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Proceeding Paper

Workshop on Positive Energy Buildings—Definition †

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Abstract: The building sector plays an important role in the transition to a climate-neutral society. The international interest in low, zero energy, or zero-emission buildings has grown as a potential means for this transition. A more ambitious step from zero energy buildings is the concept of Positive Energy Buildings (PEB), which are also contributing to the decarbonization of the surrounding built environment, not just minimizing their own carbon footprint. A shared PEB definition is needed in order to enable the design, assessment, and documentation of positive energy buildings. This article describes the ongoing discussions, concentrating on the most essential points.

Keywords: positive energy buildings; definition; user comfort; boundaries; grid interaction; dynamic matching; positive energy user

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1. Introduction

The building sector plays an important role in the transition to a climate-neutral society, which is the long-term target for the EU [1]. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement. Consequently, the international interest in low, zero, and beyond zero energy or zero-emission buildings has grown, and initiatives from several EU and non-EU public authorities, institutions, and non-profit organizations are aimed at accelerating the transition to a decarbonized building stock.

A variety of definitions for these buildings have been proposed in many slightly different terms, generic and not standardized [2,3]. A more ambitious step from zero energy buildings is the concept of Positive Energy Buildings (PEB), which are also contributing to the decarbonization of the surrounding buildings and built environment as well as providing a pleasant and comfortable indoor environment, not just minimizing their own carbon footprint. In this scenario, a shared PEB definition is needed in order to enable the design, assessment, and documentation of positive energy buildings in different contexts, climates, cultures, and markets, according to the need for a cost-effective, just, socially balanced, and fair transition. It is also worth discussing how this differs from the concept of Positive Energy Districts (PED, see e.g. [4]).

The definition has been discussed among three sister projects that were funded under the H2020-EU.2.1.5.2/Call (Cultural-E, EXCESS, syn.ikia). They have identified common points and the differences through a constructive discussion around three main topics:

(1) relevant aspects to be considered in the definition of a PEB, such as boundaries, balance, embodied energy, dynamic matching, RES; (2) how those aspects are addressed in the various projects contributing to the discussion; (3) proposed definition of PEB and recommendations, addressing all aspects listed in 1.

In order to arrive at a wider agreement on the terminology and boundaries for PEBs, the three projects wanted to discuss their findings with a bigger group of stakeholders working on PEBs or related fields. This was organized as a 90 min workshop at the Sustainable Places 2021 conference, divided into (i) a presentation of the status of the definition of the three projects, (ii) a presentation of the current development at the EU level, (iii) a discussion on the different aspects with stakeholders, and (iv) a wrap up of the conclusions of these discussions. The outcomes of this workshop are presented in this article.

2. Beyond Zero

The concept of Positive Energy Buildings differs from zero energy buildings in its renewable energy contribution to the surrounding environment, helping to reduce the carbon footprint also from neighboring buildings. This means more interaction with the energy grids, which needs to be taken into account in the definition, more than in the case of zero energy buildings. In addition, PEB definition may incorporate energy flexible assets which enable the accommodation of potential energy demand variations due to alterations of the standard context of users/householders and/or within building communities. As the current EU Energy and Climate policy aims for user involvement and empowerment, user needs are more emphasized in PEB definitions than it was in the context of zero energy buildings. Positive Energy Citizens, as PEB occupants, do in various ways shape energy demand dynamics and energy balance outcomes.

3. Workshop Structure

After the opening words and short presentations of the three sister projects, there was a short presentation of the status of the discussions and the current conclusions, regarding the points where there is a common agreement with the sister projects, and points that have been recognized as needing further discussion. These are probably issues that will require specific attention in the development of the PEB concept for the EPBD update.

