EBC

Energy in Buildings and
Communities Programme

International Energy Agency

EBC Annex 71 Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements

Project Summary Report

Technology Collaboration Programme
by iea

EBC

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Project Summary Report

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Cover picture: Onsite assessment of thermal performance of the building fabric of a newly built unoccupied dwelling
Source: Bauwens G, 2015

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Project Summary

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

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

The EBC project 'Annex 71: Reliable building energy performance characterisation based on full scale dynamic measurements' has therefore evaluated and improved replicable methodologies embedded in a statistical and building physical framework to characterize and assess the actual energy performance of buildings. The project explored for residential buildings the development of characterisation methods as well as quality assurance methods. Characterisation methods aim to translate the (dynamic) behaviour of a building into a simplified model that can be used in model predictive control, fault detection,… Quality assurance methods aim to pinpoint some of the most relevant actual building performances, such as the overall heat loss coefficient of a building, solar aperture, etc. The specific objectives of the project were to:

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

The project deliverables were completed in cooperation with the Dynastee-network (www.dynastee.info). This network of excellence on full scale testing and dynamic data analysis organises events on a regular basis, such as international workshops, annual training courses and helps organisations interested in full scale testing campaigns. This has enhanced the network and continues the promotion of reliable building energy performance characterisation based on full scale dynamic measurements.

The following reports have been published:

– EBC Annex 71: Building energy performance assessment based on

in-situ measurements: Challenges and general framework
- EBC Annex 71: Building energy performance assessment based on in-situ measurements: Building behaviour identification
- EBC Annex 71: Building energy performance assessment based on in-situ measurements: Physical parameter identification
- EBC Annex 71: Building energy performance assessment based on in-situ measurements: Description and results of the validation of building energy simulation programs

Project duration
2016 - 2021 (completed)

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Further information
www.iea-ebc.org

Project Outcomes

1. Background

In order to reduce the energy use of buildings, policy makers impose ever more stringent requirements with regard to energy performance of new and renovated buildings. These regulations also promote buildings to produce and obtain energy locally from renewable sources (EPBD 2010). District energy systems (thermal and electrical), fed by these renewable resources, become increasingly popular. In these systems buildings act as chargers and dischargers. Simultaneously, advanced techniques are introduced which make use of the flexibility of buildings to facilitate the integration of renewables and to optimise a smart operation of buildings and grids.

Unfortunately, many current claims of energy efficiency for buildings and building districts are based on theoretical models, speculative assumptions and unconfirmed extrapolations. The in-situ data currently available regarding real-world performance of energy-efficient building technologies is sparse and uncoordinated, yet it suggests almost invariably a significant gap between predicted and achieved performance (e.g. Hens et al 2007, Lowe et al 2007, Deurinck et al 2012). This can be attributed to limitations, inaccuracies and assumptions in the numerical models to predict the performance, as well as to workmanship and implementation errors during construction and operation.

It is essential that the energy-efficient technologies used in buildings do more than simply satisfy regulations based on theory. They must make genuine, measurable differences in real-world applications. Building owners, investors and governments need to know that the investments they make deliver as expected. Hence, ensuring that real performances match design performances is critical. This requires reliable methods and procedures applicable to and based on real life data. Moreover, these methods should be able to assist in developing prediction models to be used e.g. in model predictive control, fault detection and design and operation of buildings and district energy systems (Lawrence et al 2016, Reynders et al 2017).

Recently, statistical methods and system identification techniques demonstrated to be promising tools to reliably characterise and assess the as-built performance of buildings and building components. Within IEA EBC Annex 58 (www.iea-ebc.org/projects) an important step has been taken to characterize the actual energy performance of buildings based on full scale dynamic measurements. The onsite assessment methods applied within this project mainly focused on the thermal performance of the building fabric. By investigating the possibilities and limitations of black and grey box system identification models, guidelines have been developed on how to assess the overall heat loss coefficient of a building starting from dynamic measured data instead of static co-heating tests. The results look promising, but so far all data was collected making use of rather intrusive tests imposed on unoccupied buildings.

