Upgrade heritage to a Positive Energy Building in Valladolid

The concept of positive energy buildings (PEBs) emerges as a transformative solution to respond to the urgent need to combat carbon emissions and reduce our environmental impact. With their highly efficient design, renewable energy sources, and cutting-edge technologies, these buildings overcome their energy needs by producing surplus energy, which can be fed back into the grid or stored for later use. By upgrading the current building stock into positive energy buildings and districts, we can significantly reduce greenhouse gas emissions and reliance on fossil fuels while enhancing our built environment's comfort and efficiency.

At the same time that they contribute to a sustainable future, PEBs offer numerous benefits, such as improved air quality, thermal comfort, and overall building resilience. In addition, lower energy consumption and the ability to sell excess energy back to the grid results in significant cost savings over time, thus making PEBs highly attractive to building owners and buyers and offering a competitive edge in the real estate market.

This current replication example in Valladolid constitutes an essential milestone in renovating buildings towards energy efficiency because it falls upon a historic structure. Such projects often have to deal with regulations and restrictions imposed by governments to preserve local cultural heritage. By successfully implementing energy efficiency renovation measures or renewable energy supply technologies in a heritage building, this project in Valladolid helps to demonstrate that it is possible to reconcile energy efficiency with the imperative of preserving historical and architectural integrity. The replication case is based on the lessons learned from the EXCESS demo building in Valladolid, a heritage protected building that has sufficient roof space for PV and only 3 floors, important preconditions for becoming a PEB.

The renovation of this heritage building can serve as a powerful example to local, regional, and national governments across Europe. It could potentially pave the way for broader adoption of energy-efficient practices in heritage conservation, contributing significantly to the reduction of greenhouse gas emissions, and promoting sustainable development across Europe.

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1 Baseline assessment of the implementation environment

1.1 Building description

The building selected for replication is the palace known as “Casa Fernández de Muras”, located in the historical centre of Valladolid. It is a small palace from the beginning of the XVIII century, with heritage protection and included in the list of properties of cultural interest. The building is organised in the classical manner around an arcaded courtyard and the elements of staircase and hallway, with a facade of ashlar masonry and a semicircular arched entrance doorway. The interior of the building was entirely refurbished in 1988, maintaining the residential use. It features three floors of dwellings, some in a duplex typology, with commercial areas on the ground floor and an inner courtyard. The façade and windows are maintained aesthetically to preserve the look of the heritage building, like other historic buildings in Valladolid. Although the roof is complex due to different tilts and orientations with window openings, the neighboring buildings have a similar height, which warrants the absence of shading effects that could hinder the PEB objective.

1.2 Regulatory aspects and public support schemes

The building under the scope in this replication plan is located in the historic centre of Valladolid. As such, there are some rules to follow when considering a renovation of this type of building. The General Plan of Urban Ordinance of Valladolid[1] differentiates between two types of protection for buildings in the historic center, classifying them as integral or preventive protection.

The current building presents a unique challenge, because it not only has the archaeological protection level type 2B, but it is also within the catalog of protected buildings with protection type P1 (monumental) on the façade and P3 (structural and typological) through the building.

With the archeological protection, the building is under the degree of preventive protection. This level type means that “due to the remains found on the surface or the documentation available about them, there is a presumption of the appearance of archaeological evidence or finds in the subsoil, even though aspects such as the location, state of preservation, or degree of alteration of these remains are not fully known. Other actions beyond mere research and enhancement can be carried out, with the necessary interventions executed according to each project or work that affects these zones.”[2] In addition, being located in the historic centre, these buildings cannot have more than four floors.

The fact of being catalogued as P1 implies that it is regarded as an area of “Cultural Interest” (“Bien de interes Cultural - BIC”). Thus, any intervention on the building, or its surroundings, must have the authorisation of the administration with competences in the matter and will be subject to the state and autonomic legislation for the protection of the cultural heritage.

With the P3 cataloging, conservation and refurbishment works are allowed, as long as the typology and elements of interest are maintained and must be supervised by the municipal technicians. Demolition and new construction works are prohibited.

Furthermore, the autonomous community of Castilla y León promotes sustainable mobility and urban proximity. They also facilitate the improvement of energy efficiency and the use of renewable energy systems, creating the framework for this renovation work to be carried out.[3]

In addition, the Urban Planning Law of Castilla y León highlights the objective of preventing contamination while supporting public transport, sustainable mobility, and energy efficiency.[4] Also, in its Article 36 the law establishes that when renovating a building, it must reduce its energy demand, a condition that is fulfilled by renovation works focused on transforming nearly-zero energy buildings into PEBs.

[1] PGOU de VLL Catálogo Arqueológico (add)

[2] PGOU de VLL Catálogo Arqueológico p.17

[3] Decreto 22/2004, de 29 de enero, por el que se aprueba el Reglamento de Urbanismo de Castilla y León.
Artículo 81.

