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# Goodbye Passive House, Hello Energy Flexible Building?

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*ABSTRACT: The volume uptake of highly energy-efficient buildings is challenged by transformations in the energy system and the introduction of demand response strategies. In the near future buildings will be able to manage their demand and generation according to local climate conditions, user needs and variable energy prices. As buildings become prosumers of electricity and heat in intelligent networks, questions arise about the future and the need of highly energy-efficient building concepts, such as passive houses.*

*Do suppliers in the passive house sector experience a need to adopt such energy flexible buildings? To understand this need, a supply side research was done using the members of a Belgian passive house network as a feedback group. The research used three distinct approaches for exploring barriers, opportunities and knowledge needs that companies perceive. A questionnaire explored the experience that Belgian supply side actors have with energy flexible buildings. This was followed by a focus group discussion with passive house and smart grid professionals and a business model development exercise with passive house suppliers.*

*The research unravels a positive attitude in the passive house sector towards energy flexible buildings. Innovators are keen to adopt the concept of energy flexible buildings. The research shows that the market development towards energy flexible buildings cannot be ignored by suppliers in the construction sector if they want to stay active as frontrunners in energy efficiency. A shift in knowledge needs is observed from passive houses and energy positive buildings towards designing and using buildings as active component within smart grids. A need to develop a local knowledge network for energy flexible buildings was specified.*

*Further research and particularly exemplary projects are needed to understand how highly energy-efficient buildings such as passive houses can be an active storage component in smart cities. An international research programme in the framework of the International Energy Agency will explore the definition of, and indicators for, energy flexible buildings. Meanwhile demonstration buildings and testing facilities will be installed in various European countries. The need for adapted business models and certification of energy flexible buildings will be explored. Knowledge will be disseminated in local platforms.*

*Keywords: passive house, smart grids, energy systems, business models, innovation adoption*

## INTRODUCTION

Future buildings will use much less energy. The energy networks are gradually transforming to smart grids. The networks rely more and more on energy production from variable renewable energy sources. This requires a transformation in the way energy distribution networks are planned and operated and in the way buildings are connected to these energy systems.

The European Union wishes to reduce carbon emissions in construction by 88-91% by 2050 compared to 1990 levels (EU, 2011). Europe's new buildings and major renovations will be required to reach the level of "nearly zero-energy" (EPBD Recast, 2010). EU Member States are now establishing a long-term strategy to mobilize investment in the renovation of national building stocks in the framework of the Energy Efficiency Directive (EED, 2012).

A quarter of Europe's power already comes from renewables, but this proportion may rise to 50% by 2030

(De Groote and Rapf, 2015). The large-scale introduction of renewable energy production will also lead to new business and operational models for energy providers and building managers. Energy providers are challenged in creating flexible power systems that can maintain energy security and reliability while relying primarily on variable renewable energy resources. Building managers will want to save energy costs in buildings when buying electricity, heat or cold when prices are low.

The European Commission also developed an Energy Union Factsheet that specifies that a market design is required to provide storage and more flexibility in demand response, enabling consumers to better participate in markets (De Groote and Rapf, 2015). Buildings will be able to modify electricity or heat usage during system imbalances or in response to market prices. It is expected that buildings using smart control systems could even decide by themselves to harvest energy when the price is cheap. This demand response

(DR) is often linked to some form of energy storage (De Groote and Rapf, 2015).

These new developments are also reflected in national visions and research agendas. For example, the Flemish transition arena “New Energy Demand & Delivery 2025” specifies the need to transform to a new energy system in Flanders within the EU context. Captains of society and captains of industry proposed a systemic approach to create a strong basis for adapted economic modelling and the development of new business models (VRWI, 2014). They reflect that new energy systems will include interaction between energy demand, supply, storage and grids. Questionnaire results show that experts give the highest priority to develop storage (VRWI, 2014; page 226). For example, solar boilers are proposed to cover seasonal peaks, building integrated thermal storage is suggested to store energy during 24 hours and geothermal solutions are promoted to bridge seasons. Furthermore, electrical storage in batteries and the development of related control systems offer promising business perspectives.

The knowledge and innovation agenda TKI Urban Energy (2015) defines the Dutch vision for 2016-2019 for developing innovations for solar energy supply, heat and cold, energy saving, integration and intelligent control of energy systems in the built environment. Amongst other, it suggest to abandon the classical energy supply and demand system in favour of central renewable energy production (wind, hydro, large solar and bio-energy), connected local renewable energy production, energy storage using heat, cold, and electricity (also in vehicles), data management and control, and smart grids that offer variable rates and tariffs.

