Energy in Buildings and Communities Programme

Energy Technology Network

ANNEX 67 NEWS

Newsletter 3 | May 2017

Content

Lab and office building with facade-integrated PV at Fraunhofer ISE

Brief from the fourth Annex 67 working meeting

The fourth working meeting took place in Freiburg, Germany on March 15-17, 2017. The meeting was attended by 47 participants from 16 countries. The meeting was hosted by Fraunhofer ISE.

The main purpose of the work was to report on ongoing work and to allow more thorough discussions on important topics of Energy Flexibility in buildings:

- definition, terminology and characterization of Energy Flexibility in buildings
- simulation test bed and archetypes of buildings
- common exercises
- barriers and motivation for stakeholders

Definition, terminology and characterization: an article titled Energy Flexible Buildings: A review of definitions and quantification methodologies has been submitted to Energy and Buildings. The review conducted shows that although definitions in the literature have their particularities, they are based on the same principle, namely that energy flexibility is the ability to shift energy. A report with a thorough investigation of Key Performance Indicators (KPIs) has been drafted and will be finalized, but held open for new KIPs developed during the cause of Annex 67.

Simulation test bed and archetypes of buildings: one important challenge in the Annex is to ensure comparability of different approaches to obtain flexibility and for comparing of results from simulation models. Specific input parameters (e.g. type, dimension and quality of building) and results (efficiency- and flexibility KPIs) from the modelling teams are collected in order to set up a cross-comparison between different approaches, buildings and technologies.

Common exercises: in order to better understand the term Energy Flexibility in buildings a series of common exercises have been undertaken. The common exercises have shown how participants of Annex 67 perform their investigations on Energy Flexibility in buildings.

Barriers and motivation for stakeholders: an article titled: Are building users prepared for energy flexible buildings? - A large-scale survey in the Netherlands has been submitted to Applied Energy. The survey show that few have knowledge about Smart Grid, but when the concept is briefly explained many are positive towards being Energy Flexible. A questionnaire for office building has been developed and a survey are being carried out in The Netherlands, UK, Italy and Denmark.

A catalogue describing the test facilities participating in Annex 67 is being prepared. The test facilities are at IRAC (E), VTT/Alto University (SF), DTI (DK), Fraunhofer ISE (G), NTNU (N) and EURAC (I). The aim is to have a first draft of the catalogue by end June 2017 so that it can facilitate corporation between the test facilities and the modelers of Annex 67.

An EU study on introducing a Smartness Indicator in the forthcoming review of EPBD (Energy Performance of Buildings Directive) has been started. Annex 67 will try to influence this study and a dialog has already been started.

The work of IEA EBC Annex 67 is progressing according to the plans.

The participants of the fourth working meeting of Annex 67

Public seminar in Frankfurt, Germany

Energy Flexible Buildings - Results and Ongoing Research in IEA EBC Annex 67.

Frankfurt March 14th 2017

As side-event of the Annex 67 meeting in Freiburg, Fraunhofer ISE organized a workshop "Energy Flexible Buildings" at the ISH (international fair for Building, Energy, Air-conditioning Technology, Renewable Energies) in Frankfurt. The program was:

Introduction: Annex 67; Søren Østergaard Jensen, Operating Agent; Danish Technological Institute DTI

energy flexibility - grid perspective; Bernhard Wille-Hausmann; Fraunhofer ISE

evaluation concepts for grid-supportive buildings; Sebastian Stinner; RWTH Aachen

identification of potential flexible residents; Rongling Li; Technical University of Denmark

cost saving potential of energy-efficient and grid-friendly operation of office buildings; Francesco Massa; Robert Bosch GmbH

grid-supportive buildings: different flexibility options and their impact on efficiency; Konstantin Klein; Fraunhofer ISE

The workshop was located in the congress-center of the trade fair, approx. 20 people attended. As no other event was located in the congress center at that time, the audience was dominated by Annex 67 participants. Nevertheless there was a fruitful discussion about different aspects of energy flexibility: the grid perspective, especially for DSOs: potential congestions in electric grid due to local generation (PV, CHP) and/or increased demand (HP) (Wille-Hausmann and Stinner), about the challenges of low economic benefits from optimized or grid-supportive controls in comparison to other expenditures in buildings (Massa-Gray), about different approaches to obtain flexibility and their influence on efficiency (Klein) and finally about different user perception and acceptance for energy flexibility and demand side management (Li).

