TOWARD REGENERATIVE ENERGY OPTIMIZATION IN HISTORIC HOSPITALS: THE CASE OF COLȚEA CLINICAL HOSPITAL, BUCHAREST

Sofiane BENSEHLA - *University 8 Mai 1945 Guelma | Email: bensehlasofiane@gmail.com*

Abstract. The methodology combines a high-resolution energy simulation of the baseline scenario with a proposed two-pronged intervention: (1) the sensitive integration of a rooftop photovoltaic (PV) array, invisible from the street to protect urban identity, and (2) upgrades to the internal thermal envelope, including high-performance insulation and glazing. The results show a significant reduction in energy demand, with heating consumption decreasing by 21% and cooling by 13%. Crucially, the 499 MWh of annual PV production offsets 44% of the building's post-retrofit electricity needs. This work provides a validated, replicable model for transforming energy-intensive heritage buildings—particularly 24/7 healthcare facilities—into more sustainable and resilient assets, proving that deep energy retrofits are feasible without compromising historical value.

Keywords: Energy optimization; Historical buildings; Colțea Clinical Hospital.

Introduction. Historic buildings constitute a fundamental component of urban identity and cultural continuity. However, many of these structures face progressive degradation due to aging, environmental exposure, and the obsolescence of building systems (Ascione et al., 2017). In this context, renovation becomes essential to ensure their continued functionality and resilience. Beyond their cultural value, historic buildings often incorporate passive design strategies—such as thermal mass and natural ventilation—that provide valuable insights for contemporary low-carbon design. Furthermore, adaptive reuse significantly reduces the embodied carbon associated with new construction, contributing to more sustainable development pathways.

Despite these advantages, interventions in historic buildings must be approached with caution. The preservation of architectural authenticity, material integrity, and cultural significance remains a primary concern, particularly in protected or listed structures. Consequently, while improving energy efficiency and reducing carbon emissions have become critical objectives in the built environment, these goals must be carefully balanced with heritage conservation principles (Panakaduwa et al., 2024). In this regard, several studies emphasize the importance of integrating energy efficiency measures in a manner that respects the cultural and historical value of existing buildings (Cabeza et al., 2018; Fouseki & Cassar, 2014). This highlights the need for holistic renovation strategies that simultaneously address environmental performance and heritage preservation, ensuring long-term cultural and ecological sustainability.

Recent research demonstrates the feasibility of such integrated approaches. For instance, the renovation of historic buildings in Shanghai's Wukang Road district achieved significant reductions in energy demand—up to 31% in cooling, 53% in heating, and 25% in electricity consumption—through the implementation of thermal insulation and upgraded energy systems, while maintaining compliance with conservation constraints (Wang et al., 2026). Similarly, studies conducted in Italy on Palazzo Ruspoli and Palazzo Vitelleschi have shown that heritage buildings can even reach net-negative carbon emissions through the integration of photovoltaic systems within Renewable Energy Communities, thus reconciling conservation requirements with deep decarbonization strategies (Vitella et al., 2025).

At a broader scale, the building sector remains a major contributor to global energy consumption and carbon emissions, underscoring the urgency of transitioning toward more sustainable and energy-efficient practices (Aniekan et al., 2024). Within this sector, healthcare facilities represent one of the most energy-intensive building typologies, due to their continuous operation and high demands for heating, cooling, ventilation, and medical equipment (Dion & Evans, 2024). This challenge becomes even more complex in the case of historic hospital buildings, which must simultaneously satisfy stringent conservation requirements, modern healthcare standards, and environmental performance objectives (Gomes et al., 2021).

Historic hospitals, such as Colțea Clinical Hospital, exemplify this complexity. These buildings are not only valuable cultural assets but also active healthcare institutions that play a vital role in contemporary public health systems. However, their energy optimization is constrained by strict conservation guidelines that limit alterations to original materials, architectural features, and spatial configurations. As a result, conventional retrofitting approaches are often inadequate, requiring more sensitive and context-specific strategies.

In response to these challenges, this study proposes a regenerative energy optimization framework that goes beyond conventional efficiency measures by integrating environmental performance, heritage conservation, and social value. Using the Colțea Clinical Hospital as a case study, the research investigates the constraints and opportunities associated with implementing energy-efficient interventions within a protected historic building. The objective is to demonstrate that, through carefully designed and minimally invasive strategies, it is possible to reconcile heritage preservation with sustainability goals, ensuring that historic healthcare facilities can continue to operate effectively while contributing to a more resilient and low-carbon built environment.

