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Abstract. With the new EPBD directive, the European Union has announced the way forward for the construction of new buildings and the renovation of old ones. Kosovo, although not part of the European Union, does not want to fail in the sensitive issues of energy efficiency. In this article, a ZEB model building will be presented, consisting of an excellent passive system (well-insulated walls and windows) combined with a heat pump hybrid, with radiant floor heating, integrated with a photovoltaic system and batteries. This case not only presents a zero-consumption building, but also represents a massive renovation intervention, in fact the building in question was an old ruin redeveloped from scratch. The real case created starts from a project carried out in Italy, in the beautiful area of Val D'Orcia, Tuscany, which is transposed and simulated for the climatic conditions of Prizren, thanks to the dynamic hourly energy simulation of the buildings (FEM, TRNSYS and BIM).
This building also integrated two charging stations for the electric vehicle, one low and one high power for charging the electric cars. The energy class of the building is not only maximum A4, but the building will be a real case of Zero Energy Building, starting from an obsolete and historic building.

Keywords: Photovoltaics, NZEB, Storage Systems, Sustainable Economy, Energy Independence, Renewable Energy, Energy Saving, Energy Efficiency

1. Introduction

The European Union, with the new reform known as "green houses", has set as its objective the encouraging of the renovation of private and public buildings, to reduce energy consumption and CO_2 emissions of the building stock of the 27 member states.
The directive communicates that these buildings are responsible for 40% of final energy consumption and 36% of greenhouse gas emissions associated with energy, also highlighting that 75% of the total assets are not energy efficient and natural gas is mainly used for heating buildings, representing approximately 42% of the energy used for space heating and the residential sector.
In this article, will be dimensioned the renovation of a rustic house, in an NZEB building, capable of respecting all the binding parameters preset by the main European Directives relating to the construction of new buildings, including the EPBD directive.
This is a project that is being implemented in the beautiful Valle d'Orcia, a magnificent hub between the provinces of Siena and Grossetto. In phase zero, this building was an old abandoned stable, in which a plan to change the intended use was first presented and subsequently a magnificent structure for tourist reception was created. A farmhouse, focused on the bioeconomy, so the building itself

initially has zero energy consumption thanks to the photovoltaic system, the heat pump and the excellent insulation of the walls and fixtures. Furthermore, the culinary products used for customer service are zero km, organic and typical of the area (starting from good and seclusive wines, going to cheeses up to the very famous Florentine Steak, served only with free-grazing flocks, in low energy consumption agricultural structures). In short, this is not just a project for the construction of an NZEB building, but a radical productive change in the Tuscan territory, where the economic transition is not an obligation but a must for society, where everything starts from the reception structure.
It was decided to transpose the business model to the territory of Prizren, a splendid city located in the south of Kosovo.
There is no shortage of technology in this new state, indeed its desire to stand out and make its voice heard in Europe is strong. What is doing, is to simulate the Kosovan climatic conditions on this building, thanks to an hourly dynamic simulation model (with TRNSYS and FEM). The result can obviously be a technical and economic development model for Kosovo of what renovated buildings should look like, so that the European wealth parameters inherent to the new directives are aligned.

2. Thermal and boundary conditions of the project

For the simulation of the building, carried out with advanced and combined software (BIM, FEM, TRNSYS and others), the climatic conditions of Kosovo were taken into consideration, and below are the main data taken from: weatherspark.com.

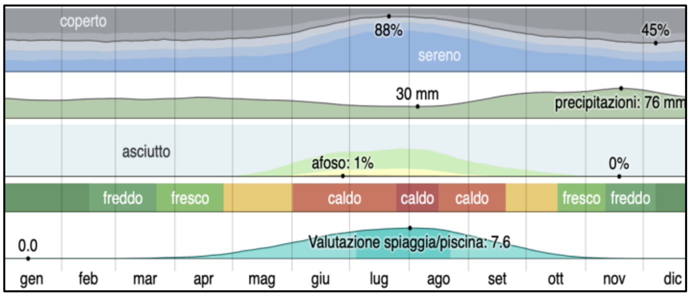

Fig. 1. Pizren weather by month (source: weatherspark)

"In Prizren, the summers are warm and mostly clear and the winters are very cold, snowy, and partly cloudy. Over the course of the year, the temperature typically varies from 27°F to 86°F and is rarely below 16°F or above 94°F.
The hot season lasts for 3.2 months, from June 8 to September 14, with an average daily high temperature above 77°F. The hottest month of the year in Prizren is July, with an average high of 84°F and low of 60°F.
The cold season lasts for 3.4 months, from November 24 to March 5, with an average daily high temperature below 49°F. The coldest month of the year in Prizren is January, with an average low of 27°F and high of 41°F."

