EBC

Energy in Buildings and Communities Programme

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

The Importance of International Collaboration

Dear Reader,

Climate change is one of the major threats with which we are currently faced. Clearly, we need to rapidly reduce CO_2 emissions globally to nearly zero by 2050, with buildings now responsible for more than 30% of these. We have to decide and demonstrate which are the optimal and rational options for disseminating zero energy buildings from various angles of design, technology, climate, policy and cost in terms of acceptable return on investment. Large scale deployment is then needed for different types of building.

Now, international collaboration in R&D is essential to meet our common goal to reduce CO_2 emissions dramatically in the buildings sector, by following optimised and economical pathways towards highly energy efficient buildings. EBC provides the best framework for facilitating this cooperation, while sharing knowledge and experiences among our participating countries.

Asia-Pacific countries, including China, India, Australia, Japan, S. Korea, USA, and others in the region, use more than 50% of total global energy. The National Energy Efficiency Conference 2016 being held in Sydney, Australia, organized with support from EBC, gives a regional focus and is an excellent opportunity for international knowledge sharing between experts from EBC and those from Australia and other countries.

In Australia, buildings emit a quarter of the country's greenhouse gas emissions and State Governments and businesses have been driving the creation of more sustainable buildings and energy efficiency, with benchmarking crucial among their efforts. It is also critical to stimulate a culture of collaboration and competition within the buildings sector through EBC's research with innovative R&D programmes and international cooperation.

In this edition, four current EBC R&D projects are described that focus on real energy use and solutions implementable within the market, these being ventilative cooling to reduce reliance on mechanical cooling, implementation of energy strategies in communities, optimised performance of energy supply systems and occupant behaviour modelling tools.

Dr Seung-eon Lee
EBC Executive Committee Member for Republic of Korea

Cover picture: 171 Collins Street Melbourne (CBUS, Charter Hall with Bates Smart Architects). This recent building is achieving Australia's highest operational energy efficiency benchmark, '6 Star' NABERS without the use of green power. It is also rated the highest '6 Stars' under Green Star Design and As Built.
Source: Charter Hall

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Benchmarking Benefits Australia's Buildings

Stefan Preuss

Government and industry in Australia are creating an energy efficient built environment, founded on high profile benchmarking schemes and delivered within a collaborative culture.

Benchmarking, innovative procurement and market power

Organisations requiring office space such as governments and larger businesses can gain market power by renting rather than owning much of their accommodation. Australian State Governments and businesses have been taking advantage of this within the commercial office sector to deliver more sustainable and energy efficient buildings.

When seeking new office accommodation, government and business procurement specifications have significantly driven private sector developers to effectively meet or surpass demanding standards for construction. This relies on the strength of robust benchmarking systems in Australia, a respected and competent service industry and the resulting ease of reporting and target setting. Australian property companies have been recognised as world leaders in sustainability. Many of Australia's newer buildings feature design, as-built and operational ratings, which complete the cycle and give the owners, tenants and occupants the greatest certainty of the quality about them.

However, as policy makers, Australia's Federal, State and Local Governments have somewhat different approaches and levels of success when it comes to setting standards for the wider implementation of energy efficiency measures. Indeed, the Australian commercial property and construction industry has been more instrumental than the Federal Government in pushing for higher standards and for more ambitious pathways for delivering energy efficient and sustainable buildings. For this to become a reality, energy and environmental benchmarking has been essential. And two such schemes have delivered this in Australia: The National Australian Built Environment Rating System (NABERS) and Green Star, a holistic rating system for sustainable buildings.

Green Star and NABERS have been successfully applied to a great diversity of exemplar buildings, ranging from the iconic world heritage Sydney Opera House (rated '4 Stars' under Green Star 'performance') to 'Pixel', the highest building in the world under the Green Star and US LEED schemes at the time. The latter has been documented as a case study in EBC's international research and development (R&D) project 'Annex 52: Towards Net Zero Energy Solar Buildings'.

NABERS

Developed by the New South Wales Government, NABERS has been instrumental in the success story of transforming Australia's premium and 'A-grade' office building stock. Australia has been one of the most successful countries at improving the energy performance of particularly office buildings in operation. One key difference between Australia and other markets internationally is the enthusiastic industry participation in NABERS, which is unprecedented. Today, more than half of the commercial office space in Australia receives a NABERS rating every year, and more than 80% of office space has been certified at least once.

This measurement-based approach to sustainability has turned Australian commercial buildings into one of the world's most successful examples of sector-wide energy savings. This has also been a key factor in the rise of different Australian property portfolios to take the top spots of many international sustainability benchmarks, with Stockland for example awarded the Industry Group Leader for Real Estate in the Dow Jones Sustainability Index 2015 and 2016.

The environmental results have also been impressive. Energy use in the average Australian office building has been reduced by 7% after just two ratings, by 22% after five ratings and 35% after nine ratings.

Following an extensive review, which found that the mandatory federal Commercial Building Disclosure legislation for office buildings (introduced in 2011) has been highly successful, legislation will be expanded from a threshold of 2000 m² down to 1000 m² for office buildings and tenancies to be leased or sold from July 2017. This legislation builds on the NABERS system.

