Positive Energy Building Upgrade Plan Intro

This Positive Energy Building (PEB) Upgrade Plan outlines the redevelopment strategy for a heritage building located in Rome, Italy, aimed at transforming it into a sustainable, energy-efficient structure that produces more energy than it consumes. The building, originally used for educational purposes, is undergoing significant architectural and structural interventions to enhance its functionality while preserving its historical value. The project integrates renewable energy sources (RES), such as photovoltaic panels, and modern energy-saving technologies to reduce the building's environmental footprint.

In the context of the city's long history, the intervention combines architectural heritage preservation with forward-looking, sustainable solutions. The building will serve as a model for other heritage buildings, showcasing how it's possible to integrate cutting-edge energy efficiency (EE) and renewable energy (RE) technologies into structures of cultural importance. The transformation process will include energy upgrades, improved insulation, and advanced heating, ventilation, and air conditioning (HVAC) systems to ensure optimal energy use. The PEB upgrade is not only intended to reduce the building's carbon footprint but also to contribute positively to the local community by sharing excess energy generated through renewable sources. This plan outlines the necessary technical, financial, and regulatory steps for achieving the project goals.

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Baseline assessment of the implementation environment

1.1 Building description

The Slaughterhouse complex is located in the Testaccio district, close to the Aurelian walls between the Monte dei Cocci, the ancient Mons Testaceum, and the Tiber. It was built between 1888 and 1891 by Gioacchino Ersoch, architect emeritus of the Municipality of Rome and a former student of Valadier. The work, which reflects the transition from classicism to modernism, is characterized by large pavilions and light canopies that feature traditional brick curtains, travertine and stucco elements but also innovative iron and cast-iron structures according to a refined balance between monumentality and industrial rationality.

The complex was decommissioned in 1975 and in 1988, due to its quality and uniqueness, it became the object of protection by the Superintendence for Architectural and Environmental Heritage of Rome. As part of the "Plan of Use" of the Slaughterhouse, the Municipality of Rome has allocated the entire complex to public services of a cultural, university and recreational nature. Several pavilions have been assigned to the Academy of Fine Arts and, due to the state of those buildings, a deep renovation is pending to adapt the space to fit teaching activities.

1.2 Regulatory aspects and public support schemes

Rome, being a historic city, faces significant regulatory challenges when it comes to renovations, especially in terms of energy retrofitting and integration of renewable energy systems. The local and national regulations are highly protective of cultural heritage, meaning that interventions in listed or historic buildings require rigorous approval processes from both the local and national heritage authorities, including the Capitoline and State Superintendence.

The regulatory framework governing energy efficiency and renewable energy integration in Italy is determined by national and EU directives. These include the EU Energy Performance of Buildings Directive (EPBD), which sets mandatory energy performance standards for buildings, and Italy's National Energy Efficiency Action Plan (NEEAP), which outlines strategies for improving energy efficiency in buildings. At the local level, there are incentives for adopting renewable energy sources, such as the Conto Energia program, which supports the installation of solar photovoltaic systems with feed-in tariffs.

Additionally, the Superbonus 110% scheme provides financial incentives for energy-efficient upgrades in buildings, including insulation, solar installations, and efficient heating systems. However, this scheme has certain limitations when applied to historic buildings, especially regarding aesthetic and architectural considerations.

In light of these regulations, the project had to carefully navigate the balance between energy upgrades and preserving the heritage of the building. Collaboration with regulatory bodies, has been essential to obtain the necessary approvals for interventions like the installation of large photovoltaic systems or the modification of roof structures for insulation and energy efficiency.

Public support schemes, such as grants or subsidies, will play a critical role in financing these upgrades, especially considering the financial constraints of renovating historic buildings. Leveraging national and EU funds will be crucial for the success of the PEB upgrade.

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

The building needs to face a very deep renovation while maintaining the heritage part, which poses significant challenges. It also creates the opportunity to showcase a PEB in an historic city such as Rome. However, the risk and threats should be evaluated carefully for the successful implementation of the technologies.

Strengths

- High PEB potential
- Heritage refurbishment

Weaknesses

- Big PV installation can lead to permit issues

Opportunities

- Transformation of another heritage into PEB.
- Huge energy surplus to share with the neighborhood

Threats

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

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2 Technical information / design specifications

The renovation of the slaughterhouse will comprise several interventions including the structure of the buildings, the aesthetics of the facades, the usage of the spaces that cannot be changed due to protection, etc.

