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# Energy retrofit and environmental sustainability improvement of a historical farmhouse in Southern Italy

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## Abstract

This paper proposes an integrated rehabilitation project of an abandoned farmhouse in a rural area in Southern Italy. The building underwent a functional recovery to become a tourist accommodation. The use of natural materials can reduce energy consumption and carbon footprints considering environmental sustainability aspects. A proper selection of interventions targeted for the specific warm climate has led to benefits for heating, cooling and lighting in the interior spaces. The project also includes the integration of hydraulic facilities and landscaping, such as planting hedges, green barriers and native trees.

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*Keywords:* Retrofit, warm climate, sustainability, natural insulation, massive wall, renewable energies.

## 1. Introduction

Improving energy efficiency in buildings is one of the priorities of the European Union. Rehabilitating existing buildings allows reducing a huge environmental impact caused by construction and demolition industries [1]. The

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European existing building stock is old, inefficient and renovated at a low pace also because it is characterized by a huge variety of types, climatic conditions, construction materials and systems [2]. These aspects, together with a lack of targeted policies and effective renovation plans, make building rehabilitation a slow and challenging process [3].

If properly planned, building rehabilitation represents a unique opportunity not only to reduce energy consumption and $CO_2$ emissions, but also to improve energy performance obtaining additional environmental, social and economic benefits [4]. Moreover, if the building is endowed with cultural significance, architectural rehabilitation retains and promotes an extra uncountable capital: the built historical heritage [5]. The process involves retrofitting to meet current energy efficiency regulations, construction guidelines, and standards on comfort and usage. However, these structures are generally quite old and particularly fragile. They should be treated as non-renewable resources whose intrinsic value should not be altered by modernization [6].

Preserving traditional architecture is embodied in the concept of sustainability as it represents an occasion for preserving a sustainable growth for future generations. Apart from technical and energetic aspects, it is evident how this concept touches cultural, economic, social, and environmental spheres [7]. Rehabilitating these buildings requires a delicate balance between maintaining their authenticity and meeting current requirements, returning their value to the society [8].

Following the principles of architectural conservation [9], local construction materials and traditional practices should be the first choice of any intervention, avoiding, when inappropriate, the introduction of new materials and systems that endanger their identity [10]. However, this does not imply an a priori exclusion the adoption of certain technologies that support energy efficiency. As example, in relation to renewables, photovoltaic systems have been successfully introduced in old structures after cautious studies and evaluations [11,12]. The rehabilitation allows a new stage within a building lifecycle, obtained by largely reusing already built components and structures, with addition of materials and energy disposal. Above all, the rehabilitation should preserve the integrity, aesthetic, and significance of the site giving back its utility and functionality that bring economic and touristic interests [13].

To comply with the Energy Performance of Building Directive (EPBD) recast (European Parliament, 2010), national governments adopted specific actions to rehabilitate and preserve buildings having a cultural value. A growing interest in this topic is testified at European level by the Standard "aiming at facilitating the sustainable management of historic buildings by integrating measures for energy efficiency improvements and reduction of greenhouse gas emissions with an adequate conservation" [14].

In the Italian framework, rehabilitation of historical buildings is particularly relevant as the 40% of world heritage is retained in this country [15]. Among the initiatives to rehabilitate dismissed buildings, in Sicily and Sardinia regions local authorities sell abandoned buildings at the symbolic cost of 1 euro, on the condition of renovating the structure within two years.

Respecting a building architectural heritage is only the starting point of multiple evaluations to be carried out within a holistic project of renovation [16]. This project should consider the building as integrated in his unique territory and peculiarities. It should be able to preserve historical values, cultural practices and distinctive landscapes. With this approach, each intervention has to be a suitable and sustainable solution chosen with respect to the characteristics of the building and its environment [17].