German perspective on energy flexibility

As part of the Federal government's Energy Concept, Germany aims to reduce its greenhouse gas emissions, as compared to 1990, by 80% by the year 2050 and to phase out its last nuclear power plants by 2022, substituting them mostly with renewable energies. Since Germany has limited potential for hydropower due to its geographic properties, most of the renewable energy has to be provided by wind and solar plants, which generate power intermittently and cannot be dispatched as required to suit the demand. As illustrated in Figure 1, the installed capacity of wind and PV plants was already increased by an average of 11% annually between 2011 and 2015. As of 2015, the combined installed capacity of wind and PV plants is already in the order of the peak electric load in the German energy system.

According to the Grid Development Plan published annually by the four German Transmission Grid Operators (TSOs), the installed capacity is expected to double until 2033 compared to 2015 (see Figure 1). Therefore, it can be expected that the variability of renewable energy generation will increase accordingly.

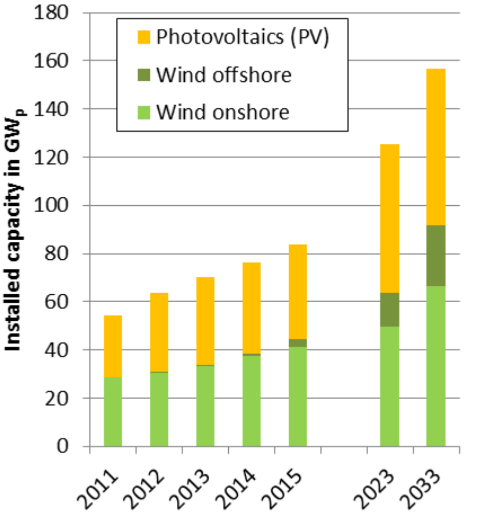


Figure 1: : Installed capacity of wind and PV plants based on historical data (EEX transparency) and projections according to the Grid Development Plan 2013/II.

In order to analyze the variations in demand for conventionally-generated, the residual load (i.e. the electric load minus the feed-in of wind and PV plants) has been calculated. In addition to the present situation, a projection for the years 2023 and 2033 is included, in which the renewable generation was scaled according to the assumed increase in installed capacity.

As illustrated in Figure 2, wind generation is on average almost independent of the time of the day, but varies significantly between seasons, whereas PV generation depends on the solar irradiation potential. Particularly PV generation amplifies both daily variability and seasonal tendencies in the residual load.

Until 2014, the lowest residual loads always occurred at nighttime, making it the preferred time of the day for electricity consumption. In June 2015, however, the lowest residual loads occurred on average around noon.

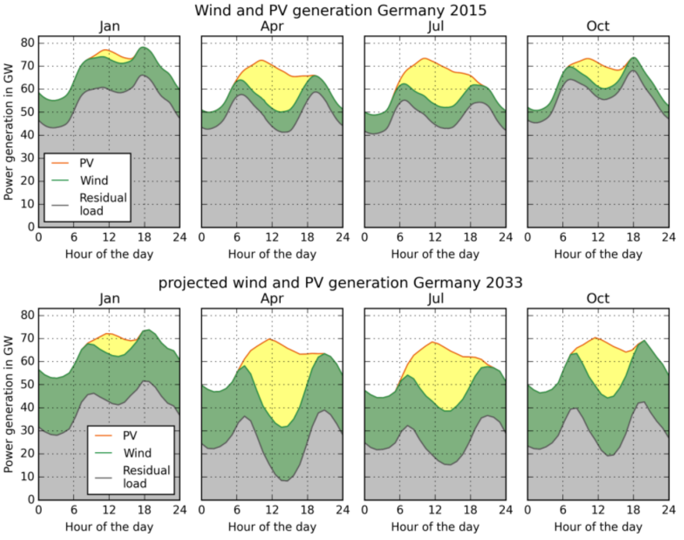


Figure 2: Daily curves of conventional, wind and PV generation in different months of 2015 and 2033.

