Energy in Buildings and Communities Programme
iea Energy Technology Network

ANNEX 67 NEWS

Newsletter 2 | November 2016

Content

Test facility at EURAC, Bolzano, Italy

Brief from the third Annex 67 working meetings

The third working meeting took place in Bolzano, Italy on October 17-19, 2016. The meeting was attended by 47 participants from 16 countries. The meeting was hosted by EURAC.

The main purpose of the work was to report on ongoing work and to define the working structure for the remaining time of Annex 67.

Energy Flexibility in buildings is a relatively new research area. Many have done work in the area, but there is as yet no real common understanding or vocabulary. Many use on one hand different wording, when they in fact refer to the same things, while many on the other hand use the same wording for different things. Because of this, a two-step working approach has been adopted. The first step is to align the participants understanding of the subject via a bottom-up approach, where the participants were allowed to present own work in order to capture how the participants deal with the subject. Furthermore common exercises were created in order to allow people to work on a common problem with their own tools and methods. As the participants start to view the subject of Energy Flexibility in buildings in a more mutual way, the working approach was at the Bolzano meeting switched to step two. Step two is a top-down approach, where the deliverables and the output from the Actions will be clearly defined, so that the participants can determine, where their work fits in. This is believed to lead to more useful output from the Annex.

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

In December 2015 a first literature review on methodologies for assessing energy flexibility in buildings was presented at the Solar Heating and Cooling for Building and Industry 2015 conference (www.sciencedirect.com/science/article/pii/S1876610216303745). The study will be followed by a more extended article to Applied Energy. The article will include the results of some flexibility indicators tested in the Common Exercise. A thorough literature review on flexibility indicators is also under way. Some first papers on market opportunities have been published: (https://pure.tudelft.nl/portal/en/publications/goodbye-passive-house-hello-energy-flexible-building(0e009e81-a339-42f7-afea-e7c3b27a2a9f).html) and a paper to the IGESC 2016 conference (Market Opportunities and Barriers for Smart Buildings). The studies conclude that there is a willingness among professionals to enter the market of Smart Buildings/Energy Flexible buildings.

A study compares the future (2030) residual loads (loads covered by power produced by fossil fuels) in fifteen countries and requirements to grid-supportive buildings operation (www.uibcongres.org/eurosun/onencia.en.html?mes=120&ordpon=1). The study reveals that the magnitude and variability of residual load varies across countries and over the year. This is important knowledge when trying to define the amount of available flexibility. The study is presented in a bit more detail later in the newsletter (page 4).

A survey among 785 residential consumers in The Netherlands showed that only 3 % had some knowledge about Energy Flexibility in buildings, but, when briefly informed most of the respondents were in the survey willing to participate in some form of Energy Flexibility. The results will shortly be documented in an article.

The participants of the third working meeting of Annex 67

Public seminar in Bolzano, Italy

The evolution of buildings: from the NZEB target towards energy flexibility - Bolzano October 19th 2016

As side-event of the Annex 67 meeting in Bolzano, EURAC organized the seminar "The evolution of buildings: from the NZEB target towards energy flexibility". This event represented the occasion to introduce to local stakeholders and practitioners the concept of Energy Flexibility. Researchers, energy provider representatives, and designers gathered in the same room to debate on the future of buildings after the NZEB target.

The seminar started with a general overview on the building evolution from the passive house target towards the energy flexibility made by Roberto Lollini (EURAC).

Søren Østergaard Jensen (Danish Technical Institute and operating agent) introduced Annex 67. In his presentation he also described the Danish energy system, highlighting that the increasing level of renewables would require the exploitation of the energy flexibility in buildings. This final point highlighted the need of methodologies to assess the level of flexibility that buildings could provide to the energy grids. During the third presentation, Igor Sartori (SINTEF) presented the new Research Centre ZEN (Zero Emission Neighbourhood) that has just been launched in Norway and that involves industries, public authorities, and research centres. The objective of ZEN is to develop competitive products and solutions that will lead to realization of sustainable zero emission neighbourhoods. After that, Roberta Pernetti (EURAC) reported on the preliminary outcomes of Annex 67 Subtask A "Definition and Context of energy flexible buildings", highlighting how the energy flexibility has both strategic targets (i.e. to reduce building sector greenhouse gasses emissions and increase rate of RES) and technical targets (i.e. keep lowest operational costs during the building life time, while ensuring high comfort level for the users).