Based on the ITACA (Institute for Innovation and Transparency of Contracts and Environmental Compatibility) protocol, the Italian National Standardization Authority (UNI) has developed the Reference Practice "Evaluation of environmental sustainability of buildings"[18]. The Green Building Council, one of the most important organization that promotes sustainability protocols, has recently realized the procedure for the environmental sustainability of historic buildings belonging to the Italian historic heritage [19]. The proposed methodological approach combines the International Leed standard with the specific need of historic buildings restoration [20]. It includes a multi-criteria analysis to evaluate the environmental sustainability of buildings. However, considering the difficulties of collecting the needed information and the risk of obtaining high approximations, the ITACA methodology appears more suitable, also in case of historic buildings.

The European Commission also promotes a Rural Sustainable Development to encourage Member States towards the renovation of existing buildings located in rural areas. Several benefits are linked to this development: growth of green areas, improvement of traditional agricultural activities, protection of historical sites, cultural and historic heritage valorization, promotion of tourism and local economy [21].

Within this framework, historic farmhouses are buildings spread across the South of Italy. In the Apulia region, these constructions are in the countryside surrounded by olive groves and vineyards. While abandoned for many decades, over recent years many of these buildings underwent rehabilitation to offer guest accommodation. Investments towards this direction have been encouraged by the Apulia region with specific actions and funds dedicated to the valorization of farmhouses and historical residences. This process appears to boost local economies, moving cultural, touristic and construction sectors. Tourists like the peaceful atmosphere that characterizes farmhouses as well as the typical warm welcome given by family members and the home-cooked cuisine that often uses local products, above of olive oil, wine, vegetables and cheese.

This paper describes the rehabilitation project of a previously abandoned farmhouse located in a rural area in the province of Lecce (Apulia region, Southern Italy). The studied building has been entirely renovated and converted into touristic accommodation. Many aspects have been considered in the project, starting from consolidation and structural interventions. Following traditional practices, local and recyclable materials, such as lime and hemp, have been adopted. The reported case study proposes an integrated approach to building rehabilitation able to boost the local economy and a sustainable tourism respecting the landscape and the environment.

**Nomenclature**

| | |
|---|---|
| S | surface ($m^2$) |
| d | total thickness (m) |
| v | volume ($m^3$) |
| ρ | density (kg/ $m^3$ ) |

### *1.1. The environmental Sustainability Protocols*

The environmental sustainability of this project is evaluated through the ITACA Protocol, developed by the Institute for Transparency of Contracts and Environmental Sustainability. The ITACA Protocol is a guide for introducing environmental sustainability in the construction sector. Through the proposed methodological approach, it is easier to identify the key elements of a sustainable building design focused on natural resources saving and life quality improvement.

The principle core aim is to share a standard workable protocol at international level as identified in the Sustainable Building Method (SB Method), i.e. a methodology of the Green Building Challenge international research project, managed by iiSBE (International Initiative for Sustainable Built Environment) since 2002. The ITACA Protocol is identified as a tool for sustainability evaluation adopted by the Italian Association of Regions.

The methodology for the calculation of the sustainability score of a project comprises different criteria, organized in five sections. The criteria cover the entire production process of a building: from its construction to maintenance, evaluating the performance for each phase. This evaluation is applicable to both new and existing buildings (refurbishment) and for different uses. The criteria have different weights within the overall score calculation. The weight is the degree of the criteria importance as assessed in the ITACA Protocol, and it is determined by estimating its environmental impact.

The ITACA Protocol encourages the re-use of materials or the adoption of recycled materials. Furthermore, the value of the project increases when materials come from natural sources such as plants or animals. Another important point is the choice of building materials from local producers in order to shorten the distance to cover to reach the building site and to decrease the emissions produced during their transport. The ITACA Protocol encourages materials produced within a 150 km distance from the building. The “eco-sustainable” criterion evaluates the percentage of eco-sustainable certified materials at national and international level.

### 1.2. Natural materials, the use of the hemp and lime

A key aspect of the rehabilitation project of this paper is the adoption of natural materials like hemp and lime. This pilot project places the attention on the necessity to use high efficient elements for building retrofit that are able at the same time to reduce global energy consumption and to minimize carbon footprints. With this aim the materials' environmental and lifecycle behaviors are considered in the analysis.