Buildings are thus becoming active players in a changing energy market, playing a key role in solving energy demand and supply issues, with solutions for energy efficiency, energy storage and demand response. This transition path is not without barriers. Besides the policy barriers for widespread adoption for highly energy-efficient buildings, the construction sector is challenged to organize effective demand, supply, storage and grid for buildings, particularly by using networks and effective collaboration structures (Mlecnik, 2013).

Smart grid technologies offer possibilities to energy providers to handle the intermittent character of renewable sources. However, there are many uncertainties on how to integrate smart grid technologies into existing energy networks (Bolton and Foxon, 2011). Innovative (decentral) energy production at the level of communities or groups of buildings poses a challenge to centralized energy provision (Seyfang and Haxeltine, 2012). Relying almost entirely on energy from variable renewable energy sources will require a transformation in the way power systems are planned and operated (Dragoon and Papaefthymiou, 2015).

Demand response and battery systems can easily be integrated in existing buildings, but they are not yet at full market maturity (De Groote and Rapf, 2015). Phase-change materials for thermal storage offer only low thermal capacity and the development of thermochemical storage is still in a research phase (VRWI, 2014). Furthermore, missing uniform technical standards hinder the adoption of smart technologies by stakeholders (van de Kaa, 2009).

But it is still unclear how “energy flexible buildings” should be best designed and operated. From a business viewpoint, this implies that the building manager becomes a ‘prosumer’, this means an actor who consumes and produces at the same time. From a technical viewpoint it is unclear how we should design buildings and energy systems that are able to manage their demand and generation according to local climate conditions, taking into account user needs and variable energy prices. In a complex energy environment, a more active role of the existing and future buildings’ infrastructure within the energy market is still a key innovation to be unlocked, with large value to be captured (De Groote and Rapf, 2015).

The basic steps to achieving net-zero energy targets are clear: make the building as energy-efficient as possible through integrated design and energy-saving technologies, add renewable energy on-site and ensure optimal building performance over time (IEA, 2015). For reducing peak loads on the grid, there is also consensus that it is important that buildings are highly energy-efficient. However, when buildings become prosumers of electricity and heat (or other energy vectors) in new energy systems, questions arise about the future and the need of well-defined integrated highly energy-efficient concepts on the scale of buildings, such as the passive house concept or zero-on-the-meter renovations. As buildings will be part of new energy systems - requiring intensive utilization of renewable energy supply, demand response and storage -, a research was started to understand how the volume uptake of passive buildings is challenged by these new developments.

## RESEARCH APPROACH

A global research approach on energy flexible buildings was designed by a working group of the International Energy Agency (IEA) in the framework of the Energy in Buildings and Communities Programme (EBC). Within this framework a preliminary research was done in Belgium to investigate the need from suppliers in the passive house sector to adopt energy flexible buildings.

The researchers from the IEA EBC Annex 67 Energy Flexible Buildings (Jensen, 2015) found that there is currently no overview or insight into how much

Energy Flexibility different building types and their usage may be able to offer to the future energy systems. They therefore defined a research programme with the aim to increase the knowledge, identify critical aspects and possible solutions concerning the Energy Flexibility that buildings can provide and the means to exploit and control this flexibility. The obtained knowledge will be used for developing business cases that will utilize building Energy Flexibility in future energy systems. According to IEA EBC Annex 67, energy flexible buildings are “buildings that are able to manage their demand and generation according to local climate conditions, user needs and variable energy prices”.

To better understand the market need for energy flexible buildings, a preliminary supply side research was done using a Belgian passive house network as a key partner. This multidisciplinary network is an independent non-profit organisation that reaches out to industry, customers and policy. It is well established as a connector of frontrunners in the field and its mission is to spread knowledge on how to reach high energy savings in buildings.

This network sees that its passive house professionals are confronted with new technological developments. For example the adoption of the passive house concept is challenged by the introduction of zero-on-the-meter concepts. The customer value of high energy saving is challenged by new possibilities for energy storage in buildings. The proposition of low heating demand in buildings is challenged by the development of low temperate heat grids. The network therefore decided to develop a trajectory on energy flexible buildings to stimulate the adoption of system(ic) innovation and first demonstration projects in Flanders. The collaboration with a researcher led to the systemic use of questionnaires, focus groups and business model generation exercises.

