings were held in 2020:

- The final Preparation-Phase Expert Meeting was held online in April 2020.
- The first Research Results Webinar was held in June 2020.
- The first Expert Meeting was held online in November 2020.
- The second Research Results Webinar was held in September 2020.

Project duration
2020–2024

Operating Agents
Stephen White, CSIRO, Australia

Participating countries
Australia, Austria, Belgium, Canada, P.R. China, Denmark, Ireland, Japan, the Netherlands, Norway, Singapore, Sweden, UK, USA

Further information
www.iea-ebc.org

Resilient Cooling of Buildings

EBC ANNEX 80

The use of energy for space cooling is growing faster than for any other end use in buildings. Rising demand for space cooling is already putting enormous strain on electricity systems in many countries, as well as driving up greenhouse gas emissions. There is no doubt that the global demand for space cooling will continue to grow for decades to come, with meeting peak electricity demands becoming a major challenge. It is essential to curb the rapid growth in demand for air conditioning and to achieve sustainable development of the cooling sector. To this end, the project is investigating resilient cooling applications according to a variety of external parameters such as climate, building typologies, internal loads and occupancy profiles, various levels of BMS capabilities and automation, new buildings and retrofitting of existing buildings.

Objectives

The general objective of the project is to support a rapid transition to an environment in which resilient low energy and low carbon cooling systems are the mainstream and are the preferred solutions for cooling and avoiding overheating issues in buildings. The specific objectives of the project are to:

- quantify the potential benefits of resilient cooling for a wide range of building typologies, climate zones, functional specifications and other boundary conditions;
- systematically assess benefits, limitations and performance indicators of resilient cooling;
- identify barriers to implementation and conduct research to overcome such barriers and facilitate implementation on a large scale;
- provide guidelines for the integration of resilient cooling systems in energy performance calculation methods and regulations, which includes specification and verification of key performance indicators;
- extend the boundaries of existing low energy and low carbon cooling solutions and their control strategies, and develop recommendations for flexible and reliable resilient cooling solutions that can create comfortable conditions under a wide range of climatic conditions;
- investigate the real performance of resilient cooling solutions through field studies, and analyse performance gaps and develop solutions to overcome them;
- analyse, exchange and encourage policy actions, including minimum energy performance standards, building codes, financial incentives and product labelling programmes, educational initiatives, as well as others;
- establish links with other international programmes, such as KIGALI – Cooling Efficiency Programme, Mission Innovation Challenge #7 and other related IEA Technology Collaboration Programmes.

Deliverables

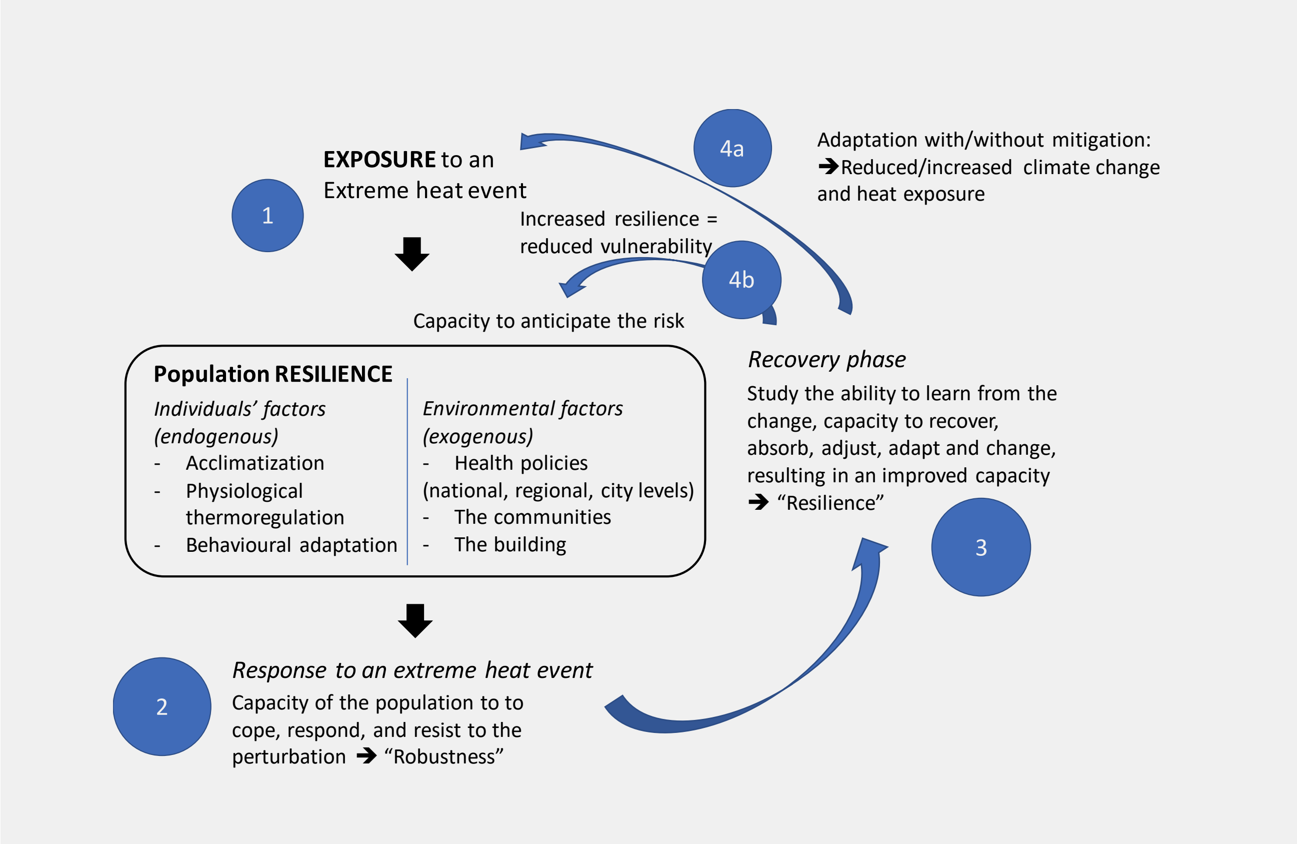
The project is producing the following deliverables:

- an overview and state-of-the-art report for resilient cooling,
- a resilient cooling source book,
- a report on resilient cooling field studies,
- resilient cooling design and operation guidelines, and
- recommendations for policy, legislation and standards.

Progress

In 2020, the paper 'Developing an understanding of resilient cooling: a socio-technical approach City and Environment Interactions' was submitted to Elsevier City and Environment. This paper reviewed risk management and natural hazard literature from diverse disciplines to develop a conceptual framework for understanding the breadth, depth, and scope of resilient cooling as a disaster risk management strategy to deal with temperature hazards. It characterises this hazard and its impact on the system of systems that exist in human societies.

Linking the scientific realm with practical application is crucial for the success of the project. Therefore the 'Advisory Board of Practitioners of Resilient Cooling' has been set up in cooperation with venticool and EBC Annex 5: Air Infiltration and Ventilation Centre (AIVC). Exchange of expertise of project participants and designers (architects,



A framework for population resilience to temperature hazards, from 'Developing an understanding of resilient cooling: a socio-technical approach City and Environment Interactions' (Miller et al, 2020)

Source: Anaïs Machard, La Rochelle University

consultants), professional users and technology companies engaged in the resilient cooling of buildings is being promoted through quarterly meetings and webinars. So far over 30 external partners from ten different countries have registered to join the advisory board.

Two papers were submitted to the journal Energy and Buildings. The first, 'Resilient cooling of buildings to protect against heat waves and power outages: key concepts and definition' has been published. This paper focuses on a scoping review covering 90 documents of existing resilience definitions and various approaches towards possible resilient buildings. In conclusion, the paper suggests a definition and a set of criteria - vulnerability, resistance, robustness, and recoverability - that can help to develop intrinsic performance-driven indicators. The second paper, 'Resilient cooling strategies - a critical review and qualitative assessment' performed a critical review on the state-of-the-art of cooling strategies, with attention to their performance under heatwaves and power outages. A definition of resilient cooling has been proposed and four capacities for resilience described - absorptive, adaptive, restorative, and recovery - and used to qualitatively evaluate the resilience of each strategy. Furthermore, many project participants took the opportunity to publish national research items in the project within a special issue of Energy and Buildings with the theme 'Building Cooling for Sustainable Societies'.

Meetings

The following meetings were convened in 2020:

- The 2nd Expert Meetings was held online in April November 2020.
- The 3rd Expert Meetings was held online in November 2020.

Project duration
2019–2023

Operating Agent
Peter Holzer, IBR&I Institute of Building Research and Innovation, Austria

Participating countries
Austria, Australia, Belgium, Canada, P.R. China, Denmark, France, Italy, Japan, UK, USA

Further information
www.iea-ebc.org

Occupant-centric Building Design and Operation

EBC ANNEX 79

Occupants' interactions with their interior environments have been identified as a major influence on building performance. Reasons for these interventions are mostly comfort-related, including among others, dissatisfaction with the building automation or system controls, inappropriately designed or malfunctioning interfaces, or disregard of occupants' needs in buildings design and operation. According to different studies, the energy use of buildings can vary by up to a factor of two as a result of occupants' interventions.

In recent years, remarkable progress in research on experimental methods, modelling and implementation of occupant behaviour models in building simulation platforms has been made. However, design and building operation practice shows that many of the models do not represent the manifold human interactions with a building appropriately enough, and that there is no guidance for designers and building managers on how to apply occupant behaviour models in standard practice. This project is seeking to bridge this gap between science and building practice, to provide new insights into comfort-related occupant behaviour and interactions in buildings, and to exploit new data mining techniques to enhance occupant modelling.

Objectives

The overall project goal is to integrate and implement knowledge and models of occupancy and occupant behaviour into the design process and building operation to simultaneously improve energy performance and occupant comfort. Within this objective, key areas of focus include:

- multi-domain indoor environment exposure and its impact on energy-related behaviour;
- interfaces and the design features that affect usability and promote energy-efficient behaviours;
- application of 'big data' and sensing to generate new knowledge about occupants;
- development of occupant-centric building design and control strategies.

Deliverables

The main planned project outcomes are as follows:

- comprehensive literature reviews for the topics tackled;
- a unified theoretical framework for perceptual and behavioural theory of building occupants;
- guidelines for research methods to evaluate occupant comfort and building interfaces, perform occupant data collection, and apply data analytics to occupant data;
- a report on best practices for building interfaces, occupant-centric design workflows, and optimal building control strategies;
- a report on best practices for interface design and evaluation criteria of new products considering multi-aspect comfort;
- recommendations on occupant modelling in building energy codes;
- recommendations for standards on occupant metering / sensing infrastructure and controls.

Progress

In 2020, the comprehensive literature reviews have been carried out and progress made on establishing a generalized methodology for collecting information on multi-domain (indoor environmental quality and behaviour) studies. Further, a survey was launched on occupants' willingness to share information, e.g. for modelling purposes. Another activity reviewed the current status and future directions of multi-domain building evaluation and rating systems. To support future experimental work in this field, test facilities for comfort, productivity, and energy saving studies have been reviewed world-wide. Literature reviews on data sources for studying and modelling occupant behaviour and data-driven occupant modelling were completed.

The work has been extended to develop the ASHRAE Global database on occupant behaviour data. Further, work on an evaluation protocol and a benchmark for data-driven occupant-centric modelling with large data has been initiated. Additionally, methods have been developed to anonymize occupant data such that the occupants cannot be

The 3rd Working Phase Expert Meeting of EBC Annex 79 was hosted as an online (hybrid) meeting by the University of Southern Denmark in September 2020.
Source: Mikkel Baun Kjærgaard University of Southern Denmark

identified from their recorded data. Finally, an investigation of metadata schemas for occupant presence and actions data was started.

Work was started on developing workflows and standardized methods for occupant-centric building design. Besides recommendations for the representation of occupants in building codes, this includes simulation-based occupant-centric design procedures and guidelines to choose fit-for-purpose occupant modelling approaches. Further, interviews with building design stakeholders were initiated to develop effective communication mechanisms for occupant-related assumptions. Another focus was on synthetic occupant models and 'big data' analytics. With regard to case studies, simulation-aided occupant centric design explorations have been developed and applied.

Real-world implementations of occupant-centric controls (OCC) have been reviewed and a survey was started to investigate common occupant sensing technologies for energy management and to determine how these technologies are used and supplemented with operator expertise. An OCC simulation environment has been set up for the development and assessment of occupant-centric control algorithms and for investigating demand response from an occupant-centric perspective. A major activity dealt with case studies, particularly with the integration of occupant-centric control algorithms to the building automation systems. In addition to this, several project cross-task activities have been launched. These are areas that require numerous perspectives and disciplines. Topics included the availability and quality of occupant data in the early design phase, advancing agent-based modelling of occupation for integration into building simulation tools, and multi-disciplinary aspects of human-building interaction and interface design.

Three seminars, workshops, panels at three different international conferences were organized in 2020 to present project research and related topics. Meanwhile, the project participants have been collaborating with ASHRAE to add a section on occupant modelling to their Fundamentals Handbook. Additionally, the project participants have actively disseminated research to industry via the ASHRAE Journal.

Meetings

The following meetings were held in 2020:

- The 2nd Working Phase Expert Meeting took place in Southampton, UK and online in April 2020.
- The 3rd Working Phase Expert Meeting took place in Odense, Denmark and online (hybrid) in September 2020.

Project duration
2018 – 2023

Operating Agents
Andreas Wagner, Karlsruhe Institute of Technology, Germany
Liam O'Brien, Carleton University, Ottawa, Canada

Participating countries
Australia, Austria, Belgium, Canada, China, Denmark, Germany, Italy, the Netherlands, Norway, Singapore, Sweden, Switzerland, UK, USA

Further information
www.iea-ebc.org

Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications

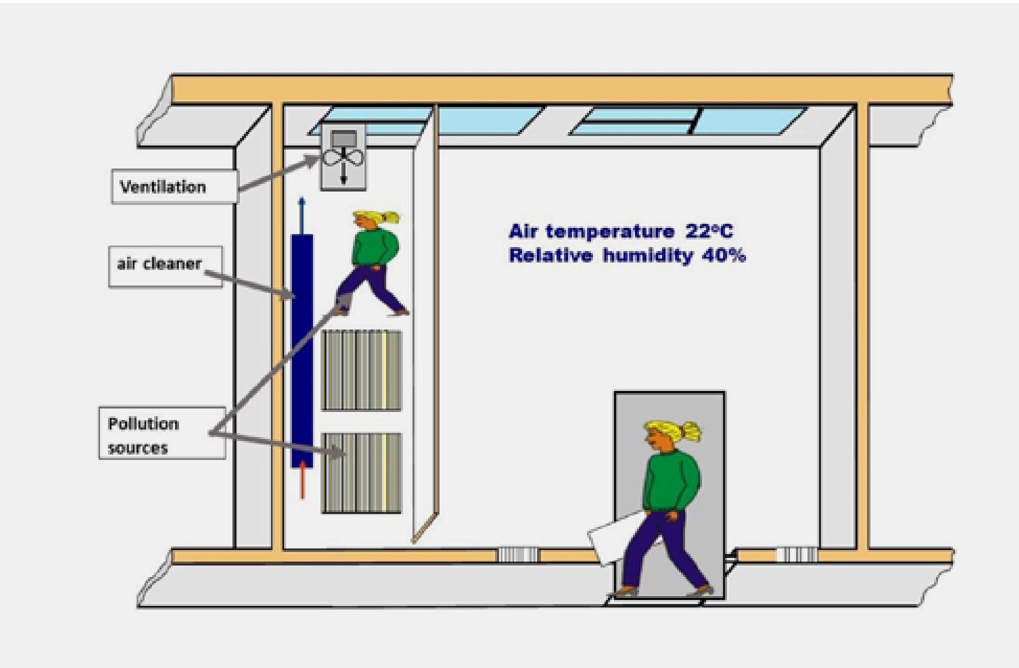
EBC ANNEX 78

Ventilation accounts for approximately 20% of the global energy use for providing an acceptable indoor environment. Moreover, the requirements for ventilation in most standards and guidelines assume acceptable quality of (clean) outdoor air.