Notwithstanding these limitations, Annex 58 showed that onsite quality checks are feasible, furthermore the project highlighted the need for non-intrusive methods. Such non-intrusive methods are not only concerned with the quality of the building fabric, but also the performance of systems and the impact of users on the energy use, and crucially in-use measurement systems should not perturb or inconvenience the

Figure 1: Onsite assessment of thermal performance of the building fabric of a newly built dwelling making use of rather intrusive tests in an unoccupied building (Bauwens G, 2015).

occupants. Today more and more buildings incorporate a kind of monitoring system recording real life data. Smart meters, home automation systems and wireless technologies for data management and communication have developed increasingly in recent years. However most real life data collection systems do not take into account the suitability of the measured records for energy performance assessment, model predictive control or building energy simulation. Some of the current measurements may be redundant, while other crucial information is not collected or the accuracy and frequency of measurement are too low to render them useful.

2. Objectives

The background section showed that a better prediction, characterization and quality assurance of the actual building energy performance is essential to realise the world wide intended energy reduction in building communities and systems. Quantifying the actual performance of buildings can only be effectively realised by optimized in-situ measurements combined with dynamic data analysis techniques. The IEA EBC Annex 58 project made a lot of progress in this field, but was mainly restricted to the thermal performance of the building envelope, making use of rather intrusive tests and focusing on scale models or test buildings. The Annex 71-project made the step towards monitoring in-use buildings to obtain reliable quality checks of daily building construction practice to guarantee that designed performances are obtained on site. The main objective of the project can be summarized as: Support the development of replicable methodologies embedded in a statistical and building physical framework to characterise and assess the actual energy performance of buildings starting from on board monitored data of in-use buildings.

The project focused on residential buildings, for which the development of characterisation methods as well as of quality assurance methods have been explored. Characterisation methods aim to translate the (dynamic) behaviour of a building into a simplified model that can be used in model predictive control, fault detection, optimisation of single buildings or district energy systems,… Within Annex 71 we refer to this as building behaviour identification. Quality assurance methods aim to pinpoint some of the most relevant actual building performances, such as the overall heat loss coefficient, the solar aperture,…. This part will be referred to as physical parameter identification.

To achieve the main objective, the following tasks were carried out, which are described in more detail in the next section:

– Investigate the possibilities and limitations of common data bases and monitoring systems
– Development and assessment of dynamic data analysis methods suitable for describing the energy dynamics of buildings
– Development and assessment of dynamic data analysis methods suitable for physical parameter identification of buildings

– Investigate to what extent the methodologies can be used in a quality assessment framework
– Undertake a highly detailed set of experiments to obtain suitable datasets for assessing simulation design software and for supporting the testing of building behaviour and physical parameter identification methods.
– Continue the Dynastee network of excellence on full scale testing and dynamic data analysis for knowledge exchange and guidelines on testing

3. Activities and Deliverables

Inventory of the challenges and developing a general framework

Assembling the knowledge, tools, and skills to reliably determine the HTC (Heat Transfer Coefficient) of a dwelling was one of the main drivers for Annex 71. However, research has been carried out in this area for several years. What set this work apart, was the idea of measurement of the HTC using cost effective data collection methods, such as smart meters and on-board devices such as thermostats, using complex analyses. The purpose was to look at what goes into these analyses and what comes out. This