Norbert Klammsteiner (Energytech), who offered the point of view of designer's, presented through real case studies the issues that need to be faced to design energy flexible buildings. Among them, he identified the users as one of the "factors" affecting the energy flexibility, and highlighted that in the project of the HVAC system of the SALEWA headquarter [1], in parallel to the sizing of the plant, he devoted a special attention on the comfort level acceptance of the users. In fact, introducing a certain level of flexibility on the users' expectations would allow to design smaller HVAC systems, reducing the cost for the systems and for its operation.

Finally, David Moser (EURAC) presented the interaction between energy grids, providers, and users, highlighting which are the open issues and market uncertainties regarding the evolution of the consumers into prosumers. Moreover, he introduced the concept of a new business model for photovoltaic systems elaborated within the H2020 project Solar Bankability [2]. During the presentation the importance of properly forecasting both the PV production and the energy use was stressed, as this will be useful data that an aggregator should communicate to the DSO.

The seminar was concluded with a discussion session, during which the participants explained their vision of flexibility and the main issues that have to be considered. As a significant feedback for the activities within Annex 67, the local practitioners highlighted the importance of the users, as the final actor dealing with the building that can determine the operation and the demand profile. Also data flows reliability was highlighted as essential. It was highlighted that the energy flexibility should introduce clear benefits, both economical and environmental (i.e. reducing energy consumptions and the related costs, improving the level of comfort), for the users in order to ensure their motivation and the effective implementation of energy flexibility in buildings.

References:

[1] Headquarter SALEWA – Bolzano. Design: Cino Zucchi & Park Associati, energy concept and HVAC plan: Energytech

[2] Solar Bankability: http://www.solarbankability.org/home.html

Italian perspective on energy flexibility

32.8 % of the total electric energy used in Italy is produced by renewable energy sources. In 2010, only 5 years earlier, the share was 22.4%, more than ten percentage points lower – see figure 1. The increment is mainly related to a wider installation of photovoltaics and wind systems. In Italy, the surplus of power generated by PV systems can be injected into the grid and it is valorized through the Net-Metering Scheme, up to a maximum yearly amount equal to the electricity consumption. This possibility, coupled with a campaign of incentives, moved the PV production from 1.906 GWh in 2010 to 22.847 GWh in 2015.

The data depicts a rapidly changing scenario, in which RES and their not programmable nature play a prominent role. In this context there is a need to work on building energy flexibility, so that a higher share of RES can be utilized and the stability of the energy grid can be guaranteed.

So far in Italy, few actions have been taken in the direction of an increased flexibility of the demand, most of all in the management of the electric energy loads. As a first simple measure aimed at modify the load profiles, three tariffs according to the timing of the energy supply during the day and during the week were defined. The aim is to foster the shift of some domestic energy consumption (i.e. the use of appliances) during the weekend or in the evening.

Another important measure, is the peak load management through interruptible electric service. The instant interruption of electricity is one of the tools used to ensure the safety of the electrical system, and promptly to balance transmission grids and to manage local congestion issues. The assignee of the interruptability service makes one or more loads in its facility available for instant interruption, which occurs when a signal transmitted by Terna (TSO) is received. For each MW of interruptible power made available, Terna reimburses the assignee based on the monthly consumption of the interruptible loads, namely a sum consisting of a fixed and variable amount, the latter depending on the number of interruptions. The service can be provided by medium-voltage and high-voltage sites connected to the grid with a power of at least 1 MW at the point of delivery. In 2014, 290 industrial customers offered, according to Terna, interruptible loads. Concerning the heating demand, there are not specific measures aimed at shaping the load profiles and to foster the energy flexibility of buildings, even if there are specific needs that would bring the market in this direction. In fact, the continuous increase of district heating systems, that arose from 60 to 300 Mm^3 (building volume) served in 20 years and that currently supply 6% of the national energy demand, will introduce new scenarios for the design of the buildings and of the heating grids. An example is district heating of Bolzano. Today the system serves around 3500 dwellings with a thermal power of 37.5 MW. A development plan released in 2014 established an increase of the grid that in the next future years will reach a significant part of the city with a total thermal power of 67.5 MW. The energy supply of such a huge amount of users, cannot be ensured only by over-sizing the heat generators, but the introduction of grid flexibility is needed and, in this case, is provided by a hot water storage of around 5.800 m^3.