Worldwide, there is an increasing number of publications related to air cleaning and there are also increasing sales of gas-phase air cleaning products. This introduces a demand for verifying the influence of using air cleaning on indoor air quality, comfort, well-being and health. It is thus important to learn whether air cleaning can supplement ventilation with respect to improving air quality, i.e. whether it can partly substitute the ventilation rates required by standards. Finally, the energy impact of using air cleaning as a supplement to ventilation needs to be estimated. This project is focusing on gas-phase air cleaning, but does not include filtration.

In some locations in the world, the outdoor air quality is so bad that it may be better to avoid ventilation. In such cases, the alternative to using ventilation is to substitute it with air cleaning, so that the indoor air can be kept at high quality. Even when outdoor air is of good quality, the use of air cleaning substituting ventilation air could reduce the rate of outside air supplied indoors and thereby energy for heating / cooling of ventilation air and for transporting the air (fan energy) can be saved.

Since it is expected that air cleaning may in parallel improve the indoor air quality and reduce energy use for ventilation, it should be considered as a very interesting technology that can be used in the future. There is, however, a need for better evaluation of its potential to improve indoor air quality (and substituting for ventilation) and the energy implications of using gas-phase air cleaning. There is also a need to develop standard test methods of the performance of air cleaning devices. Consequently, this EBC project has been established on the use of gas-phase air cleaning technologies.



Test of a gas phase air cleaner using measurement of perceived air quality by judges entering the space. Pollution sources include emissions from building products and people.
Source: Pawel Wargocki

Objectives

The project objectives are to:

- bring researchers and industry together to investigate the possible energy benefits of using gas-phase air cleaners (partly substituting for ventilation);
- establish procedures for improving indoor air quality, or reduced amount of ventilation by gas-phase air cleaning;
- establish a test method for air cleaners that considers the influence on the perceived air quality and substances in the indoor air.

Deliverables

The following deliverables are being produced in the project:

- a method for predicting the energy performance of gas-phase air cleaning technologies and the possible reduction of energy use for ventilation;
- a validated procedure for supplementing (partly substituting) required ventilation rates with gas-phase air cleaning;
- a test method for air cleaning technologies that includes chemical measurements and perceived air quality as measures of performance;
- a report on the long-term performance of air cleaning;
- models for predicting the performance of gas phase air cleaning equipment.

Progress

The focus in 2020 was on defining the concept for substituting ventilation with gas phase air cleaning. A first paper on this topic was published and presented at the Indoor Air 2020 virtual conference.

Work was carried out to review and describe the principles of gas phase air cleaning technologies. The review included the technologies such as sorbent air cleaning, photocatalytic oxidation, plasma oxidation, ultraviolet germicidal irradiation, non-thermal catalyst oxidation and botanic air cleaning.

The energy impact of using air cleaners was also examined. This work was presented at the Indoor Air 2020 virtual conference and a paper was submitted to the BS2021 conference. Air cleaners can either substitute part of the required ventilation with outdoor air or their operation will result in a higher category (class) of indoor air quality in buildings. When substituting the ventilation with outdoor air, a higher carbon dixoide (CO_2) level will be acceptable for the same indoor air quality category. This means the CO_2 set-point for demand-controlled ventilation would have to be adjusted accordingly.

During 2020, the project continued to develop a test method for gas phase air cleaning technologies that includes measurement of perceived air quality as a measure of their performance. This also includes a description of bioeffluents emitted from people as a source for challenging the air cleaner.

Meetings

The following meetings were held in 2020:

- The 2nd working phase project meeting was held online, in April and May 2020.
- The project was represented at the TC 146 SC6 WG25 meeting on the measurement of perceived air quality in September 2020.
- An online meeting was held in October 2020.
- A workshop was organised at the Indoor Air 2020 virtual conference in November 2020.

Project duration
2018–2024

Operating Agents
Bjarne W. Olesen and Pawel Wargocki, International Centre for Indoor Environment and Energy, Technical University of Denmark, Denmark

Participating countries
Czech Republic, Denmark, Italy, Japan, P.R. China, Singapore, Sweden, USA, Turkey

Further information
www.iea-ebc.org

Integrated Solutions for Daylighting and Electric Lighting

EBC ANNEX 77 – SHC TASK 61

This project is focusing on research to create and develop strategies combining daylighting and appropriate lighting control systems leading both to:
- very highly energy-efficient lighting schemes, and
- solutions offering the best lighting conditions for people.

It has brought together international experts and companies involved in dynamic daylighting, lighting and their controls.

Objectives

The overall objective of the activity is to foster the integration of daylight and electric lighting solutions for the simultaneous benefits of higher occupant satisfaction and energy savings. It includes the following specific objectives:
- review the relationships between occupant perspect-ives (needs and acceptance) and energy in the emerging era of 'smart and connected lighting' for a relevant sample of buildings;
- consolidate findings from use cases and create 'personas' reflecting the behaviours of typical occupants;
- based on a review of specifications concerning lighting quality, non-visual effects, as well as ease of design, installation and use, provide recommendations for energy regulations and building performance certificates;
- assess and improve the technical, environmental and financial robustness of integrated daylight and electric lighting approaches;
- demonstrate and verify, or reject concepts through laboratory studies and real use cases based on performance validation protocols;
- develop integral photometric, occupant comfort and energy rating models (spectral, hourly) as pre-normative work linked to relevant bodies, including CIE, CEN, ISO, and initiate standardization activities;
- provide decision making and design guidelines incorporating virtual reality sessions; integrate approaches into widespread lighting design software;
- combine competencies: bring electric lighting and façade component manufacturers together using workshops and specific projects, and thereby promote the added value of integrated solutions in the market.

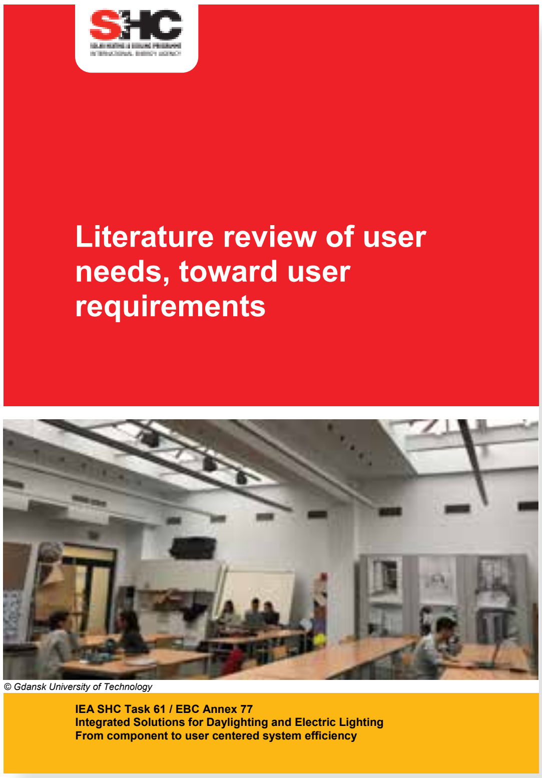
Deliverables

The following documents and information measures are being published during the course of the project:
- 'Personas for occupant-centered integrated lighting solutions' report
- 'Integration and optimization of daylight and electric lighting' report / source book
- 'Guidelines for the use of simulation in the design process of integrated lighting solutions' report
- 'Integrated solutions for daylighting and electric lighting in practice: results from case studies' report
- Standardization: Initiation of new work items by appropriate standardization bodies and proposals for methods for draft standards (BSDF daylight system characterization, hourly lighting energy demand rating method)
- Virtual Reality Decision Guide
- A Web-based tool providing an hourly lighting energy demand rating method

Progress

In 2020, a report documenting a literature review of user needs toward user requirements was published. In the report more than 100 articles were reviewed and analyzed, including the following topics: perception of light, visual comfort, psychological aspects of lighting (view out, perceived quality of space, privacy, and so on), and non-image forming aspects of light. By using these four basic aspects, several criteria for lighting quality, both image-forming and non-image forming were defined. Qualities of electric lighting and daylighting was compared. For the specific case of office work the findings were aggregated in the report into an overview of application related requirements.

The development work on an hourly based evaluation and rating method for the energy demand of integrated lighting solutions was continued. The approach is based on a clear segregation of emulating reality, i.e. daylight and room, electric lighting and room and occupancy behaviour on one side and description of sensors, actors and (network) functionality on the other side. The approach allows an integrated workflow for lighting design and commissioning of lighting installations, while avoiding double modelling / specifications in the future. This work is now connected to ISO/TC 274/ JWG 1 in revising the ISO 10916 'Calculation of the impact of daylight utilization on the net and final energy demand for lighting', by TC 274's official approval of a new work item. A draft international standard (DIS) is under preparation.



The report 'Literature review of user needs, toward user requirements', which was published in 2020.
Source: EBC Annex 77 / SHC Task 61

Meetings

The following online meetings were held in 2020:

- 5th Task Meeting was held in March 2020.
- 6th Task Meeting was held in September 2020.
- 7th Task Meeting was held in November 2020.

Project duration
2018–2021

Operating Agent
Jan de Boer, Fraunhofer Institute for Building Physics, Germany

Participating countries
Australia, Austria, Belgium, P.R. China, Denmark, Germany, Italy, Japan, the Netherlands, Norway, Slovakia, Sweden, Singapore, Switzerland, USA
Observers: Brazil

Further information
www.iea-ebc.org

Cities and Communities

EBC WORKING GROUP

Cities face extensive challenges when it comes to transformation processes of their energy and mobility systems. The generation of suitable decarbonisation strategies and the selection of the best-fit solution for their specific framework conditions require comprehensive skills, knowledge, and resources, which smaller communities often lack. In addition, these decision-making and planning processes take place in a highly dynamic environment with many further requirements that often have higher priorities. This complexity often not only leads to uncoordinated decision-making within cities, but also within different stakeholder groups. While solutions are mostly provided at a strategic level, decisions at the urban scale can have substantial impacts on individual approaches and technologies.

The EBC Working Group on Cities and Communities is therefore improving this situation by integrating these 'urban issues' into research within the IEA Technology Collaboration Programmes (TCPs), including the EBC TCP. This open project is a hosted, single-leadership, delegating structure that shares information across multiple TCPs and cities in a bi-directional approach, in which information is provided and received in both directions. The project is also linked to existing IEA Co-ordination Groups and other structures, directly, through the EBC Executive Committee Chair, or through nominated experts, and is feeding into various IEA publications and workshops.

Objectives

The project goal is to contribute to an essential step in IEA TCP research to meet cities' non-technical needs that extends well beyond providing technical solutions for energy systems. It has the following objectives:

- assess and identify the needs of cities, their actors, and associated stakeholders;
- generate appropriate non-technical ideas for 'on demand' inputs and services for cities;
- identify and discuss bottlenecks and barriers for the transformation of cities' energy and transport systems;
- provide results and recommendations on energy and mobility systems that may inform policy development;
- close the gap between the needs of cities and research outputs;
- connect TCP technical researchers with non-technical experts and city representatives.

The project is making use of a range of collaboration mechanisms, such as those listed below:

- workshops and other exchange activities;
- capacity building and training activities;
- the creation of publications on cross-TCP activities, joint publications and policy recommendations;
- short term projects and research;
- additional mechanisms targeted directly to the specific needs of a project, research or city.

Progress

The meetings of the Working Group in 2020 focussed on discussions, which were led by three subgroups:
Subgroup 1: Decarbonisation Strategies
Subgroup 2: Integrated Planning Concepts
Subgroup 3: Data, Tools and Methods

Subgroup 1 learned that the development of technology-systems for decarbonization in cities is not just a matter of research on technologies and systems. Non-technological aspects, such as legal framework conditions, social aspects, and so on, are also needed for the broad application of technologies. Only through regular exchanges with cities on their options, can evidence-based solutions be developed.

The outcomes from the Subgroup 2 work were that key steps, success factors, crucial participants and benefits of integrated planning processes can be distilled from best practice examples. Also, all stages of a formalized process are necessary to change organizational structures and foster decarbonization in cities.

Topics of the proposed IEA Technology Collaboration Programme on Cities, which would form the basis for future projects.

Source: Salzburg Institute for Regional Planning and Housing (SIR), 2020

Subgroup 3 learned that extensive research on data exists within a multitude of projects. Although gaps and questions remain, these analyses are crucial to increase our understanding of barriers related to collecting, using and distributing data, tools and methods. While innovative tools exist, the most suitable selection process are unclear to support planning and implementation and ways of integrating knowledge into existing planning instruments.

Based on the lessons learned and the results from all three subgroups, the project conjointly derived conclusions and remaining challenges for decarbonization in cities and communities. For each of the identified barriers, many studies and findings, and much in-depth knowledge exists. However, this knowledge is only occasionally made available for cities and is rarely disseminated in a way they can immediately implement. What is therefore still missing is a holistic approach that supports cities not only in overcoming a single barrier, but is dedicated to informing, improving and expanding decarbonisation processes as a whole and aims to integrate urban needs into outstanding research approaches.

Through the project it has become clear that fulfilling those objectives requires more resources as well as formal structures. Following discussions with the IEA End-use Working Party (EUWP) in 2019, the Working Group members jointly decided to propose a new TCP, 'Decarbonization of Cities and Communities' (DoCC). Drafts of the DoCC Strategic Plan and its Program of Work were subsequently developed, and discussed at the EUWP Meeting in March 2020 and amongst interested IEA CERT-members in December 2020. The discussion focussed on the potential linkages to global networks, financial contributions and the procedure to launch the TCP. Following that meeting, the name was changed to 'Cities TCP'.

The Final Report has been published including the following:

- Annex I Cities' needs (presentation and accompanying document),
- Annex II DoCC TCP Draft Strategic Plan,
- Annex III DoCC TCP Program of Work.

Meetings

The following meetings were held online in 2020:

- The 5th meeting was held in April 2020.
- The final meeting was held in October 2020.

Project duration
2017–2021

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

Participating countries
Austria, Canada, Denmark, Finland, France, Germany, Italy, Ireland, Japan, P.R. China, the Netherlands, Norway, Sweden, Switzerland, UK, USA

Further information
www.iea-ebc.org

Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions

EBC ANNEX 76 – SHC TASK 59

In many countries, historic buildings represent a significant share of the existing building stock. They are the distinctive features of numerous cities, and will only survive if maintained as living spaces. To preserve this heritage, it is necessary to find conservation-compatible energy retrofit approaches and solutions, which allow the historic and aesthetic values to be maintained while improving comfort, lowering energy costs and minimizing environmental impacts. Standard energy saving measures are often not compatible with preserving the historic buildings' character. Nevertheless, the energy performance can be improved considerably if the right package of solutions for the specific building is identified. Also, the possibilities to use solar energy in historic buildings are greater than one might expect.

