EXCESS

FleXible user-CEntric Energy poSitive houseS

Key insights on replicating the EXCESS PEB technologies

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1 Introduction

This document provides an overview and key insights on replicating EXCESS technologies and PEBs in general. It presents basic conditions and general considerations as well as the potential for replicating the technology solutions across different European regions and climate zones.

The European Union has set ambitious climate and energy targets, aiming for a full decarbonisation of the building sector by 2050. PEBs play a crucial role in this transition towards a sustainable, zero-carbon built environment. However, the current rate of renovation remains far too low to meet these targets. Therefore, the replication and scaling of PEB technologies are of high importance. Chapter 2 presents general considerations related to replication of technologies and PEBs resulting from EXCESS. Chapter 3 to 5 provides key insights related to the replication of the EXCESS technologies. The insight result from the EXCESS demos, discussions within the consortium and with the Advisory Board.

2 General considerations

When building and replicating PEBs, several general considerations must be taken into account to ensure the successful implementation of PEB technologies. Key considerations include:

Climate Zones: The replicability of PEB technologies is highly influenced by the climate zone in which they are implemented. For example, different applications of PVT panels are more suitable for southern, central, or northern European regions, depending on local temperature ranges and solar irradiation levels.

Building Types and Age: The architectural characteristics of buildings, such as wall structure, insulation levels, and available roof space, affect the integration of PEB technologies. Additionally also the used construction materials and technologies of the existing building could impact the renovation process and the implementation of new technologies.

Shape of building: The shape of the building is a central parameter. Low-storey buildings with a big roof size for PV or PVT installation, could achieve PEB-level much easier than multi-storey buildings with limited roof size. Also structural elements in the façade need to be taken into account.

Legal and Regulatory Frameworks: Local regulations, including building codes and energy performance standards, play a significant role in enabling or restricting the deployment of PEB technologies. Policies that support energy-efficient renovations and renewable energy installations are critical for large-scale replication.

Adaptability and modularity: some technologies and technology packages need to be offered in a modular way to take into account the high diversity of the European building stock. Also there may be a need to offer them with different materials that fit to the building and to fire regulations. Also the heating and cooling demand is different across climate zones. If a specific technology should be adopted in more than one climate zone, it needs different specifications.

Compatibility with legacy technologies: Compatibility with legacy technologies is key when replicating PEB solutions. Existing building materials and systems must work with new energy technologies. Modular and adaptable designs help ensure seamless integration across diverse building types and older systems

Competition with existing infrastructure: Established systems, such as traditional heating or energy grids, can hinder the adoption of innovative solutions due to cost considerations (eg redundancies of technologies) and user familiarity. Addressing this requires highlighting clear advantages, ensuring compatibility, and offering incentives to support a smooth transition

Life cycle cost analysis: Although PEB technologies typically offer lower life cycle costs through reduced energy consumption, initial capital investments are higher than for conventional technologies. Therefore, conducting a thorough life cycle cost analysis is essential to assess the long-term financial benefits.

Subsidies and fundings: PEB technologies typically require higher upfront costs compared to conventional solutions. These upfront costs could be partially recovered by lower energy costs during operation. However, to ensure large scale replication of these technologies, subsidies and funding are currently still needed to cover parts of the higher cost.

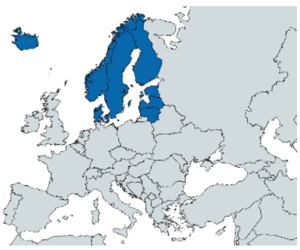
3 Photovoltaic thermal hybrid collectors (PVT)

A Photovoltaic Thermal (PVT) hybrid solar collector combines photovoltaic (PV) and solar thermal technologies into a single system, offering the potential for simultaneous electricity and heat generation. Within the EXCESS project, PVT was used on the Belgium demo in Hasselt and the Finish demo building in Kalasatama Helsinki. In order to make estimations about the replication potential, the main applications of PVT in the different European climate zones have to be analysed and outlined. Based on in-depth interviews with DualSun and internal discussions and elaborations, basically three different applications for PVT can be defined:

- Application 1: PVT as source for DHW production (mainly South Europe)
- Application 2: PVT for coupling with groundsource heatpumps (mainly North Europe)
- Application 3: PVT as single source for water-water heatpumps (mainly Central Europe)