In this scenario, the adoption of hemp and lime materials fulfils the need to use natural compounds characterized by local and biological elements. The combination of hemp and lime results in a solid structure particularly useful for envelope insulation. The vegetal part of this compound is usually a discard of the hemp manufacturing process. Using this part as a building material helps the exploitation of each part of the plant. The result is a product that can resist to the potential causes of deterioration due, for example, to environmental factors such as bacteria, moulds and all those elements that can weaken mechanical and thermal proprieties over time.

The assessment of the energy performance of the rehabilitated building is a way to highlight how these natural materials behave emphasizing their role in energy saving strategies.

### 1.3. The impact of the climatic area

Climate has an impact on the thermal comfort of a building. To address this issue, different studies focus on the optimization of the thermal parameters to reach a high efficiency envelope depending on the climatic area [22- 23].

Sami et al. [24] study buildings located in North Europe using multi–layered walls. These are characterized by structural materials with a low value of density and a high thickness of thermal insulation to reach an envelope with very low values of steady thermal transmittance. The building design in cold climates requires a focus on the winter season and on the preservation of internal heat. For these reasons, highly insulating techniques are preferred in this type of climate. In warm climates, Congedo et al. [25] demonstrate that a hyper-isolated envelope does not permit the discharge of the accumulated heat at night because of a low thermal mass and a low thermal inertia.

The authors highlight that it is not necessary to keep the thermal transmittance too far below the levels required by law. Furthermore, the thermal accumulation mass of the envelope can be used as a thermal storage reserve. In a warm climate, the thermal overload is often irreversible if there is not a correct control of radiation and heat free supply inside the building. The project illustrates that it is crucial to have a high areal heat capacity and high admittance in order to avoid overheating and summer discomfort in buildings located in this climate.

Borgo Sentinella is a farmhouse located 900 meters from the beach of Torre dell'Orso in Southern Italy (see Fig. 1).

Figure 1 - Orto photo of Torre dell'Orso, Fraction of Melendugno, Lecce, Italy.

## 2. Description of the renovation project

The farmhouse showed a high degree of degradation especially in relation to the envelope. The renovation project has been planned for a reuse of the building through a structural consolidation made in full compliance with environmental constrains. The Borgo Sentinella is composed of three buildings (Figure 2), divided in eleven apartments for a total of 36 sleeping accommodation, typically for a summer use. No area expansion has been planned, respecting the original site configuration.

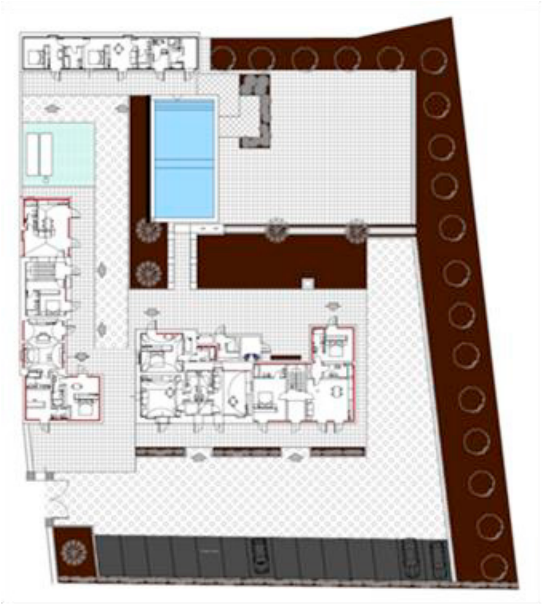

Figure 2 - Floor plan of the entire complex.

In order to preserve the integrity of the rural structure, the use of local materials has been encouraged. Stones, lime, hemp, mortars, tuff, wood and wrought iron have been used following the original style of Puglia farms. Figure 3 shows a detail of Hemp-lime internal coat and Figure 4 reports a traditional system called “incannicciato”.