Objectives

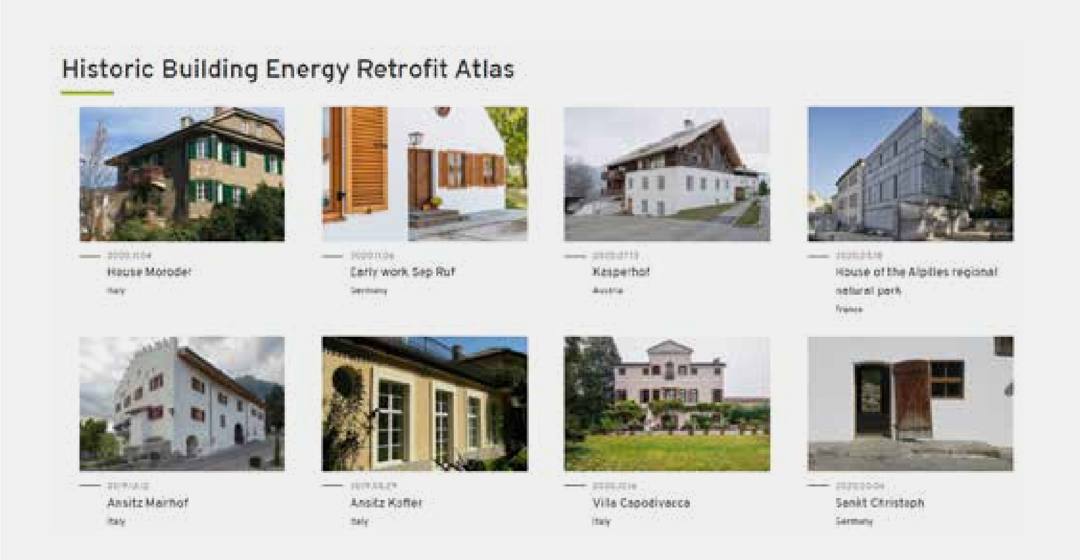
The IEA Solar Heating and Cooling Technology Collaboration Programme (TCP) is working on the project with the EBC TCP at a 'Moderate Level Collaboration', and with the Photovoltaic Power Systems TCP at a 'Minimum Level Collaboration'. The objectives are as follows:

- identify and assess replicable procedures on how experts can work together with integrated design to maintain both the heritage value of the building and at the same time make it energy efficient;
- develop a solid knowledge base on how to save energy in renovation of historic and protected buildings in a cost efficient way;
- identify the energy saving potential for protected and historic buildings according to typology studied (residential, administrative, cultural, and so on);
- identify and further develop tools that support this procedure and its individual steps;
- identify and assess conservation compatible retrofit solutions with a 'whole building perspective';
- specifically identify the potential for the use of solar energy (passive and active, heating, cooling and electricity) and promote best practice solutions;
- transfer all knowledge gained in the project to relevant stakeholders, including building owners, architects and planners, real estate developers, and policy makers.

Deliverables

The following deliverables are being produced:

- 50 best practice case studies from all participating countries documented as a web-based collection;
- an assessment report of the best practices including evaluation of the cases' replicability and the transfer-ability of specific favourable framework conditions and incentives;
- assessment of EN16883 with improvement proposals;
- an assessment of the existing tools, methods and guidelines that are relevant in relation to standard EN16883 and others (for example ASHRAE Guideline 34P) in the form of a report including 'fact sheets';
- an integrated platform with tools for holistic retrofit of historic buildings to support the planning process towards conservation compatible net zero energy buildings;
- a report on conservation compatible energy retrofit technologies, with focus on restoration and thermal enhancement of window systems, documentation and assessment of materials for robust and economically viable internal insulation, and evaluation of energy and cost-efficient heating ventilation and air conditioning (HVAC) systems and roof integrated solar technologies;
- a report on strategies to achieve high energy and environmental performance, as well as heritage value conservation, considering not only specific building typologies, but also local climate and traditional construction practices;
- online communications and dissemination of objectives and activities of the project, as well as news, audio-visuals and webinars by means of a website;
- communications and dissemination of the results by means of a workshop series, participation in stakeholder events and a touring exhibition for use by all participating experts.



Examples of the case studies in the Historic Building Energy Retrofit Atlas.
Source: EBC Annex 76 / SHC Task 59

Progress

The Historic Building Energy Retrofit Atlas (HibERATLAS) collects best practice cases in a visual and 'fun to read' way. The website was modified in 2020, including developing a user-friendly backend for adding best practice cases, user management, and the integrated process of gathering intellectual property and privacy forms. This has been available for continuing use of the best practice database after the project ends. The information sheet with basic information for architects and building owners has been prepared.

With regards to the assessment of best practice cases, an overview of the published case studies and the detailed structure of the assessment report was further developed. Besides this quantitative assessment, a qualitative part of the analysis has been completed that focused on the 'Replicability of Case Studies' and 'Transferability of Favourable Framework Conditions'. During the expert meeting in October 2020, a number of hypotheses based on this draft report were discussed and some preliminary conclusions were drawn, such as:

– an early and iterative dialogue between the planning team and the heritage authorities is in many ways a key to a successful end result and an efficient planning process,
– engaged clients can contribute to the project in many ways, from identifying what is worthy of preserving to customizing solutions, and
– limited project budgets can hamper innovative solutions which might be more efficient over the whole life cycle.

Three case studies have been used for the assessment of the implementation of EN16883 in practice. A concept for the integrated platform has been developed further, which follows the planning process as also described in EN16883. The platform enriches the quite abstract planning process with examples, tools, recommendations, and so on. It has been decided that the guidance on the application of the standard and findings will be published as a handbook.

Working groups on solar, HVAC, walls, windows and strategies focused on collecting the assessments and documentation of the solutions. A mechanism to collate and document retrofit solutions has been integrated within the HiBERATLAS functionality and was used by the project participants. Furthermore, the project participants have decided to develop the Decision Guidance Tool (originating with the Interreg Alpine Space project ATLAS) for this project and thus 'upgrade' the originally planned static report to become a more interactive tool.

Meetings

The following meetings were held online in 2020:

– The 6th Expert Meeting was held in April 2020,
– The 7th Expert Meeting was held in October 2020.

Project duration
2017–2021

Operating Agent
Alexandra Troi, Eurac Research, Italy

Participating countries
Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Spain, Sweden, Switzerland, UK, USA
Observer: Turkey

Further information
www.iea-ebc.org

Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables

EBC ANNEX 75

Buildings are a major source of greenhouse gas emissions. Reducing their energy use and associated greenhouse gas emissions is particularly challenging for the existing building stock. In contrast to the construction of new buildings, there are often architectural and technical hurdles for achieving low emissions and low energy use in existing buildings. Also, the cost-effectiveness of reaching a high energy performance in existing buildings is often lower than in the construction of new buildings. However, there are specific opportunities for district-level solutions in cities that must be explored. In this context, the project is clarifying the cost-effectiveness of various approaches combining both energy efficiency measures and renewable energy measures at district level. At this level, finding the balance between these two types of measures for the existing building stock is a complex task and many research questions still need to be answered related with the strategies to be adopted.

Objectives

The project has general objectives that are to:

- investigate cost-effective strategies for reducing greenhouse gas emissions and energy use in buildings in cities at district level, combining both energy efficiency measures and renewable energy measures;
- provide guidance to policy makers, companies working in the field of the energy transition, as well as building owners, on how to cost-effectively transform existing urban districts into low-energy and low-emission districts.

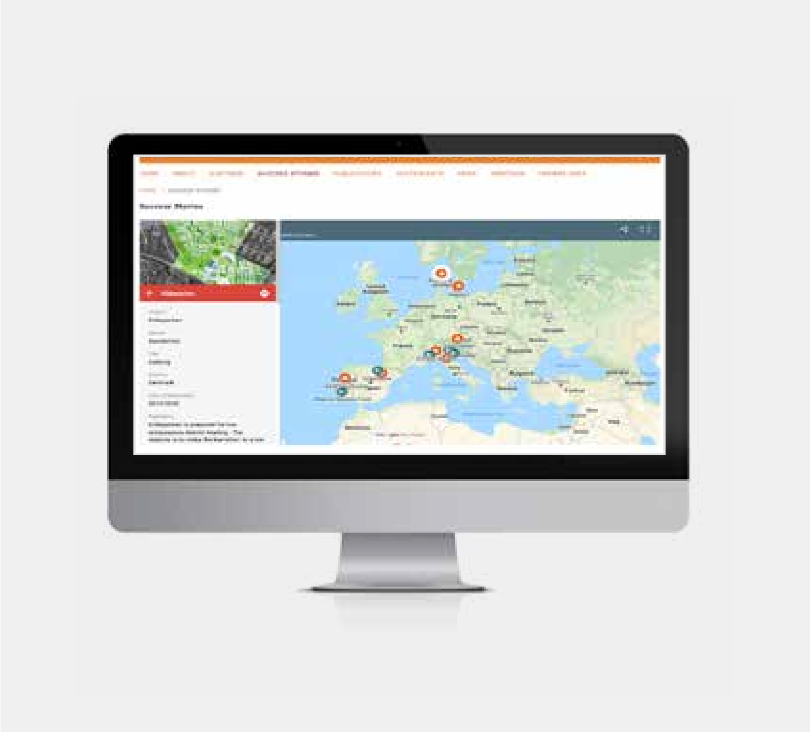
It is focusing on a number of specific objectives, which are to:

- give an overview of various existing and emerging technology options and on how challenges occurring in an urban context can be overcome;
- develop a methodology to identify cost-effective strategies for renovating urban districts, supporting decision makers in the evaluation of the efficiency, impacts, cost-effectiveness and acceptance of various solutions;
- illustrate such strategies using selected case studies and gather best-practice examples;
- give recommendations to policy makers and energy-related companies on how they can influence the uptake of cost-effective combinations of energy efficiency measures and renewable energy measures in building renovation at district level.

Deliverables

The following project deliverables are planned:

- a technology overview report on identifying energy efficiency measures and renewable energy measures at district level;
- a methodology report on cost-effective building renovation at district level;
- supporting tools for decision makers with identification and adaptation of tools to support the application of the methodology in generic and case specific assessments;
- a report on the application of the methodology in generic districts;
- a report on strategy development;
- a report on parametric assessments for case studies;
- a report on good practice examples showing strategies for transforming existing urban districts into low-energy and low-emissions districts;
- a report on enabling factors and obstacles to replicate successful case studies;
- good practice guidance for transforming existing districts into low-energy and low-emissions districts;
- a report on policy instruments, including recommendations for subsidy programmes and for encouraging market take-up;
- a report on business models and models for stakeholder dialogue;
- guidebooks containing guidelines for policy makers and energy-related industry on how to encourage the market uptake of cost-effective strategies combining energy efficiency measures, renewable energy measures, and guidelines for building owners and investors about cost-effective renovation strategies, including district-based solutions.



The interactive map showing the success stories integrated on the project website.

Source: EBC Annex 75

Progress

During 2020, the work on identifying existing and emerging technologies was completed and a final report was developed. In addition to the main characteristics of the technologies, interdependencies, obstacles and success factors have been identified, as well as potential for application and future developments.

The methodological guidelines for cost optimization of the renovation solutions were completed. Participants have developed several parametric assessments. Using pre-defined criteria, virtual districts have been assessed in Austria, Denmark, Italy, Portugal, Spain, Sweden and Switzerland.

In 2020, related to strategy development, a webinar was held on the combination of the heating and cooling potential of lakes and rivers with energy efficiency measures in buildings at district level. It benefitted from the contribution of specialists in district heating and representatives of energy companies in the cities of Luzern and Zürich, to gain insights into the strategies currently applied by stakeholders.

Following the establishment of the methodological guidelines, case studies from Austria, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and Switzerland are being investigated on cost-effective packages of renovation measures. An article was published focusing on the application of this methodology in a case study in Portugal. A first version of the common project tool to support the calculations was completed and is being tested by participants.

During 2020, additional success stories from Austria, Denmark, Italy, the Netherlands, Portugal, Spain, Switzerland and Sweden were added to the existing database. There are now 15 success stories on the interactive map integrated into the project website.

As part of providing guidance for decision making to different stakeholders, the project is promoting the identification and exemplification of archetype policy instruments and business models that will be further developed. Expert interviews are takng place with various types of stakeholders to identify recommendations on policy instruments and business models. These workshops are of utmost importance in developing the Guidelines for Policy Instruments and Stakeholder Dialogue, as they enable the collection and validation of relevant information on policies and business models in a real-world context.

Meetings

During 2020, the following meetings were convened online:
- The 7th Expert Meeting was held in March 2020.
- The 8th Expert Meeting was held in in September 2020.

Project duration
2017–2022

Operating Agent
Manuela Almeida, University of Minho, Portugal

Participating countries
Austria, Belgium, P.R. China, Czech Republic, Denmark, Italy, Germany, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland

Further information
www.iea-ebc.org

Competition and Living Lab Platform

EBC ANNEX 74

The success story of the Solar Decathlon events forms the background to this project. The Solar Decathlon is an ongoing series of international competitions for students based on an initiative of the U.S. Department of Energy that started in 2002. In each competition, universities are challenged to design, build and operate solar powered houses. It is the only student competition worldwide addressing the realization and performance assessment of buildings and not only the design. During the final phase of an edition of the competition, each interdisciplinary team assembles its house in a common Solar Village. The final phase includes a public exhibition, monitoring, and 10 competing teams, which is the reason why the competition was named a 'Decathlon'.

Eighteen competitions have been conducted up to the end of 2020, of which eight took place in the USA, four in Europe, two in P.R. China and two in Columbia. Due to the worldwide pandemic, the 2020 editions in the USA and Middle East have been postponed to 2021, and the 2021 European edition to 2022. Two countries with hot climates are holding competitions, taking place in the United Arab Emirates and Morocco. Many of the experimental houses are used as 'living labs' when transferred back to their home universities.

Objectives

The project is establishing a platform for mapping and linking the competition and living lab experiences worldwide and working towards improving competition formats. It intends to stimulate technological knowledge, scientific level and architectural quality within future competitions and living labs based on the development of a systematic knowledge platform, as well as creating a link to knowledge from previous and current IEA Technology Collaboration Programme (TCP) activities. Furthermore, the project aspires to increase the impact of competitions and living lab formats worldwide by means of communication and development of educational material. Parts of the project are linked to a separate parallel activity to document the results and lessons learned from the European Solar Decathlon edition and to communicate these within the 'Smart City Information System' of the European Commission.

Deliverables

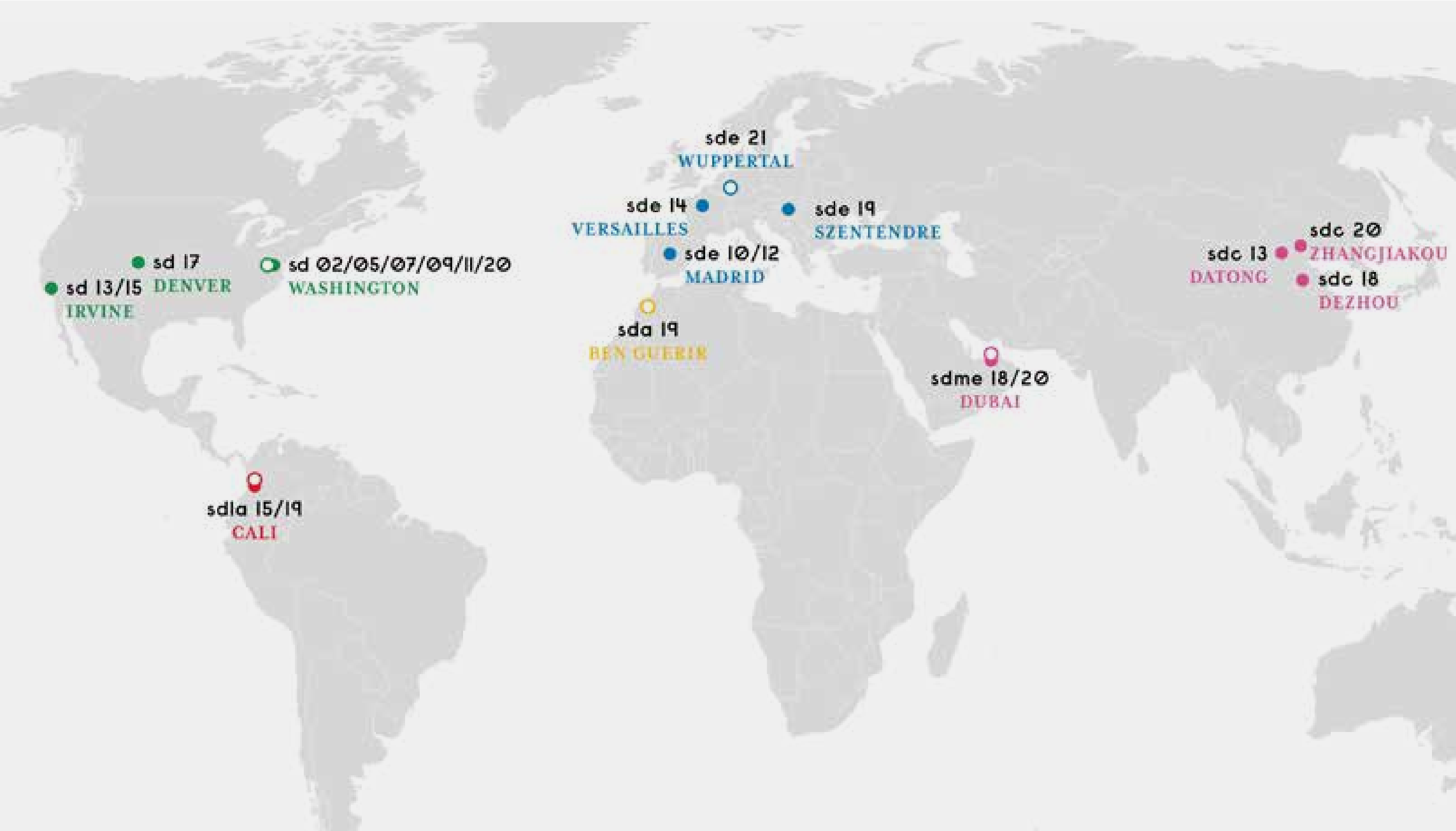
The following project deliverables are being produced:

- a web-based competition knowledge platform;
- a technology and innovation evaluation report;
- a post-competition and living lab scenarios report,
- monitoring and documentation templates;
- guides for competition rules, criteria and organization;
- educational material.

