EBC

Energy in Buildings and Communities Programme

EBC NEWS

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

iea Energy Technology Network

R&D to Support Energy Policies and Practices in the Buildings Sector

Dear Reader,

At the June 2017 EBC Executive Committee Meeting, I was privileged to be elected as the new Executive Committee Chair for a three-year term starting in January 2018. Over the past six years, our current Chair, Andreas Eckmanns, has made major improvements to our corporate design, our governance and, most importantly, to the strategic leadership that our Technology Collaboration Programme provides within the IEA for international research collaboration for buildings and communities. I would like to thank him for his work, which I am proud to continue and develop.

In my role of Chair, one of my ambitions is to improve how we share information between EBC's participating countries, particularly to gain a better mutual understanding of our respective policy frameworks, and interests in urgent R&D themes, as well as in long-term scientific work for energy saving in buildings and communities. We, as a research-centered community, are under the spotlight, where our accomplishments are to be evaluated year by year through published national or international statistics on energy use or CO_2 emissions in the buildings sector.

In the current edition of EBC News, there is an introduction of Canadian policies and movements, also with updates on EBC's major R&D projects that cover ways to realize both better indoor air quality and higher energy efficiency, reconsideration of thermal comfort for using energy more wisely, and analysis of real energy use and relevant factors by using big data. In addition, I am pleased to give an update on our Working Group on calculating HVAC energy use in non-residential buildings. Through the Working Group, we intend to promote mutual understanding on energy calculation methodologies, potentially leading to new research themes to advance them.

Please enjoy reading this latest edition of EBC News!

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

Cover picture: CANMET Materials Technology Laboratory building
Source: Elizabeth Gyde, Diamond Schmitt Architects

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Canada Connects Policy with Technologies for a Nationwide Strategy

Ken Church and Jessica Webster

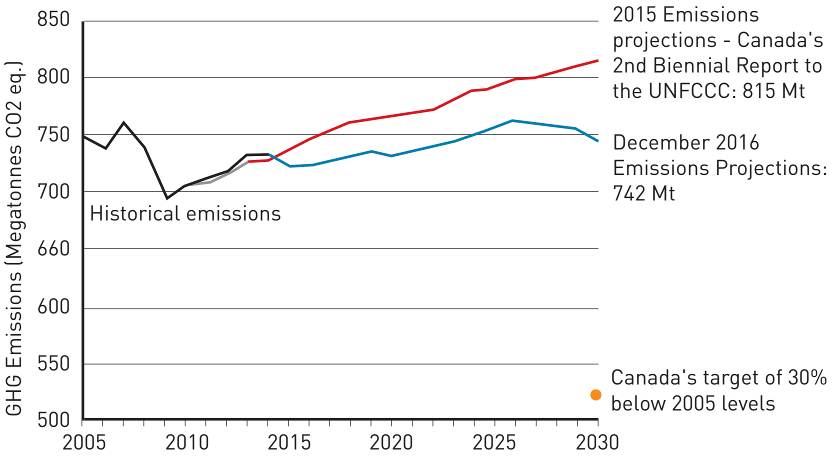
The development of a pan-Canadian approach to climate change creates an opportunity for increased research to inform all levels of government, energy utilities and industry.

The recent election of the Liberal Government in Canada signalled wide-scale public support for increased action on climate change and the transition to a low carbon economy. As part of its commitment, Canada released the 'Mid-Century Long-Term Low-Greenhouse gas Development Strategy' in November 2016. This was followed by the 'Pan-Canadian Framework on Clean Growth and Climate Change' that presented its approach to reducing its contribution to global emissions by 30% by 2030, from 2005 baseline emission levels. The Framework’s central pillar is the pricing of carbon emissions and recommends that “any carbon pricing mechanism should provide signals to both the business and industrial communities, thereby stimulating the uptake of energy efficiency measures”. Canada’s political structure comprises a single federal state with ten provinces and three territories. In this context, multiple approaches are needed, based upon political preference, the regional environment and the particular sector involved. Implementation of the plan would therefore require close cooperation between government, industry and the public.

Roles and responsibilities

The role of the federal government regarding energy relates mostly to national target setting, research and development and the creation of performance standards for transportation and end-user appliances. Energy performance is also a national responsibility through the National Energy Code for Buildings (NECB), for adoption or adaptation by the provinces and territories. The provincial and territorial governments retain control over regulatory issues for energy generation and delivery within their respective jurisdictions, as well

Emissions Projections for Canada to 2030



The Pan-Canadian Framework supports the use of either a 'Carbon Tax' or the more complex 'Cap & Trade' system as preferred by each province to stimulate their markets. The federal stipulation, however, is that provincial solutions must comply with the 2018 Federal Carbon Pricing Benchmark of CAD$10 per tonne, rising annually to reach CAD$50 per tonne by 2022.
Source: Pan-Canadian Framework on Clean Growth and Climate Change

as legislative authority for urban planning. Municipal governments in turn, implement the decisions of their provincial governments and have limited ability to modify, enhance or create energy related legislation. They are responsible for long term planning for their communities, approving building permits, as well as providing water, wastewater and waste management services for their residents.

Building Code and technologies

The National Research Council (NRC) is responsible for developing and maintaining the National Building Code of Canada, the principal legislation for design and construction of the built environment. The Code is adapted to the specific needs of each province and environmental area, but focuses on a building's safe construction and operation rather than on its energy performance. Several cities have provincial charters (Vancouver, Winnipeg, and Toronto, with Calgary expected soon) that grant them increased spheres of influence, but few others can explicitly specify energy performance requirements for their building stock. These energy improvements can be addressed instead, through bylaws that reference certification programs such as EnerGuide, R2000, LEED, or BOMA BEST.