Next, the workshop participants heard an update on the current status with the EPBD recast, provided by a Commission representative, highlighting the role of the Renovation Wave and the legislative framework in the EU, when aiming for highly efficient and decarbonized building stock by 2050. In this vision, which is looking both at buildings and neighborhoods, the following aspects play a major part: 'Energy efficiency first' principles; smart buildings; life cycle thinking and circular economy principles; as well as integration of in-built and onsite renewables [5].

After this scene-setting, the partners were invited to discuss and present their opinions on the issues recognized as further discussion points by the WS organizers. This was realized as polls, chat discussion, and spoken comments during the WS.

4. Discussion on the Different Aspects with Stakeholders

The key areas that were recognized as needing more discussion can be grouped as follows:

- Boundaries and balance: Physical boundaries, types of renewables, energy uses;
- PEBs' relation to grids: flexibility, load matching, grid interaction;
- Social aspects: Positive Energy User, affordability, indoor environment quality.

For these areas, the first ideas of the WS participants were collected through polls, and some additional comments were provided by the participants through the chat window and verbally during the WS. The outcomes are presented in the following.

4.1. Boundaries and Balance

The first question was related to the boundaries. The workshop participants were asked to give their opinion on whether the renewable energy (RE) production from a RE facility owned by the building owner/user but situated far from the building should be included in the building's energy production. The opinions were somewhat divided, but most of the respondents thought that it should be included, at least in certain circumstances. For further clarification, it would be good to list some examples of the cases where this kind of RE production could be included in the balance. It was noted that the requirement could, e.g., be that it is linked to the building's energy system, although not at the same lot, e.g., a PV system on a neighboring lot. More discussion on ownership is also needed. The owner may sell the building but keep the RE facility, and then it could change the status of the building to a non-PEB.

The poll continued with a question of whether the plug loads should be included in the energy use of the building, in the case of an apartment building, where the inhabitants pay for their own energy. This was related to the findings of the three projects, that it is not always possible to measure the plug loads, and they are also very much affected by the user behavior, and therefore not easily addressed by the design, although some solutions can be made to support energy-efficient user behavior. A big majority of the respondents thought that plug loads should indeed be included. This would be logical to fulfill the goal of an annual energy balance. The main challenge is the use of standard user profile in the calculations. During the usage phase, this can be very different, depending, e.g., on the number of inhabitants in the standard case and real case. The standard profile may also be outdated and is used in a too general way. Comparing calculated vs. measured performance would be beneficial for improving building performance strategies toward PEB targets, but it remains uncertain depending on building and community contexts. In addition, the standard profile may be not representative of the diversity of user typologies (e.g., family with children vs. student community). In addition, building codes do not typically include a comprehensive range of user profiles. When occupants have their contracts with an energy provider, then the building manager cannot necessarily access the usage profiles (without consent from the occupants).

On the inclusion of embodied energy in the definition, there was a common understanding that it should be somehow treated, either by including it in the balance or treated as a separate requirement or key performance indicator (KPI). It was noted that it is an element that cannot be measured, only calculated. Furthermore, it is an energy component that is often outside the national balance, which complicates the analysis. The choice of lifecycle duration also has a big impact on this indicator. How to compare existing vs. new buildings should be discussed.

4.2. PEBs Relation to Grids

Regarding dynamic matching, most of the WS participants considered it as important as the annual balance, although there were also contradictory opinions expressed. The decision on whether to include this or not depends highly on the main goals for the PEB in the definition: if the goal is to contribute to the overall renewable generation and self-sufficiency or offer support to the grid.

Almost all respondents also thought that dynamic matching should be calculated for all uses, including appliances. Some discussion was conducted on the position of electric vehicles (EVs) in the balance. The main conclusion was that this is one of the points that definitely need further discussion and should be addressed in the development of the PEB concept. This may be introduced later as an evolution of the PEB, which embraces more loads or is considered at the neighborhood/district level. One comment was also made on whether the dynamic matching gives any additional value towards the steady-state calculations—"especially once the underperformance of dynamic matching systems is taken into account". One hour or 15 min were considered as the most appropriate timespans for calculating the maximum power. It also depends on the available measurements

of the building. In some countries, e.g., the basic electricity fee is based on the peak power within an hour or 15 min.