Progress

During 2020, the online knowledge platform was regularly improved and new material uploaded. A new section on 'living labs' has been introduced to host and illustrate factsheets for post competition activities with a special focus on university education. The education section includes links to relevant software tools, as well as a set of 'topical papers', developed as part of the project and collected within a focus report. These papers link typical building competition topics to IEA TCP based research. They review the approaches chosen in past competitions in a compact form.

The review of the European editions of the Solar Decathlon was completed in 2020 and the results transferred to the relevant project deliverables. This review covered the building design and energy engineering of about 65 demonstration houses. Besides this review, the report includes descriptions of the monitoring approaches followed in past competitions worldwide. Existing monitoring data were visualized within a focus report and stored within the knowledge platform in a comparable format. A set of harmonized templates was developed to collect all relevant quantitative building information. In general, such an approach creates a suitable platform for future cross analyses of competition entries. Lessons learned from these activities were applied to include



Map showing the previous Solar Decathlon events held around the world.
Source: University of Wuppertal, Germany

selected scientific investigations, improved monitoring and the templates within the next European competition, taking place in Germany in 2022.

The methodology for assessing the impact of the competitions on issues such as university education, social awareness of professionals and the general public have been articulated through a combination of qualitative and quantitative analyses. The qualitative analysis come from the compilation of the experiences of the different editions, their evolution, and the lessons learned from them. They are complemented by organization factsheets, post-competition factsheets and an extensive set of interviews with decathletes, faculty members, professionals, and organizers. A worldwide survey was carried out among students, faculty members, professionals and organizers, in which their perceptions of the competitions and their qualitative and quantitative assessments were collected. With all the information gathered from the surveys, organization factsheets and the information collected in the knowledge platform, a set of variables, indicators and key performance indicators (KPIs) have been defined that form the core of the quantitative analysis.

Two reports on Impact and Performance of Solar Decathlon Competitions, and Post-competition and Living Lab Scenarios present the information gathered and the analyses developed. These include recommendations to improve the impact of future competitions, linked events, post-competition and living labs activities.

Meetings

Two online meetings took place in 2020:

- The 5th Project Meeting was held in March 2020.
- The 6th Project Meeting was held in October 2020.

Project duration
2018–2022

Operating Agents
Karsten Voss, University Wuppertal, Germany, and Sergio Vega, Technical University of Madrid, Spain

Participating countries
Belgium, P.R. China, Germany, the Netherlands, Spain, Switzerland, USA
Observers: Hungary, United Arab Emirates, Colombia, Morocco

Further information
www.iea-ebc.org

Towards Net Zero Energy Resilient Public Communities

EBC ANNEX 73

Until recently, most planners of public communities addressed energy systems for new facilities on an individual facility basis without consideration of community-wide goals relevant to energy sources, renewables, storage, future energy generation needs and resiliency aspects. Moreover, building-centric planning falls short of delivering community-level solutions for energy efficiency and energy resilience. For example, many building code requirements focus on hardening to specific threats for the 'mission-critical' buildings in a multi-building community. Disruptions of electrical and thermal energy supplies may degrade critical mission capabilities and cause significant economic impacts at military and civilian installations. Thus, sustainable community projects should consider and combine efficiency and resiliency targets. Significant energy savings would reduce the heating, cooling and power needs, and thus contribute to increased energy security.

The status quo in planning and execution of energy-related community projects does not support the attainment of current energy goals, or the minimization of costs for providing energy security. In the future, primary and end use energy, as well as carbon footprint targets, have to be made available by transformation from single building target based frameworks.

Objectives

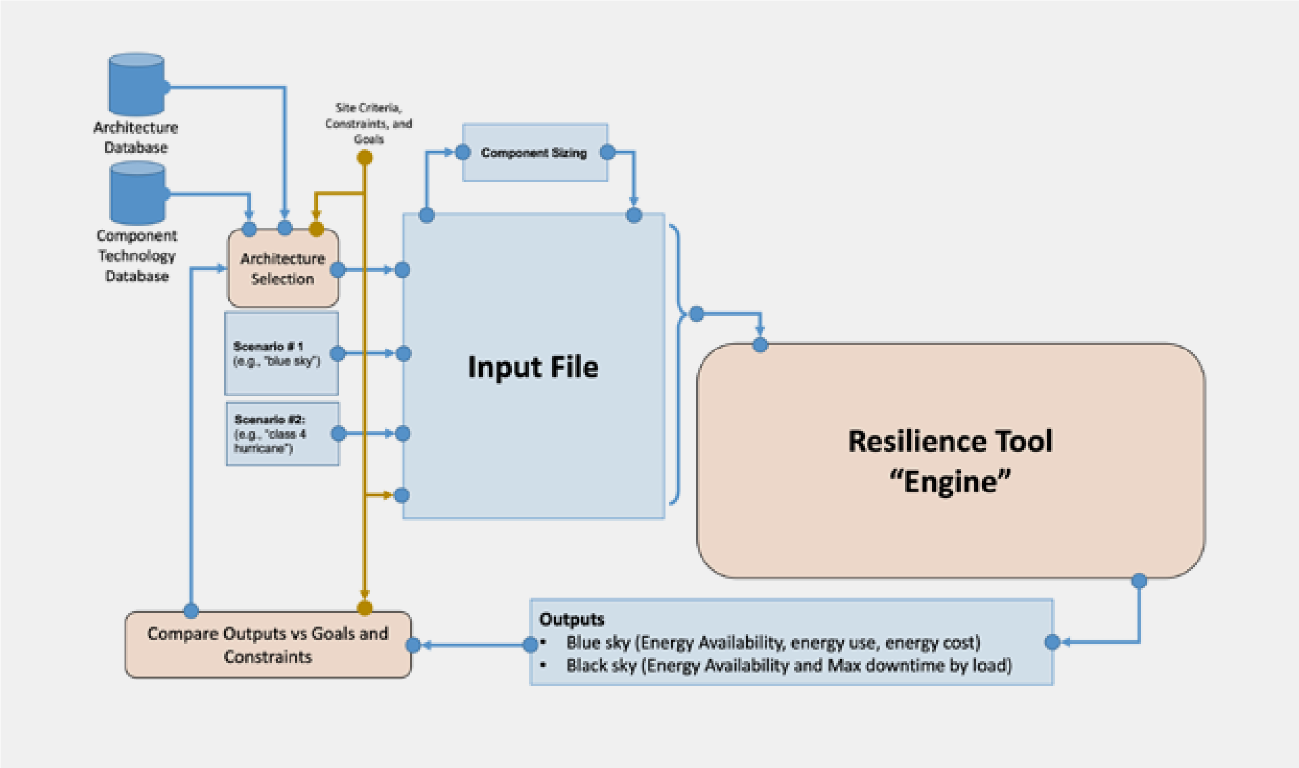
The project scope includes the decision-making process and computer-based modelling tools for achieving net zero energy resilient public-owned communities. The goal is to develop guidelines and tools that support the planning of net zero energy resilient public communities and that are easy to understand and execute. Specific objectives are to:

- assess and evaluate existing case studies with regard to replicable technical solutions, costs, and performance data for certain usage cases;
- develop a database of energy utilization indexes for public, education, and military building types and communities;
- develop energy targets for certain community usage cases based on the single building energy targets;
- summarize, develop, and catalogue representative building models by building use type, including mixed-use buildings, that are applicable to building stocks of national public communities and military bases;
- summarize, develop, and catalogue representative energy supply and energy efficiency architectures for different applications and climates;
- develop guidance for energy master planning;
- develop a functional modelling tool to facilitate the 'net zero energy master planning process', which will enhance currently used building modelling tools to address resiliency of combined energy supply and energy efficiency solutions, integrate a capability for computation of thermal and electrical network characteristics, with visualization of different architectures to support resilience decisions without significant post processing;
- collect and describe business and financial aspects, legal requirements, and constraints relevant to the implementation process of net zero energy concepts for public communities in participating countries;
- disseminate this information and train end users in the participating countries, mainly decision makers, community planners, energy managers, and other market partners.

Deliverables

The project is producing the following deliverables:

- a guide for net zero energy planning in public and military building communities,
- an energy master planning tool module,
- a book of case studies with examples of energy master plans, and
- results of several realized or partially realized schemes.



The Resilience Calculation Tool process developed during the project.
Source: EBC Annex 73

Progress

During 2020, the project has achieved the following:

- summarized typical community level framing goals and energy-related concerns for selection of energy systems architectures, and technologies;
- summarized newly developed resilience matrices, resilience requirements for representative mission critical facilities, and resilience analysis methodologies for use in the Guide and the modelling tool;
- developed more than 60 examples of 2nd to 4th generation energy system architectures for communities with and without mission critical facilities provided with power, heating, and cooling from centralized and decentralized energy sources;
- created a database of energy supply, distribution and storage technologies with their technical, cost and reliability characteristics;
- prepared and edited the draft of the Case Studies Book documenting 32 case studies from Australia, Austria, Denmark, Finland, Germany, Canada, Norway and the USA;
- finalized a draft of the guide for Energy Master Planning for Resilient Low Energy Public Communities, the guide for Resilient Thermal Energy Systems Design in Cold and Arctic Climates, and the Energy Resilience Interacting Networks (ERIN) calculation tool and user manual.

An international consultation forum 'Thermal Energy Systems Resilience in Cold / Arctic Climates' was conducted in Fairbanks, USA, in January 2020. A virtual training session 'Energy Master Planning for Resilient Public Communities' was organized in October 2020, hosted by the US National Academy of Sciences.

Meetings

The following meetings took place in 2020:

- The 5th working meeting was held online in April 2020.
- The 6th working meeting was held online in September 2020.
- A Virtual EBC Annex 73 Workshop was held in collaboration with the US National Academy of Sciences in October 2020.

Project duration
2018–2022

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

Participating countries
Australia, Austria, Denmark, Finland, Germany, Norway, UK, USA

Further information
www.iea-ebc.org

Assessing Life Cycle Related Environmental Impacts Caused by Buildings

EBC ANNEX 72

This project is providing the basis and tools to support decision makers and designers in minimising environmental impacts caused during the entire life cycle of buildings. It is advancing the research already conducted within EBC Annexes 56 and 57. It broadens the scope of EBC Annex 57 by including operational impacts of buildings in use and by addressing environmental impacts in addition to primary energy demand and greenhouse gas emissions.

Objectives

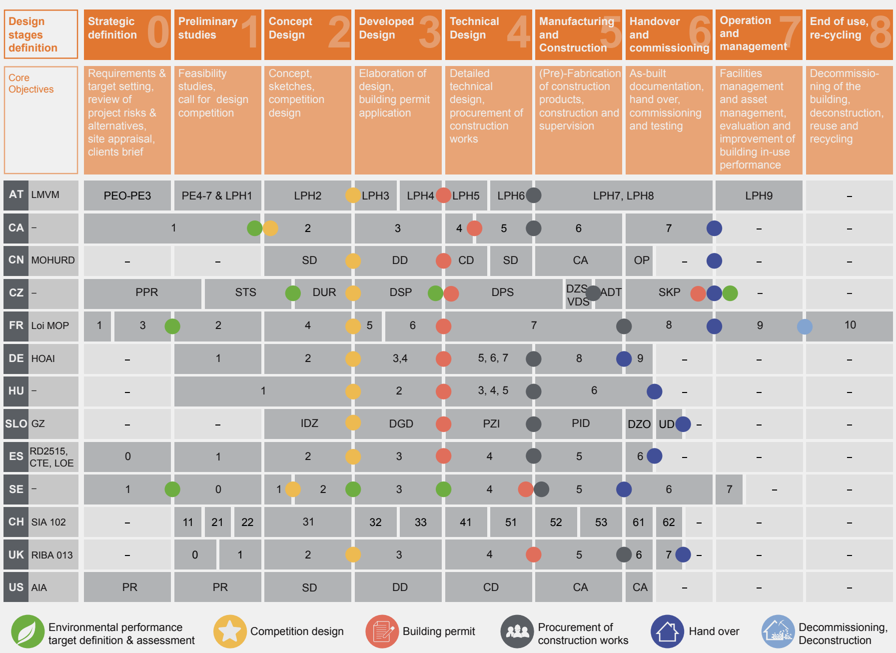
The project has the following specific objectives:

- establish a harmonised methodology guideline to assess the life cycle based environmental impacts caused by buildings;
- establish methods for the development of specific environmental benchmarks for different types of buildings;
- derive guidelines and tools (building design and planning tools, such as building information modelling) for design decision makers;
- establish a number of case studies;
- develop national / regional databases with regionally differentiated life cycle assessment (LCA) data tailored to the construction sector.

Deliverables

The following deliverables are planned:

- a report on harmonised guidelines on the environmental LCA of buildings;
- a report on establishing environmental benchmarks for buildings, including case study examples;
- a report on national LCA databases used in the construction sector;
- a report on guidelines for design decision makers on optimization using building assessment workflows and tools;
- a report on building case studies on the application of LCA in different stages of the design process;
- a report on how to establish national / regional LCA databases targeted to the construction sector.



Mapping of the preliminary results on national design stage definitions and milestones.
Source: EBC Annex 72, TU Graz

Progress

The focus in 2020 was on finalising the drafts of the project reports and establishing a general structure for all project deliverables. A survey based on a questionnaire on the definitions of net zero / carbon neutral / climate neutral buildings was circulated to gather definitions from various countries. The results of the survey were used to create an overview of terms and definitions.

The report on implementation of LCA across different design steps of buildings was finalised. In this report, national terms and definitions for design steps were analysed and common definitions were proposed. These definitions serve as a basis to assign methodological questions, assessment tools, or case studies to the different design steps and to discuss the suitability of data. Furthermore, the harmonized definitions can be used to provide the specific recommendations for various design steps.