Pressure by local governments in British Columbia led to a stringent provincial Building Code to attain greater greenhouse gas (GHG) reductions. The Energy Step Code provides consistency across the province by establishing a single set of building standards that can be voluntarily adopted by local governments. It also demonstrated a move away from prescriptive regulation as regards energy-efficiency targets. Compliance with the enhanced code requires that buildings constructed after 2020 must be carbon neutral and this has increased interest in energy modelling, whole building air tightness testing, district energy, system commissioning and building energy reporting.

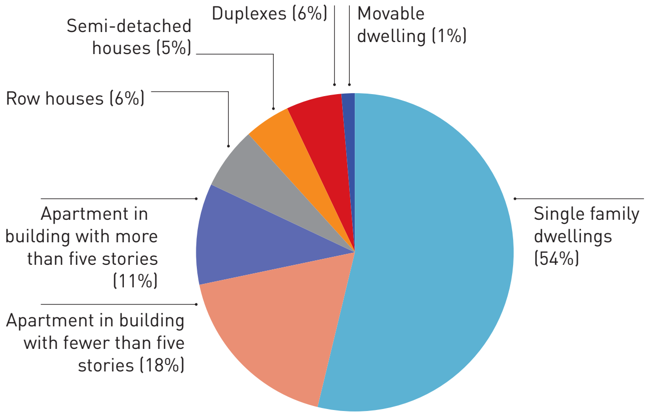
In the east of the country, the Ontario Planning Act and its regulations were revised in 2015. This raised the priority that planners could assign to energy end-use efficiency. By aligning the Provincial Policy Statement, the Ontario Planning Act and the regulations for the development of Official Plans, legislative support is effectively given to the use of energy efficiency as a design criterion within the city's planning requirements.

Energy efficiency research at the building level

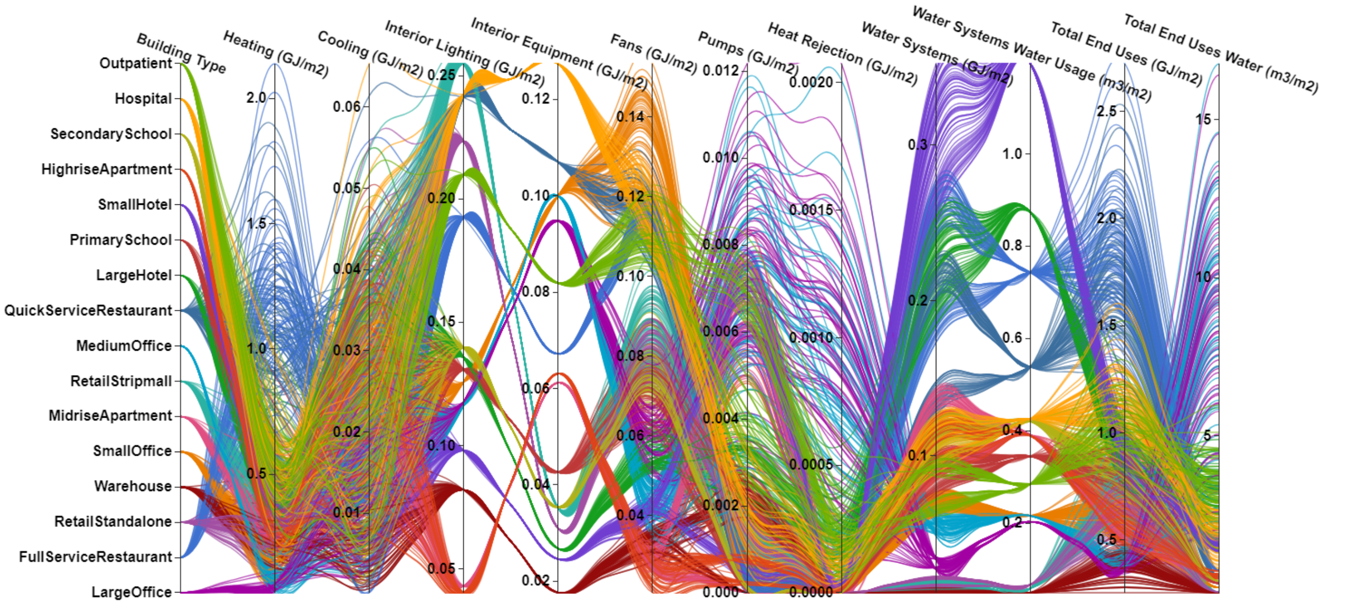
Built in the mid-1900's, many Canadian university and college campuses are now in need of upgrade with CAD$2 billion investment by the federal government in 2016 prompting a surge in retrofits for both the buildings and their energy systems. Post-secondary institutions have a tradition of receptivity towards advanced technologies with the inclusion of advanced construction techniques, low exergy energy distribution and net-zero energy principles. York University in Toronto is one example where research into the use of aquifer cold thermal storage will form part of a major upgrade for the campus. Charging the storage during the winter months using cold air will reduce or eliminate the need for chillers during the summer months. The University currently has a cooling load of 18 million ton-hours (63 GWh).