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Spanish Law
Article 15 of the Spanish Technical Building Code of Energy Savings (DB-HE) sets out the basic rules for making buildings more energy-efficient in the Spanish territory. These regulations are designed to promote a rational use of energy, reduce consumption to sustainable levels, and encourage the use of renewable energy sources. They include limitations on energy consumption based on location and building use, requirements for thermal envelope characteristics, specifications for thermal and lighting installations, and mandates for the use of renewable energy for hot water and electricity generation.

The provisions in this code are introductory and correspond to the competencies attributed to the State in the Spanish Constitution. They must be further complemented with provisions from the regional building codes for their implementation.

EU level
At the EU level, new constructions must ensure that the building meets high energy performance standards as defined in the EPBD. The directive also mandates optimising health, indoor air quality, and comfort levels in building energy calculations and highlights the IEQ impacts on the health, productivity, and overall well-being of building occupants.

1.3 Social Dimension

The replication case of "Casa de los Fernández de Muras" will be managed by an owner community that will gather all apartment owners. Each apartment has a different owner, and they share the common areas of the building and the garage with parking spaces, whose expenses are shared among the owners. The owners' association can join local energy communities operated by Energética Coop to share energy surplus and profit from energy trading mechanisms. In the long run, the association must decide if they want to share their energy production and how they will manage consumption. Additionally, the owners' association needs to decide on the maintenance aspect of the building to ensure proper operation of the installed equipment. This way, the energy-efficient renovation of the replication case also paves the way for social innovations, incentivising energy communities and sharing energy surplus. Integrating sustainable practices and energy-sharing models promotes environmental stewardship while creating economic opportunities for residents through energy savings and trading. The option of creating an energy community with another protected building next door has been raised. These practices exemplify how heritage preservation and energy renovations can coexist, enriching the community socially and environmentally and setting a precedent for responsible urban development.

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1.4 Assessing strengths, weaknesses, opportunities and threats in relation to a PEB upgrade

Although the building is a heritage-protected dwelling, it is in excellent shape and already has residential use, which means that only the adaptation for higher energy performance is needed, being a straightforward case for heritage transformation into PEB. Additionally, it has a structure similar to the EXCESS Demo building in Valladolid, allowing direct application of lessons learned and construction company-acquired know-how. As all of the buildings in the area are more or less the same height, they have no conflicting shades, allowing the installation of PV in all of the available roof areas with the proper orientation.

Strengths

- High replication potential
- Only energy refurbishment necessary

Weaknesses

- Need to engage all current inhabitants in PEB
- They need to have an alternative accomodation to do part of the works

Opportunities

- Transformation of another heritage into PEB
- More similar heritage buildings in Valladolid and in general in Spain could follow

Threats

- Local regulations can put obstacles in the placements of the PV and heat pump exterior units

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2 Technical information / design specifications

The building was refurbished in 1988 using the standards in place at the time, considering that it is a historic building. Therefore, the construction materials used result in a very poor insulation by today's standards, resulting in a relatively high energy demand. Additionally, such dwellings are excessively overheated in summer, reaching almost 40º.

The PEB refurbishment proposes interior and thin insulation of walls and roof as well as replacing windows with lower U-value windows whenever possible (the façade and courtyard are protected), similar as in the Spanish EXCESS demo case. Additionally, radiant heating and cooling supplied with aerothermal heat pumps will be installed to increase efficiency and to electrify and reduce the building energy demand for space conditioning while increasing user comfort.

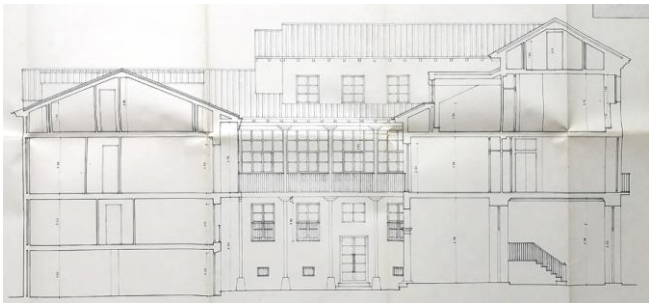

Figure 1: Technical drawing of the building. Source: Urb·Atelier

The energy demand for heating is estimated to be 57.5 MWh/year, while the energy demand for air conditioning after the actuation is estimated to be 16.5 MWh/year. One or two aerothermal heat pumps, with a total power of 40 kWh, should be installed to meet the demand for heating and cooling. Additionally, one or two inertia tanks should be installed with a total capacity of at least 1.5 m3 to increase flexibility and optimise the heat pump operation. Considering the Domestic Hot Water (DHW) consumption, another dedicated aerothermal heat pump can be installed to reduce primary energy consumption. The annual electricity consumption of DHW with a heat pump is expected to be 8 MWh.