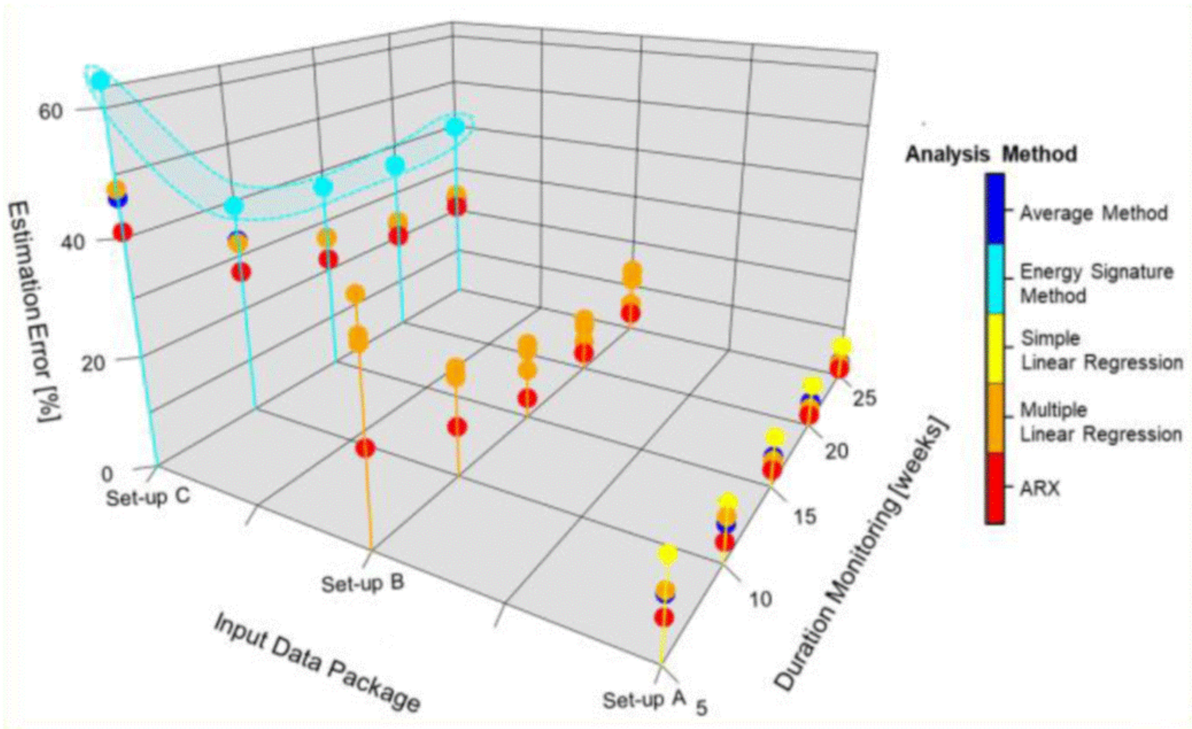


Figure 2: Example of a 3D-decision matrix, presenting expected estimation error for different statistical methods, considering (predefined) data packages and monitoring time.

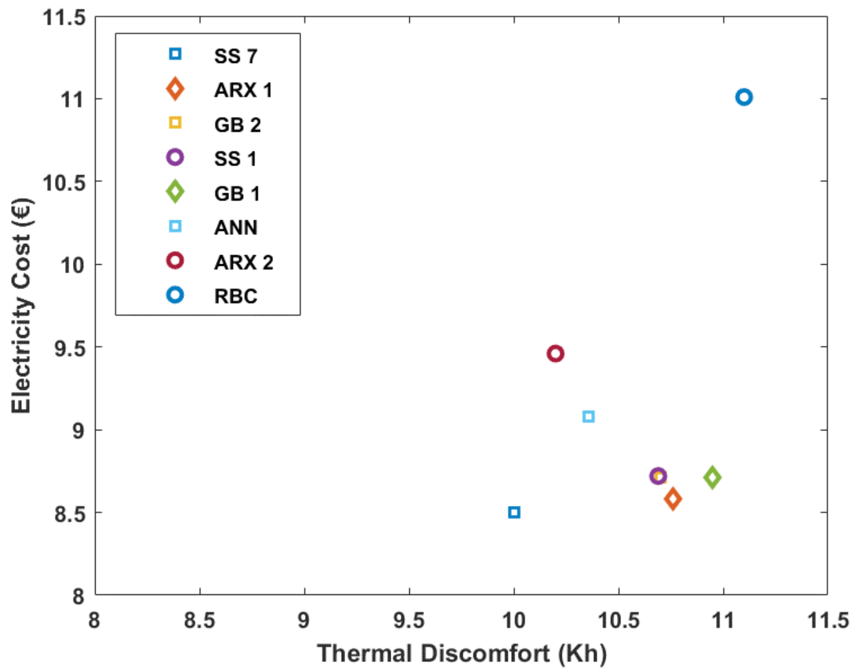


Figure 3: Evaluating two key performance indicators (electricity cost and thermal discomfort) of MPC's deploying different predictive models.

allowed us to develop a decision matrix that compares and optimises identification techniques in terms of costs and obtained accuracy. To do so, an inventory was made of common data inputs and a survey amongst relevant stakeholders on expected data outputs.