Green Star

Since 2003, the Green Building Council of Australia (GBCA) has been a lead advocate organisation for holistically sustainable buildings in Australia. Building on the UK BREEAM and US LEED assessment schemes, they created the Australian Green Star rating system, which has rated over 1300 buildings and communities since its inception. The GBCA and its members have also been the key drivers for healthy and more productive buildings.

Traditionally Green Star has been the tool for the rating of a building or precinct's design and as-built quality. More recently the system is being used for 'performance' rating incorporating the afore-mentioned NABERS rating system where applicable.

Australia is unique in that Green Star and NABERS have both been widely accepted by industry and Government leaders alike. Like NABERS, Green Star is recognised by international accreditation systems, which is critical to allow international responsible investment to flow into projects on the ground.

A culture of collaboration and competition

Central to Australia's culture of collaboration are industry organisations and non-government organisations (NGOs,) such as the unique Australian Sustainable Built Environment Council, the Property Council of Australia, the Energy Efficiency Council, the Better Buildings Partnership and many more. There are also very capable architects, engineers and other building professionals, research organisations and parts of Government such as Sustainability Victoria, the New South Wales Office of Environment and Heritage and various Federal Government bodies, which drive the agenda of better buildings. It is critical to apply the same culture to building sectors that have been lagging in energy efficiency and provision of healthier living and working environments. These include 'mid-tier' buildings, built before serious energy efficiency standards, often with outdated equipment and poorly operated. The greatest challenge is engaging with, enabling and motivating building owners and their representatives to tune and upgrade their buildings.

According to the Australian Sustainable Built Environment Council (ASBEC), the built environment contributes almost a quarter of the country's carbon dioxide (CO_2) emissions and offers a significant opportunity for emissions reduction. ASBEC's recent study, 'Low Carbon, High Performance', provides the outcomes of detailed modelling of potential emissions reductions from the buildings sector, and sets out a roadmap of policy recommendations to meet 2050 goals. The study concluded that projected 2050 emissions from buildings can be reduced using existing technologies, including energy efficiency measures, switching non-electric equipment and appliances to electricity, and greater use of solar panels. Implementing all of the opportunities identified in this study could possibly deliver over $AUD 20 billion in financial savings by 2030, in addition to productivity benefits and improvements in quality of life for businesses and households.

The Energy Efficiency Council (EEC), Australia's peak body for energy efficiency, cogeneration and demand management, is tackling the challenge of skills for better buildings operation and energy efficiency service provision through their professional development and certification program. EEC is also making a strong case for energy market reform to allow energy efficiency, demand management and distributed generation to take a sensible place in the energy system and capture respective value.

Federal Government policies and plans

As a signatory to the Paris Climate Change Agreement, Australia has committed to reaching net zero emissions by around 2050, in addition to its medium term national emission reduction target of 26% to 28% below 2005 levels by 2030 and its short term target of 5% below 2000 levels by 2020. Australia-wide energy efficiency provisions in the Building Code were first introduced in 2006, as part of the

Pixel Building, Melbourne (Grocon with Studio 505 Architects). Designed for carbon neutrality, the world's highest rated Green Star and LEED building.
Source: Grocon

National Construction Code, with some state-based provisions existing before then. But its stringency has since been increased only once in 2010. Further, the Australian Treasury has projected that the national population may increase from 22 million in 2010 up to 35.9 million by 2050 ('Australia to 2050: Future Challenges, Intergenerational Report', 2010). So, new building standards are crucial in achieving CO_2 emissions targets.

State and Local Government policies and targets

State and Local Government are emerging as key drivers of energy efficient buildings, mandating minimum standards in the procurement of office space for design (through Green Star) and operations (through NABERS) and running incentive programs. Local Governments have been competing for the most ambitious sustainability policies and targets, with various scopes and strategies for carbon neutral policies. Melbourne City Council has even set the ambitious target of zero net emissions by 2020 (beyond council operations), with a strong focus on building efficiency in its associated strategy. Melbourne also has an urban forest strategy, which aims to increase tree canopy from 22% to 40% by 2040, thereby mitigating heat island effects and associated building energy use and health impacts.

The research, development and deployment landscape

Australia is well respected for its academic and research institutions and is a popular destination for international students, particularly from Asia Pacific. In the built environment, a number of universities, the Commonwealth Scientific and Industry Research Organisation (CSIRO), as well as industry and NGOs are undertaking research on various levels. Their activities range from pioneering record-setting solar cell technologies (the University of New South Wales has recently reported achieving 34.5% sunlight-to-electricity conversion efficiency) to building design (by various architecture faculties), and from behavioural psychology (e.g. Behaviour Works at Monash University) to assessment of policy effectiveness (CSIRO) and creating the business case for better performing buildings (ASBEC, GBCA, various governments).