The University of British Columbia is likewise undergoing a major campus rebuild, converting

Vintage as per major code changes	Number of Dwellings (in thousands)		Average Size (sq m)
Before 1946	1,546	11%	126
1946-1960	1,123	8%	111
1961-1977	2,490	18%	117
1978-1983	1,451	10%	133
1984-1995	2,931	21%	137
1996-2000	993	7%	138
2001-2005	1,213	9%	146
2006-2010	1,259	9%	151
2011-2014	1,066	8%	156
Total	**14,072**		**133**



Characteristics of the Canadian housing stock
Source: Natural Resources Canada, National End-Use Database



Modelled baseline energy end-use in 16 standardised building archetypes from the National Energy Code for Buildings (2011) for 69 Canadian cities. Optimal solutions can be seen to depend on the choice of critical criteria: heating, cooling, water, and so on. The project is open source, allowing transparency and public inspection of the implementation and assumptions.
Source: Padmassun Rajakareyar, Natural Resources Canada

its energy system from steam to a biomass fired, hot water network. Many of the campus buildings have undertaken deep green retrofits including the application of low exergy energy cascading within their Earth Sciences laboratory to achieve a 59% energy cost reduction and a 93% reduction in GHG emissions.

Aside from college campuses, research parks also provide opportunities for the advancement of energy technologies. The McMaster Innovation Park in Hamilton, Ontario is aligned with nearby McMaster University with many of the buildings on this 37 acre (14.9 Ha) site are constructed to high efficiency and connected to the utility's (HCE Energy) district energy system. This system incorporates a bore-hole geo-exchange field, a solar wall and conventional technologies to heat and cool the facilities. The front cover of this newsletter shows Natural Resources Canada's (NRCan) Materials Technology Laboratory at the Park, designed and certified to LEED platinum standard.

In Winnipeg, Manitoba the research collaboration between the electricity utility (Manitoba Hydro) and the Red River College into air tightness testing has resulted in standards being developed for commercial buildings. Their research involving tests on 26 commercial buildings has provided enough support for the utility to develop and implement a Commercial Building Envelope Program for major building retrofits. Air tightness is rarely undertaken on commercial buildings in Manitoba and the development of a standard procedure could lead to significant reduction in energy demand and improved building performance. A second, more lasting outcome of the research involved the creation of a Building Envelope Technology Access Centre at the college allowing the building construction industry to access the college's equipment and expertise.

With the Pan-Canadian Strategy prioritising the need for improved building insulation, the development of vacuum insulation panels, for application both internally and externally to the building structure takes on an increasingly important role. The University of Victoria's expertise in vacuum glazing is well established and strengthened by their participation in the EBC R&D project 'Annex 65: Long-Term Performance of Super-Insulation in Building Components and Systems'. This is augmented by NRCan's own research into the technology, as well as by its current examination of prefabricated cladding employing vacuum panels for exterior walls: The Prefabricated Exterior Energy Retrofit (PEER) project is a five-year research initiative to evaluate prefabricated wall panels for Canadian housing. Currently in its second year, the research is taking into account Canada's climate zones, housing construction, and industry capacity, but to make the research immediately useful for holistic whole-home retrofits the initiative is focusing primarily on above grade wall systems.

An ongoing evaluation of net-zero energy (NZE) homes includes the monitoring of 12 homes across Canada constructed as part of the Canada Mortgage and Housing Corporation (CMHC) led EQuilibrium Project. While NZE homes are not yet considered market feasible, due to a cost premium of between CAD$100 thousand to CAD$150 thousand, the goal of the project is to reduce the risk and cost of NZE housing technologies, increasing their availability to the marketplace. To this end, monitoring will be conducted of the whole house performance and some of the new and innovative technologies required within the NZE housing.

Coordinating policy and technology

A major challenge in the development of energy efficiency programs or policies is translating national or regional emission targets into real-life actions: Which technologies can be used and how can these be applied to provide the results required? In retrofitting a single building, the range of technologies and the options available can be achieved with traditional optimisation modelling in a handful of 'what-if' scenarios. For city-scale initiatives though, the range of options make this approach impractical and a speedier approach is needed. Natural Resources Canada's researchers have combined energy analysis tools (ESP-r and HOT2000) with computer optimization algorithms and created the Housing Technology Assessment Platform (HTAP). This technique draws upon a verified database of energy savings measures, associated upgrade costs, and local utility rates for Canadian municipalities.

HTAP improves upon previous residential analysis tools such as HOT2000 (supporting Canada's EnerGuide Rating System) by using cloud computing to run hundreds of thousands of different simulations for any given home. It can also develop estimates for energy savings, utility bills, and upgrade costs for each simulation using local cost data. These results enable researchers to identify the cheapest, simplest, and most affordable ways to achieve the required policy objective (for example EnergyStar, R-2000, or Net-Zero performance goals) in a variety of housing forms across Canada. To date, HTAP has been used to evaluate new and emerging technologies on the Canadian market including zoned air distribution, combined and integrated mechanical systems and even cold-climate air source heat pumps.

Addressing non-residential buildings, a second optimisation platform is the Building Technology Assessment Platform (BTAP). This leverages the resources of both Canadian and American federal research, using as its base the OpenStudio / EnergyPlus building simulation platform, developed by the U.S. Department of Energy and the National Renewable Energy Laboratory. It also uses OpenStudio's Amazon Cloud computing scaling capabilities, allowing tens of thousands of simulations to be run in a single hour.

Summary

In its current Medium-Term Strategy for Energy Research and Technology, the International Energy Agency has stated that: To realise this transition (to a low-carbon environment), increased cooperation between governments, the private sector, and the research and investment communities will be crucial. Canada's commitment to the Paris Agreement proposes to follow this approach and the Pan-Canadian Strategy provides the backdrop for coordinated research activities across Canada. As described, this research will involve players in all levels of government, the energy utilities and the private sector.

