EUDP
The Energy Technology Development and Demonstration Programme

Danish Energy Agency

EBC
Energy in Buildings and Communities Programme

IEA EBC Technical Day

June 22, 2023
Eigtveds Pakhus, Strandgade 25D, 1401 Copenhagen

EBC (Energy in Buildings and Communities) is one of several Technical Collaboration Programs under IEA. The IEA EBC programme is an international energy research and innovation programme in the buildings and communities field. It enables collaborative R&D projects among its 26 member countries.

The Executive Committee (ExCo) meets bi-annually to evaluate the progress of ongoing project (so-called annexes) and to decide on initiating new annexes in areas of importance for not only the energy demand in buildings and communities, but also in areas like indoor climate and energy flexibility. Denmark is in June 19-21, 2023 host for the bi-annual IEA EBC ExCo meeting.

Before the COVID-19 pandemic, a Technical Day was always arranged in connection with the IEA EBC ExCo meeting. The here announced Technical Day is the first after COVID-19.

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The purpose of the IEA EBC Technical Day is twofold:

- To inform researchers in the host country about the work going on in IEA EBC
- To inform the participants of IEA EBC ExCo about research and development going on in the host country

The Technical Day on June 22, 2023 is thus a mix of EBC Annex presentations and Danish presentations. The overall layout of the day is:

- How will Denmark prepare for no fossil fuels in the energy grids
- Sustainability in the Danish Building Code
- Indoor climate and ventilation
- Smart buildings and energy flexibility
- Positive energy districts and digital decision support tools

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The hosts of the day is Danish Energy Agency represented by Søren Østergaard Jensen (snjn@ens.dk) and EUDP represented by Henrik Holm Friis.

To sign up to the IEA EBC Technical Day please register here: Registration

Deadline for registration is June 13, 2023. *There is a limited number of seats so please only register if you are certain that you will participate in the day.*

Agenda for IEA EBC Technical Day, June 22, 2023

9:00-9:30 Registration

9:30-9:40 Introduction (Søren Østergaard Jensen, Advisor, Danish Energy Agency)

9:40-10:00 Setting the scene (Stine Leth Rasmussen, Deputy Director General, Danish Energy Agency)

10:00-11:00 Sustainability

- LCA requirements in Danish Building Regulation – what is it and how did we get here? (Harpa Birgisdottir, Aalborg University, DK)
- Residential construction from 4 to 1 planet (Stig Hessellund, RealDania, DK)
- Data for a resource effective construction site (Ole Berard, Molio, DK)

11:00-11:15 Refreshment break

11:15-12:45 Indoor climate and ventilation

- Annex 79 Occupant-Centric Building Design and Operation (Rune Korsholm Andersen, DTU SUSTAIN, DK)
- Annex 86 Energy Efficient Indoor Air Quality Management in Residential Buildings (Jelle Laverge, Ghent University, Belgium)
- Is there a potential in combining diffuse ceiling ventilation with double skin façade for school renovation (I-DIFFER)? (Olena Kalyanova Larsen, Aalborg University, DK)
- Annex 5 Air Infiltration and Ventilation Centre (Arnold Janssens, Ghent University, Belgium)

12:45-13:45 Lunch

13:45-14:45 Smart buildings and energy flexibility

- Annex 81 Data-Driven Smart Buildings (Stephen White, CSIRO, Australia)
- Opsys 2.0 - Measured and predicted energy flexibility in a single family house (Ivan Katic, Danish Technological Institute, DK)
- Annex 84 Demand Management of Buildings in Thermal Networks (Anna Marszal-Pomianowska, Aalborg University, DK)

14:45-15:00 Refreshment break

15:00-16:00 Positive energy districts and digital decision support tools

- Annex 83 Positive Energy Districts (Hassan Rehman, VTT, Finland)
- Digital Twins for energy efficient smart buildings (Muhyiddine Jradi, SDU, DK)
- Data Driven Energy Experts – how AI-tools supports the missing link (Rasmus Petersen, EG, DK)

16:00 Goodbye

Teasers for presentations

Setting the Scene

How does Denmark and the Danish Energy Agency prepare for an energy system fully based on renewable energy – with special focus on buildings.

LCA requirements in Danish Building Regulation – what is it and how did we get here?

In March 2021, the Danish government introduced targets in in the building regulations for whole life carbon on new constructions which come into effect in 2023. This whole life approach embraces both operational and embodied carbon. Buildings below 1,000 m^2 will initially only be required to calculate the life cycle assessment (LCA), while buildings over 1,000 m^2 will be required to meet whole life carbon limits (CO2e). This applies for all building types, but only for new constructions. The initial limit value is 12 kg CO_2e/m^2/year, supported by a specific voluntary CO2-class with a limit value of 8 kg CO_2e/m^2/year. The limit values are to be tightened every second year until 2029. The regulation of smaller buildings is expected to commence in 2025. At the same time, methods for how to include similar requirements for building regulations have also been investigated. The limit values for new constructions were set based on studies of the whole life carbon emissions of new constructions conducted by BUILD AAU. Studies developing methods for allowing exceeding the limit values for special building cases and purposes, such as hospitals etc. were also conducted. All calculations methods for fulfilling the building regulation have been implemented in the Danish freely available LCA tool for buildings – LCAbyg.