In addition, different benchmark systems were compared. The project team analysed and discussed questions concerning the system boundary, reference units and reference study periods of benchmarks, as well as applied benchmark levels. Only one benchmark system, the Swiss benchmarks according to the technical bulletin SIA 2040, is based on a top down approach, i.e. this is derived from the overall budget of greenhouse gas emissions of Switzerland according to the intermediate target of their '2000-Watt-society' initiative. The findings are being used to provide guidance on how to establish a benchmarking system for buildings and to provide examples using existing benchmarking systems.

Meetings

In 2020, the following meetings took place:

- The 7th Expert Meeting was planned to be held at Tianjin University in March 2020, in Tianjin, P.R. China, but this was cancelled.
- The 8th Expert Meeting was planned to be held at Edinburgh Napier University in October 2020, in Edinburgh, UK, but was instead held online.

Project duration
2016 – 2022

Operating Agent
Rolf Frischknecht, treeze Ltd., Switzerland

Participating countries
Australia, Austria, Belgium, Canada, Czech Republic, P.R. China, Denmark, Finland, France, Germany, Italy, R. Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA
Observers: Brazil, Hungary, India, Slovenia

Further information
www.iea-ebc.org

Building Energy Performance Assessment Based on In-situ Measurements

EBC ANNEX 71

It is essential that energy-efficient technologies in buildings do more than simply satisfy regulations based on theory. They must make genuine differences in real-world applications. Building owners, investors and governments need to know that the investments they make are actually delivering as expected. Hence, ensuring that real performance matches design performance is critical.

Recently, statistical methods and system identification techniques have shown to be promising tools to characterise and assess the as-built performance of buildings. So far though, the studies remain dispersed. A thorough analysis of the applicability of the methods is lacking, investigating the balance between cost of data gathering versus achieved precision and reliability.

The project is evaluating and improving replicable methodologies embedded in a statistical and building physical framework to characterize and assess the actual energy performance of buildings. For residential buildings, the project is exploring the development of characterisation methods, as well as quality assurance methods. Characterisation methods translate the (dynamic) behaviour of a building into a simplified model that can be used in modelling predictive control, fault detection, and so on. Quality assurance methods pinpoint some of the most relevant actual aspects of building performance, such as for example the overall heat loss coefficient of a building, or the solar aperture.

Objectives

The project objectives are to:

- develop methodologies to characterize and assess the actual as-built energy performance of buildings;
- collect well-documented data sets that can be used for evaluation and validation;
- investigate how on-site assessment methods can be applied for quality assurance.

Deliverables

The main outcomes of the project are as follows:

- an overview of the availability and reliability of input data for on-site building performance assessment;
- dynamic data analysis methods to characterise and assess building energy performance,
- guidelines to apply the methods in quality assessment procedures, and a detailed and well-controlled experiment that can be used both for development and assessment of statistical methods, as well as for the validation of common building energy simulation models.

Progress

In 2020, the project completed its working phase and entered its reporting phase. The various project groups finalized the remaining studies and started reporting on their activities.

An extensive survey carried out amongst stakeholders revealed the interest of the building industry for methods that are capable to measure the actual energy performance of a building after delivery. This information, combined with input on acceptable cost and duration of on-site assessments, has been used to develop guidelines that link the requirements of a specific application to available statistical methods and corresponding common data acquisition techniques. Together with international examples on quality guarantee in the buildings sector, this resulted in a report presenting the general framework of this project.

Two additional reports go in detail on the suitability of different statistical methods for building behaviour identification and quality assessment. Investigated applications regarding building behaviour identification focused on model predictive control and fault detection and diagnosis. Regarding quality assessment, the main focus was on the on-site characterization of the overall heat loss coefficient of a building. On-site measured data in artificially and actually occupied dwellings have been used to explore and optimize statistical methods.

A final report describes a new building energy simulation (BES) validation exercise, that was set-up in the project as a follow up of the BES-validation exercise completed within the EBC project 'Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements'. In the current project, real measured data on a test house, heated with a real heating system and occupied by artificial users, has been used to validate common BES-models.

Meetings

Two online meetings were organized in 2020:

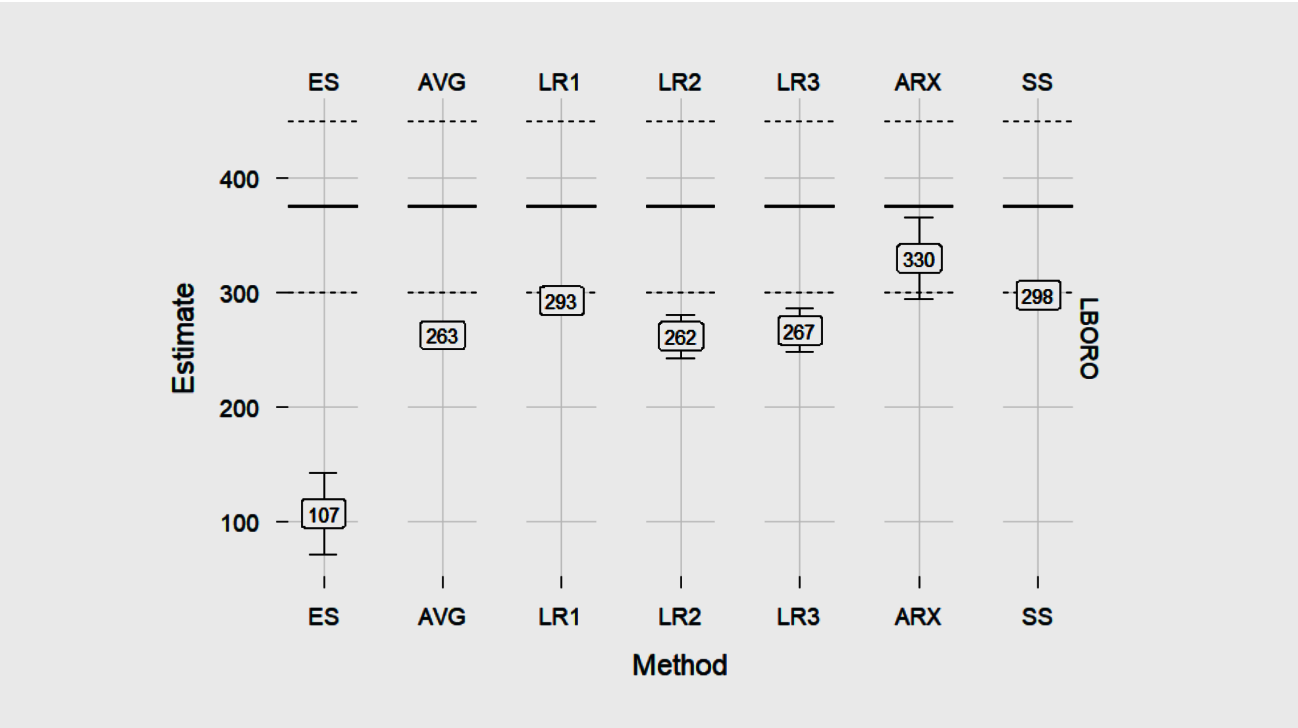
- the 8th Expert meeting took place in April 2020
- the 9th expert meeting in October 2020.

Project duration
2016–2021

Operating Agent
Staf Roels, KU Leuven University of Leuven, Belgium

Participating countries
Austria, Belgium, Denmark, France, Germany, Norway, Spain, Switzerland, the Netherlands, United Kingdom
Observers: Estonia

Further information
www.iea-ebc.org



Exploration of different methods to determine the actual heat loss coefficient of a semi-detached dwelling based on in-use data.
The horizontal thick black line corresponds to the reference value as determined by a static intrusive co-heating test. From left to right the obtained values (and standard deviations) are presented for the Energy Signature method (ES), Averaging Method (AVG), three types of linear regression method (LR1, LR2 and LR3), and two types of dynamic method: the ARMAX-method (ARX) and state space modelling (SS).

Source: Katia Ritosa, KU Leuven, Belgium

Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale

EBC ANNEX 70

To reduce carbon dioxide emissions (CO2) related to energy use in buildings, information on the building stock is needed to provide both a baseline from which to improve, along with knowing what features can achieve the greatest improvements in performance, comfort and carbon mitigation. There is therefore a growing need for countries and cities around the world to have better quality, higher frequency and greater access to data on building stocks.

The project is focused on identifying, reviewing, evaluating and producing leading edge methods for studying and modelling the building stock including: data collection techniques on energy use, building features and occupant features, and building morphology; analysis of smart meter energy data, building systems, and occupant behaviour; modelling energy demand among sub-national and national building stocks. The project is divided into three parallel subtasks:

- user engagement (needs and provisions),
- data mechanisms and foundations, and
- building stock modelling and analysis.

The results facilitate the use of empirical energy and building stock data in undertaking international energy performance comparisons, policy reviews, national stock modelling, technology and product market assessments, and impact analyses. The deliverables will promote the importance and best practices for collecting and reporting of energy and building stock data.

What is energy epidemiology? Building energy epidemiology is the study of energy use among a population of buildings to better understand its trends and the drivers that result in variations in building energy performance across the stock. This approach can be used to study and describe the mechanisms of energy demand, as well as determinants of conditions that lead to different levels of demand.

An energy epidemiology approach is well-suited to dealing with uncertainty through the use of methodological tools and analysis techniques that include: common definitions and metrics, population selection techniques, study designs for data collection, comparison and analysis, approaches to dealing with bias, guidelines for working towards identifying causal relationships, and systematic approaches to reviewing evidence.

Objectives

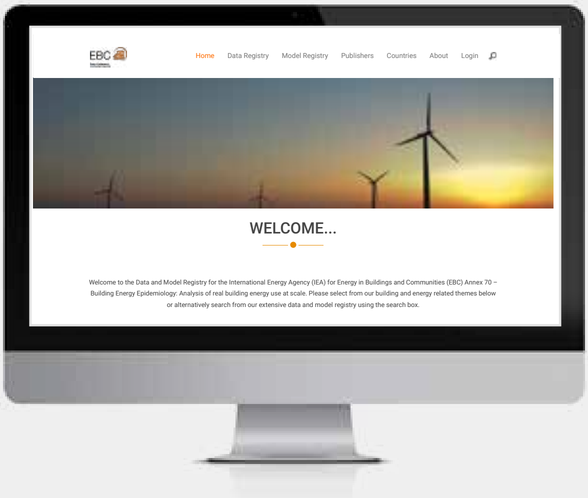
The project objectives are as follows:

- support countries in developing realistic decarbonisation transitions and develop pathways through better available empirically derived energy and buildings data;
- inform and support policymakers and industry in the development of low energy and low carbon solutions by evaluating the scope for using empirical building stock and energy use data;
- develop best practice in the methods used to collect and analyse data related to real building energy use, including building and occupant data;
- support the development of robust building stock data sets and building stock models through better analysis and data collection.

Deliverables

The following project deliverables are being created:

- a register of energy and building stock data among the participating countries and more widely;
- a register of energy and building stock models;
- a data schema for energy and building stock data for developing countries and emerging economies;
- guidelines for energy and building stock model reporting and metrics for stock model comparisons;
- a series of reports on: stakeholder key issues on needs and uses of data; best practice use cases for energy and buildings data; classification for energy and buildings stock data; classification of energy and buildings stock models; stock model uncertainty and sensitivity tests.



The EBC Annex 70 online data and model registries for energy and building stock.
Source: EBC Annex 70

Progress

During 2020, the project participating organisations were engaged in disseminating the concept of energy epidemiology along with the initial outputs of the effort. Also in 2020, the project entered its reporting phase for documenting its completed activities, including those on users' needs, energy and building stock data, and energy and building stock models.

An Energy and Buildings Stock Data Users and Needs survey has been conducted with over 800 responses from across the project participating countries. The survey sought information on what energy and building data they use and what they need to support their activities, including research, decision-making and performance improvement. A global literature review has identified key themes and uses of published data and needs, along with a network analysis of these over time. Finally, a set of case studies on the use of energy and buildings data from across the participating countries has been completed to illustrate the latest approaches to using, analysing and modelling. These activities have informed the data and model registries for energy and building stock.

The project has created an energy and building stock data registry, which progressed to beta-testing during 2020. The registry provides an online platform for identifying, describing and sharing energy and building stock data. As of the end of 2020 the registry contained information on over 1000 datasets across the themes of energy, buildings, people, environment, and other important data for energy and buildings analysis. When publicly launched, the registry will be open to all to access and contribute to. The project has also completed a set of best practice guides that focus on remote sensing, user surveys, energy metering data, geospatial energy and buildings data, and more.

The project has developed a model classification that forms the basis of the online energy and building stock model registry to enable researchers to describe building energy stock models. It has also prepared guidelines for reporting energy and building stock models and provides a framework for reporting models in peer-reviewed journal articles. Finally, during 2020 the project modelling team worked on finalising the set of common exercises that focus on model uncertainty and sensitivity.

Meetings

The following meetings took place in 2020:

- the first reporting phase meeting took place online in March 2020;
- the second reporting phase meeting took place online in June 2020;
- the third reporting phase meeting took place online in September 2020.

Project duration
2016–2022

Operating Agent
Ian Hamilton, University College London, UK

Participating countries
Australia, Austria, Belgium, Canada, P.R. China, Denmark, Germany, Ireland, Japan, the Netherlands, Portugal, Norway, Sweden, Switzerland, UK, USA

Further information
www.iea-ebc.org

Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings

EBC ANNEX 69

Adaptive thermal comfort has been identified as a key approach to establish the balance between reducing building energy use and providing a comfortable indoor environment for occupants. Adequate evidence has shown that strict indoor temperature control can result in high energy costs and greenhouse gas emissions, and may not always be beneficial to the comfort and health of the occupants. The development of adaptive thermal comfort provides criteria and inspiration for the design and operation of low energy buildings. It is evident that people living in different climate zones share different acceptable range of indoor temperature and adaptive responses. The application of adaptive thermal comfort should take seasons and climates into consideration.

The TENIO Green Design Center (Tianjin, P.R. China), which is a case study building in the project.
Source: TENIO Ltd

As long as indoor temperatures are maintained within the acceptable range, people can achieve thermal comfort through three kinds of adaptive methods: physiological, psychological and behavioural response mechanisms. A stable indoor thermal environment based on the steady-state predicted mean vote (PMV) model is not always necessary and may be incapable of signifying the actual thermal demand of all the occupants. In order to overcome some of the difficulties in introducing building energy-saving technologies, it is important to understand the actual thermal demands of the occupants and thermal adaptation mechanisms. Moreover, adaptive thermal comfort provides occupants with opportunities to control their personal environments, which can improve their satisfaction with their indoor thermal environment beyond the levels normally achieved through strict adherence to the PMV model.

Therefore, it is essential to conduct systematic and profound research on adaptive thermal comfort. If a building's services systems could be running in a 'part-time and part-space' mode depending on its occupants' individual demands, instead of the 'whole-time and whole-space' mode prevalent in many buildings today, energy use could also be reduced.

Objectives

This project is developing an analytical and quantitative description of building occupants' adaptive thermal comfort, predicated on reducing energy use while providing comfortable indoor environments. The objectives include the following:

- establish a global thermal comfort database with quantitative descriptions of adaptive responses;
- propose revised indoor environmental standards based on the adaptive thermal comfort concept;
- apply the adaptive thermal comfort concept for achieving low energy use intensities in buildings;
- provide guidelines for developing personal thermal comfort systems with perceived-control adaptation.

Deliverables

The following project deliverables are being produced:

- global thermal comfort database with a user interface;
- a developed model and criteria for adaptive thermal comfort in buildings;
- guidelines for low energy building design based on the adaptive thermal comfort concept;
- guidelines for personal thermal comfort systems.

Progress

In 2020, the project has moved towards its completion and the whole team was focusing on completing the deliverables. Deliverable 1 (database with user interface) and deliverable 2 (adaptive thermal comfort model and criteria) have been finished. Draft reports of Deliverables 3 and 4 (guidelines) were completed. Further, a Call for Papers of Special Issue 'Adaptive Thermal Comfort' in the journal of Energy and Buildings was concluded. More than 40 submissions were accepted in this Special Issue. Another Special Issue in Energy and Buildings, 'Thermal Comfort Diversity', was also opened for new submissions.