The total energy consumption estimated for the building after the renovation is expected to be around 60 MWh per year, considering that almost half of it is caused by lighting and equipment according to the values stated in the Spanish building code.

A PV system will be put on the roof, taking advantage of the parts that receive the most irradiation due to the orientation and inclination of each area to generate electricity. Theoretically, the roof can host a maximum of 65.7kWp (146 PV modules) with a theoretical maximum production of 78.9 MWh per year. The most economical installation for the building would be 23.4 kWp (52 modules), but the production would not achieve the PEB standard. To accomplish a positive energy balance, the PV installation would need 110 PV modules with a total installed power of 49.5 kW and 61.2MWh of the yearly output.

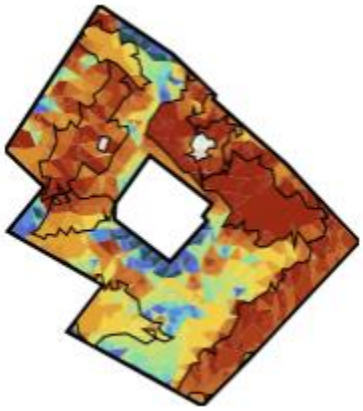

Figure 2: Solar irradiation distribution on the building roof surfaces. Source: Atlas solar Valladolid

To use the energy surplus produced by the PV installation, a 60kWh battery energy storage system is envisioned, allowing energy flexibility to optimise energy costs. A hybrid inverter compatible with the battery pack must be installed to feed electricity from/to the grid.

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A Building Management System could be installed in the building to connect and coordinate all systems. This would take advantage of the refurbishment to add more control capacities to the building and allow better control and system cooperation.

3 Business model details & possible financing arrangements

PEBs generate more energy than they consume, offering significant environmental, economic, and social benefits. However, renovation of a heritage-protected building to PEB standard requires significantly higher upfront investment costs compared to conventional renovation projects. Additionally, it is also more challenging due to regulations that have to be considered. Thus, creating a business model for renovating a heritage-protected building into a Positive Energy Building involves addressing unique challenges and opportunities due to the heritage status while aiming to transform the building into an energy-positive structure in a cost-effective way. The heritage protection of the building leads to additional construction costs and makes it necessary to involve additional stakeholders in the process. National and regional governments are an important partner as they define the heritage protection policies. The renovation of protected buildings provide a clear value proposition. The main aspects are an enhanced property value, increased comfort as well as reduced electricity costs and revenues from renewable energy production. These multiple benefits of a PEB have to be emphasised and monetised.

Furthermore, the building owner should assess the feasibility of other financing opportunities that may facilitate the overall costs model for a PED upgrade. For the case of Valladolid the following two options could be considered:

- The autonomous government provides public subsidies for building renovations, covering up to 40% of the cost, but these are paid after the renovation works are finished [4].
- The owner community can sell the energy savings to energy utilities with the system of CAEs (Energy Savings Certificates), depending on offers, compensating part of the cost of the renovation. With the proposed interventions, the building could generate up to 40.000 CAEs with an estimated value of up to 8.000€.

These amounts are paid after the renovation, so the community will need a loan to start the work. For this, the ICO (Official Institute of Credit) has a financing line providing guarantees for the consecution of the renovation loan.

The owners' community could also benefit from creating an energy community with the surrounding buildings. They could sell the energy surplus to commercial or office areas located in these buildings, where energy consumption during the day is usually higher, obtaining a higher profit as compared to if it is fed into the grid, especially in the summer months, since most homeowners live in a second home outside of the city during that time.

4 Local Government Recommendations

To accelerate energy efficiency, maximise the integration and use of renewable energy sources, and roll-out PEBs through financial incentives such as subsidies and grants, local governments could make PEB retrofits more attractive in various ways:

[4] Ayudas a la rehabilitación: Eficiencia y Sostenibilidad | Vivienda y Urbanismo | Junta de Castilla y León (jcyl.es)

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Firstly, due to the heavy restrictions on PV panels because of their disturbing appearance, local governments should generate lighthouse projects on public buildings with better visual panels disguised as tiles.[5] Despite their high cost, putting a series of small public projects out to tender improves demand and helps create a local market, pushing the private sector to develop skills while reducing costs and creating market awareness.

In addition to regional and national grant or subsidy schemes, local governments could consider establishing a special fund for PEB support and/or acting as guarantors for banks to offer low-interest loans for PEB projects.

Lastly, local governments should enhance technical advisory services (One-Stop-Shops) so that building owners can approach public officers to support them with decision-making on which measures/subsidies/grants to apply for to enhance building energy performance.

[5] https://www.dezeen.com/2023/02/10/dyaqua-invisible-solar-panels-ceramic-italian-tile/

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