Residential construction from 4 to 1 planet

This initiative aims to reduce the life cycle footprint (CO_2e/m^2) from residential construction in Denmark by 75% in a close cooperation with researchers, scientists, front-runners from the building industry and other stakeholders. We will talk about change theory, preliminary results and the road to healthy, attractive dwellings with an LCA footprint of 2.5kg CO_2/m^2/year at scale.

Data for a resource effective construction site

The construction industry's impact on the climate is substantial. While the optimization of energy use in building operations has been a focus for many years, the construction phase's resource consumption, including energy, fuel, material waste, and water, has yet to be optimized. It is essential to address this issue, and we believe that data is the key to achieving this goal.

In collaboration with five of Denmark's largest contractors, two knowledge institutions, and technology suppliers, this project aims to measure resource consumption on ten construction sites and create a common data platform. The platform will provide incentives for minimizing resource consumption, and the use of technology will enable effective data collection to optimize resource usage. By focusing on this critical aspect of construction, we can significantly reduce the industry's impact on the environment and promote sustainable practices.

Annex 79 Occupant-Centric Building Design and Operation

As buildings become more efficient and we more closely track energy use, it has become increasingly clear that occupants play a large and growing role in building performance. The field of occupant modelling emerged over four decades ago; however, it has surged in the past decade – particularly as a result of IEA EBC Annex 66 – “Simulation and Definition of Occupant Behaviour in Buildings”. Annex 66 played an important role in formalizing experimental research methods, modelling and model validation, and occupant simulation. Given the number of unanswered questions about occupant comfort and behaviour and minimal penetration of advanced occupant modelling into practice, this follow-up Annex 79 - “Occupant-centric building design and operation”, explores these issues while also focusing on application and knowledge transfer to practitioners. Annex 79 is focused on four main areas: 1) multi-domain comfort evaluation and the impact on energy-related behaviour, 2) occupant modelling fundamentals and data-driven modelling, 3) occupant-centric building design methods, and 4) occupant-centric controls fundamentals and application.

Annex 86 Energy Efficient Indoor Air Quality Management in Residential Buildings

Annex 86 is focused on the development of an integrated rating method for the performance assessment and optimization of energy efficient strategies of managing the indoor air quality (IAQ) in new and existing residential buildings. To achieve this, we gather the existing scientific knowledge and data on pollution sources in buildings, look at the opportunities that spring from the rise of IoT connected sensors, study current and innovative use cases of IAQ management strategies and develop road maps to ensure the continuous performance of the proposed solutions over their lifetime. We mainly focus on the use of smart materials (materials that have an ability to actively or passively influence IAQ in the space) and smart ventilation (as defined by AIVC VIP nr. 38), since these are strategies that have a high energy efficiency potential.

Is there a potential in combining diffuse ceiling ventilation with double skin façade for school renovation (I-DIFFER)?

The I-DIFFER solution offers a novel alternative to traditional building renovation approaches. It is proposed for buildings with high internal loads and poor indoor air quality, particularly in mild winter climates. This solution combines the benefits of diffuse ceiling ventilation and double skin façade technologies. Its performance is evaluated using both full-scale measurements and simulations utilizing IDA-ICE and Energy Plus calculation engines. The monitoring results demonstrate that the I-DIFFER solution has the potential to reduce peak operative temperatures and shift them to later hours, in part due to the efficient utilization of night-time cooling potential.

Annex 5 Air Infiltration and Ventilation Centre (AIVC)

AIVC is the IEA’s information center on energy efficient ventilation, inaugurated in 1979. The key driver in AIVC’s current activities is the challenge to achieve a climate neutral building stock with implementation of close to zero energy buildings and deep energy retrofits on a very large scale, at the same time achieving good IEQ, with major impacts on the role of airtightness and ventilation technology. AIVC's activities include the production of high-quality documents regarding energy efficient ventilation, generating strategy and advice on ventilation related issues, and disseminating information through conferences, workshops, webinars, databases and web presence. The presentation gives an overview of recent results developed by AIVC.