Meetings

An online meeting was held in May 2020.

Project duration
2015–2022

Operating Agents
Yingxin Zhu, Tsinghua University, P.R. China
Richard de Dear, University of Sydney, Australia

Participating countries
Australia, Canada, P. R. China, Denmark, Germany, Japan, R. Korea, The Netherlands, Norway, Sweden, UK, USA
Observers: India

Further information
www.iea-ebc.org

Air Infiltration and Ventilation Centre

EBC ANNEX 5

Since its launch in 1979, EBC Annex 5 'Air Infiltration and Ventilation Centre' has been continuously evolving to respond to emerging concerns, challenges and opportunities, with the main goal to provide reference information on ventilation and air infiltration in the built environment with respect to efficient energy use and good indoor environmental quality (IEQ). While 2020 marked the Centre's 41st year of operation, the COVID-19 pandemic outbreak once again spotlighted the significance of ventilation, in this case as a major element in strategies for minimizing the risk of COVID-19 transmission. Therefore, without doubt the AIVC activities need to continue, which is supported by the decision of the EBC Executive Committee to approve the continuation of the AIVC at its November 2020 meeting for a new operating period from 2022 to 2026.

Objectives

The objectives of the AIVC are to:

- identify emerging issues on ventilation and infiltration in new and renovated buildings;
- help better design, implementation, hand-over and maintenance for ventilation systems;
- provide discussion platforms, including conferences, workshops, and webinars.

Deliverables

- Events: annual conference, one to two workshops per year on specific topics, and one to two webinars per year;
- Publications: conference and workshop proceedings, technical notes and contributed reports [one per year], and a biannual newsletter

Progress

In 2020, the AIVC mainly focused its work on eight projects. Due to the global pandemic it was not possible to organize in-person events, including the annual AIVC Conference and planned workshops. Instead, this resulted in the organization of nine webinars. Furthermore, the AIVC facilitated remote discussions and supported dissemination activities for EBC Annex 62 on ventilative cooling, EBC Annex 68 'Design and Operational Strategies for High IAQ in Low Energy Buildings', EBC Annex 78 'Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications', and EBC Annex 80 'Resilient Cooling of Buildings'. The new AIVC website was also launched in 2020.

AIVC Newsletter Special Issue COVID-19

Editorial

We hope you are keeping safe and healthy during this challenging period. As announced in the November issue of the AIVC newsletter, the AIVC board decided to start a project to collect, discuss and disseminate information about COVID-19 in relation to ventilation and airtightness. A working group was created to define the activities and outputs of the project with the title 'Ventilation, airtightness and COVID-19'. The working group members are listed at the last page of this newsletter.

One of the outcomes of the project is the development of a number of questions and answers by working group members to address issues in relation to COVID-19 and building ventilation in line with most recent scientific understanding. This 2nd special issue of the AIVC newsletter presents a new set of question and answers provided by the working group. More elaborate answers are available on the FAQ-section of the AIVC-website, which received an upgrade, together with the Q&A's addressed in the previous newsletter.

The AIVC working group also organizes a number of webinars in line with the project objectives. The webinar "**COVID-19 Ventilation related guidance by ASHRAE and REHVA**" was held on November 20th, 2020 with support from ASHRAE (https://www.ashrae.org/) and REHVA (https://www.rehva.eu/). 406 people from 42 countries attended the webinar. Due to the high numbers of attendance, there were several questions addressed to the speakers who did not manage to answer to all within the event's timeframe. The article available **here** includes edited transcripts of the answers given by the speakers during the event and provides answers to the non-answered questions.

A new **webinar**, digging deeper into the role of building ventilation on COVID-19 transmission is planned on April 1st, 2021. You may find more information in this newsletter.

We wish you a pleasant reading and look forward to seeing you in our future events.

Arnold Janssens, AIVC COVID-19 Working Group chair

1 April 2021 (17:00-18:30 CET) – AIVC Webinar – Building ventilation: How does it affect SARS-CoV-2 transmission?

In this webinar, we address the potential mitigating role of building ventilation in the spread of the COVID-19 pandemic. In the first part of the webinar, we look at building ventilation as one of the mechanisms that affects exposure to infectious aerosol and the uncertainty in relating exposure to airborne transmission of the virus. In the second part of the webinar, we focus on the airflow in real indoor environments, with results from field experiments with aerosol sources and the use of pressure difference in buildings to control the spread of aerosols. This webinar is organized by the Air Infiltration and Ventilation Centre (www.aivc.org/) & the IEA EBC Annex 86 "Energy Efficient Indoor Air Quality Management in Residential Buildings" (https://annex86.iea-ebc.org/). The webinar is facilitated by INIVE (http://www.inive.org/).

Programme

- 17:00 | Introduction, *Arnold Janssens – chair of AIVC WG COVID-19, Ghent University, Belgium*
- 17:10 | The Role of Building Ventilation in Indoor Infectious Aerosol Exposure, *Andrew Persily – NIST, USA*
- 17:25 | Modelling uncertainty in the relative risk of exposure to the SARS-CoV-2 virus by airborne aerosol transmission, *Cath Noakes – University of Leeds, UK*
- 17:40 | Questions and Answers
- 17:50 | Field measurements of aerosol exposure in indoor environments, *Wouter Borsboom – TNO, Netherlands*
- 18:05 | Ventilation system design and the risk areas for spreading airborne contaminants in office buildings, *Alireza Afshari – Aalborg University, Denmark*

18:20 | Questions and Answers

18:30 | Closing & End of Webinar

Participation to the webinar is **FREE** but requires you to **REGISTER** for the event. For further information please visit our **website**.

@AIVCnews

Contents

February 2021

Call to readers

Do you have a question about COVID-19 and ventilation?

Let us know and the AIVC COVID-19 Working Group will try to provide an answer.

Email us at info@aivc.org

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The AIVC Newsletter Special issue on COVID-19 was published in November 2020.

Source: EBC Annex 5

The eight aforementioned AIVC projects are entitled 'Ventilation, Airtightness and COVID-19', 'Temperature Take-back Effect in the Context of Energy Efficient Ventilation Strategies', '40 Years of AIVC', 'Rationale Behind Ventilation Requirements and Regulations', 'Integrating Uncertainties Due to Wind and Stack Effect in Declared Airtightness Results', 'Indoor Air Quality Metrics, 'Residential Cooker Hoods', and 'Competent Tester Schemes for Building Airtightness Testing'.
The project '40 Years of AIVC' is expected to result in a Technical Note 'AIVC after 40 years', highlighting the progress and outcomes over these 40 years with contributions from various AIVC Board experts. The project 'Rationale Behind Ventilation Requirements and Regulations' is also expected to produce a Technical Note.

In May 2020, the AIVC released two Literature Lists on ventilative cooling and building and ductwork airtightness and collaborated with EBC Annex 68 to produce 'Contributed Report #19: Indoor Air Quality Design and Control in Low-Energy Residential Buildings - EBC Annex 68 | Subtask 4'. Moreover, following the launch of the AIVC's 'COVID-19' project, the first AIVC newsletter Special issue on COVID-19 was published in November 2020.

The AIVC organized nine webinars over the course of 2020: two on durability of airtightness (assessment through field measurements, and assessment through laboratory testing) held in January and February 2020; one on ventilative cooling held in March 2020; three on kitchen ventilation, ventilation requirements, moisture control held in May 2020; two on COVID-19 and building leakages held in November 2020; one on resilient ventilative cooling held in December 2020.

Editions of the AIVC newsletter were published in 2020 as listed below:

- March 2020,
- September 2020, and
- November 2020 (Special Issue on COVID-19).

To gain more interaction with related organizations and a stronger societal impact, the AIVC is a founding member of the Indoor Environmental Global Alliance (www.ieq-ga.net). In 2020, a specific COVID-19 website section was created, including 'COVID-19 Information Centre' and 'Frequently Asked Questions'. There is also ongoing close collaboration with the TightVent platform (www.tightvent.eu) and the venticool platform (www.venticool.eu).

Meetings

The AIVC Board organized several online meetings in 2020 at the following times:

- April and May 2020, and
- September 2020.

Project duration
1979–2026

Operating Agent
Peter Wouters, INIVE eeig, Belgium

Participating countries
Australia, Belgium, P.R. China, Denmark, France, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Republic of Korea, Spain, Sweden, UK and USA

Further information and reports
www.iea-ebc.org

AIVC

www.aivc.org

Completed Research Projects

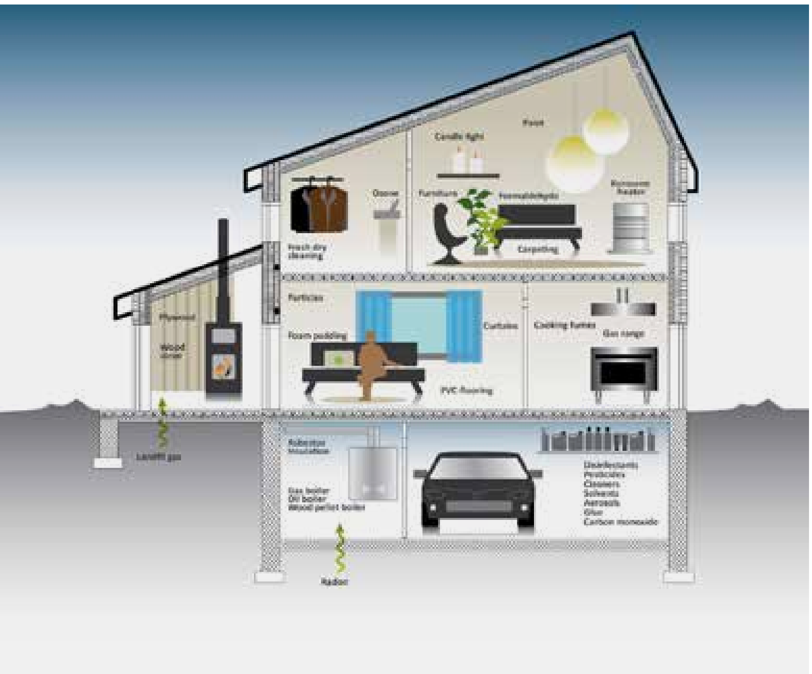
INDOOR AIR QUALITY DESIGN AND CONTROL
IN LOW ENERGY RESIDENTIAL BUILDINGS
(EBC ANNEX 68)

ENERGY FLEXIBLE BUILDINGS
(EBC ANNEX 67)

HVAC ENERGY CALCULATION METHODOLOGIES
FOR NON-RESIDENTIAL BUILDINGS
(EBC WORKING GROUP)

Indoor Air Quality Design and Control in Low Energy Residential Buildings

EBC ANNEX 68



Example of pollutants that may be anticipated in a residential building. The project has delivered fundamental yet practical knowledge to design for pollution management in energy efficient buildings in which ventilation would be governed by demand.

Source: International Centre for Indoor Environment and Energy, Technical University of Denmark

In many industrialised countries, new and deeply renovated existing dwellings are designed to be energy efficient with airtight structures. This leads potentially to a risk of high indoor pollutant loads due to occupant activities and emissions from materials in contact with indoor air. Ventilation must be supplied with the right flow rate of clean air, efficiently distributed in the occupied zone and with proper scheduling to keep indoor pollutant concentrations low, while not increasing the energy need. Building designers, contractors, owners and operators, and other decision makers need the latest knowledge on how to operate ventilation to achieve this.

The project has focused on new and existing residential buildings, although it should be underlined that many findings may also be relevant to other building types. The project objectives were to develop guidelines for design and control strategies for buildings with low energy use that will not compromise the quality of the indoor air. Operational parameters have been dealt with such as control of heating, ventilation and moisture conditions, and their optimal combinations.

First of all, the project established the performance indicators needed to obtain high energy performance and optimal indoor air quality (IAQ). To aid improvement of design and control strategies, tools have been identified, combined and refined that are able to model and analyze the combined effects of temperature, humidity and airflows on pollutant emissions from building products. For use in such modelling, new data have been collected on relevant emission effects, and analogies have been made between pollutant emission properties and well-known properties for moisture transport. A study was carried out that is relevant to practice, based on a survey of indoor environmental sensors and their potential use and variation in quality, including low cost sensors. The project identified and analyzed a number of case studies from different countries in which energy performance and optimal IAQ had been examined and optimized.

Achievements

Rather than developing new knowledge from scratch, the project mainly collected, processed and combined existing knowledge from different scientific communities, such as those relating to ventilation, chemical emissions from construction products, hygrothermal phenomena in buildings, materials, as well as thermal and air flow modelling and simulation of buildings.

At the project outset, existing indicators for IAQ were reviewed, and indicators were then defined that would specifically facilitate the other parts of the project. The IAQ indicators that were studied were documented in a report, which collected state of the art information and suggested a principle in the form of a 'dashboard' on how to balance the combination of the most significant among many pollutants to be considered. The dashboard also highlighted the energy performance aspect.

A major outcome of the project is an easy to understand and practically applicable collection of experiences with design and operational strategies to achieve optimal energy performance and high IAQ in residential buildings. This collection is intended for those involved in the construction and maintenance of buildings. Furthermore, the project created a modelling framework and design tools, suitable for integrated and coordinated design of buildings with low energy demand and high IAQ.
With regards to pollutants in buildings, data and models have been applied on sources and sinks of pollutant emissions to estimate the net pollutant loads over time under realistic environmental conditions. This is supported by databases on the properties of materials with respect to pollutant emissions.

Finally, field tests and case studies were documented for different climatic zones, as well as methodologies to carry out such testing. Specifically, this activity targeted industry partners, building owners and operators.

.An important message from the project for policy makers is to facilitate the possibility by legislation that residential buildings may be operated flexibly and intelligently with regards to demand control of building ventilation in a manner that considers realistic hygrothermal and pollutants loads in buildings. Furthermore, the project has highlighted the need for better quality management, since traditional and novel mechanical ventilation concepts such as those presented in this project all have in common that quality assurance during design, construction and operation is crucial for success, i.e. high IAQ and comfort while minimizing energy use. Consequently, a framework for quality assurance and inspection is needed.

Publications

The project has delivered six technical reports and a database as listed below:

- 'Metrics for High IAQ and Energy Efficiency in Residential Buildings' report,
- ' Pollutant Loads in Energy Efficient Residential Buildings under In-use Conditions' report,
- 'Modelling of IAQ and Energy Efficiency - Review, Gap Analysis and Categorization' report,
- 'Guidebook on Design and Operation for High IAQ in Energy Efficient Residential Buildings' report,
- 'Field Tests and Case Studies - Documentation of Residential Buildings, with regards to Performance on Achieving Optimal Combination of Good IAQ and Low Energy Use' report,
- 'Project Summary Report', and
- 'VOC emissions for IAQ simulations' database.

Meetings

No meetings were held in 2020.

Project duration
2016–2020

Operating Agent
Carsten Rode, Technical University of Denmark, Denmark

Participating countries
Austria, Belgium, Canada, P.R. China, Czech Republic, Denmark, France, Germany, R. Korea, The Netherlands, New Zealand, Norway, United Kingdom, USA
Observers: Estonia

Further information
www.iea-ebc.org

Energy Flexible Buildings

EBC ANNEX 67

Currently, the stability of power grids in many industrialised countries is ensured by fossil-fuel powered generators. But, with the increasing shares of renewable energy sources (RES) and the start of phasing out of fossil-fuel power plants, there is a need for a transition from energy 'generated on demand' to 'consumption on demand', as the demand typically does not align with the energy generation from RES. In practice, this means that energy use needs to become flexible.

Energy flexibility can be obtained in different ways: power-to-X transformation, large battery banks, large heat pumps in district heating systems, and so on. However, in distributed systems the energy flexibility of buildings is assumed to be an important means to ensure the voltage level in power outlets and smooth operation of district heating networks.