Mirvac's sustainability and energy goals

The Sirius Building, Canberra (Mirvac with May and Russel Architects) is the first Australian building to achieve the highest performance rated building ('6 Stars' NABERS without renewable electricity and '6 Stars' Green Star performance). It is also rated '5 Star' Green Star Office Design and As-Built. As part of Mirvac's Sustainability Strategy, they have implemented a strategy known as 'This Changes Everything' that details their sustainability goals and targets. Mirvac requires new developments to demonstrate their contribution to 'This Changes Everything' and to the 2018 sustainability commitments it encompasses, covering:

– Carbon: 20% reduction in carbon intensity by 2018 from FY13 baseline
– Energy: Install 1 MW of renewable energy by 2018
– Water: 15% reduction in water potable water intensity by 2018 from FY13 baseline and increase water capture and recycling to 15% by 2018 from FY13 baseline
– Waste: Increase recycling to 75% by 2018 from FY13 baseline
– Educate 1 million people on Sustainability by 2020
– Deliver their first smart building by 2018

Further information:
www.mirvac.com/sustainability/overview

Source: Mirvac

Through CSIRO, Australia is represented in the EBC international R&D project 'Annex 57: Evaluation of Embodied Energy and CO_{2eq} for Building Construction' and leading expert Professor Richard de Dear is joint Operating Agent of 'Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings'. Prof de Dear and his team are pioneering a scientific approach to adaptive thermal comfort at their Indoor Environment Quality Lab at the University of Sydney. This includes the emerging commercial world of compact, easily deployable and affordable indoor environment quality sensor units which report on comfort parameters in real time.

While there is considerable national R&D taking place, there is scope for improving collaboration between the research community and industry, and applying research in commercial design and construction practice. This is being addressed by the Cooperative Research Centre for Low Carbon Living, which has a focus on collaborative innovation, bringing together property, planning, engineering and policy organisations with leading Australian researchers as well as the other aforementioned organisations.

Further information

www.nabers.gov.au
www.gbca.org.au/green-star
www.eec.org.au
www.asbec.asn.au
www.lowcarbonlivingcrc.com.au

The State-of-the-Art for Ventilative Cooling

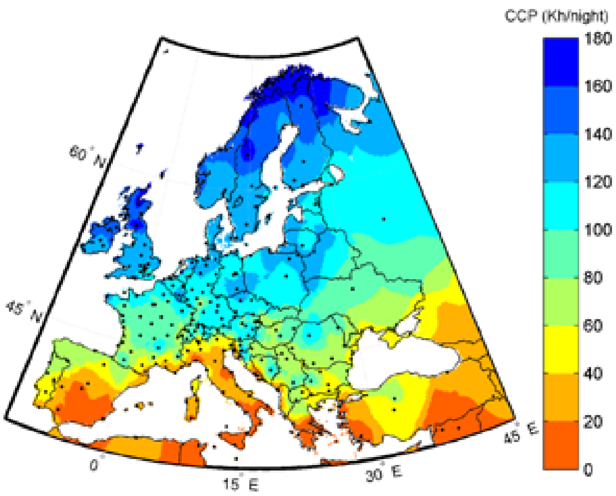
Current Project: EBC Annex 62

Per Heiselberg

Ventilative cooling for buildings may lead to cooling energy savings and improvements in thermal comfort, especially in seasonally temperate and warm climates. But, codes and regulations need to better quantify its benefits.

Introduction

In many industrialised countries, overheating in buildings is emerging as a common challenge at the design stage and during operation. It is a significant problem that compromises the health and wellbeing of occupants. Ventilative cooling, which uses natural or mechanical ventilation strategies to cool indoor spaces, could be a solution to overcome this. The effective use of outside air reduces energy use by cooling systems while maintaining thermal comfort. The most common technique is the use of increased ventilation airflow rates and night-time ventilation. Ventilative cooling is relevant in a wide range of building types and may even be critical to realize renovated or new 'net zero energy buildings' (NZEBs). A recently published study by the current international EBC R&D project 'Annex 62: Ventilative Cooling' has reviewed the state-of-the-art of research in this area. The potential of ventilative cooling has been found to be particularly promising in temperate and warm climates, for example in most of Europe, leading to possible cooling energy savings of around 30% - 50% for office buildings through night cooling. While studies on residential buildings are limited, those that exist indicate there is also potential in this sector.



Map of mean climatic cooling potential (Kh/night) in July based on Meteonorm data.
Source: EBC Annex 62

Potentials and limitations

Ventilative cooling is dependent on the availability of suitable external conditions to provide cooling and on the building type and its thermal characteristics. The state-of-the-art of existing methods suitable to estimate the cooling potential of climatic conditions consider (a) the type of building, (b) time of cooling (day or night), (c) availability of natural driving forces, and (d) the impact of the urban environment. As an example, the 'climate cooling potential' (CCP) index is used to calculate the ventilative cooling potential of night cooling for European buildings. An example for Europe is illustrated in the figure opposite.

In Northern Europe, the climatic cooling potential is generally favourable, and passive cooling by night-time ventilation is applicable in most cases. In Central, Eastern and even in some regions of Southern Europe, the climatic cooling potential is still significant, but due to weather patterns, consecutive warmer nights can occur at some locations requiring additional mechanical cooling. In regions such as southern Spain, Italy and Greece, the ventilative cooling potential is more limited without supplemental cooling systems.