Further information

Pan-Canadian Framework on Clean growth and Climate Change: https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

Canada's mid-century long-term low-greenhouse gas development strategy: http://publications.gc.ca/site/eng/9.825953/publication.html

National End-Use Database: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/home.cfm

IEA Medium-Term Strategy for Energy Research and Technology: http://www.iea.org/media/rfe/IEA_Strategy.pdf

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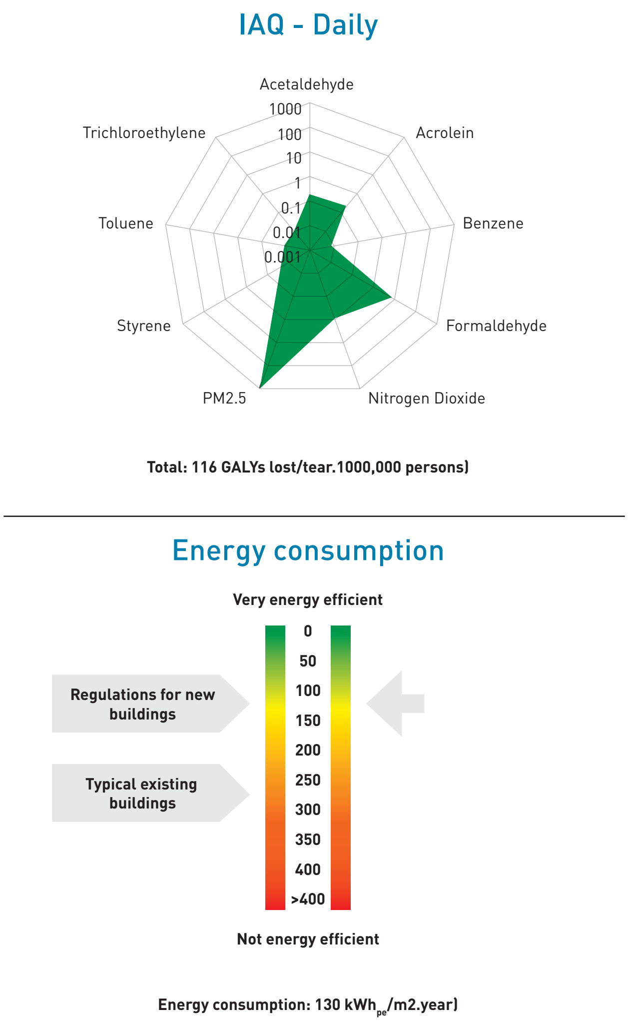
Indoor Air Quality Design in Low Energy Residential Buildings

Current Project: EBC Annex 68

Carsten Rode and Marc Abadie

Optimal strategies for design and operation of buildings are needed such that the indoor air quality is impeccable while energy use is minimised, for instance for ventilation.

The international EBC research project 'Annex 68: Indoor Air Quality Design and Control in Low Energy Residential Buildings' is focusing on design options and operational strategies that can enhance the energy performance of residential buildings, for instance: demand controlled ventilation, improvement of the building envelope, and selection of low polluting building products. A central hypothesis of the project is that good indoor air quality (IAQ) and very energy efficient buildings can be achieved only through a multi-facetted optimization approach. Therefore, it is combining elements of knowledge from various expert groups. This includes knowledge and results from the Air Infiltration and Ventilation Centre on ventilation in buildings, academic and industry groups working on chemical emissions from building products, building physicists and practitioners regarding hygrothermal conditions in buildings and their materials, and building simulation communities on modelling of buildings.



An example graphical representation of population-based 'Disability-Adjusted Life Years' lost for various indoor air quality indices (IAQ-DALYs) versus energy consumption for a building. Source: Université de La Rochelle

Defining the metrics

The first part of the project has defined metrics for the parameters involved relating to indoor pollutants and energy performance, which is already complete and has been reported. This metrics study has led to a compilation of information about potential pollutants in energy efficient buildings. Generally, lower pollutant concentration levels have been found in the newest low-energy buildings. But, exceptions to this observation have also been detected, such as instances in France and Japan where new buildings have been found to present higher levels of a certain pollutant (alpha-pinene) coming from wood-based construction, and in China where concentrations of benzene, toluene, and xylene were also found to be higher. By comparing concentration levels collected in this study with Exposure Limit Values (ELVs), a list of target pollutants for long-term exposure has been identified comprising of the following: acetaldehyde, acrolein, α-pinene, benzene, formaldehyde, naphthalene, nitrogen dioxide, PM_{10} and $PM_{2.5}$ fine particulate matter, radon, styrene, toluene and trichloroethylene. Regarding short-term exposure, the analysis has led to a shorter list consisting of: acrolein, formaldehyde, nitrogen dioxide, PM_{10}, $PM_{2.5}$, radon and total volatile organic compounds (TVOCs).

Based on a literature survey, two approaches were selected to define IAQ metrics for assessing the importance of measured concentrations of pollutants. The first approach compares typical exposure concentrations to existing exposure standards (ELVs). In this approach, the unbiased aggregation of indices for specific pollutants is achieved by selecting a maximum index. In the second approach, the direct health impacts of the pollution is estimated through 'Disability-Adjusted Life Years' (DALYs) lost. Finally, a graphical representation has been developed to facilitate visual and quantitative comparisons between a combined reference IAQ and energy situation with possible air cleaning solutions. This representation provides an example of a possible approach for labelling indoor environments with regards to combined IAQ and energy performance.