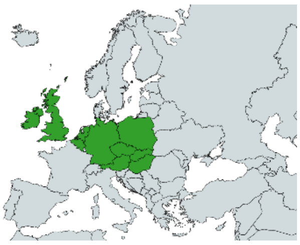
PVT as source for DHW production: This application is prevalent in building renovations where PVT panels can be used to generate DHW and thereby reduce the consumption of existing electric boilers or gas heaters. In cases where the DHW is produced with geothermal- or air source heat pumps, PVT panels are rarely used, as the heat pumps produce the DHW already with high efficiency and building owners might not want to take the higher investment costs of additional PVT panels. Therefore this application is rather seldom used for new buildings as most of these buildings use the combination of heat pumps and PV. The application of PVTs for DHW production is therefore very common for building renovations in Southern Europe as many buildings in the region currently use electric boilers or gas heaters for DHW production.

PVT for coupling with groundsource heatpumps: PVT can be used as additional heat source to increase the efficiency of groundsource water-water heat pumps. The heat energy from PVT can be also used to regenerate the groundsource collector (boreholes) and thereby further increase the efficiency of the system and in further consequence reduce the amount and depth of drillings. This application is a favourable solution if the groundsource collector is undersized (e.g. when building usage changes) of if too less space for drilling is available. This application is highly relevant in Nordic countries as buildings in these regions have high heat energy demands where the additional heat source and regeneration of collectors can enable the high efficient long-term functioning of the heating system with geothermal heat pumps. At the same time, a lot of ground source heat pumps are already available in



the Nordic region. Additionally, high heat energy demand and relatively low solar irradiation (compared to Central- and South Europe) makes it difficult to achieve PEB standard in Nordic countries which makes hybrid PVT collectors a key technology in the Nordic regions as they maximize the energy use of the solarized surface.

PVT as single source for water-water heat pumps: PVT could be used to supply heat as single source to a water-water heat pump. The PVT panels are able to collect also convective energy and thereby also ensure a sufficient energy supply to the heat pump during the night. This application is competing with groundsource heat pumps. The performance is comparable with groundsource heat pumps but the price is lower (between air-water heat pumps and groundsource water-water heat pumps) as drilling costs are saved. Therefore this application is favourable in cases where drilling is not possible or restricted on the property. However, this application is quite new and not much experienced yet but it might be a relevant application for regions in central Europe where many water-water heat pumps are uses but the heat energy demand is not too high for PVT as single source. Therefore this application is mainly relevant for new buildings in central Europe.



4 Multifunctional facades

The Excess demo building in Graz uses a multifunctional façade element that includes integrated energy producing active elements (PV), insulation and activation elements for the use of existing facades as heat/cold storage and heat dissipation system. In conjunction with the defined energy supply concept in the Austrian demo case, the overall concept transforms the exterior wall into a cost-effective energy storage as well as an interesting element to increase the energy flexibility by storing surplus electricity in the activated element. The proper operation of this multifunctional façade element and the replication of this solution on other buildings requires the fulfilment of following replication criteria.

Plain wall: Building must have a plain wall to ensure a proper thermal connection between the wall heating element of the multifunctional façade element and the existing wall of the building. This means that buildings with a structured façade (mainly buildings before 1945) cannot be equipped with this façade elements. Furthermore, must not have monument protection of the façade, as the elements are mounted on the existing walls of the building.

High U-value: The U-value of the existing wall must be higher than ~1 W/mK as lower U-values cannot ensure sufficient heat conduction from the wall heating system to the building's interior spaces. This criteria therefore excludes most of the buildings built after 1990 as the walls of those buildings already have better insulation and therefore lower U-values.