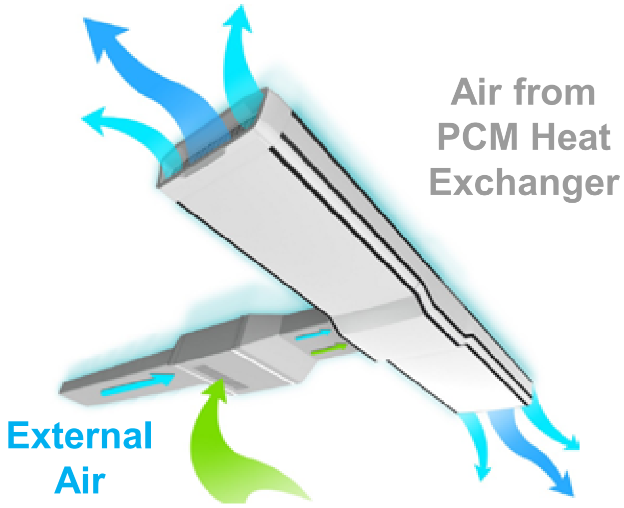
Treatment in existing energy performance regulations

Several questionnaires were completed by 26 project participants from countries around the world, focusing on ventilative cooling aspects in (a) building codes, (b) national energy demand calculations, and (c) implementation of ventilative cooling in current national building regulations. The first survey concluded that ventilative cooling requirements in regulations are complex and five categories of parameters were identified. These were (i) energy consumption for cooling, (ii) building parameters influencing ventilative cooling, (iii) ventilation requirements, both ventilation rates and ventilation openings and positions, (iv) safety, and (v) temperature, air velocity and humidity requirements. These parameters need clarification in national codes to facilitate ventilative cooling. The second survey revealed that in many countries energy performance calculations do not explicitly consider ventilative cooling and that available tools used for such calculations might not be well suited to modelling its impact.

Exemplary existing building using ventilative cooling

A large number of buildings using ventilative cooling have already been built around the world. The project team made a survey of 26 existing and operational buildings using principles of ventilative cooling from 14 different countries. All buildings were built after 2000 and are located in different climates to include hot summer / cold winter, mild summer / cold winter and mild summer / mild winter. The types of buildings range from residential to offices, educational and exhibition spaces. Most buildings within the sample are newly built, with a single retrofitted example.

Based on the survey of existing buildings and a literature search, the study found a range of available building components and control strategies. Components for ventilative cooling were classified as those for airflow guiding ventilation, airflow enhancing ventilation, passive cooling, actuators and sensors.



Project case study from the UK: cooling through night ventilation using phase change materials (PCMs) and a low energy fan. Source: EBC Annex 62

Existing analysis and design methods and tools

The state-of-the-art review has found existing analyses, design methods and tools suitable for designing and evaluating ventilative cooling aspects during building design. This included an assessment of their capabilities, gaps, needs and limitations in the context of ventilative cooling performance prediction. A summary of commonly used public domain and commercial models, together with some details of inputs and outputs required has also been produced.

Conclusion

The state-of-the-art review has revealed that ventilative cooling is an attractive option for the reduction of energy use in residential and non-domestic buildings with real examples identified in a variety of climates. As a cooling strategy, it has the potential to contribute significantly to the reduction (even elimination for certain buildings and climates) of the end use cooling energy demand and improvements in thermal comfort. The review has also revealed that in many national building codes and energy performance regulations, ventilative cooling is not explicitly referred to as a cooling option for achieving energy performance. So, applicable approaches to ventilation requirements for ventilative cooling are being created in this project and its effect on cooling energy demand reduction is being assessed.

Further information

www.iea-ebc.org

Implementation of Energy Strategies in Communities

Current Project: EBC Annex 63

Oskar Mair am Tinkhof and Helmut Strasser

Optimised urban planning processes are a key element to achieving global energy demand reduction goals.

Introduction

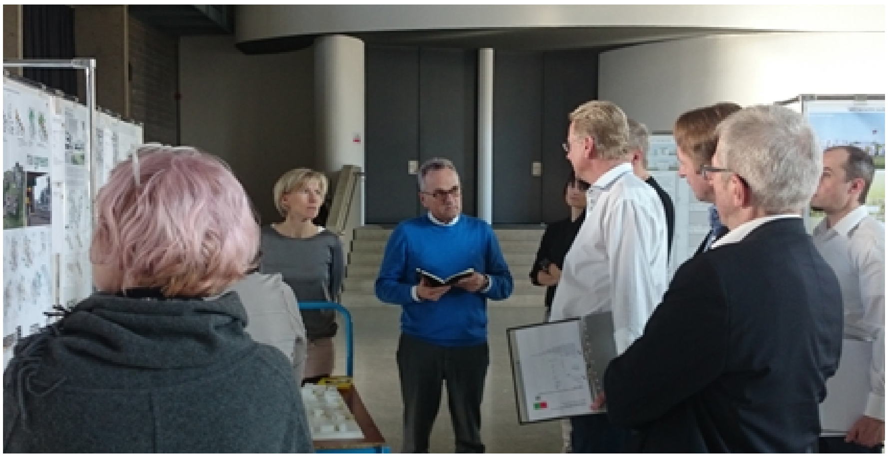
Urbanised districts are responsible for emitting much of the world's energy-related greenhouse gas emissions and because of this, cities in industrialised countries often set their own demanding emissions reduction goals. But, achieving these goals in the real world is a complex process. Optimised community-level energy strategies can only be successful when embedded into urban strategies and planning frameworks. Therefore, the current international EBC R&D project 'Annex 63: Implementation of Energy Strategies in Communities' has elaborated a set of recommendations for linking energy and urban planning processes.