Methodology. The methodology commenced with the identification and detailed characterization of a case study building, encompassing its complete physical and geometric properties. A baseline energy model was subsequently developed using CitySim Pro to simulate the building's annual energy consumption. This model was then modified to evaluate the impact of two energy strategies: first, the enhancement of the building envelope through added insulation, and second, the integration of a rooftop photovoltaic (PV) array. The results from both scenarios were rigorously analyzed to quantify and discuss the reduction in net energy demand

achieved through the combined effects of improved energy efficiency and on-site renewable energy generation.

Case study. This study focuses on the Coltea Hospital, a historical building situated in the old town of Bucharest (figure 1), Romania. Originally constructed in 1888 and subsequently renovated on several occasions, the building serves as a representative case study for the energy performance of heritage structures. The local climate of Bucharest is classified as humid continental, characterized by cold, wet winters with average minimum temperatures of –5 °C and hot, moderately humid summers with average maximum temperatures reaching 30 °C. This climatic context, with an annual average humidity of 70%, presents significant heating and cooling demands. Furthermore, the city experiences high solar irradiation, with approximately 2,100 annual sunshine hours, while prevailing winds originate predominantly from the east and northeast at an average speed of 2.4 m/s. These specific climatic conditions are critical factors for evaluating the building's energy needs and the potential for renewable energy integration. (World weather online, 2025).

Building energy model. The CitySim Pro software platform was selected to conduct the energy simulations for this study. This tool was chosen based on its established efficacy in modelling building energy dynamics at an urban scale(Kämpf, 2009). Developed by the Solar Energy and Building Physics Laboratory at EPFL, CitySim Pro facilitates efficient simulations of key performance metrics, including heating and cooling demands, solar irradiation, and on-site energy production (Vázquez-Canteli et al., 2019). Its underlying radiation and output models have undergone rigorous validation (Walter & Kämpf, 2015), and the software is well-documented in literature concerning urban energy planning (Mauree et al., 2017; Mohajeri et al., 2019), occupant behaviour, and energy demand assessment (Haldi & Robinson, 2011). particularly its integrated capability to simulate both building energy consumption and renewable energy generation within an urban context.

To facilitate the simulation process, a geometric model of the case study building was constructed in SketchUp software at Level of Detail (LOD) 2. This level of detail was deemed sufficient to accurately represent the building's form for energy analysis and ensured compatibility for export into the CitySim Pro environment (Fig. 2).

The key physical characteristics of the building's thermal envelope and glazing systems, which form the fundamental inputs for the energy model, are comprehensively detailed in Tables 1 and 2. These parameters, including the 50 cm thick external masonry walls as a critical component of the envelope, define the baseline thermal performance of the building fabric and are critical for accurately simulating its energy behaviour.

Climate data. Climatic data for the simulation were sourced from the Meteonorm software, a recognized weather data generator (Remund et al., 2010). The tool was used to produce an hourly Typical Meteorological Year (TMY) dataset for Bucharest, Romania. The selected parameters, essential for the energy modeling in CitySim Pro, encompassed: air temperature, relative humidity, wind speed, wind direction, precipitation, nebulosity, ground surface temperature, diffuse horizontal irradiance, and beam normal irradiance.

The energy improvement of the case study. **Intervention in the building envelope.** Due to patrimonial restrictions protecting the historical façade, envelope upgrades were limited to internally applied insulation and window replacements. Phenolic insulation was selected for its optimal balance of high thermal performance including very low conductivity, fire resistance, moisture resistance, low weight, and medium cost, following established retrofit methodologies (Civic & Vucijak, 2014; Kośny & Yarbrough, 2022). However, its low vapor permeability, which may limit the drying capacity of masonry walls, is recognized as a limitation of this study. In the present work, this aspect was addressed by positioning the insulation on the interior side of the wall assembly, allowing it to function as a vapor control layer that limits indoor vapor diffusion toward the colder masonry. Particular attention was given to the hygrothermal behavior of the system in order to reduce moisture accumulation and mitigate the risk of interstitial condensation. Furthermore, the existing glazing system was upgraded to a high-performance triple-pane configuration, enhancing the overall thermal insulation of the building envelope. Although this solution results in a slight reduction in visible light transmittance when compared to conventional double-pane glazing, it significantly improves energy efficiency by reducing heat losses and minimizing thermal bridging effects (Delarami et al., 2024). This trade-off between daylight penetration and thermal performance is considered acceptable within the context of optimizing indoor environmental quality and reducing energy demand. The revised thermal properties of the building envelope components, including the upgraded glazing system, are detailed in Table 3, 4, and illustrated in Figure 3, providing a comprehensive overview of the improvements achieved.