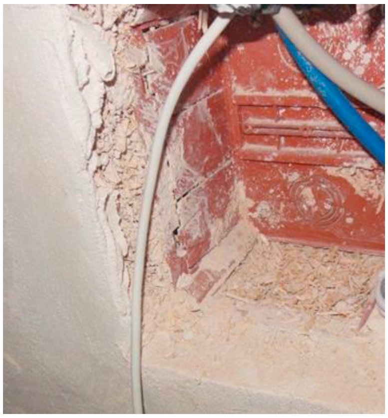

Figure 3 - Detail of Hemp-lime internal coat.

Figure 4 - Detail of “incannicciato”.

The accommodation is surrounded by the typical Mediterranean flora, with reeds, carobs, prickly pears, olive trees and pomegranates. The project involves the reorganization of the outdoor spaces to meet new functional requirements. These include the planting of native trees and shrub species to recover the local environment (Figure 5) around the buildings. Following the ITACA protocol, there is a graywater storage tank for the bathroom services (Figure 6). Ten bicycles are available to users.

Figure 5 - Mediterranean vegetation.

Figure 6 - Greywater tank.

### *2.1. Envelope Efficiency*

In order to improve the envelope efficiency and the reduction of heat losses, the farmhouse recovery project has focused on the envelope surfaces.

In relation to the opaque vertical surfaces, a 0.1 m thick hemp/lime thermoplaster has been realized. Further interventions have been conducted on the horizontal opaque surfaces through the insulation and the solar pavement refurbishment as well as the realization of a pavement with an isolated ventilated crawl space to limit the effects of rising damp and the dispersion of energy towards the ground.

About the windows, wooden frames (thickness 0.068 m) have been installed. These are characterized by low-emissivity glasses 3+3/15/3+3 ($U_g$ 1,4 W/mqK), $U_w$ 2,2 W/mqK.

The shading is guaranteed using shade screens in a traditional shading scheme, as shown in Figure 7. The system is designed to be disassembled to allow free solar radiation entering the structure in winter.

Figure 7 - The traditional shading systems with canes.

In order to evaluate the environmental sustainability, the origin of each building material has been considered together with the distance from the construction site. The purpose of this evaluation is to encourage the use of local materials to reduce the environmental impact of transport and to promote the local economy. The data used in the calculation are reported in Table 1 with the indication of the provenience of the local heavy materials that originate at a distance within 300 km from the site. Table 2 shows the finishing materials and their source of origin that is located within 150 km.

Table 1. Data for the calculation of the% of material from establishments within 300 km.

| | Elements | S(mq) | d(m) | v(mc) | ρ(Kg/mc) | No local Heavy materials (Kg) | Local Heavy materials (Kg) | Total Heavy materials (Kg) |
|---|---|---|---|---|---|---|---|---|
| External Walls (25 cm) | Hemp and lime plaster | 360 | 0,1 | 36 | 200 | | 7194,9 | 7194,9 |
| External Walls (30 cm) | Hemp and lime plaster | 174 | 0,1 | 17 | 200 | | 3486,8 | 3486,8 |
| External Walls (35 cm) | Hemp and lime plaster | 17 | 0,1 | 2 | 200 | | 348 | 348 |
| External Walls (40 cm) | Hemp and lime plaster | 68 | 0,1 | 7 | 200 | | 1363,8 | 1363,8 |
| External Walls (45 cm) | Hemp and lime plaster | 29 | 0,1 | 3 | 200 | | 572 | 572 |
| External Walls (50 cm) | Hemp and lime plaster | 61 | 0,1 | 6 | 200 | | 1212,2 | 1212,2 |
| External Walls (60 cm) | Hemp and lime plaster | 57 | 0,08 | 5 | 200 | | 572 | 572 |
| External Walls (65 cm) | Hemp and lime plaster | 103 | 0,08 | 8 | 200 | | 1643,2 | 1643,2 |
| External Walls (80 cm) | Hemp and lime plaster | 29 | 0,06 | 2 | 200 | | 349,8 | 349,8 |
| External Walls (100 cm) | Hemp and lime plaster | 34 | 0,06 | 2 | 200 | | 406,08 | 406,08 |
| Ground floor | Leveling screed | 473 | 0,02 | 9 | 2200 | | 20820,8 | 91800,8 |
| | Reinforced screed with hemp and lime | 473 | 0,1 | 47 | 1500 | | 70980 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Wooden roof | Screed in tuff lime and natural fiber | 233 | 0,1 | 23 | 1500 | | 34879,5 | 55807,2 |
| | Clay roof tiles | 233 | 0,05 | 12 | 1800 | 20927,7 | | |
| Reinforced concrete roof | Reinforced concrete slab (20+5) | 103 | 0,25 | 26 | 1200 | | 30816 | 73547,52 |
| | Screed (8 cm) | 103 | 0,08 | 8 | 2200 | | 18078,72 | |
| | Tuff (10 cm) | 103 | 0,1 | 10 | 1800 | | 18489,6 | |
| | Cursi stone (4cm) | 103 | 0,04 | 4 | 1500 | | 6163,2 | |
| Vaulted ceiling | Screed | 127 | 0,08 | 10 | 2200 | | 22341,44 | 52.807,04 |
| | Tuff | 127 | 0,1 | 13 | 1800 | | 22849,2 | |
| | Cursi stone | 127 | 0,04 | 5 | 1500 | | 7616,4 | |
| Wooden loft | Hemp and lime plaster | 174 | 0,02 | 3 | 200 | | 696,48 | 30863,49 |
| | Gypsum fiber | 174 | 0,02 | 3 | 1150 | 4010,51 | | |
| | Screed in tuff lime and natural fiber | 174 | 0,1 | 17 | 1500 | | 26155,5 | |
| Windows | Glass | 63 | 0,008 | 1 | 2500 | | 1250,4 | 2891,55 |
| | Frame | 16 | 0,07 | 1 | 1500 | | 1641,15 | |