Analysing the status quo

Analysis of the participating countries' national urban and energy planning frameworks has led to a detailed list of 88 categorised measures, including a short description of each measure, the entry points in urban and energy planning and the effectiveness, motivation and distribution of the measure. Most countries follow a similar pattern in which overall responsibility for environmental issues lies with high-level government, who in turn delegate responsibility to lower government levels or to municipalities themselves.

Planning practices draw direct links between the energy delivery and urban development only in a few countries. Overall, while there are plenty of voluntary measures (termed "Effectiveness: Enable, Engage"), there have been found to be fewer mandatory instruments (termed "Effectiveness: Enforce").

Evaluation meeting of the Architectural Competition for Housing project 'Kendlerstraße'



During the evaluation process of an urban design competition held to demonstrate urban planning best practice in Salzburg, Austria in 2016, various energy-related indicators were used to evaluate the competition entries. The winning entry included a masterplan that included specific energy goals.

Source: SIR – Salzburg Institute for Regional Planning and Housing

Twenty-two best practice examples have been collected and conceptualised within the project to show how innovative approaches work. Based on all of this information - a description of national political frameworks, process flows and best practice examples - a set of recommendations has been developed in collaboration with the 20 cities involved in the project.

Recommendations

National workshops have shown that every urban and energy planning process has its strengths and weakness, with varying optimisation opportunities and risks. Therefore, strategic guidance for the transfer of relevant elements in different processes has been summarized under nine themed clusters as follows:

- Vision, target and commitment: Visions and targets indicate what a country or city wants to achieve in the long term. Most countries have set themselves targets. Interim targets help to break down and develop the idea from theory to practice; this is the central goal of the first recommendation.
- Organisation and process: Due to the number of people involved in urban development and energy planning at the local level, the effective and efficient organisation of the process design and implementation is of great importance. Because formal planning processes are prescribed in each country, the description of new governance instruments and methods are the focus of this work to support local administrations to develop and implement urban and energy planning concepts in collaboration with the relevant stakeholders.
- Stakeholder engagement and political support: The goal here is to develop guidelines that meaningfully engage stakeholders, generate feedback and move towards consensus in an effective and timely manner.
- Municipal renewable energy strategies: These serve as information tools for municipalities and other local actors to identify the potential, and define priority areas for interventions. The output of this aspect of the work is a description of different approaches and recommendations for improved implementation.
- Information tools: These support decision making in urban and energy planning by providing information, supporting analysis and advancing monitoring and evaluation.
- Inclusion of social-economic impact and financial models: Investing in energy efficiency can bring many benefits to many stakeholders whether by directly reducing energy demand and associated costs, or by helping to achieve other objectives. This recommendation aims to provide practical guidance on how to apply policy development and assessment tools that account for these impacts.
- Criteria for urban design competitions: This recommendation helps urban energy departments integrate energy and global warming issues into their urban design competitions.
- Enabling legislation: This clarifies which legislative issues are useful (and thus should be made possible by legislation) and which are counterproductive (and thus should be avoided).
- Monitoring: This sets out the different levels of energy-related urban development monitoring and why this is important.

The results from this process are being discussed with representatives from municipalities. For some clusters, specific outputs addressing certain stakeholders are also being created. So, for example it is planned to contribute to education material for universities, to produce standard presentational materials for interested organisations and a description of effective workshop formats for use by city departments.

Preliminary recommendations arising from the project for policy and decision makers are that up-scaling of building solutions to the level of communities is not possible. To optimise communities, solutions at the building scale are necessary, but the general frameworks will be set at an early stage through urban planning. Therefore, it is important to include all relevant stakeholders as soon as possible and specify their input. This can be achieved by restructuring urban planning processes and by including both internal and external know how.

Further information

www.iea-ebc.org

Optimised Performance of Energy Supply Systems

Current Project: EBC Annex 64

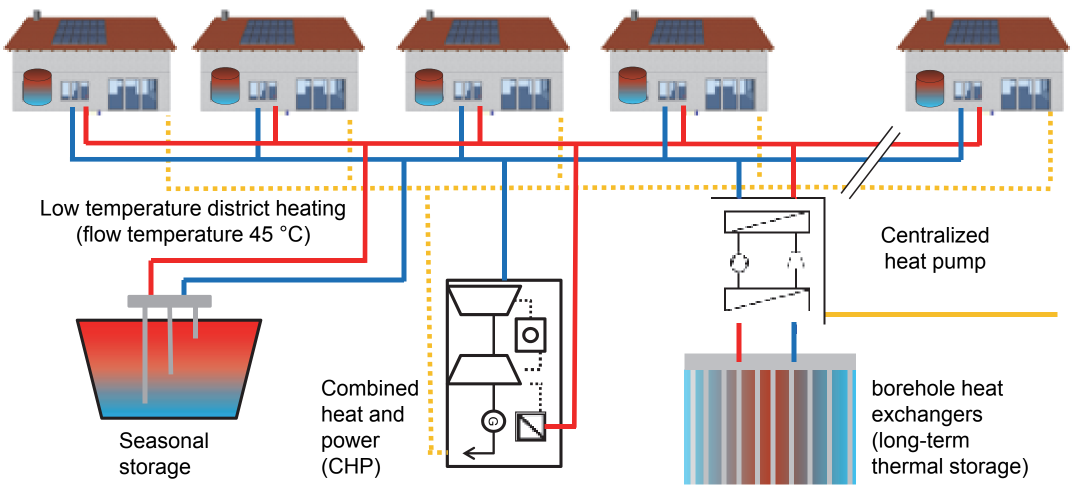
Christina Sager, Dietrich Schmidt and Anna Kallert

