Energy in Buildings and Communities Programme

ANNEX 67 NEWS

Newsletter 5 | May 2018

Content

Energy Smart Lab at IREC, Barcelona, Spain
Photo by David Lavernia

Brief from the 6th Annex 67 working meeting

By Søren Ø. Jensen, DTI & Anna Marszal-Pomianowska, AAU

The sixth working meeting took place in Barcelona, Spain on March 26^{th}-28^{th} 2018. The meeting was attended by 53 participants from 14 countries. The meeting was hosted by IREC.

The main part of the meeting was used to focus on the Anne67 Deliverables. In total seven deliverables are planned and they are as follows:

D1 - *Source Book: Principles of Energy Flexible Buildings* summarizes the main findings of the Annex 67 and targets all interested in what Energy Flexibility in buildings is, how can it be controlled, and which services may it deliver.

D2 - *Definition, indicators and methodology for characterization of Energy Flexibility in buildings* presents the terminology around energy flexibility, the existing indicators used to evaluate the flexibility potential and their application in a common exercise conducted by Annex 67 participants.

D3 - *How to characterize and label Energy Flexibility in Buildings* introduces the Flexibility Index and Flexibility Function which are the first attempt to characterize and label energy flexibility.

D4 - *Stakeholders' perspectives on energy flexibility in buildings* displays the view point of eight types of stakeholders towards the energy flexible buildings.

D5 - *Control strategies and algorithms* reviews based on the input from literature and case studies the applied and tested control strategies for energy flexibility in buildings

D6 - *Test facilities* presents the existing test facilities, describes the finalized and planned experiments related to energy flexibility and draws the recommendations for future testing activates.

D7 - *Examples on how to obtain Energy Flexibility in buildings* summarizes good examples of energy flexible buildings.

During the meeting the methodology for characterization and labelling of Energy Flexibility in buildings and its test was further discussed. The methodology has 2 main goals: the identification of the flexibility function – which describes the available flexibility of a system as a transfer function relating penalty (input) to power (output) – and the flexibility index – which gives a more comprehensive insight into the impact of using energy flexibility in a certain context (e.g. energy savings, CO_2 reduction).

Finally, the Flexibility Characteristics can be derived from the Flexibility Function. The main outcome from the test was that the use of model predictive control for the direct simulation results in an anticipation of the control to the penalty step-change and the obtained Flexibility Characteristics are sensitive to the shape and timing of the step change.

Hence, when using the direct simulation approach, it comes down to define a good penalty function. Further research is needed to identify what are the prerequisite of the penalty signal since it will influence the flexibility estimation. As next steps for the common exercise, in support of the further development of the cookbook, is n intensive work-group planned in May 2018.

The participants of the 6^{th} working meeting of Annex 67

Public workshop in Barcelona, Spain

By Jaume Salom, IREC

On Monday the 26th of April 2018, an open workshop about "Energy flexible buildings" was organized by IREC, in the building of the Palau Robert in the heart of Barcelona. The objective of the workshop was to disseminate the ideas behind energy flexible buildings to a wider audience, and raise the awareness of local engineers, designers, architects and any other citizens interested in this engaging topic. Energy flexible buildings constitute a key asset in the future energy system, and could help tackle the challenges raised by increasing penetration of renewable energy sources in the energy systems. To succeed and increase the users' acceptance, it is, however, important to educate building owners, operators and occupants (i.e. everyone!) to the needs and reasons behind such research. The workshop also served as a prelude to the Annex 67 biannual meeting, which was hosted by IREC and took place in Barcelona the days following the workshop.
Jaume Salom opened the workshop, which organization was supported by INCITE, RIS3CAT & ICAEN. Søren Østergaard Jensen, started as the first speaker to introduce the IEA EBC Annex 67. Next, Cristina Corchero from IREC presented the work carried out in another framework of the IEA, the Hybrid and Electric Vehicle (HEV) programme, and more specifically Task 28, titled "Home grids and V2X technologies". This task aims at using electric cars as storage elements and for other purposes than powering the vehicle, starting from the statement that EVs are not utilized during 52% of the time. Different applications are investigated in Task 28, such as vehicle-to-grid (V2G), vehicle-to-load (V2L), vehicle-to-vehicle (V2V) or vehicle-to-home (V2H). All these applications make a flexible use of the battery of the EVs to improve the management of the power grid and provide additional services. The following presentation was given by Albert Cot from COMSA about REFER. In this local project, the objective is to implement demand-side management strategies in a network of public libraries. If the flexibility is accumulated at an upper level, for instance at the scale of the libraries network in the REFER project, the aggregator can offer such flexibility to potential markets. Analyzing this economic potential was the object of the next presentation by Mattia Barbero from IREC, who reviewed the markets to trade with aggregated energy flexibility.

