Rehabilitation of a traditional building in Aglantzia.

Pilot experience to improve the thermal performance of a traditional building.

Type of intervention

☐ *Restoration* ☒ *Rehabilitation / Renovation*

Concerned elements on the intervention project

☐ *1. Foundations and underground structures*
☐ *2. Vertical structures*
☐ *3. Horizontal structures and vertical connections*
☒ *4. Roof and terraces*
☐ *5. Façade and building envelope*
☒ *6. Finishes and completion elements*
☒ *7. Integrate services*
☒ *8. General strategies for building recovery*

Site	Mpakaliko stin Palia Aglantzia, Andrea Demetriou 3, Aglantzia, 2108
Objectives	Rehabilitation intervention and energy retrofit.
Property	Public: Aglantzia Municipality
Designer	FOSS Research Centre for Sustainable Energy, University of Cyprus: Aimilios Michael, Chryso Heracleous, Maria Xenophontos
Date	2001 (renovation from Ioakim & Loizas) 2017-2021 (Rehabilitation intervention and energy retrofit)

Background to the intervention

The dwelling was restored and conserved using traditional material and techniques. The proposal aims at creating a multifunctional space where besides the promotion of contemporary technologies, it will have the possibility to host events, seminars, artistic performances etc. and at the same time it will function as a reading room - a digital library for young citizens and students.

The traditional building was selected to be an example where a hybrid electrical-thermal storage system will be installed in the Mediterranean region as part of an ongoing research programme i.e. HYBUILD, which is funded by the European Union through HORIZON 2020. The installed system will be used as a Renewable Energy and Smart Solution Center by the municipality with the support of the University of Cyprus. The selection aims at the rehabilitation of vernacular buildings and the promotion of both bioclimatic features incorporated in vernacular architecture and new technologies that can be adapted in such buildings.

Description of the building

The building is a representative vernacular building, in terms of typology and building materials. The building under study is located in the core of the traditional settlement of Aglantzia (lowland region - climatic zone 2). Like the rest of the island, Aglantzia has a Mediterranean climate with hot-dry summers and relatively cold-wet winters. With regard to typology, the building plan is “I”-shaped as a more compact and simple form of linear placement of the individual spaces. The interior arrangement of the central part of the building volume is divided into a double bay (dichoro).

The traditional buildings are characterized by main spaces with high ceilings of approximately 3.5-4.5m. The high ceilings help in the isolation of heat gains on upper levels maintaining indoor spaces cooler during the summer period while enhancing the potential for natural ventilation. The traditional buildings were mostly made of materials available in the region. Thick masonry walls made of adobe and stones are the most common materials. The building under study has a 50-55cm thick stone masonry wall with rubble infill providing high thermal inertia. The thermal conductivity of the stone is estimated at 0.538W/m2K based on laboratory measurements and calculations.

The roof is slightly inclined and originally consisted of a thick layer of beaten earth which was laid on matting. The roof layers were supported by timber beams. At the retrofitting stage the beaten earth was replaced with OSB and thermal insulation of 12cm extruded polystyrene giving a thermal conductivity of U value = 0.28 W/m2K. The windows consist of single glazing with 30% of surface to be wooden frame of total U value 4.7 W/m2K.