PV modelling

For this study, a widely available and commonly installed photovoltaic (PV) module type in the Romanian market was selected. According to industry reports, LONGi Solar has a significant market presence in Romania, distributed primarily by Solargroup, and is a leading supplier of PV modules for both residential and commercial applications (BALKAN GREEN ENERGY NEWS, 2024; guanji tech, 2024).

The total available roof area of the building is 8140 m². A suitability analysis, considering factors such as solar exposure and shading, identified a well-exposed area of 1595.1 m², predominantly facing south. To maintain a balance between energy generation and structural or aesthetic considerations, a conservative percentage of 20% of this suitable area (319.02 m²) was allocated for the PV array. The existing roof inclination of 30.5° is considered adequate for solar energy capture, minimizing the need for additional mounting structures.

Results and discussion

Baseline scenario energy demand of the building

The baseline simulation reveals a substantial total energy demand for the historic Coltea Hospital, characterised by a high heating demand of 91 kWh/m²·year. This finding aligns with a well-documented challenge in

heritage building operation: thermal performance is often constrained not by inherent deficiencies in traditional construction, but by the mismatch between original design parameters, which did not anticipate contemporary insulation standards, and the restrictive conservation protocols governing façade interventions. The combined energy demand for heating, cooling, and electricity amounts to 229 kWh/m²·year, situating the building within the expected range for European hospitals, albeit at the upper end of the distribution, thereby supporting the credibility of the simulation (Čongradac et al., 2012; IEPF, 2006; Sala et al., 2016) The high heating demand constitutes the primary target for retrofit interventions, as it represents the largest single end-use category. This is directly attributable to heat loss through the uninsulated historic envelope. Moreover, the considerable electricity consumption (90 kWh/m²·year) reflects the intensive operational requirements of a healthcare facility, powering critical medical equipment, HVAC systems, and other essential loads.

Improved scenario of energy demand of the building. The effectiveness of the suggested retrofit measures is confirmed by the simulation of the enhanced scenario, which shows a notable improvement in the building's overall energy performance.

Decreasing the Demand for Energy

Triple glazing and internal insulation were effective in reducing energy usage for all end uses:

The largest decrease was seen in heating demand, which dropped from 91 to 72 kWh/m²·year (20.9%). This demonstrates that the main cause of thermal inefficiency was the envelope of the historic building. By directly reducing heat loss, the intervention reduced the amount of energy needed to heat the space.

Cooling Demand: Decreased by 12.5%, from 48 to 42 kWh/m²·year. The enhanced insulation lowers the cooling load on the mechanical systems by retaining heat in the winter and minimising undesired heat gain in the summer.

Demand for electricity decreased by 8.9%, from 90 to 82 kWh/m²·year. The decreased operational load on the heating and cooling systems (such as circulation fans and heat pump compressors), which are significant electricity users, is primarily responsible for this secondary savings.

Effects of Renewable Energy Generation on-Site

The addition of the photovoltaic (PV) system is revolutionary. The on-site generation directly offsets a significant amount of the building's electricity consumption from the grid, with an annual production of 499,000 kWh.

The net energy consumption must be taken into account in order to completely understand the impact. By successfully lowering the building's final grid-supplied electricity, the PV system helps it achieve a much smaller net energy footprint. The foundation of a deep energy retrofit strategy is the synergy between energy generation (clean supply) and energy efficiency (reduce demand).

The data confirms that the building envelope was the primary source of thermal inefficiency. The heating demand saw the most substantial absolute reduction (261,971 kWh/year), directly attributable to the reduced heat loss through the insulated facade and high-performance glazing.

Impact of On-Site Renewable Energy Generation and Net Performance

The integration of the photovoltaic (PV) system, with an annual production of 499,000 kWh, is a transformative addition. This production must be analyzed in the context of the building's electricity demand, which is the only form of energy the PV system can offset.