Project structure

The four main aspects to the project are as follows:

- 'Pollutant Loads in Residential Buildings', which is collecting information from literature, databases and from new measurements on emissions from some examples of volatile organic compounds. This activity also seeks to establish paradigms for how to model emissions from materials, including how the emissions depend on temperature and humidity.
- 'Modeling, Review, gap analysis and categorization' has identified a set of calculation tools to assess the overall hygrothermal and indoor environmental conditions in buildings for publication as a 'tools platform'.
- 'Field Measurements and Case Studies', is gathering experimental full-scale evidence on three levels: (1) single-room isothermal tests, (2) tests with two coupled spaces, and (3) a complete test house, where trials are in progress. This is collecting information from relevant national activities, such as from the French Observatory for Indoor Air Quality.
- As a primary outcome, all activities are being documented for dissemination through 'Design and Control of Buildings', which will form a guide to optimal, practical and applicable design and control strategies for good indoor air quality in residential buildings.

Further information

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Indoor air quality monitoring in the P+ Experimental Building in Wujin, Jiangsu, P.R. China, comprising measurement of VOCs, $PM_{2.5}$, thermal and humidity conditions, as well as energy performance.
Source: Nanjing University

Adaptive Thermal Comfort in Buildings

Current Project: EBC Annex 69

Yingxin Zhu, Richard de Dear and Bin Cao

Greater understanding of adaptive thermal comfort is a key point to establish the appropriate balance between reductions in energy use and providing comfortable indoor environments in buildings.

Much evidence has shown that close control of indoor temperatures drives high energy costs and greenhouse gas emissions, and may not always provide benefits for occupant comfort and health. The concept of adaptive thermal comfort is regarded as an important advance that may play a significant role in low energy building design and operation. As long as indoor temperatures are maintained within acceptable ranges that relate with the outdoor climate changing through annual seasonal cycles, it is possible for people to achieve thermal comfort through physiological-, psychological-, and behavioural-adaptive approaches. That means an unchanging indoor thermal environment with mechanical cooling or heating is not always necessary, so that it is possible to reduce energy use. Furthermore, the degrees of freedom for individual personal environmental control have positive impacts through both psychological and behavioural adaptive approaches, which can further enhance occupants' satisfaction with their indoor thermal environments.

If buildings and their services are designed to operate in a 'part-time and part-space' mode depending on the occupants' individual demands instead of the 'whole-time and whole-space' mode prevalent in many buildings at present, energy use can also be reduced. The current EBC international research project 'Annex 69: Strategy and Practice of Adaptive Thermal Comfort in. Low Energy Buildings' is exploring how to achieve this goal.

Thermal comfort and expectations

Occupant satisfaction is an outcome of the balance between actual thermal environments and subjective comfort expectations that are understood to be based on recent experiences. In addition to new construction or retrofitting to lower environmental impacts and improve thermal environments in the building stock, transforming comfort expectations presents an alternative policy pathway. In contrast, in many international thermal comfort standards (such as ISO 7730) assessments are expressed in terms of how tightly indoor temperatures are controlled around a theoretical optimum and seek to minimize the temporal and spatial fluctuations.

To meet this challenge, greater flexibility in thermal comfort strategies should be encouraged. To some extent, the adaptive comfort model encourages adaptive behaviour by occupants when suitable conditions and opportunities are available. In fact, it has been proposed to redefine thermal comfort standards according to different perspectives such as climate change, environmental sustainability, human health and even cultural diversity. For instance, a fundamentally different comfort framework called 'alliesthesia' has recently been put forward with a view to establishing such flexibility: This framework deals with qualities of 'pleasantness' or 'unpleasantness' of the thermal environment. At a practical level some new comfort strategies such as personally controllable comfort systems, moving air for comfort, mixed-mode buildings and even dynamic environment control strategies are beginning to receive greater attention. Clearly, there is no lack of intelligent approaches to take advantages of HVAC technologies. But, there is some way to go before which kinds of indoor climates are sustainable enough is fully understood, considering comfort perception, productivity, health, energy expenditure, and so on.

Perceived personal control

Building occupants' perceived abilities to exert control over their thermal environments may improve their thermal comfort perceptions, and these improvements are simply due to psychological influences. With perceived control, people are more likely to report better thermal sensations and higher thermal satisfaction in both warm and cool conditions. In hot or cold conditions, if personal control approaches are utilized, occupant thermal discomfort may be reduced through even a slight improvement of local thermal conditions. In practice, it is recommended that occupants should be provided with sufficient opportunities to control their thermal environments through openable windows, fans, controllable air terminal conditioning systems, and so on. In these ways, occupants' thermal demands may be better met.

Mixed-mode buildings

'Mixed-mode' (MM) buildings either have both air-conditioned (AC) and natural ventilated (NV) spaces, or are operated in AC mode during some periods of the year and in NV mode during others. MM buildings are actually the most common cases in the real world. In MM buildings, occupants' actual thermal sensations and acceptance of thermal conditions has been found to vary when the building changes from AC to NV mode, or vice versa. During the NV period, occupants tend to accept a wider range of indoor thermal conditions and are more likely to report a neutral thermal sensation. The adaptive comfort model was found to be applicable to MM buildings, especially in NV mode. In contrast, the 'Predicted Mean Vote / Predicted Percentage of Dissatisfied' model approach (PMV / PPD, see ISO 7730) was inaccurate for buildings in which occupants had numerous adaptive opportunities, for example with operable windows, fans, individually controllable systems, and so on. In the MM building case, the PMV / PPD model deviated from the actual thermal responses even when the building was operating in AC mode. In some current thermal comfort standards, the application of the adaptive comfort model is still conservatively constrained to pure NV spaces. For instance, ASHRAE Standard 55 and GB/T 50785 conservatively classify MM buildings as AC buildings. This not only limits MM buildings to operating within more restricted indoor thermal conditions; it also fails to maximize the energy-saving potential of the 'hybrid' philosophy behind such buildings.