Cristina Corchero gave a second speech to present SABINA, a European H2020 project. SABINA aims to develop new technology and financial models to connect, control and actively manage generation and storage assets to exploit synergies between electrical flexibility and the thermal inertia of buildings. The latter is considered as one of the cheapest possible sources of flexibility, and thus is particularly targeted by the project.
Kyriaki Foteinaki, a PhD student from the Technical University of Denmark then presented some results from her external stay as a visiting researcher in IREC. Within the EnergyLab Nordhavn project, her work focuses on the flexibility potential of the district heating network of Copenhagen, in a neighborhood of newly-constructed energy-efficient buildings, therefore she brought a different perspective to the topic of energy flexibility. Up next, Thibault Péan, PhD student at IREC, presented his work carried out in the framework of the INCITE project. His thesis revolves around the development of innovative control strategies to enhance the energy flexibility of buildings, and especially for heat pump systems. Heat pumps supplied with renewable electricity represent an excellent combination for decarbonizing our energy grids, and they also provide potential for unlocking the energy flexibility of building thermal loads, if controlled in a smart manner. Thibault thus first presented a short review of the existing control strategies in this domain, mainly separated between rule-based control strategies and model predictive control.
Closing the workshop, Lluís Morer i Forns, Head of Energy Efficiency at ICAEN presented the vision of this institution regarding the role of buildings in the energy transition of Catalonia. The energy mix of this region highly depends on nuclear and fossil fuels, but the authorities aim to at least fulfill the European targets set in the "2030 Climate and Energy Package": 27% of renewable electricity and an improvement of 30% of the energy efficiency. Buildings present a great potential for this last action, given their important share in the global final energy use. To achieve the energy efficiency targets, the actions will first focus on the public buildings owned by the region and the municipalities.

Opening presentation by Jaume Salom

Spanish perspective on energy flexibility

By Jaume Salom, IREC

In line with the EU policies, the Spanish energy system is facing a major shift away for the fossil fuels towards renewable energy sources (RES), which according to the national roadmaps should in coming decades cover the major part of Spanish energy consumption. For the last 5 years, around 40% of the electricity consumption came from renewable energy sources. In 2017, wind power covered 18.2% of the electricity demand being the major renewable energy source followed by hydro power (7.0%), solar photovoltaic (3.1%) and solar thermal (2.1%). In 2017, however, due to the extreme drought in the hydro power production, the share of RES in the national system was only 33%

Though the plans for the installed capacities are ambitious, i.e. in 2020 - 35.0 GW of wind and 7.25 of PV [2], and in 2035 - 46.1 GW of wind and 37.0 GW of PV [3], since 2013 there was almost no increase in the installed generation capacities of renewable energy systems.

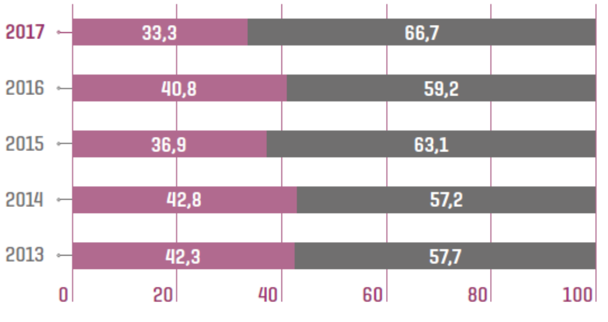

Figure 1. Percentage of renewable energies (left part of the bars) in the power production system in Spain along the last five years. Renewables count for hydro, wind, solar PV and thermoelectric, other renewables and 50% of waste urban [1].