Total Electricity Demand (Improved Scenario): 1,130,611 kWh/year

Total PV Production: 499,000 kWh/year

This means the PV system can cover 44.1% of the building's total annual electricity demand. The concept of net electricity demand becomes key:

Net Electricity from Grid = Total Electricity Demand - PV Production

Net Electricity from Grid = 1,130,611 kWh - 499,000 kWh = 631,611 kWh

Therefore, while the efficiency measures reduced the building's absolute electricity demand by 110,304 kWh, the PV system displaces a further 499,000 kWh that would have been drawn from the grid. This synergy between energy efficiency (reduce demand) and energy generation (clean supply) is the cornerstone of a deep energy retrofit strategy.

Conclusion.The study illustrates that a comprehensive energy retrofit is both attainable and significantly beneficial for historic hospitals, even within the stringent limitations of heritage preservation. The proposed regenerative strategy for Colțea Clinical Hospital—combining a sensitively integrated rooftop PV system and internal envelope upgrades—successfully reduced heating demand by 21% and enabled on-site solar power to meet 44% of the post-retrofit electricity needs. The case demonstrates that it is feasible to substantially improve the energy efficiency and durability of continuous healthcare operations in a historic structure, thereby converting it into a paradigm of sustainable stewardship while preserving its cultural significance. This method gives the building industry a way to align heritage preservation with urgent climate goals that can be used again and again.

References.

1. Aniekan, A. U., Peter, E. O., Onyinyechukwu, C., Bright, N., Adetomilola, V. F., & Kenneth, I. I. (2024). Incorporating energy efficiency in urban planning: A review of policies and best practices.

2. Ascione, F., Ceroni, F., De Masi, R. F., de'Rossi, F., & Pecce, M. R. (2017). Historical buildings: Multidisciplinary approach to structural/energy diagnosis and performance assessment. Applied Energy, 185, 1517-1528.

3. BALKAN GREEN ENERGY NEWS. (2024). LONGi Solar's high-end modules build strong presence in Hungary and Romania through Solargroup. https://balkangreenenergynews.com/longi-solars-high-end-modules-build-strong-presence-in-hungary-and-romania-through-solargroup/?utm_source=chatgpt.com

4. Cabeza, L. F., De Gracia, A., & Pisello, A. L. (2018). Integration of renewable technologies in historical and heritage buildings: A review. Energy and Buildings, 177, 96-111.

5. Civic, A., & Vucijak, B. (2014). Multi-criteria optimization of insulation options

for warmth of buildings to increase energy efficiency. Procedia Engineering, 69, 911-920.

6. Čongradac, V., Prebiračević, B., Jorgovanović, N., & Stanišić, D. (2012). Assessing the energy consumption for heating and cooling in hospitals. Energy and Buildings, 48, 146-154.

7. Delarami, A., Mohammadbeigi, A., & Gharib, M. R. (2024). The influence of the climate, the materials of the walls, and the gas effects of double and triple-glazed windows in terms of energy evaluation and economic expenses. Results in Engineering, 23, 102793.

8. Dion, H., & Evans, M. (2024). Strategic frameworks for sustainability and corporate governance in healthcare facilities; approaches to energy-efficient hospital management. Benchmarking: An International Journal, 31(2), 353-390.

9. Fouseki, K., & Cassar, M. (2014). Energy efficiency in heritage buildings—future challenges and research needs. In (Vol. 5, pp. 95-100): Taylor & Francis.

10. Gomes, M. G., Rodrigues, A. M., & Natividade, F. (2021). Thermal and energy performance of medical offices of a heritage hospital building. Journal of Building Engineering, 40, 102349.

11. guanji tech. (2024). PV products. https://www.guanjitech.com/longi-solar/?gad_source=1&gad_campaignid=22306279676&gclid=Cj0KCQjwnJfEBhCzARIsAIMt-fKLKQxTenXHuYFlPdTk3mXJavSP2XPdvL02yee24l1MECI8nrIaaV1QaAvNtEALw_wcB

12. Haldi, F., & Robinson, D. (2011). The impact of occupants' behaviour on building energy demand. Journal of Building Performance Simulation, 4(4), 323-338.