First, a questionnaire was designed to understand the level of knowledge market actors have about energy flexible buildings. The questionnaire was introduced and distributed during an event that attracted about 80 frontrunners, an expert day on the future of passive buildings within communities, organised in Mechelen 11 June 2015 by the key partner. The programme of the event showed introductions about NZEB definition, energy storage, heat grids, energy flexible building concept, exemplary NZEB projects, smart metering and renewable energy landscapes. This was followed by a debate on architecture and city planning and the collection of the filled-in questionnaires. The questionnaire used open and closed questions to explore the experience that Belgian supply side actors have with energy flexible buildings.

Secondly, a few months later, an expert discussion was organised on energy flexible buildings by the key partner. This event took place 11 September 2015 during a Passive House building fair in Brussels. It attracted mainly professionals active in the field of passive houses. The results of the questionnaire were presented. An expert on smart grids was invited to share the viewpoint from the energy sector. A dedicated scientist moderated a focus group discussion with all participants and gave the opportunity to all participants to state their view on barriers and opportunities for energy flexible buildings.

Finally, in December 2015, a business model development exercise was done with passive house suppliers to understand the supply and demand side needs for energy flexible buildings. The participants were dedicated members of the Passive House organisation. As a tool for reflection the business model canvas developed by Osterwalder and Pigneur (2010) was introduced by the researcher and used by the participants under moderation of the researcher.

## RESEARCH RESULTS

The following section describes the results of these three research approaches to understand the market need for energy flexible buildings.

### *Questionnaire*

The questionnaire led to 24 respondents, a response rate of 30%. The results were grouped according to the activity and size of the company/ institute, the experiences actors have with energy saving projects, the themes addressed on energy flexible buildings (experiences, relevance, outlook), and open remarks on the readiness to implement.

Figure 1 shows the core activity of each respondent (multiple answers possible per respondent). 80% of the respondents were small and medium enterprises (SME's). A wide variety of actors was interested to reply to the questions: clients, scientists, project developers, architects, energy consultants, engineers, contractors, installers, manufacturers and suppliers. The black dots represent the respondents who declared to be highly interested in the topic of energy flexible buildings. Not surprisingly, mainly engineering offices and installers – some of them also doing general contracting - are highly interested. The former wish to develop services for clients, in order to remain at the frontline for energy saving services. The latter see opportunities for installing smart technologies and control systems. On the one hand the responding clients were not that interested, but project developers and managers saw an opportunity.

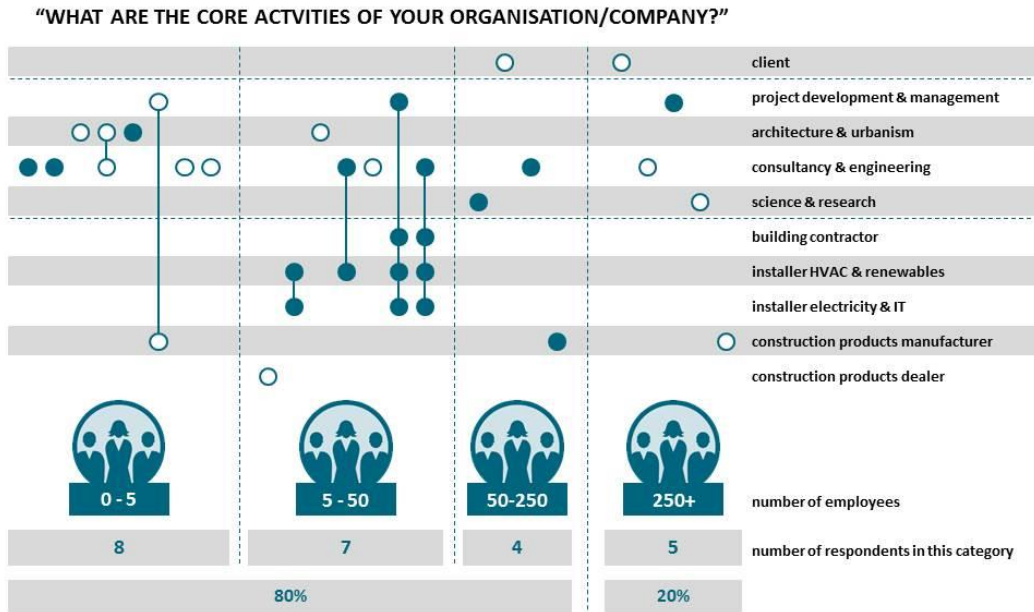


Figure 1: Core activities of the respondents to the questionnaire.