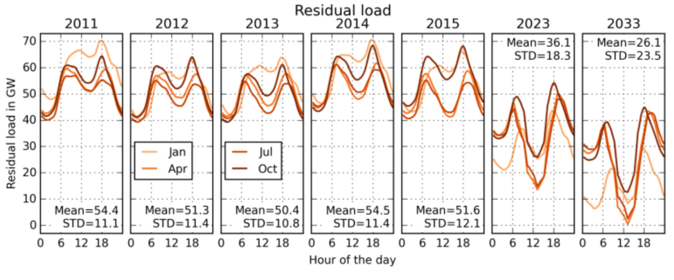


Figure 3: Residual load: daily profile 2011-2015 and projection for 2023 and 2033.

The projections for 2023 and 2033 suggest that this trend will continue as PV accounts for an increasing share of the electricity mix. In addition, mean residual loads will expectedly continue to decrease (mostly as a result of wind power, which is not tied to specific times of the day) and the variability of the residual load will likely continue to increase (mostly due to the highly variable PV generation). The residual load will regularly undergo daily variations in the order to 20-30 GW and the temporary lack of either wind or solar generation will cause spikes in the residual load, particularly in the heating season. This builds a strong case for load flexibilization by grid-supportive building operation.

Parts of this text are based on the unpublished PhD thesis "Quantifying the energy flexibility of building energy systems. Evaluation of grid-supportive concepts for space heating and cooling in non-residential buildings" by Konstantin Klein.

Test facilities at Fraunhofer ISE

“**Q-TEC**”: heat-pump and chiller testing

The lab is 550 m² (figure 4) and is equipped for testing thermal and electrical driven heat pumps and their components. A specialty is the capability to handle natural (flammable)

Figure 4: Test lab “Q-TEC”

refrigerants like hydrocarbon refrigerants with three enclosed test stands, equipped with gas detection and emergency ventilation as part of an integral safety concept for flammable and toxic refrigerants. Specialized test benches for compressors, leakage, sorption modules are installed, including high-end analytics for specific, in-depth investigation: shadowgraphy, laser doppler velocimetry, gas chromatography, scanning laser vibrometer (2-3D).

All test rigs have a modular media conditioning and measurement concept, easy to adapt and to extend; for steady-state and highly dynamic tests. In addition to the on-site tests, „Virtual labs“ can be realized through network connections between specialized laboratories within ISE and other Fraunhofer institutes.

Figure 5: Test rig for heat pump tests.

The test rigs are for system and component tests according to standards, dynamic tests, hardware-in-the-loop, customized and bespoke test sequences as well as characterization of components and systems, development and optimization of simulation models. Tests capabilities include gas driven systems (GSHP, hybrid HP) – with natural gas or test gases, including flue gas measurements.

In addition to the test rigs two climate chambers for component testing are available: each chamber is sized 4x4x4 m³, both chambers are easy to combine. They can be conditioned in a temperature range from -25 to 50 °C, a humidity range: 15 to 95 % RH with a power of 40 kW for heating and 50 kW for cooling for each chamber with an automatic calibration. For testing of combustion processes, flue gas analytics is integrated.

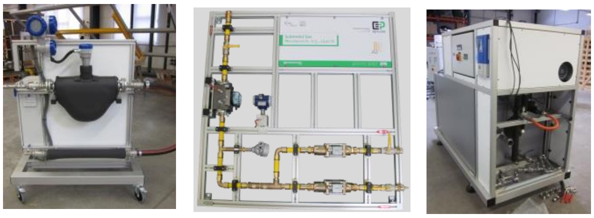


Figure 6: sub-modules for heat balancing (left), gas balancing (mid) and DHW tapping cycles (right).