The changes at the generation side should go hand in hand with the changes at the demand side. By acting as prosumers and/or modulating energy demand profiles, building sector is envisioned as one that has significant potential for contributing to the paradigm shift of the energy system. In order to foster the building sector to implement the green-transition-supportive actions, the government and other regulatory parties have introduced some regulatory changes and incentives. Among these actions, one can highlight:

- The deployment of smart meters in all the households, planned to be completed in 2018
- The new Building Technical Code, planned to enter in force in 2018, introducing the nearly Zero Energy Buildings energy frame and using non-renewable primary energy as key indicator
- The promotion of electrical vehicles
- The promotion of self-consumption based on PV systems by some regional governments and social groups despite of the regulatory barriers at national level

Yet, the impact of the announced measures is still limited and further campaigns must be launched.

Finally, the interested parties from the building and electricity sector, which act on the individual building level as well as on the aggregated level, see the management of energy flexibility in buildings as a business opportunity. Nevertheless, there is a long way to follow, especially knowing that the market to exploit and trade energy flexibility in buildings at aggregated level is yet not established in Spain.

References:

[1] Red Eletrica de España. El sistema eléctrico epañol. Avance 2017.

[2] Resumen del Plan de Energias Renovables (PER) 2011-2020, Ministerio de Industria, Turismo y Comercio, Gobierno de España

[3] Klein, K. et al., Comparison of the future residual load in fifteen countries and requirements to grid-supportive building operation, EuroSun 2016 Conference, Palma de Mallorca, 2016.

Stakeholders' perspectives on energy flexibility buildings

By Zheng Ma, Center for Energy Informatics, University of Southern Denmark (SDU)

There are various stakeholders involved in the energy flexibility buildings with different roles. Stakeholders' engagement is essential for the success of the realization and implementation of energy flexible buildings. This innovation not only changes stakeholders' business models (e.g. DSOs' and energy retailers' business models) and behaviors (e.g. occupants), but also their relationships. SDU conducted comprehensive interviews with around ten types of stakeholders and more than twenty interviews, see Table 1.

Table 1. stake types and interviewed companies

Stakeholder type	Interviewed companies
Building manager	University- SDU service
BMS providers	Schneider Electric Siemens
Electricity supplier	EnergiFyn
Energy consulting	Grøn Energi
DSO	Trefor
TSO	Energinet
Industrial consumers: Brewery	Bryggeriet Vestfyen A/S
Industrial consumers: Greenhouse	Alfred Petersen & Søn
Expert in energy and buildings	Civil and Architectural Engineering, SDU
Expert in building automation	Center for Energy Informatics, SDU
Occupants x 10	University students

The result shows, that stakeholders believe that three aspects need to be seriously considered in relation with energy flexible buildings: buildings, grid and market, and building-to-grid communication, see Figure 2. Besides the influences of regulation and policies, integrated building automation solutions and stakeholders' collaboration are important. The majority of stakeholders believe consumers take the most important role in the adoption of flexible energy buildings. However, the project shows that the readiness of energy flexible buildings requires all stakeholders' engagement.

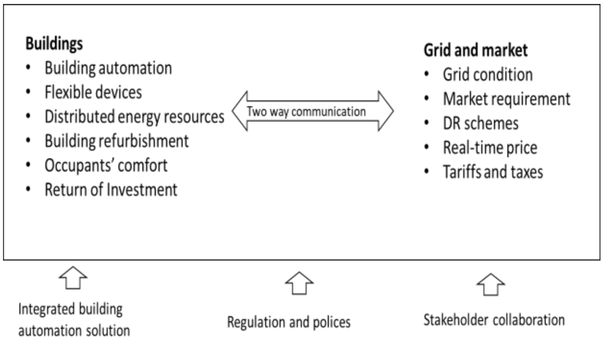

Figure 2. Readiness for Energy Flexible Buildings

Energy flexible buildings: An evaluation of definitions and quantification methodologies applied to thermal storage

By Anna Marszal-Pomianowska, AAU, Glenn Reynders, EnergyVille and Rui Lopes, Universidade Nova de Lisboa

https://www.sciencedirect.com/science/article/pii/S037877881732947X?via%3Dihub

A review of definitions of energy flexibility has indicated that a majority of the studies starts from the concept that energy flexibility implies the ability to shift energy. Though, each of these studies were found to focus on specific aspects or properties of energy flexibility. Based on the review, these different focus points could be grouped into five categories: focus on energy infrastructure context, focus on electricity, focus on energy price, focus on possibility of compromising other building performances (e.g. thermal comfort) and focus on systems interacting with the building.

