The role of Plus Energy Buildings in decarbonizing the building stock

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Path to market valuable Plus Energy Buildings

First PEH: Heliotrope
First Plus Energy neighborhood: Solarsiedlung
First multifamily PEH: Activ-Stadhaus, Frankfurt

EPBD Nearly Zero Energy Buildings

Multi-storey PEB as power plant for the neighborhood
PEB contribution to EU building stock decarbonization

PEB shall contribute to reduce the greenhouse gas emissions in the surrounding energy system.

PEBs shall support e.g., older buildings, where the transition to zero energy state would not be cost-efficient.

PEBs shall contribute to reduce the stress on energy grids by providing a flexible energy asset that allows buildings and energy communities to act as integrated part of the energy system and exchange energy between among them or with the grid.
What is a Plus Energy Building (PEB)?

A Plus Energy Building is an energy efficient building that produces more final energy than it uses via locally available renewable sources over a time span of one year.*

Positive balance reached by ensuring a good dynamic matching between load and generation providing building flexibility.

Positive balance reached by ensuring the lowest greenhouse gas emissions.

Building uses include both building operation and user related energy consumption.

Heating

Cooling

Domestic Hot Water

Auxiliaries

Ventilation

Plug Loads

Energy generation shall be performed by renewable energy systems located within building footprint.

It can be extended to adjacent lots as long as there is a physical connection and direct control of renewable energy generation system.

Ownership of the buildings or lots, neighborhood grid infrastructure and building management is a must.

PEBs shall ensure an added value providing accessible, comfortable and healthy indoor environments.

PEB shall ensure an added value providing easy access to e-mobility.

*The definition applies to all-electric buildings and the energy balance is based on measured or predicted final energy between load and generation. In case of new buildings electrification is an inevitable process. In case other renewable energy vectors are used in the building (i.e. biomass, biogas...), final energy balance shall be zero.

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How can PEB become the new building standard?

- **Put user/households at the center** i) understanding user’s needs and ii) guiding them towards better energy practices

- **Defining viable and tailorable technology concepts**

- **Integrated climate and cultural approach** that encompasses overall building configuration, technology selection, and user/systems interaction.

- **Define viable business models** that include attractive financial mechanism and co-benefit evaluation
Listening to residents’ voices

**THE RESIDENTS’ VOICES**
**Conflicting practices**

**NEED**
Getting rid of cooking smells

**RESPONSE**
Using both mechanical ventilation and natural ventilation (creating a draught)

**THE RESIDENTS’ VOICES**
**Conflicting practices**

**NEED**
Relaxing in the outdoor balcony (all year round) and being in contact with outdoor space

**RESPONSE**
Using an electric heater on the balcony

**THE RESIDENTS’ VOICES**
**Conflicting practices**

**NEED**
Pleasing visitors when hosting at home

**RESPONSE**
Adjusting temperature to the visitors’ thermal comfort expectations

**THE RESIDENTS’ VOICES**
**Conflicting practices**

**NEED**
Getting rid of cleaning odours

**RESPONSE**
Opening windows instead of using mechanical ventilation

**THE RESIDENTS’ VOICES**
**Conflicting practices**

**NEED**
Sleeping comfortably with an adequate temperature

**RESPONSE**
Opening windows (having “cracked open” windows) & having appropriate duvets

**THE RESIDENTS’ VOICES**
**Conflicting practices**

**NEED**
Ventilating and being in contact with the outdoor space

**RESPONSE**
Opening windows. Very little use of the ventilation system
Thermal comfort expectations are driven by cultural factors

Indoor operative temperatures that optimize thermal feeling (neutral sensation)

Users in different countries respond differently to standardized (EN 16798) indoor environmental quality scenarios.

Key technology concepts of Cultural-E project

- Cloud-based House Management System
- Active window system
- Smart air movement
- Decentralized packed Heat Pump system
- Strategies for building flexibility
Active Window System

- Easy and quick installation
- protected but accessible semi-ventilated cavity.
- interaction between the ventilation of the shading cavity and the ventilation of the indoor space
- shading control strategies optimised
Increased air movement through smart ceiling fans up to 60% energy saving were estimated without jeopardizing thermal comfort.

Laboratory tests with human participants showed no significant difference in terms of user satisfaction with indoor environment between automated and manual control.
Packed heat pump system

all-in-one system for **heating, domestic hot water and ventilation** with demand driven and learning controls for an optimal demand/response management

- Compact system
- Higher efficiency, load shifting capacity and free summer cooling thanks to the bigger thermal capacity
- Data driven optimization of control
- Full off-site assembly
- Attractive concept also for building retrofit
- Maximises self-consumption
Cloud-based House Management System

- **Leverage data** from indoor and outdoor sensors, renewable energy systems, storages, web services, grid signals, and other buildings.
- **Enable user-centred services** that informs and guides the users on how to interact with the systems and adopt energy-efficient behaviour.
- **Cost-effective solution** that requires no maintenance and can be easily integrated with existing equipment.
Factsheets

**HIGH-RISE BUILDING**  **LOW-RISE BUILDING**  **SOLUTION SETS**

- 2x Building archetypes
- 2x Solution Sets

**MEDITERRANEAN GEO-CLUSTER**  **OCEANIC GEO-CLUSTER**  **CONTINENTAL GEO-CLUSTER**  **SUB ARCTIC GEO-CLUSTER**

- 4x Geoclusters
- 16 factsheets

**Oceanic climate**

- Tot final energy consumption [kWh/m²]: 2406 €/m²
- Energy balance* [MWh]: 72

**Sub-artic climate**

- Tot final energy consumption [kWh/m²]: 3425 €/m²
- Energy balance* [MWh]: 75

**Continental climate**

- Tot final energy consumption [kWh/m²]: 3697 €/m²
- Energy balance* [MWh]: 63

**Mediterranean climate**

- Tot final energy consumption [kWh/m²]: 3340 €/m²
- Energy balance* [MWh]: 54

*generation-load energy balance excl. appliances
Exchange with the energy grid

Feeding energy into grid results in low profits or even loss of profit. Self-consumed energy has a higher value.
Environmental payback of technology solutions

Payback (PB) periods calculated by assuming a variable (dynamic) electricity mix (EU scenario 2020).

Italian and German examples reach environmental payback periods by 2050.

In the French and Norwegian cases, slower trend. Payback periods affected by the carbon intensities of current national electricity generation.

Lesson learned and key messages

- Most of the total electrical consumption is due to plug loads, which are difficult to reduce or to shift in time. **Empowering users** in reducing energy consumption is fundamental.
- **Understanding social and cultural practices** can lead to more efficient buildings.
- Multi-residential PEBs in continental and sub-artic climates have very low space cooling demand, which can be covered by implementing a device for smart air movement.
- PEBs can play a significant role in reducing the stress on the energy grid infrastructure (with **up to 70% self-consumption rates**)
- Even though **decentralized HVAC systems** have several other advantages, they impact significantly the overall investment costs (up to 10% more compared to centralized systems)
- **LCA analysis** shall be applied in the decision-making process to have an impact on construction material choices and PV-battery system size.
Thank you for your attention!

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More info on our project website:  
https://www.cultural-e.eu/