13. IEPF, I. d. l. é. e. d. l. e. d. l. f. (2006). La maîtrise de l'énergie dans les établissements de santé. https://www.ifdd.francophonie.org/media/docs/publications/246_Fi-MEenESante.pdf

14. Kämpf, J. H. (2009). On the modelling and optimisation of urban energy fluxes Verlag nicht ermittelbar].

15. Kośny, J., & Yarbrough, D. W. (2022). Short history of thermal insulation and radiation control technologies used in architecture. In Thermal Insulation and Radiation Control Technologies for Buildings (pp. 1-35). Springer.

16. Mauree, D., Coccolo, S., Kaempf, J., & Scartezzini, J.-L. (2017). Multi-scale modelling to evaluate building energy consumption at the neighbourhood scale. PloS one, 12(9), e0183437.

17. Mohajeri, N., Gudmundsson, A., Kunckler, T., Upadhyay, G., Assouline, D., Kämpf, J., & Scartezzini, J. (2019). A solar-based sustainable urban design: The effects of city-scale street-canyon geometry on solar access in Geneva, Switzerland. Applied Energy, 240, 173-190.

18. Panakaduwa, C., Coates, P., & Munir, M. (2024). Identifying sustainable retrofit challenges of historical Buildings: A systematic review. Energy and Buildings, 313, 114226.

19. Remund, J., Müller, S., Schilter, C., & Rihm, B. (2010). The use of Meteonorm weather generator for climate change studies. 10th EMS annual meeting,

20. Sala, M., Alcamo, G., & Nelli, L. C. (2016). Energy-saving solutions for five hospitals in Europe. Mediterranean green buildings & renewable energy: Selected papers from the World Renewable Energy Network's med green forum,

21. Vázquez-Canteli, J. R., Ulyanin, S., Kämpf, J., & Nagy, Z. (2019). Fusing TensorFlow with building energy simulation for intelligent energy management in smart cities. Sustainable cities and society, 45, 243-257.

22. Vitella, D., Barbaro, L., de Lieto Vollaro, E., & Battista, G. (2025). Energy Retrofit of Heritage Buildings Through Photovoltaic and Community Energy Approaches: A Case Study Analysis. Buildings, 15(20), 3768.

23. Walter, E., & Kämpf, J. H. (2015). A verification of CitySim results using the BESTEST and monitored consumption values. Proceedings of the 2nd Building Simulation Applications conference,

24. Wang, K., Wang, M., & Zhou, J. (2026). Integrating heritage conservation into urban building energy modelling for retrofit decision-making in historic districts. npj Heritage Science, 14(1), 1.

25. World weather online. (2025). https://www.worldweatheronline.com/bucharest-weather-averages/bucuresti/ro.aspx?utm_source=chatgpt.com

Figures.

Figure 1. Situation of the case study.
Figure 2. Representation of the case study in the software.
Figure 3. Wall and roof layer configurations simulated: (a) base case and (b) case with insulation.
Figure. 4. Yearly solar irradiation with the designed rooftop PV system for building rooftop layouts.
Figure 5. Building Energy Performance: Baseline vs. Improved scenario.

Table 1: Thermal properties of the case study

	Layer	Thickness (m)	λ (W/m·K)	R (m²·K/W)
Wall	Exterior plaster	0.015	0.9	0.017
	Solid brick	0.5	0.6	0.833
	Rock wool	0.06	0.038	1.579
	Interior plaster	0.015	0.9	0.017
Roof	Galvanized steel sheet	0.001	50	0.00002
	Wooden boarding (pine)	0.02	0.18	0.111
	Rock wool	0.06	0.038	1.579
	Interior plaster	0.02	0.35	0.057
Floor	Tile flooring	0.015	1.4	0.011
	Cement screed	0.05	1.1	0.045
	Concrete slab	0.15	1.4	0.107

Table 2: Thermal properties of opening of the case study

Glazing Type	U-value (W/m²·K)	g-value
Standard double glazing 4-16-4	~2.6	0.75

Table 3. Wall and roof layer properties.

	Layer	Thickness (m)	λ (W/m·K)	R (m²·K/W)
Wall	Exterior plaster	0.015	0.9	0.017
	Solid brick	0.5	0.6	0.833
	Phenolic insulation	0.06	0.022	2.727
	Interior plaster	0.015	0.9	0.017
Roof	Galvanized steel sheet	0.001	50	0.00002
	Wooden boarding (pine)	0.02	0.18	0.111
	Phenolic foam	0.06	0.022	2.727
	Interior plaster	0.02	0.35	0.057

Table 4. Glazing characteristics with the proposed amelioration.