The review of the quantification methodologies of energy flexibility of buildings in a design or operational context has identified two general approaches. The first approach quantifies energy flexibility indirectly assuming a specific energy system and/or energy market context and using past data. The second approach directly predicts the energy flexibility that a building can offer to the energy system without considering if this flexibility can or will be used by the system. These quantification methodologies can, therefore, be interpreted as bidding curves for energy flexibility.

The latter approach was analyzed more extensively whereby different proposals for indicators and corresponding quantification methodologies were found. Although those studies have a different focus, three general properties of energy flexibility can be observed, i.e. (i) the temporal flexibility, (ii) the amount of energy or power that can be shifted and (iii) the associated cost of activating this flexibility. In all cases, these three properties are calculated by comparison against a reference scenario where no external demand for energy flexibility is considered.

Application of the identified methodologies to a case study revealed that methodologies that quantify energy flexibility by analyzing flexibility events at specific times have clear advantages when dealing with systems with thermal losses and multiple time constants, such as thermal mass of buildings. In contrast, methodologies that relied on cumulated energy profiles lose their interpretability for such systems mainly since they treat a system governed by multiple time constants as a single state system. Moreover, results of Methodologies proposed by De Coninck et al [1,2], Oldewurtel [3] and Heussen et al. [4] and Reynders et al. [5,6] are found to be highly comparable and reflect the dependence of the predicted energy flexibility on dynamic boundary conditions such as climate and occupancy.

Between the methodologies of De Coninck and Oldewurtel the only difference was found in the way the final results are communicated. Between method of De Coninck and Heussen et al. & Reynders et al. limited differences were found as result of using respectively an optimal control based or rule based quantification method. Finally, although the method of Stinner et al. [7] gave physically interpretable results a quantitative comparison was not possible as they start from a completely different problem description, especially in terms of reference conditions.

The conclusions of the conducted analysis are a first step to communicate the key properties found among existing definitions and to support the development of a harmonized communication on energy flexible buildings between the interested parties, such as building and energy system designers and operators, aggregators and governments.

References:

[1] De Coninck, R., & Helsen, L. (2013) Bottom-up quantification of the flexibility potential of buildings. Proceedings of Building Simulation, 13th International Conference of the International Building Performance Simulation Association, IBPSA, Chambery, France.

[2] De Coninck, R., & Helsen, L. (2016). Quantification of flexibility in buildings by cost curves – Methodology and application. Applied Energy, 162, 653–665. http://doi.org/10.1016/j.apenergy.2015.10.114

[3] Oldewurtel, F., Sturzenegger, D., Andersson, G., Morari, M., & Smith, R. S. (2013). Towards a standardized building assessment for demand response. In 52nd IEEE Conference on Decision and Control (pp. 7083–7088). IEEE. http://doi.org/10.1109/CDC.2013.6761012

[4] Heussen, K., Koch, S., Ulbig, A., & Andersson, G. (2010). Energy storage in power system operation: The power nodes modeling framework. In 2010 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT Europe) (pp. 1–8). IEEE. http://doi.org/10.1109/ISGTEUROPE.2010.5638865

[5] Reynders, G., Diriken, J., & Saelens, D. (2017). Generic characterization method for energy flexibility : application to structural thermal storage in Belgian residential buildings. Applied Energy, 198, 192-202. https://doi.org/10.1016/j.apenergy.2017.04.061

[6] Reynders, G., Diriken, J., & Saelens, D. (2016) Quantifying the active demand response potential: impact of dynamic boundary conditions. Proceedings of the 12th Rehva world congress: Clima 2016, Aalborg, Denmark.