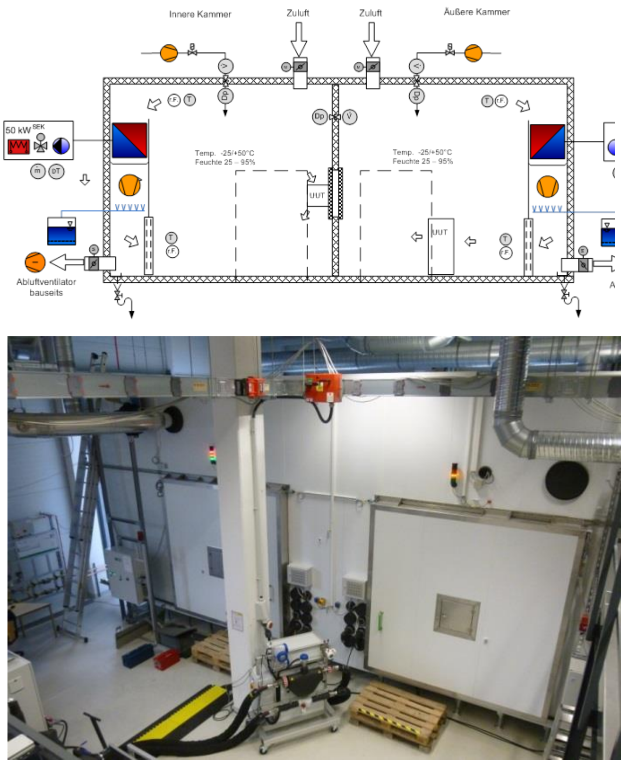


Figure 7: Schematic and picture of climate chambers

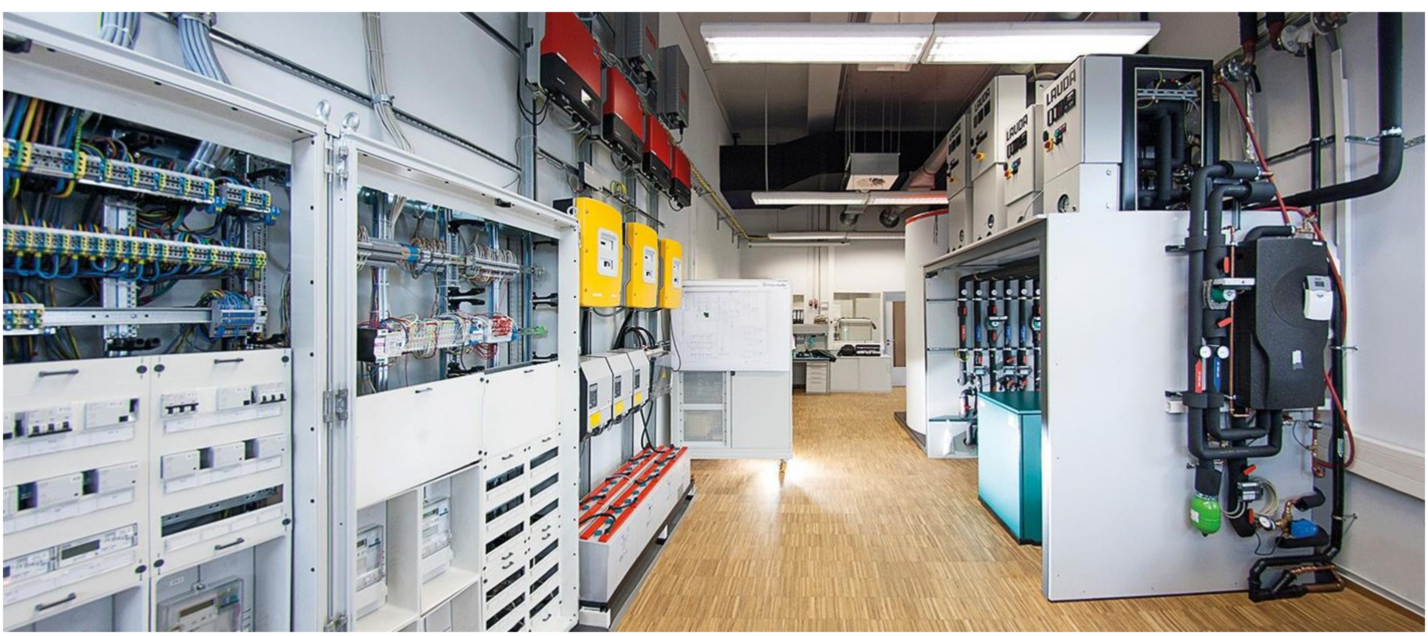
An important part of the work that has been conducted in the lab is "Labelling and Certification". The lab will be accredited for tests according to:

- EN 14511
- EN 14825
- EN 16147
- EN 12309
- testing for the EU Energy Label
- EHPA Quality Label
- HP Keymark
- acoustic measurements according to EN 12102, in cooperation with Fraunhofer IBP