Glazing Type	U-value (W/m²·K)	g-value
Standard Triple glazing 4-16-4-16-4	~0.7	0.55

Table 5. Specifications of the PV module used in the simulations.

Heating kWh/m². year	Cooling kWh/m². year	Electricity kWh/m². year	PV generation
91	48	90	0

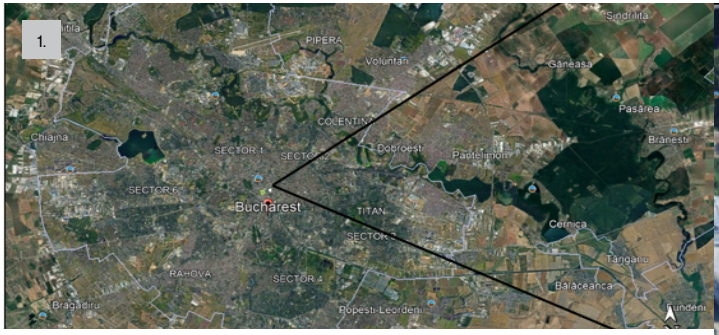
Table 6. Baseline Energy Performance of the building

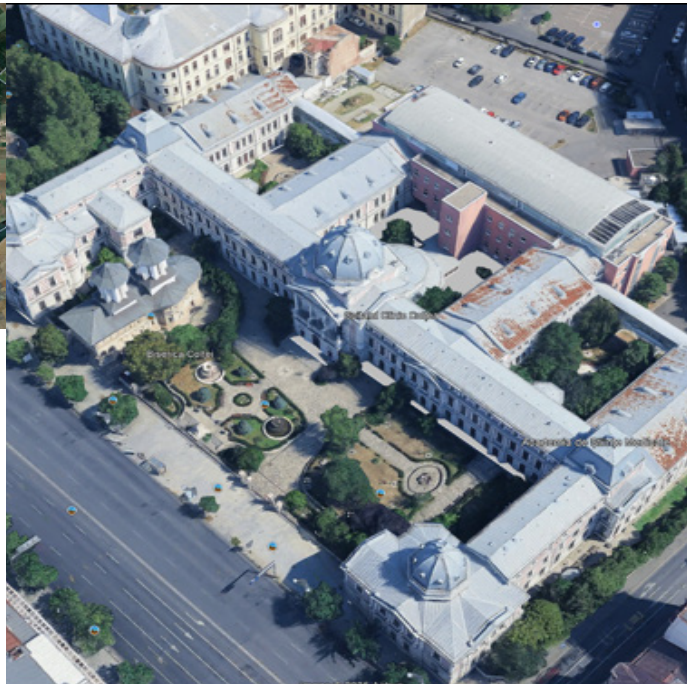
Heating kWh/m². year	Cooling kWh/m². year	Electricity kWh/m². year	PV generation kWh/year
72	42	82	499000

Table 7. Improved scenario energy Performance of the building

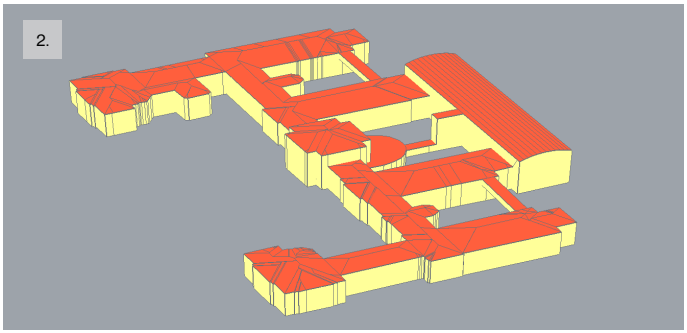
Energy End-Use	Baseline (kWh/year)	Improved (kWh/year)	Reduction (kWh/year)	Reduction (%)
Heating	1,254,703	992,732	261,971	20.90%
Cooling	661,821	579,093	82,728	12.50%
Electricity	1,240,915	1,130,611	110,304	8.90%
Total Consumption	3,157,439	2,702,436	454,973	14.40%

1.