[7] S. Stinner, K. Huchtemann, D. Müller, Quantifying the operational flexibility of building energy systems with thermal energy storages, Appl. Energy 181 (2016) 140–154. http://doi.org/10.1016/j.apenergy.2016.08.055

National Projects

Intermittent Energy – Integrating Household, Utilities and Buildings (InteHUB)

By Anna Marszal-Pomianowska, AAU

The vision of the InterHUB project is that the future buildings will be an active and integrated part of the energy system. This will have implications for everyday household practices, the ways in which buildings and their associated technologies are designed and for the ways in which energy providers operate. The roles of the involved actors will change, e.g. utilities will become service providers rather than energy providers, consumers will take roles of prosumers (both providing and consuming energy), and buildings will serve as energy storage units and energy producing units. These changes call for increased collaboration and an aligning of practices across each of these domains, as indicated in Figure 3. Thus, central research topics to be investigated are: how households interact with and understand different types of building technologies, how households relate to utilities providing different services, how different types of professionals communicate with each other and with households on energy issues, and how developments within buildings and provision systems influence each other.

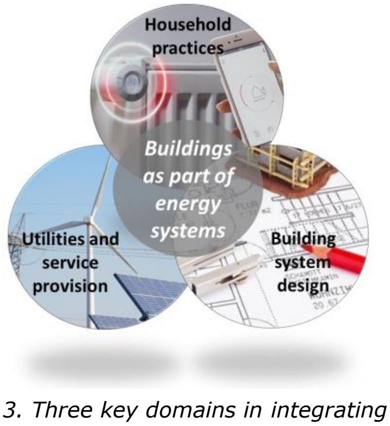

Figure 3. Three key domains in integrating buildings into energy systems

The InterHUB project's major contribution is its interdisciplinary approach to a societal problem where a deeper understanding of the actors' different interests and priorities is absolutely needed for being able to deliver solutions that will work in real life. The project provides new insights by integrating different types of data and research approaches from different disciplines, and by working together on the same research topics. InterHUB looks across these sectors and specifically addresses the interactions between key actors involved in the transition processes.The project investigates three areas:

- The interactions between household practices and building system designs

- The interactions between utility provision systems and household practices
- The interrelations between utility service provision and building system designs.

The InterHUB project will provide new understandings of how household practices can be utilized in developing new energy services, building technologies and designs, and of the influential role of communication in constituting new practices. This research will contribute to the on-going scientific and policy debates as how to ensure a sustainable, efficient, flexible, stable and affordable balancing of energy supply and demand. The project will develop new knowledge on households in the changing energy system, on new buildings solutions and on how different utility services impact both households and the energy system. The project will also provide new knowledge about and methods to enhance communication amongst actors involved in these transition processes.

Project leader: professor Kirsten Gram-Hanssen, SBi-AAU, kgh@sbi.aau.dk

Project timeframe: 01.04.2018 – 31.03.2021

Project webpage: http://www.strategi.aau.dk/Forskning/Tv%C3%A6rvidenskabelige+forskningsprojekter/interHUB

ForEVER: Flexibility potential of building technology in electrical distribution networks

By Tim Schlösser and Markus Schumacher, RWTH Aachen University

ForEVER investigates the flexibility potential of buildings to stabilize the electrical distribution networks. The multiphysics simulation platform developed within the project enables the integrated calculation of a variety of possible scenarios, particularly with regard to settlement structure and development of renewable electricity generation yielding insight for planning and adjustment of energy systems. In particular, it support the assessment of grid stability and of the expansion of electricity distribution networks and the identification of

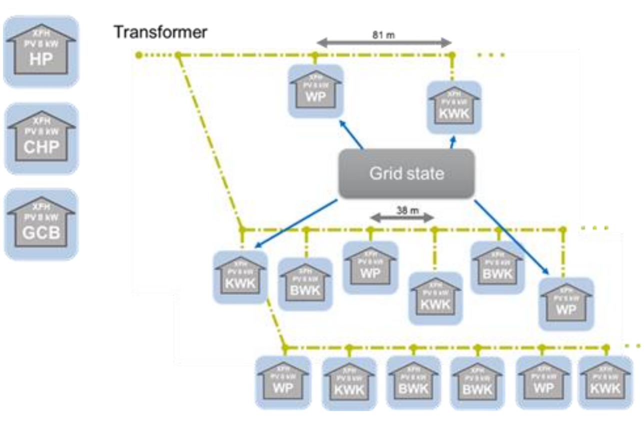

Figure 4. Three key domains in integrating buildings into energy systems

technology pathways for buildings and system engineering.