Achievements

The available energy flexibility from a building depends on the type of building, the types of energy end uses in the building, the control possibilities, the climate, the time of day and year, the acceptance of the 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 to which the building may provide flexibility services. The amount of available energy flexibility can, thus, not be expressed by a single number, as for example when dealing with energy use. Therefore, the project has developed a methodology including key parameters for the characterization of energy flexibility based on the response of buildings when receiving some sort of control signal - referred to here as a 'penalty signal'.

The penalty signal can be chosen according to specific conditions: Often the penalty signal is a price signal, but it can also be a signal based on the actual CO2 emissions intensity of the energy supply, or the level of energy from RES in an energy network. For these signals the controller should minimize the price or CO2 emissions, or maximize the utilization of RES. Based on the response to a penalty signal, it is possible to obtain a 'flexibility function', which describes the response and thereby the energy flexibility of a building due to the chosen penalty signal. When using the flexibility function in connection with the needs of an energy network it is possible to calculate the 'energy flexibility saving index' (EFSI) and the 'flexibility index' (FI), which state how much (cost or CO2) the building can save (EFSI) when delivering energy flexibility and how much the building can help the energy network (FI). In this way, it is possible to quantify the benefit of providing energy flexibility to the surrounding energy networks. In fact, EFSI and FI may form the basis for a labelling scheme of buildings for energy network operators and aggregators to evaluate if a certain building is suited to deliver flexibility services to the surrounding energy networks.

Since in many cases buildings are unpredictable consumers of energy, optimal control strategies are a key technology in next-generation energy efficient buildings. However, twelve case studies carried out in the project showed that traditional, rules based, control strategies are still being used in most building subsystems even with the recent development of better alternatives. In addition, many studies have focused on independent components of the building rather than building-wide optimization, neglecting the potential efficiency improvements to be exploited for the entire system to achieve significant energy flexibility.

Stakeholder acceptance and behaviour are crucial to the success of strategies for energy flexibility in buildings. Without careful design and implementation, introducing energy flexibility has the potential to disrupt occupant lifestyles, or building systems for thermal comfort and health, as well as potentially increasing cost or energy use. Stakeholder acceptance and behaviour may thus be barriers, but these can be reduced, or overcome entirely, if the related stakeholders are informed about flexibility measures and support the measures that are introduced.

Test and demonstration in real buildings is preferable when evaluating new concepts such as energy flexibility in buildings, but there are many non-controllable variables in a real building, which makes it difficult to draw reliable, significant conclusions, unless the concept is demonstrated in several buildings. Moreover, test and demonstration in real buildings is time consuming and often expensive. On the other hand, simulation is relatively cheap and fast, so that parametric studies can easily be performed. However, since all inputs and the environment are often specified in a simplified way, this may lead to conclusions that are not viable in the real world.

Hardware-in-the-loop test facilities, where parts of a system are physical components while others are virtual, has therefore been investigated in the project to establish a bridge between simulations and tests in real buildings for energy flexibility. Compared to field testing, dynamic tests in a controlled laboratory environment with a semi-virtual approach offer the flexibility of imposing well-controlled and repeatable boundary conditions on real physical equipment, without waiting for given conditions to occur in the real world. Of course, field tests are still necessary for a complete performance assessment, but semi-virtual testing allows going further than conventional laboratory tests at a fraction of the cost of a pilot project. Nine hardware-in-the-loop test facilities have been described in the project. Based on the performed tests, advice on how to carry out future tests in hardware-in-the-loop test facilities has been given.

To support the investigation of different possibilities of obtaining and controlling energy flexibility from buildings, the project has studied several specific cases, either by modelling, or by measuring in real buildings and systems. From this work, it has documented 33 case studies. These case studies cover a broad variety of building typologies, energy systems, sources of flexibility and control strategies.

An overview of the interface for the Energy Flexibility Evaluation Tool (FET): (1) overall inputs for timespan, time steps, cost-function / penalty signal and units, (2) input data about a building's load profile, flexible load profile and a cost function based on the time steps, timespan and units, and (3) evaluation charts and characterization.

Source: Weiss et al., 2019. Tool to Evaluate the Energy Flexibility in Buildings - A Short Manual (EBC Annex 67 technical report)

Publications

The project outcomes are documented in a set of deliverables, which are listed below :

– 'Principles of Energy Flexible Buildings',
– 'Characterization of Energy Flexibility in Buildings',
– 'Control Strategies and Algorithms for Obtaining Energy Flexibility in Buildings',
– 'Experimental Facilities and Methods for Assessing Energy Flexibility in Buildings',
– 'Stakeholder Perspectives on Energy Flexible Buildings',
– 'Examples of Energy Flexibility in Buildings', and
– 'Project Summary Report'.

Project duration
2014–2020

Operating Agent
Søren Østergaard Jensen, Danish Technological Institute, Denmark

Participating countries
Austria, Belgium, Canada, P.R. China, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Switzerland, UK

Further information
www.iea-ebc.org

HVAC Energy Calculation Methodologies for Non-residential Buildings

EBC WORKING GROUP

The real performance of building energy systems is still poorly understood. Methods to obtain information about real performance are essential for performance prediction and development of supporting design and decision tools. Above all, calculation methods for energy use are of the utmost importance and underpin dependable metrics of building energy performance, and this is one of the focal areas of the EBC programme. However, building energy calculation methodologies should never be followed by practitioners simply when they are mandatory. In fact, these calculations should be reliable and sufficiently useful as tools to estimate actual energy use in buildings. An additional challenge for the buildings sector is the complexity and variety of non-residential building functions, as well as the wide range of technical building systems that the calculation methodologies need to address.

Achievements

The objectives of this completed project were to:

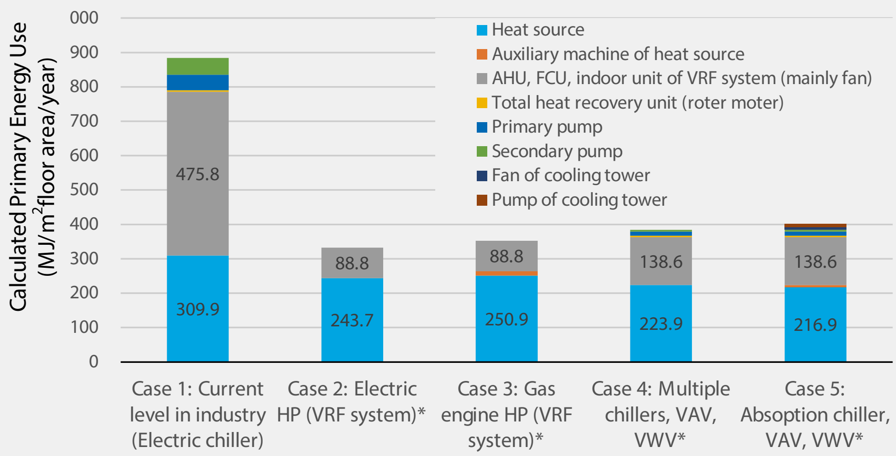
- collect world-wide technical documents on energy use calculation methodologies for HVAC systems in non-residential buildings and on their rationale including information on their validation;
- analyse the collected documents and define methodology characteristics which are appropriate for broader utilization as best-practice examples;
- identify the problems of modelling of core energy-saving functions of HVAC systems in their energy calculation methodologies. Such problems would form the basis of future R&D themes.

Seven national building energy calculation methodologies (Australia, Germany, Italy, Japan, Switzerland, UK and USA), relevant national standards for HVAC equipment, relevant international standards for HVAC equipment and international standards for building energy calculation methods (ISO and CEN) were reviewed and analysed. National documents for the logic and rationale of energy calculations for HVAC systems have been analysed. Even though these documents have been prepared in a very transparent way, it requires considerable work to understand and interpret them. The outputs from this kind of analysis should be shared among experts engaged in the improvement of calculation methods as policy tools and for their background scientific basis.

It has emerged that each of the national calculation methodologies for HVAC systems in non-residential buildings has taken a very long time to be developed with the engagement of the national building industry. Moreover, maintenance and improvement of calculation methodologies and relevant documents need significant national resources. If the relationship between calculated and actual energy use can be sufficiently improved, and if the operation of the calculation methodologies and compliance checking can be carried out in an appropriate way, the goal of reducing energy-related CO_2 emissions due to buildings would be accomplished more efficiently.

Coordination among national calculation methodologies: Even though some common regional or international standards for thermal demand calculations (e.g. ISO 13790) and equipment product standards (e.g. EN 14875, AHRI 550/590) are referred to, coordination among national calculation methodologies does not currently exist. Moreover, national practices in building and HVAC industries do not necessarily follow common standards for design and construction. Therefore, further development of international standards for building energy calculations is a key recommendation from the project. This activity is proposed to take place in collaboration with CEN and ISO, with its outputs followed up especially by EBC Annexes and Working Groups. In addition, it is strongly recommended their R&D outputs in turn should contribute to standardization activities.

Quantifying energy uses for air / water conveyance and heat / cold generation: The energy use by HVAC systems is influenced by factors including thermal demands, heat losses during heat conveyance / emission to the air-



An example of HVAC energy calculations for four energy efficient cases (Cases 2 to 5) compared with the target energy use (criterion of building energy standard compliance for this example office building).

Source: EBC Working Group on HVAC Energy Calculation Methodologies for Non-residential Buildings

conditioned space, power for air / water conveyance, and heat / cold generation. In every national and international energy calculation methodology there have been substantial efforts made on how to quantify energy uses for the power for air / water conveyance and the heat / cold generation in HVAC systems. These energy uses predominate over other energy uses for HVAC systems. There is still much room for improving the reliability and effectiveness of their energy calculation methodologies.

Power consumption for fans and pumps: To estimate electric power demands of motors for fans / pumps for air / water conveyance in HVAC systems, energy efficiencies of motors and variable frequency drives under actual part load conditions are needed in addition to the required power input to motors. Even if these parameters are not known when the energy calculations are completed in the early stages of the design process, reasonably assumed default values are required. In addition to optimized sizing of fan and pump systems, control strategies for fans / pumps to reduce air / water conveyance volume by responding to heat / cold needs are remarkably promising to conserve energy for air / water conveyance. However, it was found that neither definitions nor calculation logic for the control strategies have yet been implemented in existing energy calculation methodologies.

Energy use for heat and cold generators: As for heat / cold generation, even when sizing practices are carried out during design, the partial load ratio (ratio of the actual output to the capacity of the generator) can be quite low in the majority of actual operation periods, for example 10% to 30%. Therefore, the energy efficiency of generators under a low partial load ratio is critical in energy calculations. It was revealed that six national calculation methodologies apply different methods for estimating the energy efficiency under a low partial load ratio.

Transparent approaches are needed to share information on actual behaviour of heat and cold generators as a basis to further develop more reliable energy calculation methods, particularly between HVAC equipment manufacturers and the building industry. While the former has sought consistent product standards for efficiency comparisons, but without accurate information on building installations, the latter has tried to apply such product standards for HVAC energy calculations including information on the building and climatic conditions at its location. As a minimum, further R&D is needed for the building industry side to better understand the characteristics of various types of heat and cold generators, and to search for reasonable ways to estimate energy efficiencies under low partial load ratios.

Publications

EBC Working Group Final Report: HVAC Energy Calculation Methodologies for Non-residential Buildings - A Survey of National Methodologies, and Relevant National and International Standards

Project duration
2016–2020

Operating Agent
Takao Sawachi, Building Research Institute, Japan

Participating countries
Australia, Canada, P. R. China, Germany, Italy, Japan, the Netherlands, Switzerland, UK, USA

Further information
www.iea-ebc.org

Background Information

EBC and the IEA

THE INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster cooperation among the thirty IEA member countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D). The current framework for international energy technology RD&D cooperation was approved by the IEA's Governing Board in 2003. More information about the energy technology RD&D framework can be found at:
www.iea.org/tcp

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

- reduced cost and avoiding duplication of work,
- greater project scale,
- information sharing and networking,
- linking IEA member countries and non-member countries,
- linking research, industry and policy,
- accelerated development and deployment,
- harmonised technical standards,
- strengthened national RD&D capabilities, and
- intellectual property rights protection.

ABOUT EBC

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

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

OBJECTIVES AND STRATEGY

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

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

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

- the environmental impacts of fossil fuels;
- business processes to meet energy and environmental targets;
- building technologies to reduce energy use;
- reduction of greenhouse gas emissions;
- the 'whole building' performance approach;
- sustainability;
- the impact of energy reduction measures on indoor health, comfort and usability;
- the exploitation of innovation and information technology;
- integrating changes in lifestyle, work and business environments.

MISSION STATEMENT

The mission of the IEA Energy in Buildings and Communities Programme is as follows: 'To support the acceleration of the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge, technologies and processes and other solutions through international collaborative research and open innovation.'

NATURE OF EBC ACTIVITIES

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

b. Formal coordination through cost shared activities: EBC currently supports one cost shared project, Annex 5, the Air Infiltration and Ventilation Centre (AIVC). In recent times, Annex 5 has subcontracted its information dissemination activities to the Operating Agent, by means of a partial subsidy of costs and the right to exploit the Annex's past products.

c. Informal coordination or initiation of activities by participants: Many organizations and groups take part in the activities of EBC including government bodies, universities, nonprofit making research institutes and industry.

d. Information exchange: Information about associated activities is exchanged through the EBC and through individual projects.

The EBC website (www.iea-ebc.org), for example, provides links to associated research organizations. Participants in each project are frequently associated with non IEA activities and can thus ensure a good cross-fertilization of knowledge about independent activities. Information exchange additionally takes place through regular technical presentation sessions and 'Future Buildings Forum' workshops. Information on independent activities is also exchanged through the EBC newsletter, which, for example, carries regular reports of energy policy development and research activities taking place in various countries.

EBC PARTICIPATING COUNTRIES

Australia
Austria
Belgium
Brazil
Canada
P.R. China
Czech Republic
Denmark
Finland
France
Germany
Italy
Ireland
Japan
R. Korea
New Zealand
The Netherlands
Norway
Portugal
Singapore
Spain
Sweden
Switzerland
Turkey
UK
USA

COORDINATION WITH OTHER BODIES

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

COLLABORATION WITH IEA BUILDINGS-RELATED TECHNOLOGY COLLABORATION PROGRAMMES

The EBC TCP continues to coordinate its research activities, including Annexes and strategic planning, with all IEA buildings-related TCPs through collaborative projects and through the BCG (Buildings Coordination Group), constituted by the IEA Energy End Use Working Party (EUWP) Vice Chair for Buildings and the Executive Committee Chairs of the following IEA Technology Collaboration Programmes:

– District Heating And Cooling (DHC)
– User-Centred Energy Systems (Users)
– Energy in Buildings and Communities (EBC)
– Energy Conservation through Energy Storage (ECES)
– Heat Pumping Technologies (HPT)
– International Smart Grid Action Network (ISGAN)
– Photovoltaic Power Systems (PVPS)
– Solar Heating and Cooling (SHC)
– Energy Efficient Electrical Equipment (4E)

Beyond the BCG meetings, EBC meets with representatives of all buildings-related TCPs at Future Buildings Forum (FBF) Think Tanks and Workshops. The outcome from each Future Buildings Forum Think Tank is used strategically by the various IEA buildings-related Technology Collaboration Programmes to help in the development of their work programmes over the subsequent five year period.Proposals for new research projects are discussed in coordination with these other programmes to pool expertise and to avoid duplication of research. Coordination with SHC is particularly strong.

COLLABORATION WITH THE IEA SOLAR HEATING AND COOLING PROGRAMME

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

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

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

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

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

- technology development via international collaboration;
- information dissemination to target audiences;
- enhancing building standards;
- interaction with developing countries.