Further information

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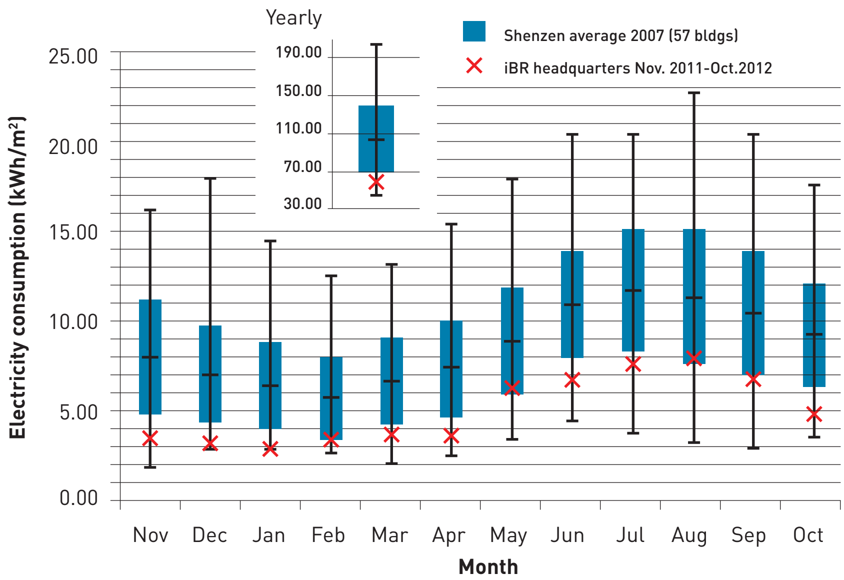

Electricity use at Shenzhen iBR headquarters, P.R. China, a typical mixed-mode building, in comparison with other local buildings.
Sources: (Left) Damiens Jérôme, Tsinghua University, P.R. China (Right) Shenzhen iBR, P.R. China

Big Data Discovery Science for Energy Efficient Buildings

Current Project: EBC Annex 70

Ian Hamilton

Common definitions and data platforms to describe energy and building stocks provide opportunities to benefit many stakeholders through innovation based on insights and providing services.

In the energy and buildings field, access to and use of 'big data' may provide the stimulation needed to examine long held assumptions on how and where energy is used and, when connected to information about the users, the practices for why it is demanded. To this end, the current EBC research project 'Annex 70: Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale' is supporting the development of a strong evidence base on the energy performance of buildings. This requires having access to research from different 'levels' of data, from high-level aggregate ecological style studies (for instance using small area statistics), cross-sectional studies of individual units of observations (people, buildings, households, premises, meters, and so on), carefully constructed representative samples, exploratory and investigative studies (which in turn need to be examined within the population again). For building energy analysis, big data science has to encompass all of these levels.

Reliable processes and data for the long term

Reliable processes for describing and reporting on energy and building stocks are crucial. Such processes need to include both data and models. They underpin the creation of a transparent and accessible evidence base to support energy efficiency and the low carbon transition of buildings. Access to, linking and matching data on energy and building stocks together can provide numerous benefits, including for research, education and training, and public policy making. At the same time, concerns about making data accessible including privacy, management of access and communication protocols, commercial sensitivity, intellectual property, archiving and legacy repository. Also, the mechanisms to support long term data access need to be funded and carefully planned.

To ensure that research data have a life beyond the project in which they were created, it is essential that data are stored and that they are described by sufficiently detailed meta-data (i.e. data that describes other data) in order to be useful for other researchers. Data must also be logged and made available to the wider community from accessible repositories; for example, the UK Data Archive. The risk is that without detailed data collection and storage, longitudinal analysis or systematic reviews of research findings are not viable to support project-by-project learning. The implication of this limited data collection and access is that empirical studies have had a limited impact on the policy making process.

A Wiki-based Data Registry

The project is identifying and reviewing relevant data, as well as its development and foundations employed in the participating countries. It is building on an international survey of users and producers of energy and building stock data to develop a 'Data Registry'. The first task for this is to develop a framework to describe and classify energy and building stock data, including: attributes, types, variables, standards, and so on. This framework is being used for surveying existing data sources among the participating countries. The breadth, depth and quality of data available at the national, sub-national and field trial levels are also being reviewed.

The next activity is then to create the registry of energy and building stock data through a detailed description of the dataset meta-data. In this approach, energy and building stock data are classified through meta-data such that it can be placed within a 'Wiki' structure (a website on which users collaboratively modify content and structure directly from a web browser) with all the relevant meta-data to support energy and building stock research. An existing example of such a registry structure is the Open Energy Information (OpenEI) data Wiki.

Data collection processing and reporting

Alongside this data structure development, a review is being conducted of methods for data collection, processing and reporting of national building stocks and energy use and field trials including: collection techniques, data sources, applicable standards, access and reporting mechanisms. This review is documenting best practices on data access, harmonisation, anonymization and approaches for addressing privacy associated with energy and building stocks data.

The buildings and energy demand field can build on the lessons learnt around data access and protection in the scientific health research field. In the latter field, linking patient records to the use of health services has led to the development of epidemiology as an indispensable part of public health policy. Analogously, the availability and use of individual meter and sub-meter high frequency data combined with collection of building and occupant data through robust research designs can support an epidemiological approach for energy, essential for the development of policy relying on evidence-based energy demand.