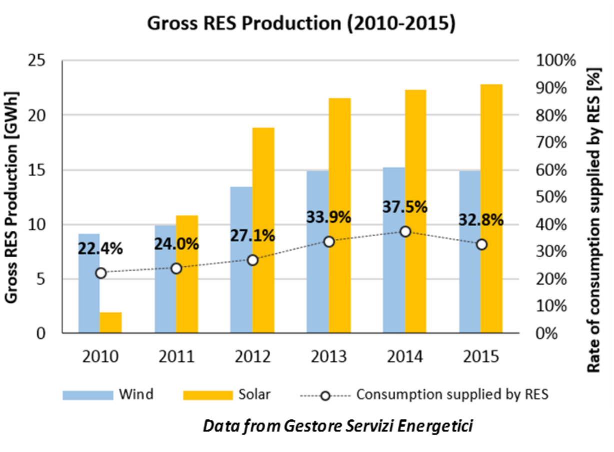


Figure 1. Gross RES production 2010-2015 (Source: Italian Energy Service GSE)

Comparison of the future residual load in fifteen countries

Many countries in the world plan to increase their share of wind and solar power. In order to efficiently utilize large amounts of intermittent renewable power, flexible consumers such as buildings with heat pumps and chillers may play a crucial role. However, it is not clear how heat pumps and chillers should be operated in order to make the best use of the volatile renewable energy. For this purpose, the residual loads of 14 European countries and Alberta in the year 2030 were simulated and analyzed. The term "residual load" refers to the electricity demand that is not covered with intermittent renewable systems and that, therefore, must be met by dispatchable electricity generation units. It was calculated as the difference of the wind and PV generation simulated as part of this study, and the electric load of 2011.

The results show a high relative variability in the residual load in almost all analyzed countries. In winter, the lowest residual loads (i.e. the most favourable times for electricity consumption) occur either around noon (particularly in the countries with the highest amount of wind and solar power), or at night. In summer, the residual loads are usually lowest around noon, which coincides well with the typical cooling load profile of a building. PV-dominated countries show stronger daily variations in the residual load, which can be managed even with relatively small storage capacities as typically found in buildings. In contrast, in wind-dominated countries, the residual load fluctuates on longer time scales, which requires larger storages.

The paper further show how heating and cooling of buildings may be controlled in order to support the grids by using more electricity when the residual load is low and less electricity when the residual load is high.

The paper may be down loaded from:

(www.uibcongres.org/eurosun/onencia.en.html ?mes=120&ordpon=1).

Outdoor test facilities at EURAC

The increasing penetration of distributed renewable thermal and electrical energy generation and the need of decarbonizing the existing energy infrastructure (both thermal and electrical) have led to a new set of challenges. These have to be tackled in the next years, to make sure that the full potential of renewables can be exploited within electric grids and thermal networks. EURAC is exploring the concept of integrated energy grids (i.e. the synergy between thermal and electrical grids) to enable high renewable energy penetration in efficient energy buildings and districts. A reduction of the demand of not-renewable energy (and of CO_2 emissions) is thus possible thanks to a better match between energy generation from renewables and loads, exploiting synergies between buildings and the energy grids.

In this scenario, EURAC is developing novel modelling environments and innovative outdoor laboratory infrastructures aimed at proving the validity of advanced energy system concepts, by performing the analysis in actual operation conditions. They will be the means also for further development of robust technology solutions and reliable business models for integrated energy grids as defined above, clearly identifying and strengthening the competence on the topic in the Province of Bolzano, being useful for local stakeholders, and attractive for national and international industry and research actors.