Fig.1: Exterior views of the building before conservation.
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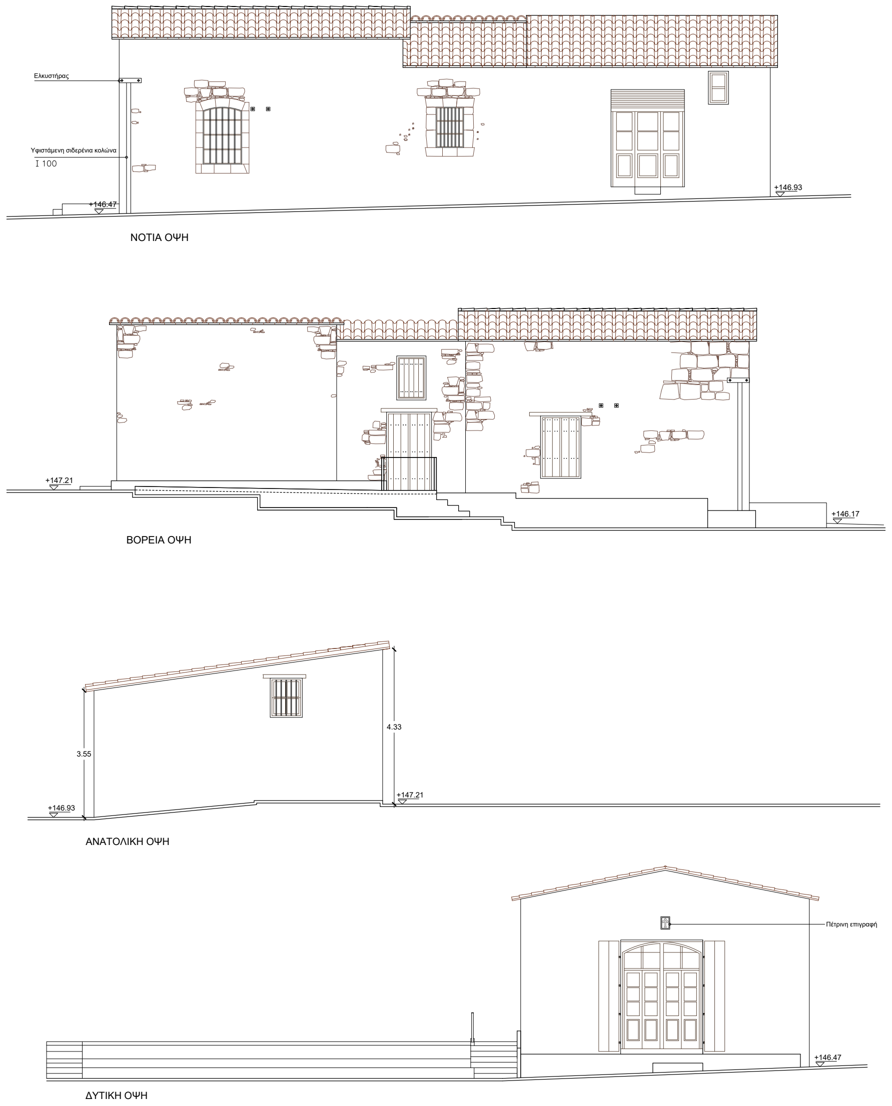

Fig.2-3: Drawings of the elevations of the building.
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The Diagnosis of the building (values and state)

Before the rehabilitation of the building, the building was not in use and empty. The building had no heating and cooling systems, leading to high levels of moisture in the walls. Moreover, suffering from obsolete electrical and lighting systems and with no furniture equipment relevant to the proposed use.

Fig.4: View of the building before restoration. © FOSS Research Centre for Sustainable Energy / University of Cyprus

For the investigation of the thermal performance of the vernacular building, a field study has been carried out from January 2019 until February 2020, covering all seasons. During the period under investigation, specific environmental parameters were recorded in the outdoor and indoor environment. It should be noted that the monitoring period started after the retrofitting of the roof and the installation of 12cm extruded polystyrene.

Fig.5: View of the building before restoration. © FOSS Research Centre for Sustainable Energy / University of Cyprus

During January, February and March, the building fails to maintain indoor thermal comfort as no recorded time falls within 90% or 80% acceptability limits descripted by ASHRAE. The maximum average temperature in the building during these three months is 15.47°C. However, it is interesting to mention that the mean minimum temperature indoors is about 7-7.5°C above the outdoor temperature. During April, the percentage within the 80% and 90% acceptability limit is only 10.3% and 3.1% of the time respectively. During May, the building is within the 80% and 90% acceptability limit for 61.7% and 52.9% of the time respectively, while during June the building achieved one of the highest percentages within the comfort zone compared to other months. Specifically, the operative temperature was within the 80% and 90% acceptability limit for 88.1% and 81.1% of the time. During July, the percentage within the 80% acceptability limit drops to 46.8%. The percentage within the 90% acceptability limit drops to 4.6%. It is worth noting that the whole building fails to maintain indoor thermal comfort during August as none of the spaces exhibits temperatures within the comfort zone.

However, it should be noted that although the outside temperature reaches up to about 40°C, the indoor temperature shows small temperature deviation from the acceptable limits in a range of 1 - 2.3°C difference from the 80% acceptability limit. The building remained closed; therefore, the heat absorbed by the building could not be released to the outside environment leading to higher indoor temperatures. During September, the building is within the 80% and 90% acceptability limit for 50.4% and 28.6% of the time, while during October, the building is nearly all the time within the comfort zone with a percentage of 99.4% for the 80% acceptability limit. During November, the percentage is reduced to 69.8% and 60.7% for the 80% and 90% acceptability limit, while during December, the temperature falls out of the comfort zone most of the time, being only 5.5% of the time within the 80% acceptability limit.