Exergy based thinking helps municipalities to realise highly efficient and renewable energy systems on a community scale.

Municipalities across Europe and worldwide are striving to meet ambitious environmental goals, with energy efficiency and integration of renewable energy sources agreed to be key measures to achieving them. The exergy 'idea' is to provide energy sources to meet the requirements for heating, cooling and domestic hot water (DHW) supply at matching temperatures, or 'quality' levels, so avoiding unnecessary conversion losses. This leads to solutions that fundamentally integrate locally-available renewable energy sources and optimise the energy conversion chains of the entire fossil and renewable energy supplies.

The exergy based approach involves carrying out a holistic analysis of efficiency potentials and the use of available energy sources using thermodynamic modelling. While exergy modelling itself is a complex task, exergy based thinking is greatly beneficial for general energy planning. Among other sustainability indicators, for instance primary energy consumption, energy-related CO_2 emissions, planning criteria and investment and operational costs, exergy analysis can help evaluate the efficiency of energy supply systems. This approach mainly focuses on heat supply systems, but also integrates renewable electricity. The central question is how to integrate high-exergy electricity from fluctuating renewable sources in an optimal way into the holistic supply system.

As districts and communities differ in their circumstances and energy efficiency potentials, many different technologies find their optimal application in low exergy (LowEx) community systems, with technical integration business models and network management solutions all important factors for



Simulation model for the assessment of community energy systems based on exergy principles.
Source: Fraunhofer IBP, EBC Annex 64

success. The international EBC R&D project 'Annex 64: Optimized Performance of Community Energy Supply Systems with Exergy Principles' is addressing these topics from technological, modelling and implementation perspectives, as well as from a business model development point of view. So, it is providing robust strategic decision-making support for municipal stakeholders.

The LowEx approach on a community scale

In the development or re-development of urban districts, many principle decisions on energy infrastructure have to be agreed at the early planning stage. For the development of a LowEx community or city district, some general considerations have to be taken into account:

- The heating and cooling demand for buildings is usually responsible for the largest share of the final energy demand. It is important to focus on efficiency measures to reduce the overall demand.
- To make efficient use of available renewable heat and cold sources, it is important to limit the supply temperatures and implement low-temperature heating and high-temperature cooling systems in buildings.
- Low temperature district heating grids are useful heat distributors with LowEx system solutions and are able to integrate renewable and waste heat sources efficiently. On a district scale the options for building or extending heating and cooling networks should be investigated.
- As for the building systems, low temperature and ultra-low temperature district heating systems result in high exergy efficiencies, minimising losses.

In existing urban districts, the exergy approach can be used to identify efficiency potentials and synergies in existing energy supply chains. The central aim is usually to integrate more renewable energy sources into existing systems. Potential energy sources include geothermal and solar thermal energy and waste heat from industrial processes. All these sources commonly arise from low temperature outputs.

Turning case studies into guidelines

In the project framework, advanced technologies are adapted and analysed to show the efficiency potentials. The work is focusing on a number of case studies from different countries that aim to achieve optimised LowEx performance. To transfer knowledge and general insights in LowEx community planning, the project team has summarised the results and outcomes of the case studies into guidelines on technologies (demand and supply side), models and tools. The project case studies showcase different approaches and practical implementation. The emerging barriers, technical questions and modes of operation demonstrate the feasibility of exergy based approaches for planning practice. Three of the case studies in particular illustrate the variety of approaches examined within this project: The first case study focuses on tool development, the second on district planning, and the third on technology improvement. These are summarised below:

- LowEx OLEC: This is the Dutch 'low exergy optimisation for local energy infrastructures by a cluster approach' (OLEC) project intended to support the development of low exergy based energy infrastructures. In this project, hybrid energy systems have been applied that integrate local renewable sources combined with energy storage and smart heating and cooling grids. As outputs, a planning catalogue provides the necessary information for technology selection, calculations, modelling and business models.
- The Kassel Zum Feldlager new residential district: In the new Zum Feldlager residential development in Kassel, Germany, several LowEx technologies have been applied to achieve a 100% renewable energy supply. The district's heating is generated via a low-temperature grid supplied by a central heat pump. Decentralised solar thermal collectors and storage meet the DHW heat demand. Solar absorbers serve to recover heat from the ground and minimise the space needed for boreholes.
- The Danish EUDP project: A Danish Energy Technology Development and Demonstration (EUDP) programme funded project has analysed the options for district heating supply at below 40°C. In this project the performance of district heating substations has been measured in five existing residential buildings. Important evaluation parameters are the electricity consumption, reduction of heat losses and costs.