An economic assessment of technology paths helps identifying new business models and risks & opportunities for the energy industry.

The simulation environment is flexible, scalable and highly automated. It can accommodate a large number of neighborhoods, with given number of buildings, composition, predominant system engineering, user behavior, network topology, etc.

By time-resolved simulation conclusions about the suitability of certain technologies and their optimal dimensioning and distribution depending on the considered quarters can be drawn. Furthermore, the influence of these thermal-electric plants can be analyzed for the stability of the electrical distribution network. Through the investigation and assessment of a variety of different scenarios, the complexity of future decentralized energy systems is covered and improves the understanding of the system.

Project partners:

- Institute for Automation of Complex Power Systems (ACS), RWTH Aachen University
- Institute for Energy Efficient Buildings and Indoor Climate (EBC), RWTH Aachen University

Project timeframe: 02.2016 – 01.2019

Project sponsor: BMWi – Federal Ministry for Economic Affairs and Energy, promotional reference 03ET1390A

Project webpage: http://www.ebc.eonerc.rwth-aachen.de/cms/E-ON-ERC-EBC/Forschung/Forschungsprojekte2/Projekte-Urbane-Energiesysteme/~mqly/FoREVER/?lidx=1

Test facilities at IREC

By Jaume Salom, IREC

The main test facilites are the Semi-Virtual Energy Integration Laboratory (SEILAB) located in Tarragona and Energy Smart Lab placed in Barcelona.

SEILAB provides advanced expertise to assess the development and integration of renewable energy solutions and innovative thermal and electrical equipment that are designed to improve energy efficiency in buildings and energy systems. The laboratory is provided with cutting-edge technology comprising systems for energy generation, heat and cool storage and state-of-the-art facilities for testing HVAC equipment and the interaction of energy systems with the grid. The laboratory operation is based on a semi-virtual testing approach, which allows for real equipment to be operated as a function of the behaviour of a dynamic virtual model. The laboratory is pioneer in addressing the smart integration of electrical and thermal components and aims to become a leading experimental facility for improving the development of Net Zero Energy Buildings and Flexible Energy buildings.

Energy Smart Lab is an infrastructure conceived as a flexible and versatile platform for innovative technological developments for both industry and competitive R&D projects. The areas of expertise of this laboratory pivot around the following technologies:

- Power Electronics for the integration and control of the elements within a building or community: Renewable Energy Sources (RES), Energy Storage Systems and Electric Vehicles (EV).
- ICT Platform for smart communications and energy management of systems, building,
- Energy System Integration technologies for smart and flexible buildings and grids including RES and EV.

The laboratory operation is based on the hardware emulation approach, which allows for real physical equipment to be operated under a broad range of scenarios without depending on the real occurrence of the boundary conditions suitable for the experimental validation. The laboratory is pioneer in addressing the concept and implementation of micro-grids and aims to become a leading experimental facility for improving the optimal development of Flexible Energy Buildings and Flexibility Aggregation at community level.

Further information on SEILAB and Energy Smart Lab may be found in the Annex 67 report: *Laboratory facilities used to test energy flexibility in buildings*. http://annex67.org/media/1469/lab-description-report-first-edition.pdf

Next IEA EBC Annex 67 meetings

- IEA Annex 67 7th expert meeting – autumn 2018. Probably in Canada
- IEA Annex 67 8th expert meeting – spring 2019. Possible location Leeds, UK or Aalborg, Denmark

Energy flexibility related events

- CLIMA 2019

May 26th-29th 2019
Bucharest, Romania
http://www.clima2019.org/

- 16th International IBPSA Building Simulation Conference and Exhibition

September 2nd-4th 2019
Rome, Italy
http://buildingsimulation2019.org/

- CISBAT 2019 International Scientific Conference

September 4th-6th 2019
EPFL, Lausanne, Switzerland
https://cisbat.epfl.ch/

Photo of SEILAB test facility at IREC

IEA EBC ANNEX 67

Energy Flexible Buildings

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