The proposed PEB refurbishment builds upon the experience in the historic EXCESS Demo in Valladolid, Spain, proposing interior and thin insulation of walls and roof, and change of windows to the extent possible. The space conditioning will be provided by a central system composed of two multifunctional air-source heat pumps with a total capacity of 800kW. This production system will supply the pavilions' air handling units (AHU). At the same time, some spaces will be conditioned via fan coil units and heaters in the toilets. The efficiency of the heat pumps will be key on reducing the conditioning energy demand.

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

With these actuations, the energy demand for climatization after the actuations is estimated to be 39 MWh/year. To increase flexibility and optimize heat pump operation, one or two inertia tanks could be installed to allow the heat pumps to operate when they are more efficient. The total energy consumption estimated for the building after the renovation is expected to be of 71 MWh per year considering that more than 25% of it is caused by lighting and equipment.

To generate electricity, a PV system will be put in the roof taking advantage that the main pavilion is almost south-oriented. Theoretically, the southwards facing roof can host a maximum of 480kWp with a theoretical maximum production of 672 MWh per year, however that will be too much energy generated for the building consumption. Considering the building annual electricity consumption of 350MWh, at least half of the southwards facing roof should be covered in solar panels to achieve a positive energy balance. This would mean an installation of 250kWp.

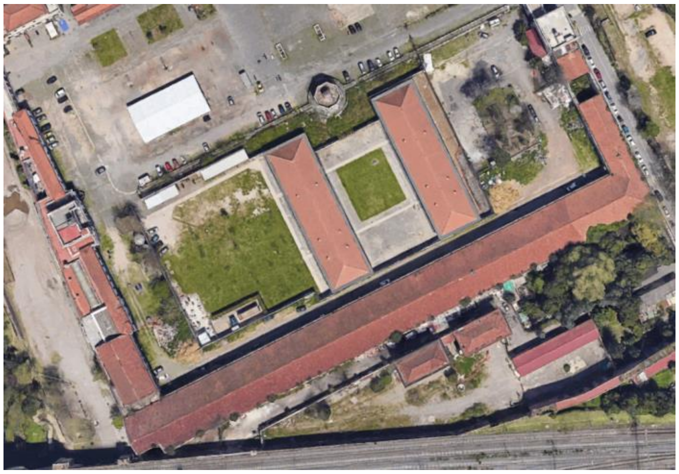

Figure 2: Satellite image of the Slaughterhouse roof

To be able to use the energy surplus produced by the PV installation a battery energy storage of at least 300kWh should be installed to allow the activation of energy flexibility to optimize energy costs.

The size of the required installation of this building makes required different equipment than that used in the Spanish EXCESS Demo, which was designed for a much smaller building. However, the Model Predictive Controller and Energy Management System could be applied to this case, leading to a reduction of at least a 15% in energy usage and an increase of the system revenues due to the flexibility optimization.

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5 Local Government recommendations to accelerate EE of building stock and RES-integration

To accelerate the energy efficiency (EE) and renewable energy systems (RES) integration in the building stock, local governments (LGs) can focus on several key actions.

Incentivizing Heritage Building Upgrades
Local governments should consider providing financial incentives or subsidies to property owners of heritage buildings to support energy-efficient renovations while maintaining the aesthetic integrity of the structure. Schemes like the Superbonus 110% can be tailored to accommodate heritage considerations.

Streamlining Permitting Processes
Local governments should be working closely with cultural heritage bodies to streamline permitting processes for the integration of renewable energy systems in historical buildings. Clear guidelines and frameworks for heritage building upgrades can facilitate faster approvals for such interventions.

Facilitating Energy Sharing Initiatives
Encouraging energy sharing between upgraded heritage buildings and local communities can help maximize the impact of energy-efficient technologies. LGs can support the development of local energy networks and facilitate energy trading or sharing schemes.

Public Awareness Campaigns
Local governments could promote the benefits of PEB upgrades through public awareness campaigns, showcasing successful examples of energy-efficient renovations in heritage buildings.

Collaborating with Research Institutions
Local governments should consider collaborating with universities, research centers, and technology providers.

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