Figure 2 shows the practical experiences of the respondents for realizing energy flexible or zero energy buildings. About one third of the respondents – this means passive house frontrunners – has some experience with energy producing buildings and some of them also have experience with designing or implementing energy storage. However, for connecting the building to smart grids or developing energy positive neighbourhoods, most respondents still have no or limited experience.

Figure 3 shows the knowledge or innovation the respondents still seek to realize energy flexible buildings. Most respondents see an important need to develop the knowledge for realizing energy positive buildings further, for all topics addressed. Particularly, the respondents seek to bring energy positive buildings into practice. To do this, good definitions and calculation methods are needed. There is also a need to develop energy positive architecture on the urban level. This requires specific knowledge about energy storage in buildings, about the integration of renewable energy systems, and about the connection to smart electricity grids and heat networks.

**“WHAT KNOWLEDGE OR INNOVATION DO YOU STILL SEEK TO REALIZE ENERGY FLEXIBLE BUILDINGS?”**

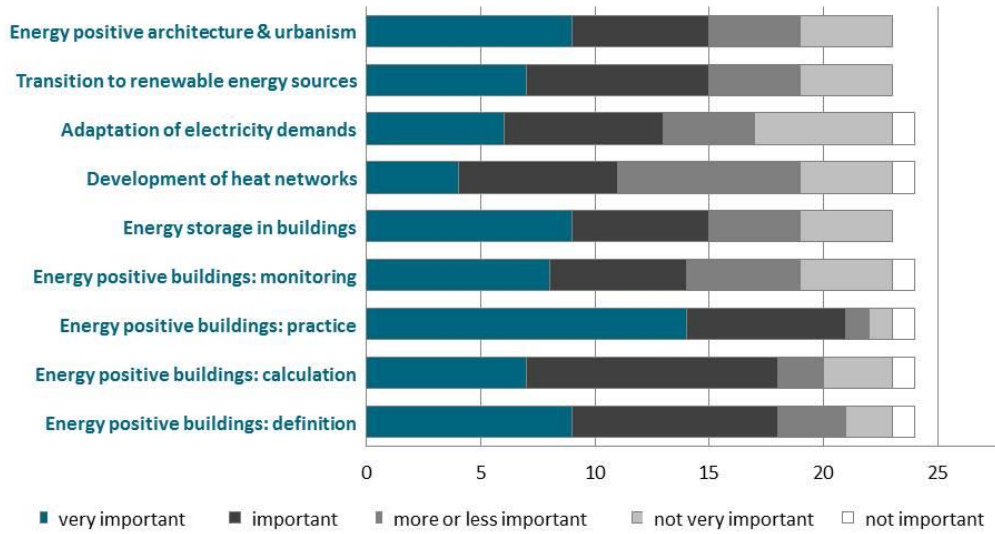
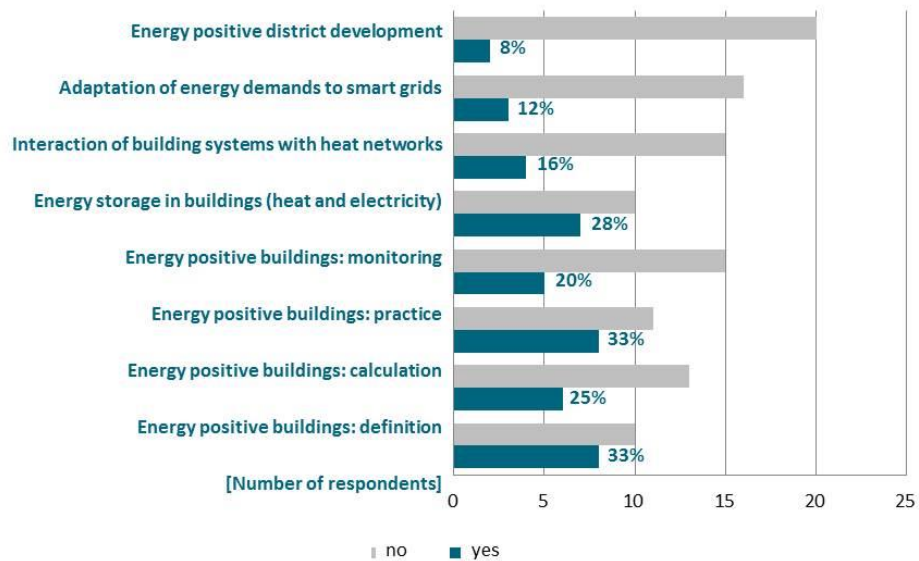


Figure 2 (above): Practical experiences of the respondents with energy flexible or zero energy buildings.