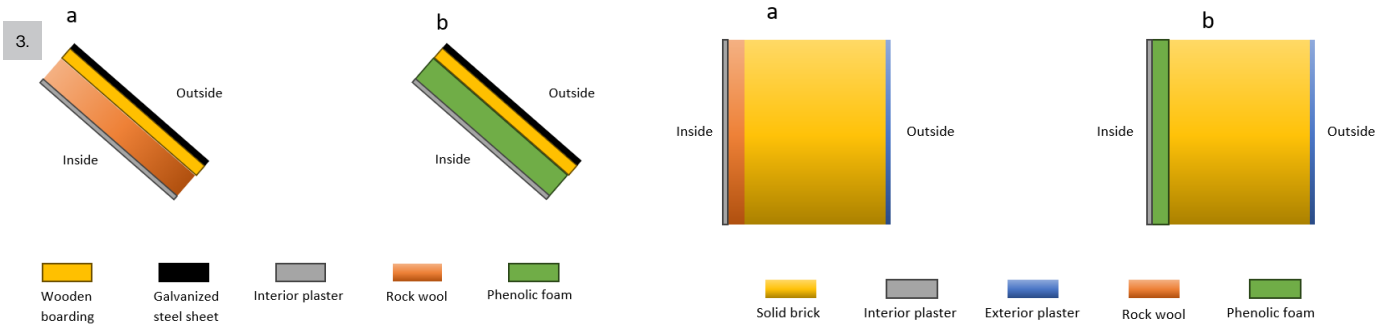

PIPERA
Voluntari
Ganeasa
Pasarea
COLENTINA
Chiajna
SECTOR 1
Dobroesti
Pantelimon
Branesti
SECTOR 6
Bucharest
TITAN
SECTOR 3
Cernica
Tangaru
RAHOVA
SECTOR 4
Balaceanca
Bragadiru
Popesti-Leordeni
Fundeni



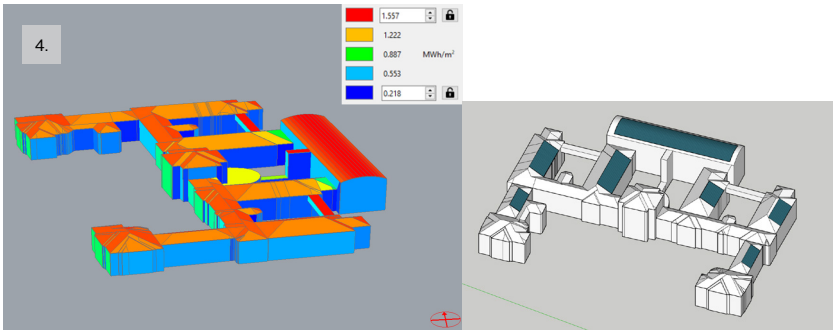
2.



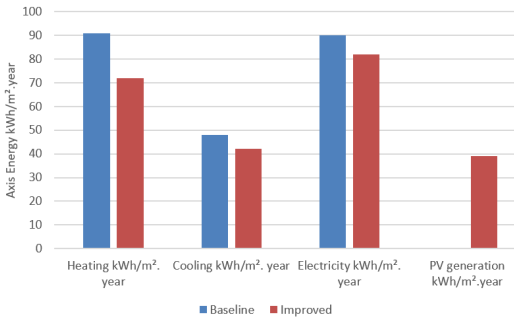
3.


a
Outside
Inside
b
Outside
Inside
Wooden boarding
Galvanized steel sheet
Interior plaster
Rock wool
Phenolic foam
a
Inside
Outside
b
Inside
Outside
Solid brick
Interior plaster
Exterior plaster
Rock wool
Phenolic foam

4.


1.557
1.222
0.887
MWh/m²
0.553
0.218

5.


100
90
80
70
60
50
40
30
20
10
0
Axis Energy kWh/m².year
Heating kWh/m². year
Cooling kWh/m². year
Electricity kWh/m². year
PV generation kWh/m².year
Baseline
Improved

ENERGY EFFICIENCY INTERVENTIONS IN THE CONVENT OF CARMEN IN GEA DE ALBARRACÍN

Luis Bosch Roig / *Universitat Politècnica de València, School of Architecture / Email: luibosro@upv.es*
María José Ballester Bordes / *Universitat Politècnica de València, School of Architecture*
Ignacio Bosch Reig / *Universitat Politècnica de València, School of Architecture*

Abstract. This text focuses on the intervention project carried out at the convent of El Carmen, located in Gea de Albarracín, twenty kilometres west of Teruel, Spain. The commission was established as a result of the Ministry of Transport, Mobility, and Urban Agenda's grant of aid for the promotion of public building rehabilitation (PIREP). This programme introduces as conditions that the intervention must be comprehensive, responding to criteria of sustainability, inclusion and aesthetic quality; it must include actions aimed at improving energy efficiency with a climate contribution coefficient of 100%; as well as a management plan for at least 70% of the non-hazardous waste generated in the work. Finally, it is worth mentioning that the actions are based on the concepts of minimum intervention with reuse of the structural system, acting only occasionally with current materials and designs, essentialised, so that they are integrated into the quality of permanence, while showing their commitment to the current time and culture.