Table 2. Data for the calculation of the% of local materials for the finishing within a distance of 150 km.

| | Elements | S(mq) | d(m) | v(mc) | ρ(Kg/mc) | No local finishing materials (Kg) | Local finishing materials (Kg) | Total finishing materials (Kg) |
|---|---|---|---|---|---|---|---|---|
| External Walls (25 cm) | Lime solution | 360 | 0,002 | 0,7 | 1150 | 827 | | 827 |
| External Walls (30 cm) | Lime solution | 174 | 0,002 | 0,3 | 1150 | 401 | | 401 |
| External Walls (35 cm) | Lime solution | 17 | 0,002 | 0 | 1150 | 40 | | 40 |
| External Walls (40 cm) | Lime solution | 68 | 0,002 | 0,1 | 1150 | 157 | | 157 |
| External Walls (45 cm) | Lime solution | 29 | 0,002 | 0,1 | 1150 | 66 | | 66 |
| External Walls (50 cm) | Lime solution | 61 | 0,002 | 0,1 | 1150 | 139 | | 139 |
| External Walls (60 cm) | Lime solution | 57 | 0,002 | 0,1 | 1150 | 132 | | 132 |
| External Walls (65 cm) | Lime solution | 103 | 0,002 | 0,2 | 1150 | 236 | | 236 |
| External Walls (80 cm) | Lime solution | 29 | 0,002 | 0,1 | 1150 | 67 | | 67 |
| External Walls (100 cm) | Lime solution | 34 | 0,002 | 0,1 | 1150 | 78 | | 78 |
| Ground floor | Gres floor | 473 | 0,01 | 4,7 | 2300 | 10884 | | 10884 |
| Reinforced concrete roof | Cursi stone | 103 | 0,04 | 4,1 | 1500 | | 6163 | 6163 |
| Vaulted ceiling | Cursi stone | 127 | 0,04 | 5,1 | 1500 | | 7616 | 7616 |
| Wooden loft | Gres floor | 174 | 0,02 | 3,5 | 2300 | 8021 | | 8021 |
| Coating with micro-concrete | Block A | 155 | 0,003 | 0,5 | 2200 | | 1023 | 4950 |
| | Block B | 229 | 0,003 | 0,7 | 2200 | | 1511 | |
| | Block C | 366 | 0,003 | 1,1 | 2200 | | 2415 | |

According to the environmental sustainability protocol, the use of recyclable materials, the energy consumption reduction deriving from raw materials and the demolition wastes have been considered in the analysis.