Figure 3 (below): Knowledge gaps as observed by the respondents.

**“WHAT PRACTICAL EXPERIENCE DO YOU HAVE WITH ENERGY FLEXIBLE OR ZERO ENERGY BUILDINGS?”**



### *Focus group*

The focus group discussion was attended by 8 persons representing engineering offices, contractors, architects and a representative from Smart Grid Flanders. Addressing each participant's knowledge needs, three key questions were identified for elaboration.

The first question concerned the relevance of the market (segment). The participants observed that energy storage capacity and excess heat is higher in industry, which could make the building as an energy storage component secondary. Energy flexibility seems to be stronger developed in for example greenhouse farming, where cogeneration plants are already present. In the residential sector the investments are perceived as high and the gains as low. When it comes to the building sector the participants observe that energy flexibility will probably first be implemented in non-residential buildings. On the other hand, a central heating in a residential building can easily be replaced by a connection to the heat grid.

The second discussion topic was about how to control the energy flexibility. It was an eye-opener for most participants that in the near future there will be negative energy prices, as commented by the energy grid sector professional. During specific time slots building managers will be able to gain money by storing energy. This makes new energy storage systems lucrative. For example, hydrogen storage only becomes interesting when energy prices are negative.

Some participants commented on the need for smart meters in buildings. Energy flexible buildings make no sense if there are no smart meters installed, that can track energy demand and supply at short intervals. It was concluded that "smart grid" in the current context is a bad name as the grid itself is not smart. The intelligent coupling of energy users seems to be a precondition to make energy flexible buildings a smart solution.

The third discussion round was about remaining barriers the participants perceive. In Flanders there is a lack of regulatory framework for heat grids. Some municipalities have to develop all legal documents. The Netherlands were mentioned as an example where a regulatory framework for heat grids was introduced. Further, participants suggested to define what makes a good exemplary energy flexible building. Finally, a supply chain gap was addressed. If a client wants an energy flexible building, who should be contacted?