The experimental facilities are located in the southern part of the new technology park of Bolzano ("NOI – Nature Of Innovation"), an ex-industrial area whose deep renovation is scheduled to be completed by Autumn 2017. Figure 2.

The testing facilities addressing buildings and energy grids systems, is divided in three main research topics as reported in the following.

1. MultiLAB, an active rotating building emulator, for performance characterization of envelope systems and development of comfort models through a comprehensive control of environmental conditions. Figure 3.

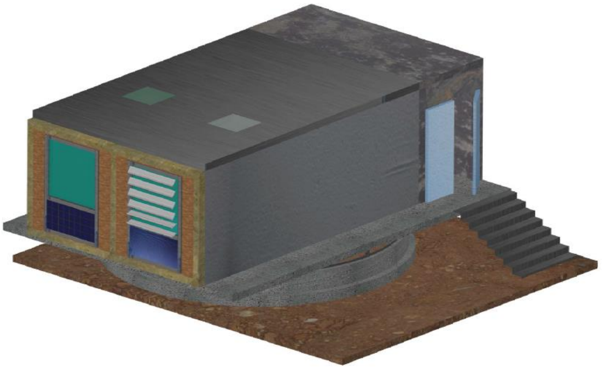


Figure 3. MultiLAB, for testing envelope system and studying comfort models.

2. Flexible mock-up frameworks for easy implementation of BIPV, loads emulator and management system enabling both working in island and grid connected mode for analyzing building integrated RES technologies and smart grids. Figure 4.
3. Ex-CHangE, a testing facility with distributed inlet and outlet points to characterize last generation of district heating and cooling systems. The main water loop is connected to a tri-generation system (solar field and boiler, ORC, chiller) and to an HP, to emulate different possible uses. Figure 5.

The physical proximity among the different test rigs enables to develop integrate design of

Figur1 2. Rendering of the under construction Bolzano Technology Park (source: https://noi.bz.it/en) experiments for emulating energy systems at district scale, combining physical components and realistic built environment, operating in actual working conditions. EURAC planned, within the ERDF proposal INTEGRIDS, an integration of lab architecture on a higher level, allowing for communication and energy flows – when possible – between the existing lab infrastructures. Figure 6.

The INTEGRIDS approach will provide a shared platform for the communication and data exchange (load and generation profiles) between the existing outdoor facilities. Thanks to a central control system, generation and consumption profiles (both electrical and thermal) will pass from one lab to another in real time allowing for the emulation of a complex thermal and electrical grid. In addition, the electrical grid and the effects of renewables will be emulated with a dedicated experimental set-up.

Energy grids will be modelled for different time resolution, in order to analyze:

i) energy flows based on generation and demand profile;
ii) transients to determine the technical feasibility of the energy flows;
iii) impact of renewables on the electrical quality of the grid.

The concept of energy flexible buildings will be modelled to study the potentiality of buildings and district to optimize exchange with the grids through local storage (of electrical and thermal energy) and through demand side management.

Figure 4. Running campaigns on PV+battery system (left) to match scaled down single user profile aimed at evaluating different control strategies and effect on component efficiency. Adding eV charging system and Innovative Energy Storage System (right) managed by iBEMS (EU FP7 CommONEnergy project, http://www.commonenergyproject.eu)

Figure 5. Work in progress at the Ex-CHangE lab of Eurac Research for district heating and cooling systems (DHC) in the industrial zone of Bolzano/Italy. The lab (ready in spring 2017) will simulate a new generation of DHC networks that reduce energy transportation losses (EU H2020 Flexynets project, http://www.flexynets.eu)

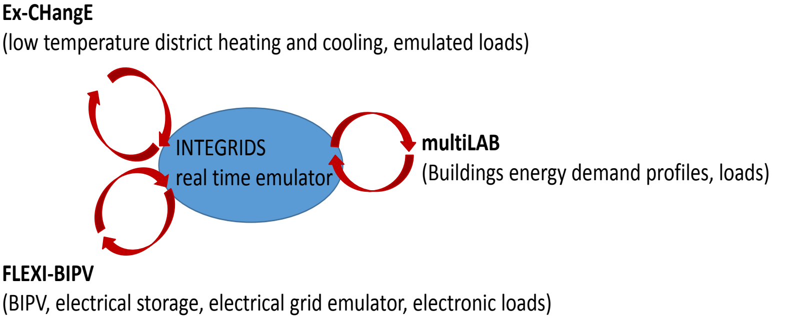


Figure 6. INTEGRIDS will establish communication between three existent (Flexi-BIPV) or in the planning/construction phase (Ex-CHangE, multiLAB) outdoor laboratory infrastructures.