### *2.2. Energy evaluation*

Figure 8 shows the three-dimensional model of the building used for the energy calculation. The building location presents 1153 degree-days, a typical value of the national climatic zone C, characterized by 137 heating days and an average irradiance value equal to 315 W/mq during the maximum radiation month.

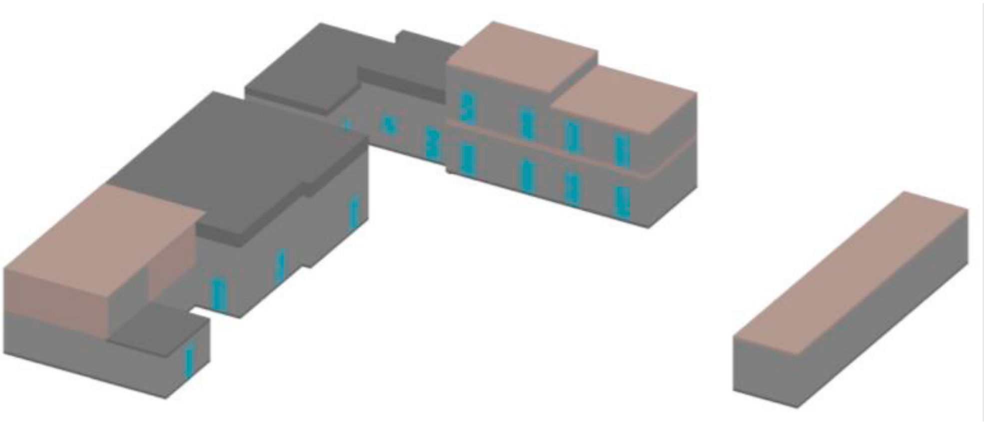

Figure 8 - Three-dimensional model of the building.

The farmhouse site is characterized by a Mediterranean climate with not extreme winters and very dry summers. Rainfall is concentrated mainly in autumn and winter. The heating period runs from November 15th to March 31st with an internal set point temperature of 20°C, while the design temperature is fixed at 26°C in summer.

As reported in Figures 9-11, the complex has been divided into three thermal zones and each zone has been split into different locals. Table 3 reports the geometry adopted for the calculation.

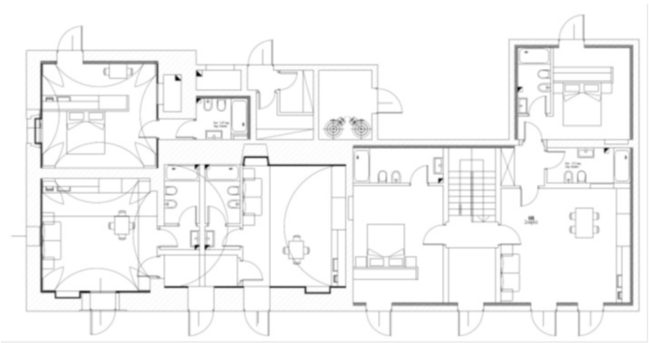

Figure 9 - Thermal zone A.

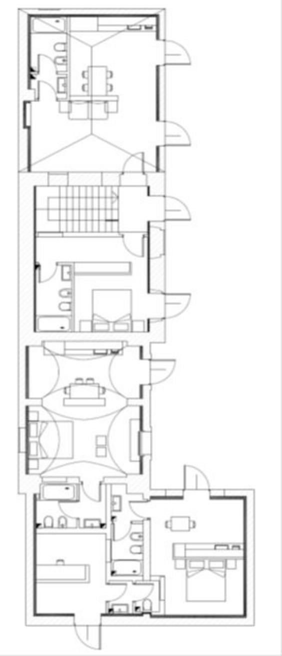

Figure 10 - Thermal zone B.