Keywords: Environmental sustainability, Architectural Intervention, Conservation, Restauration

Introduction. The climate emergency at the end of 2019, coupled with the effects of the COVID-19 pandemic, led to the European Commission launching a Recovery and Resilience Facility, as well as the Fit for 55 package of measures, which proposes reducing greenhouse gas emissions by at least 55% in 2030 compared to 1990 levels, requiring member states to develop strategies for renovating their building stock. In Spain, one of the mechanisms proposed has been the Programme to Promote the Renovation of Public Buildings (PIREP), which aims to provide comprehensive intervention based on criteria of sustainability, inclusion and aesthetic quality and must include actions aimed at improving energy efficiency with a climate contribution coefficient of 100% (Secretaría General de Agenda Urbana y Vivienda, 2022). As part of this programme, in 2023 the Ministry of Transport, Mobility and Urban Agenda awarded a grant for the renovation of the Convento del Carmen in Gea de Albarracín, Teruel.

The project proposes a series of actions aimed at regenerating the building and reusing it for socio-cultural purposes, organised into five blocks: improving energy efficiency, focusing on improving the building's thermal envelope on the one hand and improving the thermal and electrical installations on the other; improving environmental sustainability, which includes aspects such as water, use of materials, waste management, adaptation to climate change and protection of biodiversity; improving physical and environmental accessibility; improving habitability and safety; and, finally, actions for the conservation of the building.

Among all the actions taken, it is worth highlighting those related to energy efficiency, which exceed the 30% target set by the PIREP, achieving the goal of zero consumption by improving the insulation of the building envelope, installing a photovoltaic system for use in the building, and improving the heating, electrical and water consumption systems. This text focuses on describing the actions taken in the building to meet the energy efficiency requirements outlined in the PIREP.

Description of the building. The building is located at the eastern end of the town, bordered to the north by the main street and to the west by Plaza del Carmen. It was founded by the Order of Discalced Carmelites in 1673, with construction completed in 1705, and follows the compositional laws of the conventual type, with a rectangular floor plan measuring 46x36m with perimeter naves arranged around a central cloister, built with stone masonry walls. The convent features a church on its north side, accessible from the west façade facing the square, and is divided into three floors, with an additional floor on the south side due to the uneven terrain. The building is sober, massive and closed to the outside, with an architecture where the relevant spaces are concentrated in the interior (Figure 1).

The building has undergone various renovations throughout its history, notably the bricking up of the cloister openings during the 18th century, as well as the work carried out in recent years to adapt the complex for cultural use, which has not been particularly respectful of the original building. Currently, the building is partially in use and exhibits various signs of damage, including cracks, flaking, missing pieces, cement mortar plastering, capillary dampness, and woodworm infestations in the wooden structures.

The premises in use are heated by underfloor heating, which is powered by a boiler located in one of the basement rooms, with a heating oil burner. This same boiler supplies the domestic hot water required by the building. The average seasonal efficiency of the boiler, considering factors such as its age, the type of fuel used, which causes significant soiling of the home, and the lack of control over when it is switched on and off, is barely 72-75%.

On the other hand, the building lacks any type of mechanical ventilation and, consequently, no heat recovery from the extracted air. Currently, the only method of ventilation is through infiltration due to the poor condition of the building envelope and carpentry.

In terms of lighting, the building lacks low-energy lighting installations, such as those utilising LED technology. Many of the rooms are still lit by fluorescent lighting, and some even use incandescent lighting.

In summary, it is estimated that the low energy efficiency of the facilities, together with thermal losses in various areas of the building, leads to high energy expenditure on heating the property (62.14 kWh/m² per year) and lighting the premises (97.86 kWh/m² per year) which, added to the costs of heating water, amounts to a total of 172.05 kWh/m² per year.