Further information

www.iea-ebc.org

Occupant Behaviour Modelling Tools

Current Project: EBC Annex 66

Tianzhen Hong and Da Yan

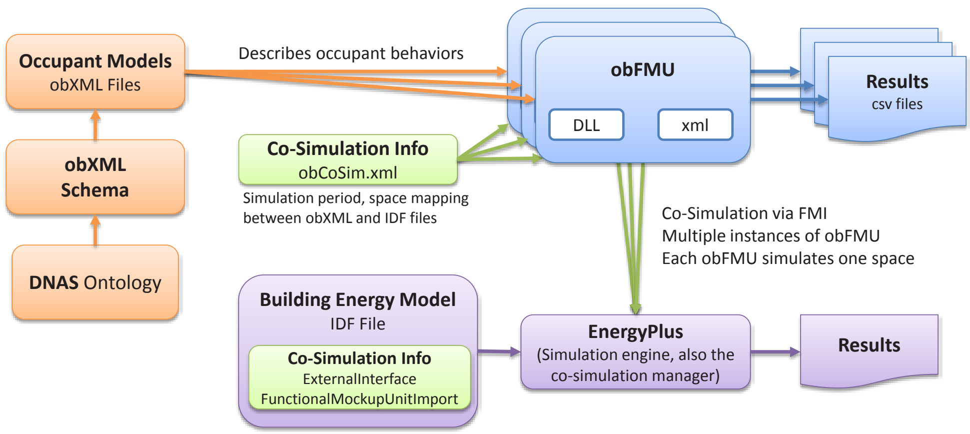
A new suite of occupant behaviour models for use in building performance simulation captures its diversity, uncertainty and complexity, allowing improved evaluations of behaviour change initiatives along with its impact on technology performance and energy use.

Introduction

Building performance simulation (BPS) programs are widely applied to evaluate the performance of building energy systems and technologies. However, occupant behaviour, a key driver of building performance, is usually represented in BPS models with oversimplified and pre-defined static schedules or fixed settings and rules. This leads to deterministic and homogeneous simulation results ignoring the uncertain nature, dynamics and diversity of occupant behaviour. One of the objectives of the international EBC R&D project 'Annex 66: Definition and Simulation of Occupant Behavior in Buildings' is to develop quantitative descriptions and models of occupant behaviour in order to analyse and evaluate its impact on building energy use.

Three new occupant behaviour modelling tools developed within the project can be used with BPS programs (for example EnergyPlus, ESP-r, IDA-ICE, and DeST) to improve building performance simulation by:

1. enabling the exchange and use of occupant behaviour models between BPS programs, applications and users to improve consistency and comparability of simulation results,
2. generating realistic occupant schedules, and
3. reducing discrepancies between simulated and measured energy use in buildings.



The software architecture of an 'occupant behaviour functional mockup unit' (obFMU).
Source: LBNL

Occupant behaviour XML schema

The occupant behaviour XML (obXML) schema is an XML schema (a description of a type of Extensible Markup Language document) to standardise the representation and exchange of occupant behaviour models for building performance simulation. The four key elements of the obXML schema are:

- drivers (time, environment, event type, other constraints), which represent the environmental factors that stimulate occupants to fulfil a physical, physiological or psychological need;
- needs (physical), which represent the physical and non-physical requirements of the occupant that must be met in order to ensure satisfaction with their environment;
- actions (interactions), which are the interactions with systems or activities that occupants can perform to achieve environmental comfort;
- systems (HVAC, lights, windows, plug loads, thermostats, shades and blinds), which refer to the equipment or mechanisms within the building with which occupants may interact to restore or maintain environmental comfort.

A library of obXML files, representing typical energy-related occupant behaviour in buildings, has been developed from the literature. These obXML files can be exchanged between different BPS programs, different applications and different users.

Occupant behaviour functional mockup unit

An 'occupant behaviour functional mockup unit' (obFMU) is a modular software component represented in the form of a functional mockup unit (a form of tool independent standard) enabling its use via co-simulation with BPS programs using the standard functional mockup interface. obFMUs read occupant behaviour models represented in obXML and function as solvers. A variety of occupant behaviour models are supported by obFMUs, including:

- lighting control based on an occupants' visual comfort needs and availability of daylight,
- comfort temperature set point,
- HVAC system control based on occupants' thermal comfort needs,
- plug load control based on occupancy, and
- windows opening and closing based on indoor and outdoor environmental parameters.

obFMUs have been used with EnergyPlus and ESP-r via co-simulation to improve the modelling of occupant behaviour.

Occupancy Simulator

Occupancy Simulator is a web-based application running on multiple platforms to simulate occupant presence and movement in buildings. It also generates sub-hourly occupant schedules for each space and individual occupants for BPS. Occupancy Simulator performs agent-based simulation for each occupant. A hierarchical input structure is adopted, simplifying the input process, while allowing flexibility for information capturing about the diversity of space use and individual occupant behaviour. Users can choose to see the simulated occupancy results for an individual space or the whole building.