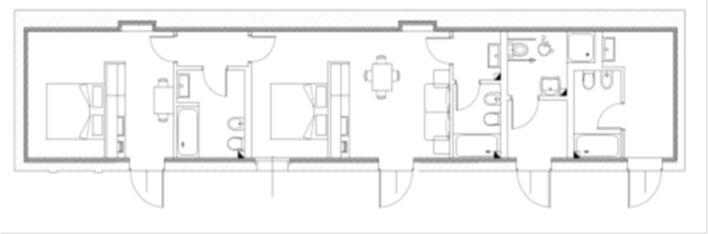

Figure 11 - Thermal zone C.

Table 3. Geometries adopted for the calculation.

| | Block A | Block B | Block C |
|---|---|---|---|
| Total Surface ($m^2$) | 323,3 | 253,2 | 98,2 |
| Net Surface ($m^2$) | 231,1 | 175,9 | 66,2 |
| Total height ($m^2$) | 460 | 437 | 400 |
| Net height ($m^2$) | 370 | 367 | 340 |
| Net Volume ($m^2$) | 855,1 | 534,8 | 225,1 |

### *2.3. Resource consumption*

The opaque structures present transmittance values significantly below the regulatory limits. The thermal inertia of the building envelope ensures limited fluctuations in temperature between the indoors and the outdoors caused by variations of the external temperature. This kind of envelope maintains good thermal comfort conditions inside the building in summer, avoiding overheating. The related parameters result extremely low and optimal for a warm climate. Three VRF (heat pump) for each zone have been used both for heating and cooling (Table 4).

Table 4. System characterization.

| | | | GMV-140WL/A-T | GMV-224WM/B-X | GMV-280WM/B-X |
|---|---|---|---|---|---|
| Capacity | Cooling | kW | 14,00 | 22,40 | 28 |
| | Heating | kW | 16,50 | 25,00 | 31,5 |
| Connection Ratio | | % | 15-135 | 10-100 | 10-100 |
| EER | | | 3,52 | 4,31 | 4 |
| COP | | | 4,14 | 4,55 | 4,32 |
| Rated input | Cooling | kW | 3,98 | 5,20 | 7 |
| | Heating | kW | 3,99 | 5,50 | 7,3 |
| Rated current | Cooling | A | 19,20 | 9,30 | 12,5 |
| | Heating | A | 19,30 | 9,80 | 13 |
| Refrigerant | Type | | R410A | R410A | R410A |
| | Charge Volume | Kg | 5,00 | 5,90 | 6,7 |
| Airflow rate | | m3/h | 6.300,00 | 11400 | 11400 |
| Wiring connection | Cable size | mm2 | 4,00 | 2,50 | 2,50 |
| Piping | Gas Pipe size | inch | 5/8 | 3/4 | 7/8 |
| | Liquid Pipe size | inch | 3/8 | 3/8 | 3/8 |
| Sound pressure level | | dB(A) | 56,00 | 60 | 61 |
| Outline dimension | W | mm | 900,00 | 930,00 | 930,00 |
| | D | mm | 340,00 | 765,00 | 765,00 |
| | H | mm | 1.345,00 | 1.605,00 | 1.605,00 |
| Net weight | | Kg | 110,00 | 225,00 | 225,00 |
| Maximum ID NO. | | unit | 8,00 | 13,00 | 16,00 |
| Max. equivalent pipe lenght | | m | 120,00 | 165,00 | 165,00 |
| Recommended Circuit breaker | | A | 32,00 | 20,00 | 25,00 |

Two solar thermal systems have been designed. Each one is made of 12 panels of 2.26 $m^2$ of absorbent surface with an inclination of 45° and a storage tank of 1000 l. A photovoltaic plant of 15 kWp and 10° inclination have been installed. In Figure 12 the building thermal requirements are shown.