At the start of the project, an introduction to the HTC was presented with its simple uses and benefits. Then, a review was performed of the industry views and opinions across the member countries of this Annex. From here we assembled a large piece of research around the current methods used to do this work (the established and more modern ways of measuring the HTC). Furthermore, the current data inputs available in this area were examined, such as smart controls and a complete review of smart meter data across the EU. This included a state-of-the-art review of Building Automation Solutions (BAS). Finally, a series of use cases were presented with several international case studies, alongside some suggested future use cases for the metric.

Models for building behaviour identification

Throughout the course of Annex 71 different data analysis methods suitable for describing and predicting the energy dynamics of buildings have been evaluated. Such modelling techniques are gaining importance in the ongoing energy transition. The shift towards renewable energy sources introduces a new paradigm where not only the amount of energy use but also the time of usage becomes significant and requires matching the energy demand with the intermittent production of energy from renewable sources. During the operational phase, knowledge of the expected energy behaviour can be used to determine correct functioning of the building and its installations.

Building behaviour identification methods were studied for their ability to translate the (dynamic) behaviour of a building into a simplified model. Within Annex 71, this evaluation has primarily focused on predicting the dynamic indoor temperature in single-family houses. The activities were organised through setting up common exercises in which participants could contribute to a particular topic. The common exercises first explored the existing modelling techniques for building behaviour identification. Subsequently we focused on two applications in which building behaviour identification plays an important role: the identification of models for Fault-Detection and Diagnostics (FDD) and models for Model Predictive Control (MPC).

Models for physical parameter identification

Physical parameter identification typically makes use of simplified statistical models applied on sparse on-site collected (dynamic) data to identify relevant performance indicators of the building, such as the HTC, the solar aperture, the system efficiency,…. The main focus of Annex 71 was on the determination of the HTC. Methods to determine this value, ranging from static methods, e.g. linear regression or energy signature, to dynamic models such as ARX or stochastic state space models, were established and further developed. To evaluate the impact of the model simplification, firstly a complete heat balance of a typical dwelling was constructed to pinpoint the physical phenomena that are lumped into the estimated parameters. By zooming in on each significant term in the overarching heat balance different approaches could be determined that best represent these terms in a simplified way. The different approaches have been tested on four case studies, which have been extensively monitored and for which a solid reference performance indicator is available. Finally, the step was made towards real life applications. Realistic measurement campaigns of five houses, with no additional energy usage monitoring other than smart meters, have been provided via the Technical Evaluation of SMETER Technologies (TEST) project, phase 2 of the UK (Allinson et al, 2021). This offered the possibility to perform a blind test and validate the assumptions and guidelines developed.

BES-validation exercise

To check the reliability of detailed dynamic simulation programs, commonly used in practice and research for predicting the energy and environmental performance of buildings, an empirical validation experiment on a full scale building has been performed and the measured data compared with predictions. The experiment was conducted