Availability of the tools

The obXML files and obFMUs are available for free use at: behavior.lbl.gov. The Occupancy Simulator is also freely available at: occupancysimulator.lbl.gov

Further information

www.iea-ebc.org

The occupant behaviour modelling tools developed in the project were used to study an office building in the USA.
Source: Goldnpuppy

EBC International Projects

Current Projects

Annex 5 Air Infiltration and Ventilation Centre
The AIVC carries out integrated, high impact dissemination activities with an in depth review process, such as delivering webinars, workshops and technical papers.
Contact: Dr Peter Wouters
aivc@bbri.be

Annex 56 Cost-Effective Energy and CO_2 Emissions Optimization in Building Renovation
The project is delivering accurate, understandable information and tools targeted to non-expert decision makers and real estate professionals.
Contact: Dr Manuela Almeida
malmeida@civil.uminho.pt

Annex 57 Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction
The project is developing guidelines to improve understanding of evaluation methods, find better design and construction solutions with reduced embodied energy and related CO_2 and other GHG emissions.
Contact: Prof Tatsuo Oka
okatatsuo@e-mail.jp

Annex 59 High Temperature Cooling and Low Temperature Heating in Buildings
The project is improving HVAC systems, by examining how to achieve high temperature cooling and low temperature heating by reducing temperature differences in heat transfer and energy transport processes.
Contact: Prof Yi Jiang
jiangyi@tsinghua.edu.cn

Annex 60 New Generation Computational Tools for Building and Community Energy Systems
The project is developing and demonstrating new generation computational tools for building and community energy systems using the Modelica modelling language and Functional Mockup Interface standards.
Contact: Michael Wetter, Christoph van Treeck
mwetter@lbl.gov, treeck@e3d.rwth-aachen.de

Annex 61 Business and Technical Concepts for Deep Energy Retrofit of Public Buildings
The project aims to develop and demonstrate innovative bundles of measures for deep retrofit of typical public buildings to achieve energy savings of at least 50%.
Contact: Dr Alexander M. Zhivov, Rüdiger Lohse
alexander.m.zhivov@erdc.usace.army.mil,
ruediger.lohse@kea-bw.de

Annex 62 Ventilative Cooling
This project is addressing the challenges and making recommendations through development of design methods and tools related to cooling demand and risk of overheating in buildings and through the development of new energy efficient ventilative cooling solutions.
Contact: Prof Per Heiselberg
ph@civil.aau.dk

Annex 63 Implementation of Energy Strategies in Communities
This project is focusing on development of methods for implementation of optimized energy strategies at the scale of communities.
Contact: Helmut Strasser
helmut.strasser@salzburg.gv.at

Annex 64 LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles
This project is covering the improvement of energy conversion chains on a community scale, using an exergy basis as the primary indicator.
Contact: Dietrich Schmidt
dietrich.schmidt@ibp.fraunhofer.de

Annex 65 Long-Term Performance of Super-Insulating Materials in Building Components and Systems
This project is investigating potential long term benefits and risks of newly developed super insulation materials and systems and to provide guidelines for their optimal design and use.
Contact: Daniel Quenard
daniel.quenard@cstb.fr

Annex 66 Definition and Simulation of Occupant Behavior in Buildings
The impact of occupant behaviour on building performance is being investigated to create quantitative descriptions and classifications, develop effective calculation methodologies, implement these within building energy modelling tools, and demonstrate them with case studies.
Contact: Dr Da Yan, Dr Tianzhen Hong
yanda@tsinghua.edu.cn, thong@lbl.gov

Annex 67 Energy Flexible Buildings
The aim of this project is to demonstrate how energy flexibility in buildings can provide generating capacity for energy grids, and to identify critical aspects and possible solutions to manage such flexibility.
Contact: Søren Østergaard Jensen
sdj@teknologisk.dk

Annex 68: Design and Operational Strategies for High Indoor Air Quality in Low Energy Buildings
This project focuses on design options and operational strategies suitable for enhancing the energy performance of buildings, such as demand controlled ventilation, improvement of the building envelope by tightening and insulating products characterised by low pollutant emissions.
Contact: Prof Carsten Rode
car@byg.dtu.dk

Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings
The project provides a scientifically based explanation of the underlying mechanism of adaptive thermal comfort, and is applying and evaluating the thermal adaptation concept to reduce building energy consumption through design and control strategies.
Contact: Prof Yingxin Zhu, Prof Richard de Dear
zhuyx@tsinghua.edu.cn,
richard.dedear@sydney.edu.au

Annex 70 Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale
This project seeks to support decision-makers and investors in their efforts to transform to a low carbon and energy efficient building stock by focusing on developing best practice methods for collecting, accessing, analyzing and developing models with empirical data of energy demand in buildings and communities.
Contact: Dr Ian Hamilton
i.hamilton@ucl.ac.uk

Annex 71 Building Energy Performance Assessment Based on In-situ Measurements
This project is supporting the development of replicable characterisation and quality assurance methodologies embedded in a statistical and building physical framework to characterise and assess the actual energy performance of buildings, and disaggregating building energy use to its three main sources: building fabric, systems and occupants.
Contact: Prof Staf Roels
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Energy in Buildings and Communities Programme

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