The onsite monitoring results during the winter period, and early intermediate period, show that the thermal comfort conditions of spaces are unsatisfactory and require a large amount of energy to keep indoor thermal comfort. During the late intermediate period, and early summer period, the building provides acceptable indoor temperatures without the aid of an artificial system. However, the building requires much less energy for cooling.

The recorded data for relative humidity show that for most of the time (from May to December) the building totally meets the norms with values between 40-70%. During February and March, the building exhibits higher relative humidity due to lower indoor temperatures having only 20-30% of the data between acceptable limits.

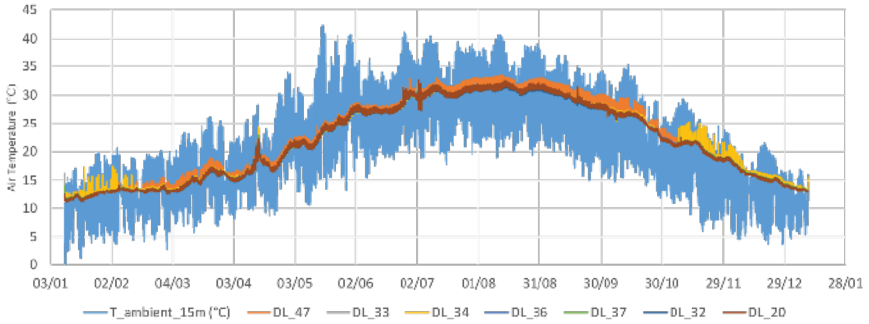

Fig.6: The existing lighting system uses halogen lamps with large energy losses. © FOSS Research Centre for Sustainable Energy / University of Cyprus

Rehabilitation works

The building is upgraded to a hands-on technology exhibition area of renewable energy systems complimented with visual means to enhance the experience of visitors under a Research European Programme (Horizon 2020).

Interior retrofitting works

The internal configuration of auxiliary spaces (toilets and mechanical room) has been changed in order to assist in the smooth operation of the building. Moreover, the problems of moisture on the walls inside and outside have been repaired.

Fig.7: Interior view of the central space – double space room (dichoro). © FOSS Research Centre for Sustainable Energy / University of Cyprus

Fig.8: Interior view of the central space – double space room (dichoro). © FOSS Research Centre for Sustainable Energy / University of Cyprus

Fig.9-11: Renderings of the proposal.

Fig.12-17: Views of the building during conservation. © FOSS Research Centre for Sustainable Energy / University of Cyprus

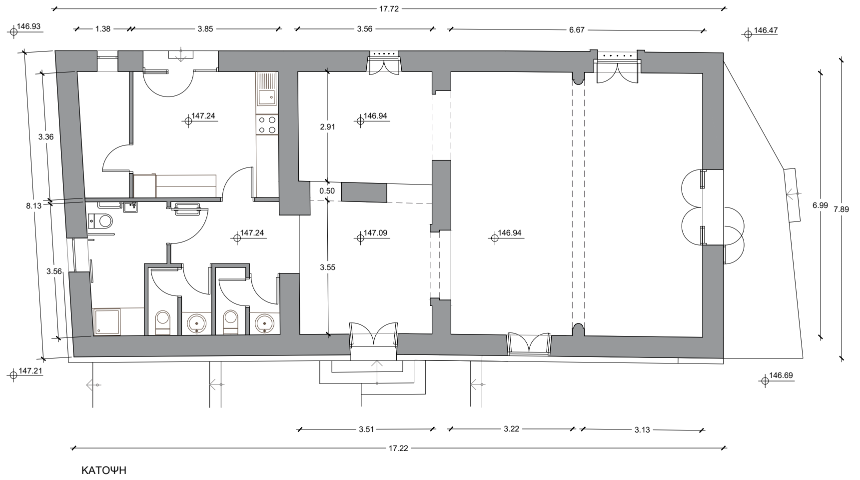

Fig.18: Floorplan before restoration. © FOSS Research Centre for Sustainable Energy / University of Cyprus