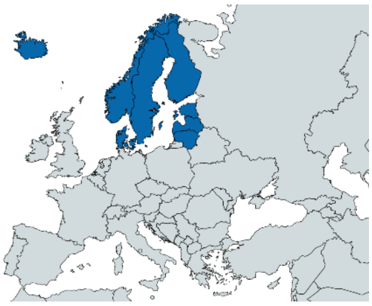
Heating supply after renovation: The wall heating system of the multifunctional façade element replaces existing heat distribution systems with radiators and does not need a change to floor heating system. which is one of the main advantages of a renovation with the multifunctional façade element. As the renovated buildings will be only heated with the active wall heating part of the façade element, the heat energy demand after renovation must be below a certain limit which is defined based on existing wall insulation level, ratio between façade area and useful floor area as well as the heat energy demand based on climatic conditions. For central Europe this criteria is at roughly 25W/m2 or lower for buildings with a ratio of façade/floor area > 0.6. Nordic countries have a rather high heat energy demand which makes most of the buildings inappropriate for the renovation with multifunctional façade elements.

Based on above replication criteria, it can be concluded that the highest replication potential for the multifunction façade elements is at renovation projects in central Europe for buildings with construction year 1970 to 1990. Those buildings mostly have plain walls with U-values > 1W/mK. Heat energy demand after renovation and the façade/floor ratio in central Europe is also suitable for most of the buildings in central Europe. According to the EURAC 2021[1], around 15% of all residential buildings and 18% of all non-residential buildings were constructed between 1970 and 1990. Around 50% of those buildings (57% for 1970-1980, 38% for 1980-1990) have a plain wall where the multifunctional façade elements could be used. Considering that the multifunctional façade element is best suitable for apartment blocks or multifamily houses in central Europe, we can conclude that there is a replication potential for the multifunctional façade element of more than 1million buildings in Europe. In new Member States large panel system buildings may be highly suitable. Additionally, in Southern Europe, the multifunctional façade system could be also used for cooling which represents another potential case of application.

The replicability depends also on the specific technological details such as offering the system with a steel frame as developed in EXCESS instead of the standard wooden frame, in case fire protection rules request it. Also the insulation layer needs to be tailored to the Climate zone. As concluded in EXCESS the size of the façade elements should be compatible with PV layers that can easily be purchase on the market.

5 Hybrid Geothermal Energy System

The PEB solution developed for the Finnish demonstration in EXCESS is based on a highly energy-efficient building combined with a hybrid energy system. It combines semi-deep geothermal energy wells with coaxial collectors in ~600 meter deep boreholes, heat pumps, PV panels and solar thermal PVT (combined PV and thermal panels) that will produce electricity and heat for the building. The hybrid energy system represents an innovative approach to modern energy challenges, offering numerous strengths and opportunities that set it apart from traditional systems. This system boasts lower energy consumption, reduced life cycle costs, and decreased carbon emissions while harnessing various energy sources through advanced digital controls. However, its complexity and the necessity for extensive expertise present notable weaknesses and potential threats, such as unpredictable electricity prices and maintenance availability.



The replication of this hybrid energy system across different regions and building types requires the consideration of following aspects:

Drilling permission: They EXCESS thermal system can be only replicated in areas where it is permitted to drill deep boreholes (>600m). Drilling is not permitted in many areas of the EU. In some cases it could be beneficial to drill on public property (e.g. streets or parks), which requires special permissions, but avoid technical complexities when placing the system under a building.

[1] Eurac Research, European Building Stock Analysis: A country by country descriptive and comparative analysis of the energy performance of buildings, 2021

Suitable bedrock: The functionality of the system depends on the quality of the bedrock and its suitability for deep boreholes.

Technical know-how: One of the strengths of the hybrid energy system is its ability to integrate diverse energy sources through sophisticated digital controls. However, this complexity necessitates a high level of technical expertise, both for installation and ongoing operation.

Scalability and Standardization: To replicate hybrid energy systems on a large scale, standardization of system components and procedures is essential. This ensures that the technology can be adapted to different building types and regions without the need for extensive customization each time.

Technology redundancy: The system may compete with existing district heating systems. In case of existing district heating systems decarbonising them may be an alternative solution.

6 Conclusion

The EXCESS project demonstrated the potential for replicating PEBs and PEB technologies across various European regions and climate zones. Key factors such as climate zone, building types and age, building structure, heating and cooling demand as well as regulatory and legal frameworks play critical roles in determining the suitability of PEB technologies. In addition adaptability and modularity is key to implement solutions in the highly diverse European building stock and possibly in more than one climate zone. Finally competition with existing or conventional systems needs to be considered, when identifying optimal locations for deploying new technologies.