4.3. Social Aspects

In reference to how end-users could improve energy efficiency, the participants were asked how PEB design could conceptualize and react upon the energy trade-off in front of daily practices on comfort, cleanliness, and convenience bases. On this, the opinions were quite equally divided between two options: it should be done by (i) applying user-centric design and human–computer interaction approaches or (ii) through the integration of social sciences research into building design criteria. One conclusion of this outcome was that we need to incorporate the two approaches by a multidisciplinary team. Instead, it was not considered a viable option to reduce the user control over the building systems. When users fall into big categories, then designers are lost, and more specific levels may be needed. One idea that was presented is a notion of the Positive Energy User, which would improve the possibilities of achieving a positive energy balance. This is a building user who adopts energy-efficient behaviors and is ready to adapt everyday practices, hence the energy demand, in accordance with the availability of RE in the building site at a certain time.

There was a general agreement that there is a gap between the available methods/tools—capabilities/outcomes—and the required insights which make a PEB project successful. For most respondents, this gap was partially caused by the fact that existing tools do not allow designers to integrate specific user profiles smoothly. Some pointed out the failure of existing tools to provide outcomes that may support an improved design by accounting for users.

A great agreement was expressed on the extent that the PEB design needs to provide users' personal control over the environment and systems. All agreed that the best way forward would be to combine user-friendly solutions and personal control, which may lead to a positive energy balance. The participants did not think that providing personal control would put into risk the energy demand management, nor that reduced personal control would help to obtain successful performance outcomes. It was, however, noted that it could be difficult to combine user-friendly system design and deep control capabilities. Some also thought that it would be difficult to measure user-friendliness, as well as challenging to tailor the level of personal control based on predicted specific user profiles. Another point of view was also that what is user-friendly today may not be regarded as such in a decade.

On the role that user training and education play in successful PEBs, the opinions were slightly divided. Most of the respondents thought that user training was crucial towards a successful, positive energy balance, while almost as many pointed out user-friendly solutions without training as the key element for successful PEB implementation. Regarding the latter opinion, it was noted that not everybody is so interested to learn how the building operates, and then it would be favorable if the system is intuitive and the kind of information displayed responds to user expectations and everyday life needs, in order to support user engagement. On the first option, a comment was made that training may fail in future scenarios, as the building lifecycle is relatively long, and it is not evident that new users will be reached for training in connection with the crossover. Moreover, solutions may work for the first years, but then access to the users is no longer guaranteed. A chat comment from the WS concretized nicely the challenges related to training: "Imagine if you needed lots of training to use your mobile phone? Would you use it?"

5. Conclusions and Next Steps

Although the WS participants only represented a very small sample of the built environment professionals, only about 40 participants, the results of the WS give indication of the key aspects that need further attention. The discussions and polls confirmed the earlier conclusions of the sister projects: When formulating the definition for Positive

Energy Buildings, it is first important to clarify the goals of PEB implementation and the reference case for PEBs: Is it a building that fulfills the building regulations or, e.g., a net-zero energy building? That will then facilitate the creation of KPIs.

A clear common understanding is that user inclusion is a key aspect in the design and use of PEB in order to make it successful.

One idea born during the discussions was that it would be wise to formulate different categories for PEBs, e.g., for tight urban environments or rural environments with more space for renewables, as well as for different types of buildings (residential, offices, etc.).

A recording of the workshop can be found on the SP21 conference site, at: https://www.sustainableplaces.eu/positive-energy-buildings-definition/ (accessed on 23 November 2021). The outcomes of the workshop will contribute to a more detailed position paper that is being prepared by the three projects and which will be published on the websites of these projects.

Supplementary Materials: Recording of the workshop: https://www.sustainableplaces.eu/positive-energy-buildings-definition/.

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