National Projects

iPower, Denmark

iPower was a large Danish research and innovation project running from 2011 until autumn 2016 with a budget of approx. 16 mill €. iPower focused on power system integration of a large amounts of electricity from fluctuating renewable energy sources such as wind power and photovoltaics by activation of flexible demand from a large amount of small consumers like residential houses, offices, supermarkets, etc. The aim was to develop smart grid solutions combining flexible demand side units with the necessary communication and control solutions in order to increase power consumption in high wind periods and decrease power consumption in low wind periods. iPower linked research and demonstration to actual product development by specifying methods, technologies, requirements and services for smart grid products, and enabled the industry partners to become first movers in a new and growing world market.

In iPower control of residential heat pumps, supermarket refrigerated/freezing display cases, ice storage for air condition, etc. was investigated and developed, and it was shown how the flexibility from these units could be aggregated in order to be traded on a flexibility marked. The investigated control possibilities ranged from simple on/off control to very advances EMPC (Economic Model Predictive Control) with forecasts. A prototype of a flexibility marked was developed and demonstrated. It was further investigated how the users/owners of the flexible units will perceive, that an aggregator remotely controls their units. Finally, private and socio economic studies have been carried out.

iPower has produces a large number of reports, PhD theses, articles and papers, which in the near future will be made available via www.ipower-net.dk.

The Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN), Norway

The Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN) will develop solutions for future buildings and urban areas – solutions that will contribute to the embodiment of the zero-emission society.

A clear commitment to the zero-emission society

The ZEN centre will be one of eight new Research Centres for Envirnmental-friendly Energy (FME in Norwegian) financed by The Research Council of Norway. NTNU is the host, and will lead the centre in collaboration with SINTEF Building and Infrastructure. In total there are 34 partners, from producers of materials and products to architects and consultants, from municipalities to governmental bodies.

Through the centre, local government, trade and industry, authoritative bodies and researchers will cooperate closely in order to plan, develop and operate areas without greenhouse gas emissions. More efficient energy use, production and use of renewable energy will contribute to a sounder local environment and to reaching national climate targets.

The economic frame of the centre is NOK 400 million during an eight years period. The Research Council of Norway finances half of the budget, the partners the other half with their own money and efforts. This is a significant budget for research and innovation; for a powerful effort from the industry partners and public partners, so that solutions will be developed and implemented in each organization and in collaboration.

Great ambitions

The vision of the centre is "sustainable areas with no greenhouse gas emissions". To achieve this, the project will:

- Develop tools for planning of zero emission areas
- Create new business models, roles and services which contribute to a flexible transition to the zero emission society
- Develop cost- and resource-effective buildings with eco-friendly materials, technologies and construction systems
- Develop technologies and tools for planning and operating energy flexible areas
- Develop tools for optimization of local energy systems and the interaction of these with the larger energy system
- Develop seven zero emission areas, which will function as innovation arenas and testing areas for the technologies and solutions that are developed in the centre

The seven areas are located at different places in Norway, and include both new and existing areas that will be upgraded and developed further. The areas are located in Oslo, Bergen, Trondheim, Bodø, Steinkjer, Elverum and Evenstad.

The work is organized in six work packages, as seen on the next page, where multidisciplinary collaboration is crucial in order to find the good solutions.

WP4 "Energy flexible neighbourhoods" is closely related to the IEA EBC Annex 67 "Energy Flexible Buildings".