Annex 81 Data-Driven Smart Buildings

Digital technology has the potential to reduce costs and overcome barriers to energy efficiency, through advanced control and operation of building HVAC systems. Unfortunately, adoption of these technologies has been slow. Interoperability and data access barriers have made deployment complex, requiring significant manual intervention and cost. Modern IT approaches for the managing data, combined with use of data-driven algorithms, have created an opportunity for more scalable deployment of these technologies. Annex 81 aims to develop knowledge, standards, protocols and procedures for low-cost high-quality data capture, sharing and utilization in buildings. It further aims to showcase, benchmark and demonstrate the benefits of data-driven applications including (i) model predictive control, (ii) fault detection and diagnosis and (iii) grid integrated control of buildings. A number of case studies have been reported on an Annex web-portal. The Annex has also been collecting data-sets suitable for training data-driven algorithms, a key resource for enabling machine learning/ AI research. The Annex is using such data to run AI competitions, as a means of stimulating innovation.

Opsys 2.0 - Measured and predicted energy flexibility in a single family house

Both EU and IEA sees the energy flexibility of buildings as an important resource for facilitating the transition of energy grids from fossil fuels to RES, and heat pumps and PV systems in buildings are two key elements in this. However, today's heat pumps and heat distribution systems do not fully exploit the highly variable cost of electricity - including self-production – to minimize the cost of energy. The Opsys 2.0 project has demonstrated how local energy storage in a concrete and advanced forecasting can be implemented in practice with new software and hardware solutions. Data from an inhabited house and from a test rig at DTI will be shown.

Annex 84 Demand Management of Buildings in Thermal Networks

The overarching Annex 84 aim is to provide comprehensive knowledge and tools for the successful activation of the demand management of buildings in DHC systems. The work is divided into four following objectives representing the social, technological, methodological, and practical aspects of the demand response (DR) concept.

- Provide knowledge on partners/actors involved in the energy chain and on collaboration models/instruments for successful demand management.
- Classify, evaluate and provide design solutions for new and existing building heating and cooling installations for successful demand management in various DHC systems.
- Develop methods and tools to utilize data from energy and IEQ monitoring equipment for real-time data modelling of thermal DR potential in buildings and urban districts.
- Provide knowledge from and drive adaptation and visualization of Annex results through case studies and best practices.

Annex 83 Positive Energy Districts

Annex 83 focuses on the development of the concept of Positive Energy Districts (PED) and its techno-economical and socio-environmental framework. It aims to create an in-depth definition of PED and document the technologies, planning tools and the decision-making process related to positive energy districts. The basic principle of a PED is to create an area within the city boundaries, capable of generating more energy than consumed, being agile/flexible enough to respond to the variation of the energy market because a PED should not only aim to achieving an annual surplus of net energy. Rather, it should also support minimizing the impact on the connected centralized energy networks by offering options for increasing onsite load-matching and self-consumption, technologies for short and long term storages, and providing energy flexibility with smart control. To achieve this the annex collects case studies, databases and available sources at an international level, and performs in-depth analysis for the definition and framework development. In addition, detailed PED energy models are developed for the performance and impact assessment, developed on state-of-the art modelling and simulation tools and on proprietary simulation platforms and validated against the available case studies, datasets, databases and available sources from the world. The impact assessment of the PED models and tools is performed by developing various criteria to assess the performance of PEDs in different climate zones through economic, technical, social and environmental criteria. All the positive and negative impact of the PEDs are assessed. The best practices, regulations and guidelines for PEDs are also collected and disseminated to provide guide to the relevant stakeholders to make informed decisions on the energy transition towards sustainable districts. The PED framework, methods, assessment tools and guidelines are important to build future carbon neutral and energy positive cities.

Digital Twins for energy efficient smart buildings

The use of digital technologies is essential for creating new comfort levels, security, smartness, and efficiency in buildings. Buildings will shift from being a static, reactive element in the energy sector to being a proactive important component with the capacity to intelligently adapt to changes in the dynamic environment and interact efficiently with other structures and networks in smart communities and grids by possessing an array of sensors and meters everywhere, as well as a vast database of digital information. To address this, we propose merging historical, real-world, and forecast data into a context information model to characterize and better comprehend buildings. This is accomplished by digitally representing real-world assets as Digital Twins, enabling for integrated data-driven decision making across the building life cycle. The digital twin combines dynamic energy models and real-time data to provide a variety of operational services such as real-time performance monitoring and analysis, continuous commissioning, strategic planning, and energy retrofitting assessments and optimization.

Data Driven Energy Experts – how AI-tools supports the missing link

The operators and owners of large property portfolios have a large potential impact on the green transition – and are able to make a huge impact with fast outcome. However – the challenge is to find the right business cases and do the right things, in a fast manner. Today, this requires a lot of manual work by specialists.

The EUDP funded Data Driven Energy Experts, seeks to support this pain, by leveraging a combination of existing data and IoT data for identifying the most relevant energy efficiency projects among large portfolios, supporting the decision makers in identifying, execution and reporting of these initiatives, while reducing the need for specialists and manual work.