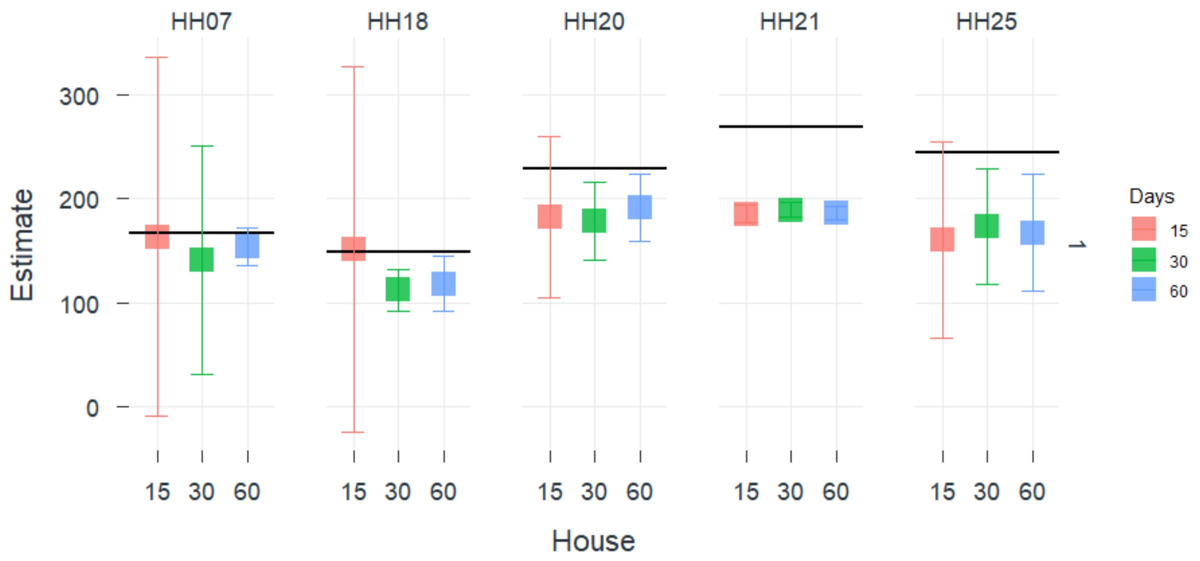
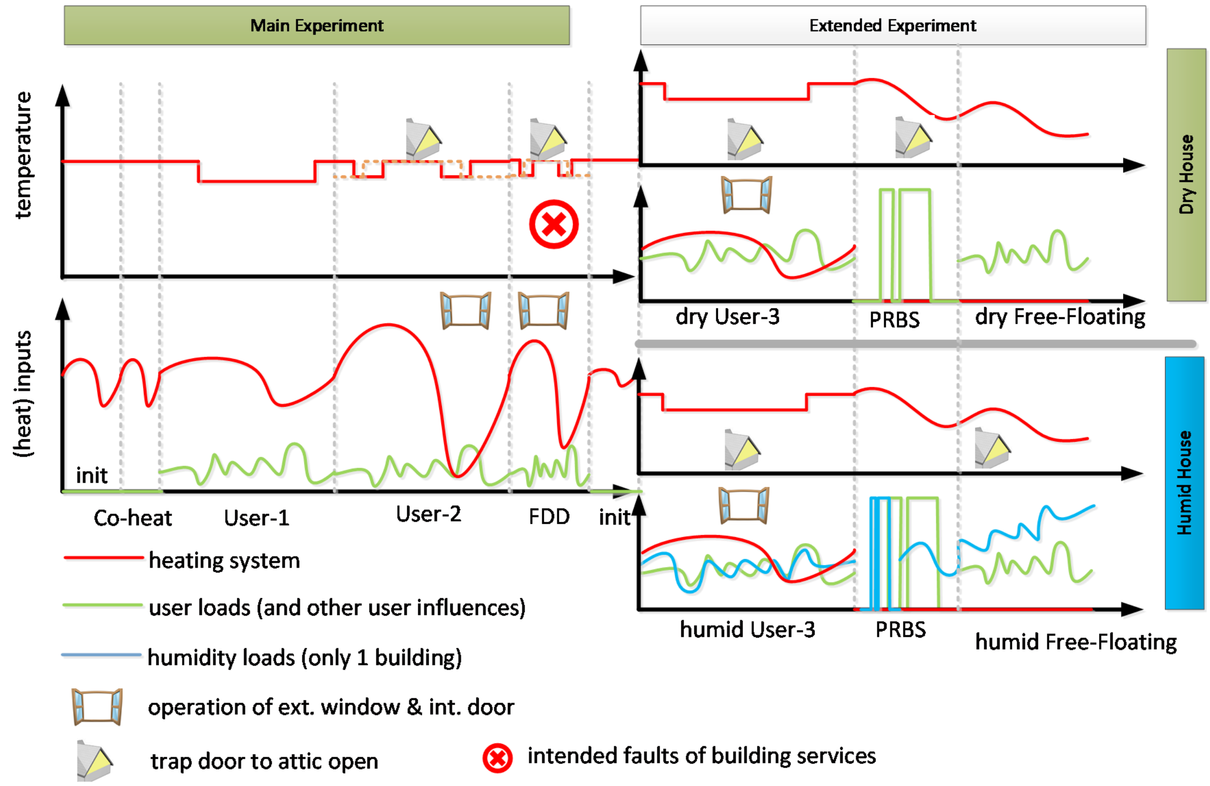