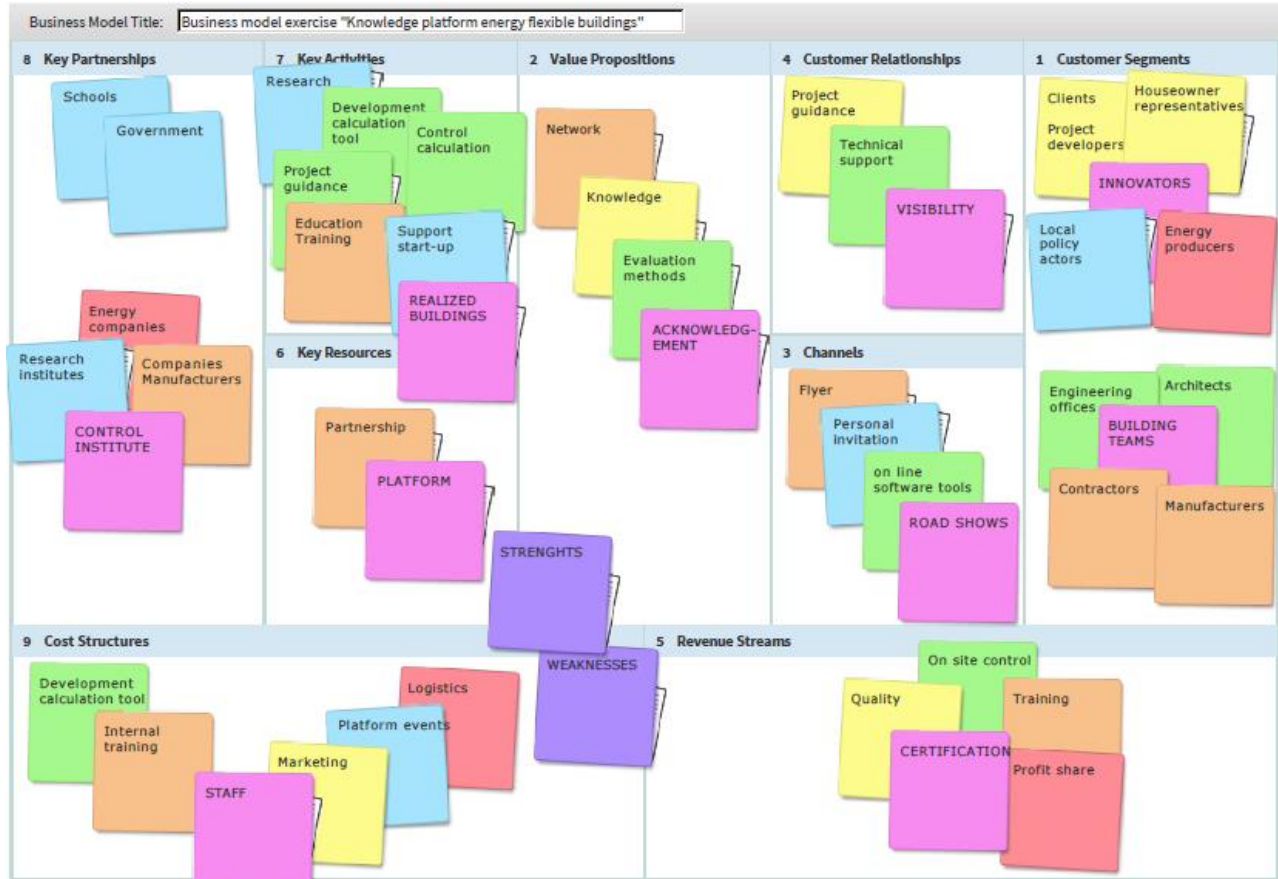


Figure 4: Suggestions of participants on the business model for a knowledge platform for energy flexible buildings (in Dutch).

### Business model exercise

Figure 4 shows the results of the third initiative, the development of a business model for a knowledge platform for energy flexible buildings, by members of the passive house network.

Referring to the results of the questionnaire, participants see that the main customer segment for knowledge exchange is a group of frontrunners that aim to realize energy flexible buildings. These frontrunners are best organized as multidisciplinary building teams serving innovating clients. The frontrunners seek specific customer values: networking, knowledge and evaluation methods for approval of energy flexible buildings. They want to be informed about these issues via personal invitations, flyers and roadshows and they want to use on-line software tools. The knowledge exchange network should provide visibility of the actors, project guidance and technical support. The network could get income from training and certification of energy flexible buildings, but could also share in the profits of the members or provide paying services for quality assurance and commissioning.

The key activities of the platform further include the development of the calculation tools, research and training. Key to the network development are first visible demonstration projects in Flanders. Partnerships should be organized with energy providers, governments, research institutes, product suppliers, certification bodies and schools.

Following this mind exercise the participants were asked to reflect on strengths and weaknesses of such a model for a network for promoting energy flexible buildings. The participants thought the business model could mainly work because of the active use of frontrunners, the building upon existing knowledge and the focus on demonstration projects. The business model could also fail because of the rigid structure of the supply chain and the (negative) marketing power of certain building companies. The participants found that the model should be checked according to experiences abroad.



## CONCLUSION

The research unravels a positive attitude in the passive house sector towards further developing energy flexible buildings. Innovators are keen to adopt the concept of energy flexible buildings. The research shows that the market development towards energy flexible buildings is not ignored by supply chain actors in the construction sector. Moreover, they understand that they need to engage in energy positive and flexible buildings if they want to stay active as frontrunners in energy efficiency. As still few energy experts are already engaged in designing, calculating or constructing energy positive or flexible buildings, an important challenge is to develop knowledge exchange using a network of innovators and international know-how from demonstration projects. End users still need to be attracted and motivated to adopt energy flexible buildings. An important challenge will be to determine what motivates building managers and project developers to decide to adopt energy flexible buildings.

Further research and particularly trusted demonstration projects are now needed to understand what is a “good” energy flexible building. The IEA EBC Annex 67 can activate the deployment of such buildings by developing a sound definition of, and clear indicators for, energy flexible buildings. It is particularly important to know how highly energy-efficient buildings such as passive houses can be an active storage component in smart cities.

## OUTLOOK

The passive house network has embraced the concept of energy flexible buildings and has confirmed the development of a new strategic business line towards the topic of intelligent buildings.

In the framework of the IEA work, demonstration buildings will be realized and tested and living labs will provide new insights in various European countries. The need for adapted business models and certification of energy flexible buildings will be explored. User experiences with energy flexible buildings will be investigated. Knowledge will be disseminated in local platforms.

It is the understanding of experts that high energy efficiency remains a precondition for achieving stable energy grids and effective peak shaving. Therefore, there is no “goodbye” yet for highly energy-efficient buildings, such as passive houses and zero-on-the-meter renovations. But there is certainly a “hello” for energy flexible buildings and this development will influence the way we perceive the design, construction, commissioning and certification of highly energy-efficient and passive buildings.

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