Servicelab Smart Energy

As they become more economically attractive, distributed electricity generators, electric vehicles, heat pumps and electric storage units can be found in many residential buildings. At the same time, changes in the regulatory boundary conditions are resulting in completely new operating strategies, which are moving away from feeding all the generated electricity into the grid toward on-site consumption with control strategies which help to stabilize the local grid. ServiceLab Smart Energy is comprehensively equipped with the types of distributed generators and storage units that will be found in future residential buildings. This includes a simulator for electric loads to emulate triple-phase profiles with single-second accuracy and a PV simulator to provide IV characteristics for inverters with 1 s resolution. The laboratory works with powerful simulation tools, which allow model-based "hardware-in-the-loop" operation to evaluate system controllers. This means that innovative system components such as PV battery systems and heat pumps can be evaluated for any desired dynamic scenario of consumption and generation in the residential building context:

Figure 8: ServiceLab Smart Energy.



- Simulator for electric loads to emulate triple-phase profiles with 1 s accuracy
- PV simulator to provide IV characteristics with 1 s resolution for inverters
- Simulation of thermal load and solar thermal technology by computer-supported "hardware- in-the-loop" emulations
- Test rig for all common battery storage systems
- Network-connected charging stations for integration of electric vehicles into the domestic electricity circuit

The ServiceLab Smart Energy is equipped with the complete infrastructure needed to investigate questions concerning the system integration of distributed energy systems in a Smart Grid. System providers can thus test and evaluate both individual systems and also complete concepts in a realistic environment, such that business models and control strategies can be checked. These customized investigations include performance analyses of novel electricity / heat supply systems in a realistic system environment, the evaluation of grid compatibility of distributed generator systems, the assessment of PV battery systems with respect to efficiency and grid compatibility with the help of any required reference scenarios, the evaluation of thermal storage concepts with respect to distributed generation, the design and prototyping of intelligent operation management concepts and network-connected control systems, and the implementation of prototype systems with any type of interface.

Control strategies for building energy systems to unlock demand side flexibility – A review

Paper submitted to 15th International Conference of IBPSA, San Francisco, USA, August 2017. Has been accepted.

Conventional key performance indicators (KPI) assessed in building simulation lack specific measures of how the building interacts with the grid and its energy flexibility. This paper aims to provide an overview of specific energy flexibility performance indicators, together with supporting control strategies. If applied correctly, the indicators help improving the building performance in terms of energy flexibility and can enable minimization of operational energy costs. Price-based load shifting, self-generation and self-consumption are among the most commonly used performance indicators that quantify energy flexibility and grid interaction. It has been found that the majority of performance indicators, specific to energy flexibility, are combined with rule-based control. Only a limited amount of specific energy flexibility KPIs are used in combination with optimal control or model predictive control. Both of these advanced control approaches often have a couple of economic or comfort objectives that do not take into account an energy flexibility KPI. There is evidence that recent model predictive control approaches incorporate some aspects of building energy flexibility to minimize operational cost in conjunction with time varying pricing.

John Clauß, Christian Finck, Pierre Vogler-Finck and Paul Beagon.

National Projects

Net Zero Energy Buildings – Key Technologies and Demonstration, China and USA

This is a collaborated research between China and USA from December 2016 to December 2019. The budget is 153 million Chinese Yuan (21 million Euro) for the China side research. The purpose of this research is to study the key technologies for net zero energy buildings (NZEBs) and demonstrate the technologies in several buildings to be built. The key technologies to be studied include:

1) Construction technologies for NZEBs, i.e. integrated design and construction of Prefabricated building;
2) Big data based building commissioning;
3) Direct current power distribution and storage in buildings;
4) Indoor air quality guarantee with low energy consumption;
5) Policy and business model for promoting NZEBs.