Further information

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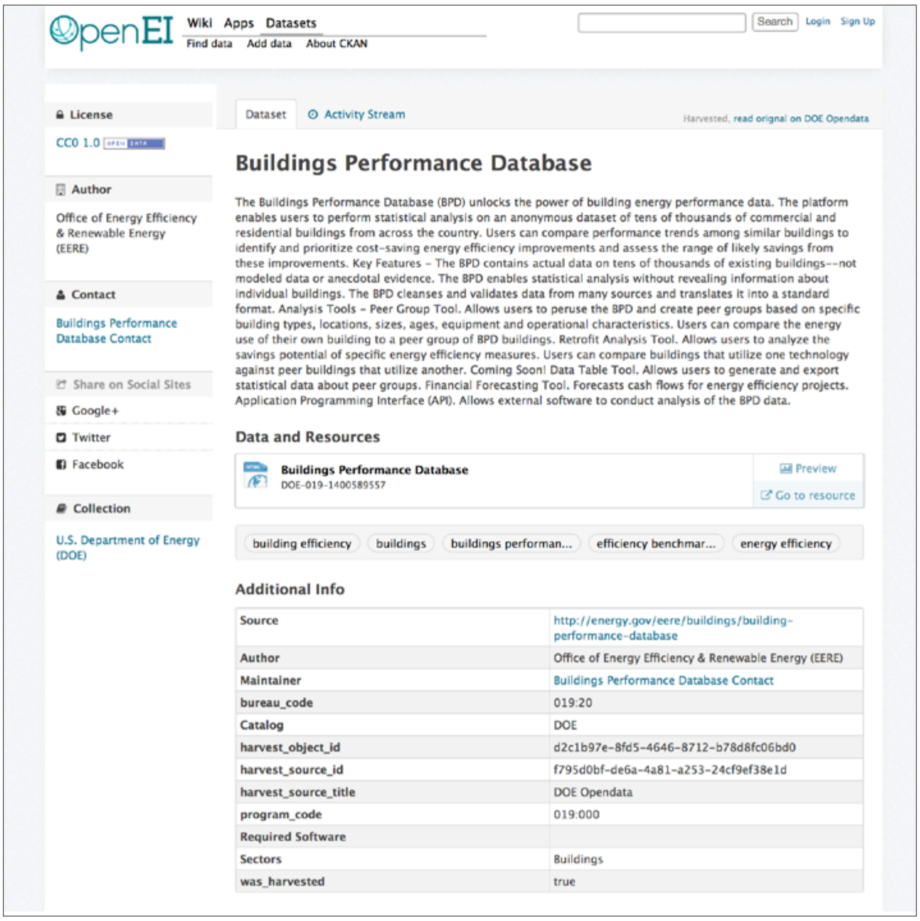


Buildings Performance Database on Open Energy Information (OpenEI) data Wiki
Source: US DOE 2017, CC0 1.0 License

Reliable Calculations for Energy Use in HVAC Systems

Current Working Group

Takao Sawachi

Calculating energy use in buildings is increasingly a key practice not only for regulatory compliance, but also for decision making in the design process.

Many countries have set national targets to reduce energy-related CO_2 emissions in the buildings sector in line with their own policies or international agreements. Once the demand side reduction target has been determined on the basis of overall energy use (rather than CO_2 emissions), the specific target for the building industry and policy makers can be identified. To implement any kind of energy reduction strategy for the buildings sector, energy calculation methodologies are commonly applied to judge whether building designs are consistent with energy use targets. But these methodologies can vary in transparency, accuracy or reliability as influenced by the strictness of the national policies that they support.

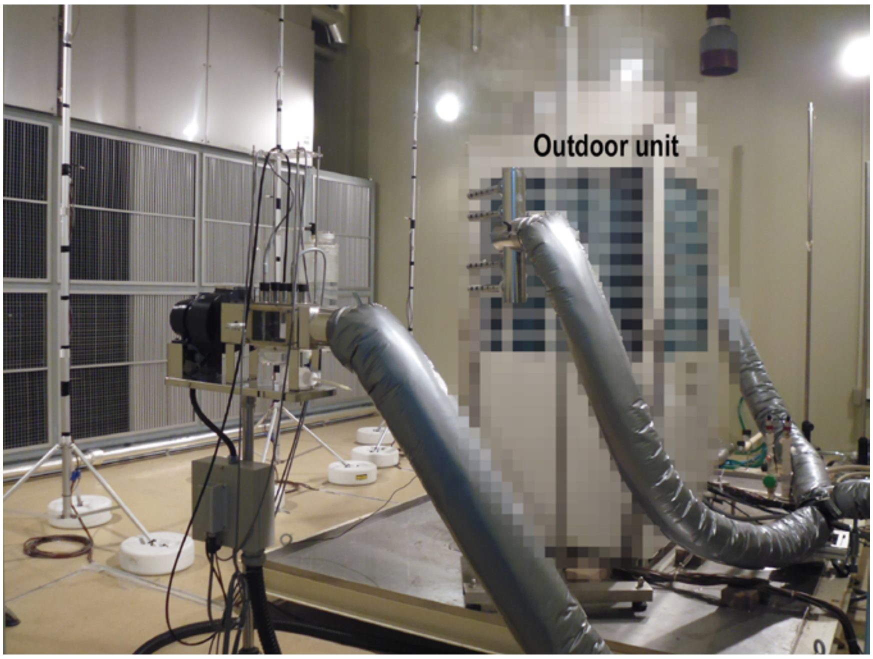
The necessity of reliability and accuracy