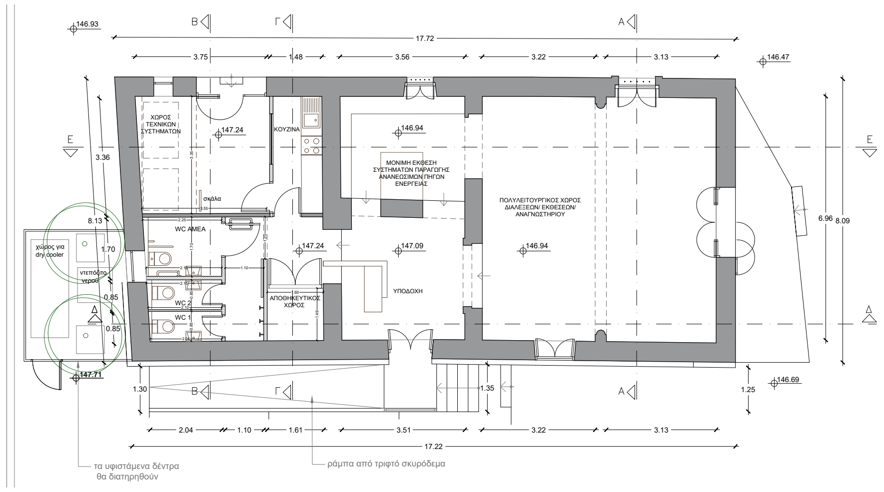

Fig.19: Floorplan after restoration. © FOSS Research Centre for Sustainable Energy / University of Cyprus

Improvement of thermal performance of the roof

At the retrofitting stage the beaten earth was replaced with OSB and thermal insulation of 12cm extruded polystyrene giving a thermal conductivity of U value = 0.28 W/m2K.

Fig.20-22: Improvement of the roof's thermal performance. © FOSS Research Centre for Sustainable Energy / University of Cyprus

Lighting

The lighting system was replaced with LED-type sources for the improvement of energy efficiency. The choice of LED light sources meets the following performance requirements:

- luminous efficiency, for obvious economic reasons;
- the high colour rendering;
- the luminance;
- lifespan and maintenance of the luminous flux over time;
- the colour temperature suitable for the materials and characteristics of the surfaces to be illuminated;

Installation of PV System

For the needs of the project, 5kWp installed peak power were installed.

Fig.23-25: Installation of PV System.

HYBUILD System

The HYBUILD systems combine thermal (sorption, latent and sensible) and electric storages in one system. Solar energy can be stored in the sorption storage (Mediterranean concept) as well as in an electric storage. The electric power within the systems is provided by a DC-bus system, which is more efficient than a state-of-the-art AC based system. The DC architecture is expected to reduce the volume of conversion and distribution by 1/3 as compared to an AC architecture while a long term reduction of the costs by about 20% is realistic.

The electrical storage will be properly selected among the most efficient technologies already in the market, and will be adapted to the operation of the domestic building environment. The primary function of a heating / cooling system in the Mediterranean climate is the provision of cooling energy during the summer period, which is usually achieved in installed systems by means of electrically driven steam compression cooling systems. The system of Aglantzia demo site is built with priority on the provision of cooling during the summer months, combining the production of electricity from RES as well as electrical and thermal storage.

The system is divided into two main subsystems, the electrical system and the thermal system.

The electrical system consists of a 5kwp installed photovoltaic system which is connected via a DC-DC string optimizer to the electric rack which includes the battery with its charging controller, power meters, optimizers and the DC-AC inverter for connection to the main AC distribution grid.

On the other hand, the thermal system consists of the Heat Pump (HP), which is powered by DC power from the DC side of the DC-AC inverter, the Dry cooler which is the outdoor unit of the HP, and the RPW- HEX with the latent storage module. Motorized 3 way valves allow the reversibility of the chiller between cooling and heating modes, by swapping the hydraulic circuits.

Depending on the internal temperature of the building, the ambient temperature, the condition of the various components of the system as well as the needs of the user, the system can automatically decide the optimal scenario to follow and which function it will perform.

This selection is made through a central controller (PLC) which receives data from the various sensors of the system and is designed to decide the optimal operation of the system.

Fig.26: HYBUILD System installation. © FOSS Research Centre for Sustainable Energy / University of Cyprus

Fig.27: HYBUILD System unpacking. © FOSS Research Centre for Sustainable Energy / University of Cyprus

Accessibility (Design for all)

The intervention project also implemented accessibility to all, through the introduction of a ramp connecting the level of the square with the main entrance of the building.

Fig.28-29: Construction of accessible routes for the building. © FOSS Research Centre for Sustainable Energy / University of Cyprus

Assessment of the results

The installation of the HYBUILD system is going to be completed and commissioned in September 2021.

References

HYBUILD project website: http://www.hybuild.eu/. The HYBUILD project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 768824.

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