The developed technologies will be demonstrated in three demonstration buildings that will be built in three typical china climate zone, i.e. severe cold area, hot summer and cold winter area, and hot summer and warm winter area. Among these technologies to be developed, the DC power distribution and storage is closely related to the scope of Annex 67. By using the battery to store and discharge electricity, considerable energy flexibility in buildings can be achieved. Even the ultimate power demand shift, i.e. constant electricity use from grid, can be achieved by optimizing the battery capacity and charge/discharge control. The extensive use of DC power distribution and storage in buildings can solve the grid problems caused by large difference between peak and valley demand, such as curtailment of renewable energy, low energy efficiency during valley demand period, high investment cost of power plant and grid, etc.

http://www.us-china-cerc.org/Building_Energy_Efficiency.html

The Energy Systems Integration Partnership Programme (ESIPP), Ireland

"Energy sources, fossil, renewable and nuclear, are converted, transported and delivered to the end user typically through distinct systems with unique physical, commercial and regulatory characteristics. Driven by the societal need to improve security of supply, competitiveness and environmental sustainability there is a growing trend to integrate these and other related systems including data and water. This is particularly true with increasing levels of variable renewables (wind and solar), e.g. using excess electricity to provide heat. EnergySystems Integration (ESI) is focussed on the interfaces between these systems where there are new challenges and opportunities requiring research, demonstration and deployment to reap the commercial and societal benefits.

Through Energy Systems Integration Partnership Programme (ESIPP), we bring together a multidisciplinary, multi-institutional research team in Ireland with expertise in electricity, gas, water and data, with the relevant industry partners to focus on building the human capacity and to develop a national coherent research activity in ESI. ESIPP is the flagship programme of the Energy Institute at UCD & involves 23 academics from 7 institutions across Ireland. There are 3 strands of research:

– Modelling and Data

– End Use

– Markets & Strategic Planning

ESI is a recent emerging area globally and ESIPP will give Ireland a first move competitive advantage in the research domain, and through our industry partners and collaborators, commercial advantage."

The 'End Use' strand is partially focussed on optimising building energy use in relation to the entire energy system. Demand Side Management and building flexibility (thermal and electric) are main components of this optimisation.

http://energyinstitute.ucd.ie/wp/research/esipp/

Flexibility Analysis in the ELSA H2020 Project, Ireland

United Technologies Research Centre (UTRC) Ireland is the Irish partner in the Energy Local Storage Advanced System (ELSA) Horizon 2020 project. The ELSA project is combining second life electric vehicle (EV) batteries with other flexibilities in buildings to deliver services to the grid. UTRC Ireland's role is to mature and pilot an ICT platform based Building Energy Management System (BEMS) that optimally coordinates building loads, local generation and energy storage (2nd life batteries) to enable demand response and other ancillary grid services. The BEMS will be deployed in two of the 6 pilot sites in the project. The other four pilot sites consist of two districts, a residential district and a battery only installation. The two UTRC building scale pilot sites are in the Sunderland, UK and Paris, France.

As part of the overall project, UTRC Ireland developed a flexibility assessment methodology as a standardised and easily implementable means of assessing site loads, storage and generation, to give an off-line indication of the range of power flexibility available, prior to any investment in upgrades to facilitate demand response capability. The methodology is based on flexibility formulations and optimization requirements. It characterises the loads, storage and on-site generation, incorporates site assessment using the ISO 5002:2014 energy audit standard, benchmarks performance against documented studies and documents key information in a KPI label. The methodology has been presented at the recent IEA Annex 67 Meeting hosted by Fraunhofer ISE in Freiburg, Germany.

The ELSA project co-ordinator is Bouygues Energies & Services, second life EV batteries are provided by Renault and Nissan and other partners included RWTH Aachen, Engineering, ASM Terni, Gateshead College, BAUM, egrid and AUW Kempten.

http://www.elsa-h2020.eu/Home.html

Acknowledgement: The project Energy Local Storage Advanced system (ELSA) receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646125.

Next IEA EBC Annex 67 meeting

IEA Annex 67 5th expert meeting:
September 27-29, 2017, Graz, Austria.

Energy flexibility related events

IBPSA Building Simulation Conference 2017
7-9 August 2017, San Francisco, USA
http://www.buildingsimulation2017.org/index.html

CISBAT 2017 International Scientific Conference
6-9 September 2017, EPFL, Lausanne, Switzerland
www.cisbat.org

Smart Energy Systems and 4th Generation District Heating. 3rd International Conference. 12-13 September 2017, Aalborg, Denmark.
www.4dh.eu/conferences/conference-2017