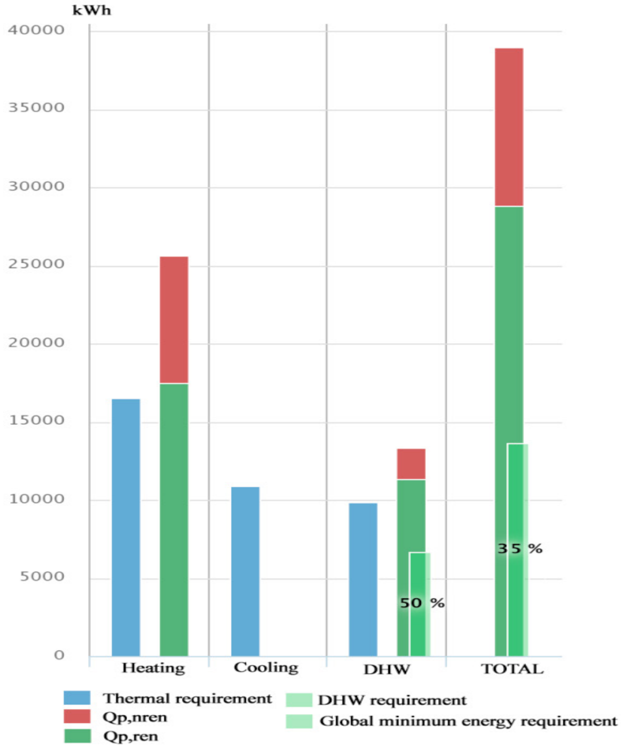

Figure 12 – Thermal requirements.

The building has a primary energy consumption of 22.23 kWh/m² year. The net energy requirement for heating is determined by three major contributions: free gains, ventilation demand and envelope heat transmission. Benchmark strategies are aimed at containing the energy wasted for heat transmission through the envelope and ventilation, maximizing at the same time free internal and solar gains (Qi = 20102 kWh/year). The net energy demand for cooling is the minimum theoretical amount of energy needed to cool the building during summer. Considering these aspects, the studied building appears to be efficient since it has a massive envelope and the insulation does not include excessively light materials (Epe = 6384 kWh/year).

## 3. Conclusions

This paper presents a rehabilitation project of a farmhouse located in a rural area in Southern Italy (Apulia region, province of Lecce). This building was previously abandoned and underwent a functional recovery to be converted into touristic accommodation.

The project includes a series of actions aimed to improve the energy efficiency and environmental sustainability of the whole building. The envelope efficiency has been improved through external walls with a thermal-plaster made of natural materials such as lime and hemp. A VRF system has been considered in order to air-condition the internal environment and RES to optimize the relative power consumption.

In compliance with the ITACA protocol, the materials used for this project are local, natural and re-usable for new uses at the end of their life. The study points out the results achieved using hemp and lime for the rehabilitation of the building. The obtained compound presents some advantages such as low-density and good thermal performances. The study underlines how this compound is adequate to the local climate and has a positive impact on the building internal comfort. It is able to regulate the indoor humidity through the release and absorption of moisture thanks to its porous physical structure. It has been also noted that the reduction of energy consumption and the improvement of the indoor microclimate implies benefits for human health due a better indoor air quality.

To account for the effects of humidity and energy dispersion through the ground, a floor with isolated ventilated crawl space has been designed. Furthermore, the installation of thermal break windows with low-emissivity glass has been realized.

Besides energetic aspects, the origin of each individual building material has been evaluated. With this aim, the distance from the construction site has been considered to encourage the use of local and recyclable materials that reduce the environmental impact of transport and promote the local economy.

The farmhouse has a prevailing summer use, so shade screens were provided in a traditional "incanicciato" scheme outside the glass surface. This structure can be removed in winter to avoid the shading of windows.

A careful rehabilitation design which considers the building climatic conditions and the use of natural resources has led to significant benefits for lighting, ventilation and cooling of the interior spaces. In particular, in winter the building is able to limit the energy lost for heat transmission through the envelope thanks to a massive envelope and a proper insulation which also reduce ventilation. At the same time, the structure is able to maximize free internal and solar gains in winter while a low amount of energy is required to cool the building in summer.

The renovated building has a primary energy consumption of 22.23 kWh/m² year. The building components, in addition to fulfill their specific function, are also capable of performing energy requirements, namely to capture, accumulate, store and return the thermal energy.

The proposed retrofit project presents several benefits, reducing energy consumption: it boosts the local economy involving cultural, touristic and construction sectors. The methodological approach and implemented measures can be used as a guide for similar rehabilitation projects.

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