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

NON-IEA ACTIVITIES

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

- Mission Innovation (MI)
- The European Commission (EC), and
- The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

Recent Publications

Air Infiltration and Ventilation Centre (AIVC) – EBC Annex 5

Databases

AIRBASE – bibliographical database, containing over 22,000 records on air infiltration, ventilation and related areas, Web based, updated every 3 months

AIVC Conference Proceedings

– 40th AIVC Annual Conference, held Ghent, Belgium, October 2019

Ventilation Information Papers

– VIP 38: What is smart ventilation?, 2018
– VIP 39: A Review of Performance-based Approaches to Residential Smart Ventilation, 2019
– VIP 40: Ductwork airtightness - A review, 2020

Contributed Reports

– CR18: Ventilation and Indoor Air Quality in New California Homes with Gas Appliances and Mechanical Ventilation, 2019

Ventilative Cooling – EBC Annex 62

– Ventilative Cooling Sourcebook, 2018
– Ventilative Cooling Design Guide, 2018
– Ventilative Cooling Case Studies, 2018
– Status and Recommendations for Better Implementation of Ventilative Cooling in
–Standards, Legislation and Compliance Tools, 2018

Implementation of Energy Strategies in Communities – EBC Annex 63

– Volume 1: Inventory of Measures, 2017
– Volume 2: Development of Strategic Measures, 2017
– Volume 3: Application of Strategic Measures, 2018
– Volume 4: Stakeholder Support Materials, 2018
– Volume 5: Recommendations, 2018

Long-term Performance of Super-insulating Materials in Building Components and Systems – EBC Annex 65

– State of the Art on Materials and Components: Case Studies, 2019
– Characterization of materials and components: Laboratory Scale, 2019
– Practical Applications: Retrofitting at the Building Scale – Field Scale, 2019
– Sustainability: LCC, LCA, EE – Risk & Benefit, 2019

Definition and Simulation of Occupant Behavior in Buildings – EBC Annex 66

– Final Report, 2018
– Reference Procedures for Obtaining Occupancy Profiles in Residential Buildings, 2018
– Technical Report: An International Survey of Occupant Behavior in Workspaces, 2017
– Technical Report: Studying Occupant Behavior in Buildings - Methods and Challenges, 2017
– Technical Report: Surveys to Understand Current Needs, Practice and Capabilities of Occupant Modeling in Building Simulation, 2017
– Technical Report: Occupant Behavior Modeling Approaches and Evaluation, 2017
– Technical Report: Occupant Behavior Case Study Sourcebook, 2017

Integrated Solutions for Daylighting and Electric Lighting – EBC Annex 77 / SHC Task 61

– Workflow and Software for the Design of Integrated Lighting Solutions, 2019

Energy Flexible Buildings – EBC Annex 67

– Stakeholders' Perspectives on Energy Flexible Buildings, 2019
– Principles of Energy Flexible Buildings, 2019
– Characterization of Energy Flexibility in Buildings, 2019
– Control Strategies and Algorithms for Obtaining Energy Flexibility in Buildings, 2019
– Examples of Energy Flexibility in Buildings, 2019
– Experimental Facilities and Methods for Assessing Energy Flexibility in Buildings, 2019

Design and Operational Strategies for High IAQ in Low Energy Buildings – EBC Annex 68

– Subtask 1: Defining the Metrics, 2017
– Subtask 2: Pollutant Loads in Residential Buildings (Common Exercises), 2020
– Subtask 3: Modelling of Energy Efficiency and IAQ - Review, Gap analysis and Categorization, 2020
– Subtask 4: Current Challenges, Selected Case Studies and Innovative Solutions Covering Indoor Air Quality, Ventilation Design and Control in Residences, 2020
– Subtask 5: Field Measurements and Case Studies, 2020
– Subtask 5: Field Measurements and Case Studies - Appendix to Final Report: Case Studies, 2020

Working Group on HVAC Energy Calculation Methodologies for Non-residential Buildings

– Final Report, 2020

Working Group on Cities and Communities

– Final Report, 2020

EBC Executive Commitee Members

CHAIR
Dr Takao Sawachi (Japan)

VICE CHAIR
Prof Paul Ruyssevelt (United Kingdom)

AUSTRALIA
Stanford Harrison
Department of Industry, Science, Energy and Resources
stanford.harrison@industry.gov.au

AUSTRIA
DI (FH) Isabella Warisch
Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology
Isabella.Warisch@bmk.gv.at

BELGIUM
Dr Peter Wouters
Belgian Building Research Institute (CSTC – WTCB)
peter.wouters@bbri.be

BRAZIL
Carlos Alexandre Principe Pires
Ministério de Minas e Energia
carlos.pires@mme.gov.br

CANADA
Meli Stylianou
Natural Resources Canada
meli.stylianou@canada.ca

P.R. CHINA
Prof Yi Jiang
Tsinghua University
jiangyi@tsinghua.edu.cn

CZECH REPUBLIC
Hana Rambousková
Ministry of Industry and Trade
rambouskova@mpo.cz

DENMARK
Søren Østergaard Jensen
The Danish Energy Agency
snjn@ens.dk

FINLAND
Dr Ala Hasan
VTT Technical Research Centre of Finland
Ala.Hasan@vtt.fi

FRANCE
Marjorie Musy
CEREMA
marjorie.musy@cerema.fr

GERMANY
Katja Riess
Forschungszentrum Juelich
k.riess@fz-juelich.de

IRELAND
Conor Hanniffy
Sustainable Energy Authority of Ireland
conor.hanniffy@seai.ie

ITALY
Michele Zinzi
ENEA - UTEE ERT
michele.zinzi@enea.it

JAPAN
Dr Eng Takao Sawachi (Chair)
The Building Center of Japan, Japan
sawachi_t@bcj.or.jp

REPUBLIC OF KOREA
Dr Seung-eon Lee
Korea Institute of Construction Technology
selee2@kict.re.kr

NETHERLANDS
Daniël van Rijn
Netherlands Enterprise Agency
daniel.vanrijn@rvo.nl

NEW ZEALAND
Michael Donn
Victoria University of Wellington
michael.donn@vuw.ac.nz

NORWAY
Mari Lyseid Authen
Norges Forskningsråd
mlau@forskningsradet.no

PORTUGAL
João Mariz Graça
Direção-Geral de Energia e Geologia
Joao.Graca@dgeg.gov.pt

SINGAPORE
Dr Gao Chun Ping
Building and Construction Authority
GAO_Chun_Ping@bca.gov.sg

SPAIN
Francisco Rodriguez Pérez-Curiel
Tecnalia Research & Innovation
francisco.rodriguez@tecnalia.com

SWEDEN
Dr Jörgen Sjödin
Swedish Energy Agency
jorgen.sjodin@energimyndigheten.se

SWITZERLAND
Andreas Eckmanns
Bundesamt für Energie BFE
andreas.eckmanns@bfe.admin.ch

TURKEY
Assoc. Prof Dr. Gülsu Ulukavak Harputlugil
Çankaya Üniversitesi
gharputlugil@cankaya.edu.tr

UK
Prof Paul Ruyssevelt (Vice Chair)
University College London
p.ruyssevelt@ucl.ac.uk

USA
David Nemtzow
US Department of Energy
David.Nemtzow@ee.doe.gov

EBC Executive Committee Support and Services Unit (ESSU)
Malcolm Orme
essu@iea-ebc.org

IEA Secretariat
Michael Oppermann
michael.oppermann@iea.org

EBC Operating Agents

Air Infiltration and Ventilation Centre (AIVC) – EBC Annex 5
Dr Peter Wouters
INIVE EEIG, Belgium
info@aivc.org

Energy Flexible Buildings – EBC Annex 67
Søren Østergaard Jensen
Danish Technological Institute, Denmark
sosje@dtu.dk

Design and Operational Strategies for High IAQ in Low Energy Buildings – EBC Annex 68
Prof Carsten Rode
Technical University of Denmark, Denmark
car@byg.dtu.dk

Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings – EBC Annex 69
Prof Yingxin Zhu
Tsinghua University, P.R. China
zhuyx@tsinghua.edu.cn

Prof Richard de Dear
University of Sydney, Australia
richard.dedear@sydney.edu.au

Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale – EBC Annex 70
Dr Ian Hamilton
University College London, UK
i.hamilton@ucl.ac.uk

Building Energy Performance Assessment Based on In-situ Measurements – EBC Annex 71
Prof Staf Roels
University of Leuven, Belgium
staf.roels@bwk.kuleuven.be

Assessing Life Cycle Related Environmental Impacts Caused by Buildings – EBC Annex 72
Rolf Frischknecht
treeze Ltd., Switzerland
frischknecht@treeze.ch

Towards Net Zero Energy Resilient Public Communities – EBC Annex 73
Dr Alexander M. Zhivov
Energy Branch US Army Corps of Engineers, USA
Alexander.M.Zhivov@erdc.usace.army.mil

Rüdiger Lohse
KEA-Climate protection and energy agency of Baden-Württemberg GmbH, Germany
ruediger.lohse@edlhub.org

Competition and Living Lab Platform – EBC Annex 74
Prof Karsten Voss
University Wuppertal, Germany
kvoss@uni-wuppertal.de

Prof Sergio Vega
Technical University of Madrid, Spain
sergio.vega@sdeurope.org

Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables – EBC Annex 75
Dr Manuela Almeida
University of Minho, Portugal
malmeida@civil.uminho.pt

Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions – EBC Annex 76 / SHC Task 59
Dr Alexandra Troi
EURAC Research, Italy
Alexandra.Troi@eurac.edu

Integrated Solutions for Daylighting and Electric Lighting – EBC Annex 77 / SHC Task 61
Dr-Ing Jan de Boer
Fraunhofer Institute for Building Physics, Germany
jan.deboer@ibp.fraunhofer.de

Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications – EBC Annex 78
Prof Bjarne Olesen
Technical University of Denmark
bwo@byg.dtu.dk

Dr Pawel Wargocki
Technical University of Denmark
paw@byg.dtu.dk

Occupant-centric Building Design and Operation - EBC Annex 79
Dr Liam O'Brien,
Carleton University
liamobrien@cunet.carleton.ca

Prof Andreas Wagner
Karlsruhe Institute of Technology
wagner@kit.edu

Resilient Cooling of Buildings - EBC Annex 80
Dr Peter Holzer
Institute of Building Research and Innovation
peter.holzer@building-research.at

Data-Driven Smart Buildings – EBC Annex 81
Dr Stephen White
CSIRO, Australia
Stephen.D.White@csiro.au

Energy Flexible Buildings towards Resilient Low Carbon Energy Systems – EBC Annex 82
Søren Østergaard Jensen
Danish Technological Institute, Denmark
sosje@dtu.dk

Positive Energy Districts - EBC Annex 83
Dr Pekka Tuominen
VTT Technical Research Centre, Finland
Pekka.Tuominen@vtt.fi

Dr Francesco Reda
VTT Technical Research Centre, Finland
Francesco.Reda@vtt.fi

Demand Management of Buildings in Thermal Networks
- Annex 84

Dr Anna Marszal-Pomianowska
Aalborg University, Denmark
ajm@build.aau.dk

Indirect Evaporative Cooling
- Annex 85

Dr Xiaoyun Xie
Tsinghua University, P.R. China
xiexiaoyun@tsinghua.edu.cn

Energy Efficient Indoor Air Quality Management in Residential Buildings
- Annex 86

Ghent University, Belgium
jelle.laverge@ugent.be

HVAC Energy Calculation Methodologies for Non-residential Buildings
EBC Working Group

Dr Eng Takao Sawachi
Building Research Institute, Japan
tsawachi@kenken.go.jp

Communities and Cities
EBC Working Group

Helmut Strasser
Salzburg Institute for Regional Planning and Housing, Austria
helmut.strasser@salzburg.gv.at

Building Energy Codes
EBC Working Group

David Nemtzow
US Department of Energy , USA
David.Nemtzow@ee.doe.gov

Meredydd Evans
Pacific Northwest National Laboratory , USA
m.evans@pnnl.gov

Past Projects

Annex 1 Load Energy Determination ofBuildings
Annex 2 Ekistics and Advanced Community Energy Systems
Annex 3 Energy Conservation in Residential Buildings
Annex 4 Glasgow Commercial Building Monitoring
Annex 6 Energy Systems and Design of Communities
Annex 7 Local Government Energy Planning
Annex 8 Inhabitants Behaviour with Regard to Ventilation
Annex 9 Minimum Ventilation Rates
Annex 10 Building HVAC System Simulation
Annex 11 Energy Auditing
Annex 12 Windows and Fenestration
Annex 13 Energy Management in Hospitals
Annex 14 Condensation and Energy
Annex 15 Energy Efficiency in Schools
Annex 16 BEMS 1-User Interfaces and System Integration
Annex 17 BEMS 2-Evaluation and Emulation Techniques
Annex 18 Demand Controlled Ventilation Systems
Annex 19 Low Slope Roof Systems
Annex 20 Air Flow Patterns within Buildings
Annex 21 Thermal Modelling
Annex 22 Energy Efficient Communities
Annex 23 Multi Zone Air Flow Modelling (COMIS)
Annex 24 Heat, Air and Moisture Transfer in Envelopes
Annex 25 Real time HEVAC Simulation
Annex 26 Energy Efficient Ventilation of Large Enclosures
Annex 27 Evaluation and Demonstration of Domestic Ventilation Systems
Annex 28 Low Energy Cooling Systems
Annex 29 Daylight in Buildings
Annex 30 Bringing Simulation to Application
Annex 31 Energy-Related Environmental Impact of Buildings
Annex 32 Integral Building Envelope Performance Assessment
Annex 33 Advanced Local Energy Planning
Annex 34 Computer-Aided Evaluation of HVAC System Performance
Annex 35 Design of Energy Efficient Hybrid Ventilation (HYBVENT)
Annex 36 Retrofitting of Educational Buildings
Annex 37 Low Exergy Systems for Heating and Cooling of Buildings (LowEx)
Annex 38 Solar Sustainable Housing
Annex 39 High Performance Insulation Systems
Annex 40 Building Commissioning to Improve Energy Performance
Annex 41 Whole Building Heat, Air and Moisture Response (MOIST-ENG)
Annex 42 The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM)
Annex 43 Testing and Validation of Building Energy Simulation Tools
Annex 44 Integrating Environmentally Responsive Elements in Buildings
Annex 45 Energy Efficient Electric Lighting for Buildings
Annex 46 Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)
Annex 47 Cost-Effective Commissioning for Existing and Low Energy Buildings
Annex 48 Heat Pumping and Reversible Air Conditioning
Annex 49 Low Exergy Systems for High Performance Buildings and Communities
Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings
Annex 51 Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers
Annex 52 Towards Net Zero Energy Solar Buildings (NZEBs)
Annex 53 Total Energy Use in Buildings – Analysis and Evaluation Methods
Annex 54 Integration of Microgeneration and Other Energy Technologies in Buildings
Annex 55 Reliability of Energy Efficient Building Retrofitting – Probability Assessment of Performance and Cost
Annex 56 Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation
Annex 57 Evaluation of Embodied Energy and Carbon Dioxide Equivalent Emissions for Building Construction
Annex 58 Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurement
Annex 59 High Temperature Cooling and Low Temperature Heating in Buildings
Annex 60 New Generation Computational Tools for Building and Community Energy Systems
Annex 61 Business and Technical Concepts for Deep Energy Retrofit of Public Buildings
Annex 62 Ventilative Cooling
Annex 63 Implementation of Energy Strategies in Communities
Annex 64 LowEx Communities – Optimised Performance of Energy Supply Systems with Exergy Principles
Annex 65 Long-term Performance of Super-insulating Materials in Building Components and Systems
Annex 66 Definition and Simulation of Occupant Behavior in Buildings
Annex 67 Energy Flexible Buildings
Annex 68 Indoor Air Quality Design and Control in Low Energy Residential Building