The calculated total energy use of buildings and their services for heating, ventilation and air conditioning (HVAC), domestic hot water systems, lighting, and so on, as well as that produced by renewable energy systems are the principal indicators of building energy performance. However, it has been found that the reliable and accurate calculation of energy use by HVAC systems seems to be a particularly difficult issue. Moreover, there has been a scarcity of relevant international research collaboration in this area. So, as a starting point to resolve this, the current three-year EBC Working Group, 'HVAC Energy Calculation Methodologies for Non-Residential Buildings', is carrying out a comprehensive analysis of certain national calculation methodologies of HVAC energy use, as well as of relevant international standards. In part due to time limitations, the Working Group is not covering residential buildings or other building services systems. Its objectives are to:

1. collect world-wide technical documentation on calculation methodologies of energy use for HVAC systems in non-residential buildings and on their scientific basis including research works on their validation;
2. analyse the collected documents and pick up characteristics of methodologies that are appropriate for broader application as good practice examples;
3. identify any apparent lack of scientific basis and problems in HVAC energy calculation methodologies as possible future R&D themes.

Why focus on HVAC systems for non-residential buildings?

In reality, HVAC systems in non-residential buildings are often particularly complex and simplifications are usually made to represent them in energy calculation methodologies. For example, in some calculation methods, seasonal average efficiencies of heat generators are treated independently from both the calculated energy demands of the building and the capacity of the heat generators to be installed; they are simply applied to calculate energy use from the energy demand. However, such a considerably simplified calculation limits accuracy when evaluating actual energy efficiencies under partial load conditions. As a further example, although in some situations fan energy use can be comparable to that needed heat generation, fans are often grouped into 'auxiliary equipment', with



An experimental set-up for HVAC system testing, showing an outdoor unit in a climate chamber. By this means, the necessary parameters to be used in a certain calculation methodology are obtained. (The outdoor unit is blurred to preserve client confidentiality.) Source: Building Research Institute, Japan

their energy use calculated using simple coefficients, which are selected according to the specification of the fan control.

It can be said that current energy calculation methodologies for HVAC systems apply more or less simplified calculation logic, which can be the cause of significant discrepancies between calculated and actual energy use in buildings. That is one of the reasons why some national calculation methodologies are not recommended as design tools by their creators. But, if other methodologies do in fact exist that are more appropriate as design tools, what are the actual deficiencies of such national calculation methodologies, underlying erroneous comparisons? Once this has been clarified, various improvements to national calculation methodologies become possible.

Analysis of methodologies and standards

National experts from Australia, China, Italy, Japan, Netherlands, Switzerland, UK, and USA, are participating in the Working Group and analysing calculation methodologies developed in six countries: DIN-V-18599 (Germany), UNI / TS 11300 (Italy), Web-Program (Japan), SIA-2044 and relevant standards (Switzerland), SBEM (UK), EnergyPlus (USA). In addition, the EN ISO 52000 series and their precedent EN standards are within the scope.

Initial observations

While though these are not final conclusions and they remain to be confirmed, the following initial observations have already been made by the Working Group:

- In some calculation methodologies, judgement criteria for energy efficiency and hence energy use differ according to the type of HVAC system. This means that a sort of relative evaluation of energy performance among similar energy systems is adopted.
- In some areas, monthly calculations are common, while dynamic calculations, which are more complex, are accepted and becoming more popular. Yet, there is possibly an issue about how the appropriateness of such alternatives to national calculation methodologies should be approved as compliance checking tools.
- The energy calculation methodology is central for integrating various aspects and components of buildings and energy systems.

Further information

www.iea-ebc.org

EBC International Projects

Current Projects

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

Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings
This project has developed and demonstrated 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 has developed design methods and tools related to cooling demand and risk of overheating in buildings and has proposed 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 developing robust approaches for implementing community-scale optimized energy strategies.
Contact: Helmut Strasser
helmut.strasser@salzburg.gv.at

Annex 64: 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: Dr Dietrich Schmidt
dietrich.schmidt@ibp.fraunhofer.de

Annex 65: Long-Term Performance of Super-Insulating Materials
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 is being investigated to create quantitative descriptions and classifications, develop effective calculation methodologies, implement these within 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 is scientifically explaining 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 is focusing on developing best practice methods for collecting, accessing, analyzing and developing models with empirical data of energy demand in buildings and communities.
Contact: Dr Ian Hamilton
i.hamilton@ucl.ac.uk

Annex 71: Building Energy Performance Assessment Based on In-situ Measurements
This project is advancing in-use monitoring to obtain reliable quality checks of routine building construction practice to guarantee that designed performance is obtained on site.
Contact: Prof Staf Roels
staf.roels@bwk.kuleuven.be

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

Annex 73: Towards Net Zero Energy Public Communities
The project is advancing 'near zero energy communities', to enhance existing masterplanning strategies and modelling tools, and expand their application with standardized country-specific building data on specific building types.
Contact: Dr Alexander M. Zhivov, Rüdiger Lohse
alexander.m.zhivov@erdc.usace.army.mil,
ruediger.lohse@kea-bw.de

Annex 74: Energy Endeavour
This initiative is benefitting from the lessons learned from the Solar Decathlon events worldwide, and is extending the format with new competitions and a series of networking events under a common umbrella.
Contact: Prof Karsten Voss, Peter Russell,
kvoss@uni-wuppertal.de,
peter.russell@solardecathlon.eu

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

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

Annex 5: Air Infiltration and Ventilation Centre
The AIVC carries out integrated, high impact dissemination activities, such as delivering webinars, workshops and technical papers.
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www.iea-ebc.org

EBC

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