Figure 4: Investigating the impact of the period length (15, 30 or 60 days) on the HTC estimation and its uncertainty for the blind test on five SMETER test case dwellings when state space modelling is performed. The black line corresponds for each house to the target value as determined by a co-heating test on the house.

on the Twin Houses at the Fraunhofer IBP test site in Holzkirchen, Germany in the winter of 2018/19. The previous Annex 58 used the same houses to also perform two Building Energy Simulation program empirical validation experiments (Strachan, et al., 2016). Those experiments were designed to focus on the fabric-related functionality of BES programs including transmission heat losses, thermal bridges, solar gains, internal heat gains, window / blind models and internal and external air exchange. It did not consider occupancy user behaviour or typical heating and cooling systems. The empirical model validation study of Annex 71 increased the realism and complexity, by including building services equipment (underfloor heating and electrical heating), the attic of the houses as sleeping zones, (synthetic) occupancy profiles and moisture effects. A 'main experiment' consisted of a multi-stage operational schedule: a constant temperature period (for Co-heating test assessment), a simple User 1 period with a temperature profile consistent across all rooms, and a User 2 period with a more complex user profile which varies from room to room and includes window and door opening. A second experiment, the 'Extended Experiment', included moisture injection. This dataset is publicly available under: http://dx.doi.org/10.24406/fordatis/76 The experiment was also designed in such a way that it could be used by the Annex 71 participants working with simplified models and methods of system identification. The datasets were designed to be suitable for identification of physical parameters



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and for the development of reduced order models useful for fault detection and model predictive control.

Network of excellence on full scale testing and dynamic data analysis for knowledge exchange and guidelines on testing

Annex 71 has been working closely together with the Dynastee-network (www.dynastee.info). Enhancing this network and promoting actual building performance characterisation based on full scale measurements and the appropriate data analysis techniques via this network was one of the initial aims of the project. This network of excellence on full scale testing and dynamic data analysis exchanges knowledge, tools and data, organises on a regular basis events such as international workshops, annual training courses and supports organisations interested in full scale testing campaigns.

4. Concluding Remarks

The outcome of this project and parallel dissemination of the results via both the EBC programme and the Dynastee network will certainly promote best practices with respect to reliable building performance characterisation. The intensive international collaboration led to a major step forward in applying simplified models for building behaviour identification and physical parameter identification. The work performed within the framework of this project is specifically valuable to:

1. develop real building quality assessment bridging the gap between designed and on site obtained performance
2. organize the operation of energy systems by generating models that can be used to quantify the dynamic response and the flexibility available in different buildings, and
3. evaluate and optimise current building energy simulation models by providing detailed validation data collected on realistic cases.

Project Participants

Country	Organisation
Austria	University of Innsbruck Bauen
Belgium	KU Leuven INIVE-DYNASTEE BBRI BCCA Ghent University
Denmark	Aalborg University DTU Compute
Estonia	Tallinn University of Technology
France	CSTB INSA Lyon Cerema LOCIE, université Savoie Mont Blanc Saint-Gobain ISOVER
Germany	Technichal University of Applied Sciences Rosenheim Fraunhofer Institute for Building Physics IBP German Aerospace Center (DLR)

Country	Organisation
Norway	Norwegian University of Science and Technology
Spain	CIMNE UPV/EHU University of Vigo
The Netherlands	Saxion University of Applied Science TNO
UK	Leeds Beckett University Build Test Solutions Leeds Beckett University Loughborough University University of Strathclyde University of Salford