The aim of WP4 is to develop knowledge, technologies and solutions for design and operation of energy flexible neighbourhoods. An energy flexible neighbourhood manages the buildings' energy demand and the onsite and nearby distributed energy resources (DER) according to local climate conditions, user needs and grid constraints and prices. Flexibility is embedded in both thermal and electric systems and in the interplay between them. Flexibility can further be made available outside the neighbourhood to the grid. Knowledge from the fields of buildings, energy and ICT must be brought together to realize the full economic potential of increased energy flexibility.

For thermal energy, local smart thermal grids offer the opportunity to exchange heat between buildings and allow a local heating/cooling system to provide cost effective generation and storage solutions. Local networks can operate at low temperature, with boosters in the single buildings, using waste heat available nearby and the district heating return line in cascade to improve the economic performance and lower greenhouse gas emissions.

For electricity, local optimization of resources and power flows within the low voltage distribution grid's bottlenecks is an indispensable and integral part of both the DER paradigm of the power system and the smart grid concept. If ambitious targets on decarbonisation of the power sector are to be met, large scale and centralized resources for generation and storage, such as wind parks and hydropower, need to be accompanied by small scale and distributed resources, such as photovoltaic, electric vehicle batteries.

For flexible operation of local resources, advanced controls and novel approaches will be investigated and developed, such as grey-box modelling and agent based modelling.

WP4 will create the following innovations: realized local heating system prototypes, incl. CHP, heat pump, and borehole field storage, a smart EV charging system prototype, design guidelines for thermal and electric local resources, methodology for quantification of energy flexibility and its cost, verified operational control strategies, and an eco-visualization interface.

Furthermore, WP 4 will educate 4 PhD and 1 postdoc researchers, plus a number of master students, and will participate in 3 IEA Tasks/Annexes, including the EBC Annex 67 on "Energy flexible buildings".

Next IEA EBC Annex 67 meetings

- IEA Annex 67 4th experts meeting – March 15-17, 2017 Freiburg, Germany
- IEA Annex 67 5th expert meeting – autumn 2017, Austria

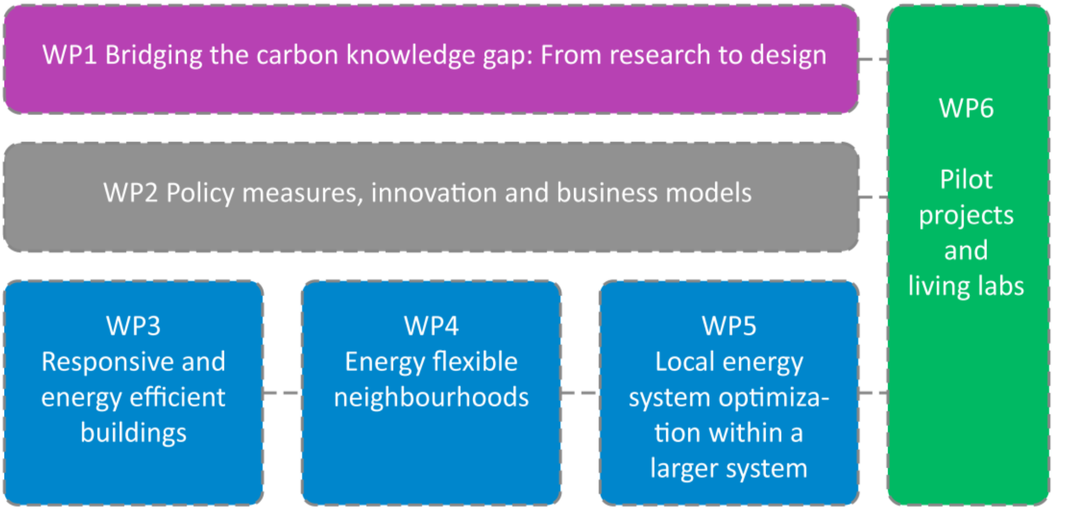
Energy flexibility related events

HPC 2017 12th IEA Heat Pump Conference
15-18 May 2017, World Trade Center, Rotterdam, the Netherlands
http://hpc2017.org/

eceee 2017 Summer Study (European Council for an Energy Efficient Economy)
29 May – 3 June 2017
Belambra Presqu'île de Giens, Hyères, France
http://www.eceee.org/summerstudy/for-authors/

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



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Energy Flexible Buildings

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