Project Publications

1. Allinson, D., Roberts, B. Lomas, K., Loveday, D., Gorse, C., Hardy, A., Thomas, F., Milse Shenton, D., Johnston, D., Glew, D., Rakshanbabanari, K., Fylan, F., Farmer, D., Elwell, C. Crawley, J., Hollick, F., Wingfield, J., Roberts, G. and Reevell, L. (2021) Technical Evaluation of SMETER Technologies (TEST) Project. Technical Report. DOI: 10.13140/RG.2.2.23975.62886.
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7. Reynders G., Diriken J., Saelens D. (2017). Generic characterization method for energy flexibility: Applied to structural thermal storage in residential buildings. Applied Energy, 198, 192-202
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EBC and the IEA

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 30 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The high priority research themes in the EBC Strategic Plan 2019-2024 are based on research drivers, national programmes within the EBC participating countries, the Future Buildings Forum (FBF) Think Tank Workshop held in Singapore in October 2017 and a Strategy Planning Workshop held at the EBC Executive Committee Meeting in November 2017. The research themes represent a collective input of the Executive Committee members and Operating Agents to exploit technological and other opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy technologies, systems and processes. Future EBC collaborative research and innovation work should have its focus on these themes.
At the Strategy Planning Workshop in 2017, some 40 research themes were developed. From those 40 themes, 10 themes of special high priority have been extracted, taking into consideration a score that was given to each theme at the workshop. The 10 high priority themes can be separated in two types namely 'Objectives' and 'Means'. These two groups are distinguished for a better understanding of the different themes.

Objectives - The strategic objectives of the EBC TCP are as follows:

– reinforcing the technical and economic basis for refurbishment of existing buildings, including financing, engagement of stakeholders and promotion of co-benefits;
– improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real-world operation;
– the creation of 'low tech', robust and affordable technologies;
– the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible;
– the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport energy system implications.

Means - The strategic objectives of the EBC TCP will be achieved by the means listed below:

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

The themes in both groups can be the subject for new Annexes, but what distinguishes them is that the 'objectives' themes are final goals or solutions (or part of) for an energy efficient built environment, while the 'means' themes are instruments or enablers to reach such a goal. These themes are explained in more detail in the EBC Strategic Plan 2019-2024.

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*):

Annex 1:	Load Energy Determination of Buildings (*)
Annex 2:	Ekistics and Advanced Community Energy Systems (*)
Annex 3:	Energy Conservation in Residential Buildings (*)

Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction (*)
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
Annex 62: Ventilative Cooling (*)
Annex 63: Implementation of Energy Strategies in Communities (*)

Annex 64:	LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles (*)
Annex 65:	Long-Term Performance of Super-Insulating Materials in Building Components and Systems (*)
Annex 66:	Definition and Simulation of Occupant Behavior in Buildings (*)
Annex 67:	Energy Flexible Buildings (*)
Annex 68:	Indoor Air Quality Design and Control in Low Energy Residential Buildings (*)
Annex 69:	Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings
Annex 70:	Energy Epidemiology: Analysis of Real Building Energy Use at Scale
Annex 71:	Building Energy Performance Assessment Based on In-situ Measurements (*)
Annex 72:	Assessing Life Cycle Related Environmental Impacts Caused by Buildings
Annex 73:	Towards Net Zero Resilient Energy Public Communities
Annex 74:	Competition and Living Lab Platform
Annex 75:	Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables
Annex 76:	Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions (*)
Annex 77:	Integrated Solutions for Daylight and Electric Lighting (*)
Annex 78:	Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications
Annex 79:	Occupant-centric Building Design and Operation
Annex 80:	Resilient Cooling
Annex 81:	Data-Driven Smart Buildings
Annex 82:	Energy Flexible Buildings towards Resilient Low Carbon Energy Systems
Annex 83:	Positive Energy Districts
Annex 84:	Demand Management of Buildings in Thermal Networks
Annex 85:	Indirect Evaporative Cooling
Annex 86:	Energy Efficient Indoor Air Quality Management in Residential Buildings
Annex 87:	Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems
Working Group -	Energy Efficiency in Educational Buildings (*)
Working Group -	Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group -	Annex 36 Extension: The Energy Concept Adviser (*)
Working Group -	HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group -	Cities and Communities (*)
Working Group -	Building Energy Codes

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