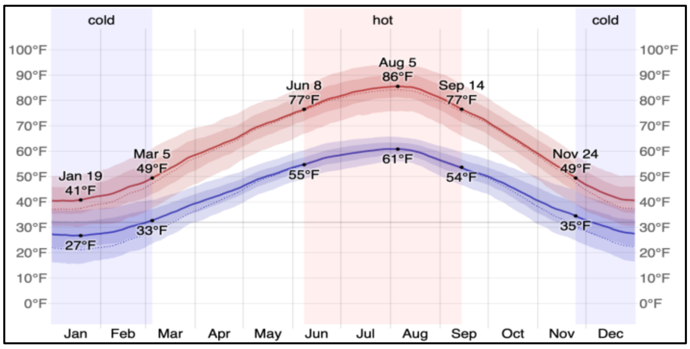

Fig. 2. Average High and Low Temperature in Kosovo (source: weatherspark)

The conditions of clouds, precipitation and snowfall have been well set in the software, which thanks to its dynamic interaction can give an optimal value of the building-environment simulation (the source where the climate data were taken is: https://weatherspark .com).

3. Characteristics of the building

The building subject to energy requalification is a 275 m^2 building, developed on two floors and three residential units, one on the first floor and two on the second floor.
The renovation was very solid, starting first with a complete internal demolition (with structural reinforcements on all the load-bearing walls, in fact the structure is in natural stone) and complete renovation of the roof composed of inclined pitches.
This work will only present the intervention relating to energy requalification; therefore, the structural reinforcements will not be the subject of study.
Below we list the energy improvement interventions implemented on the building.

A.- Passive structure:
The main characteristics of the building envelope are summarized below.

- The old load-bearing masonry, made of natural stone, will be insulated by a natural hemp fiber insulator, with k = 0.029 W/mK, creating a thermal resistance to the wall of 5.28 m^2K/W.
- The replaced fixtures, of the low-emissivity aluminum-wood type, are certified with a transmittance of 0.95 W/m^2K.
- The roof and the ground floor were completely renovated, whereby the first was insulated in the extrados with a 12 cm Pir polyurethane fiber, reaching 0.18 W/m^2K of transmittance, while the second was at a transmittance of 0.20 W/m^2K, with a natural bio resin finish and XPS panel.
- The need to respect the acoustic parameters meant that sound-absorbing mattresses were used in the partitions and inter-storey ceilings, which obviously resulted in an excellent contribution to the thermal insulation of the building itself.
- The thermal bridges were all made compliant with project requirements.

Fig. 4. Image of the property in its current state

Fig. 5. External project status of the farmhouse

<u>B.- The building's heating and electrical system</u>

The building's systems have been well sized between electrical and thermal system. Below are the main characteristic data:

- The thermal generation, both for DHW and for heating, is completely powered by 3 heat pumps of 8kW thermal power for the two apartments on the second floor, and 14 kW for the apartment on the first floor.
- There are 3 photovoltaic systems, which power the three apartments located in the structure adjacent to the technical room, with a power of 5,16 kW and 15 kWh of storage for the two smaller apartments and 7.74 kW and 15 kWh of storage for the bigger.

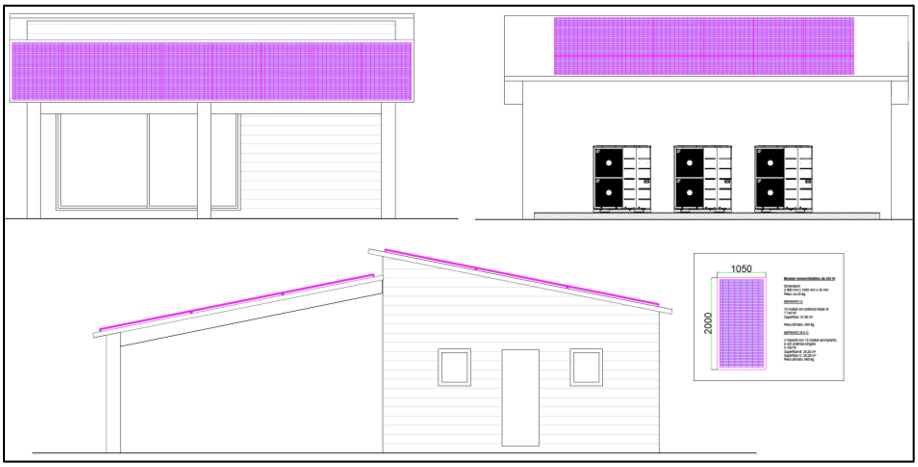

Fig. 6. Layout of PV system 3 plants with 7,74 kW for app. A, 5,16 kW for app. B and C

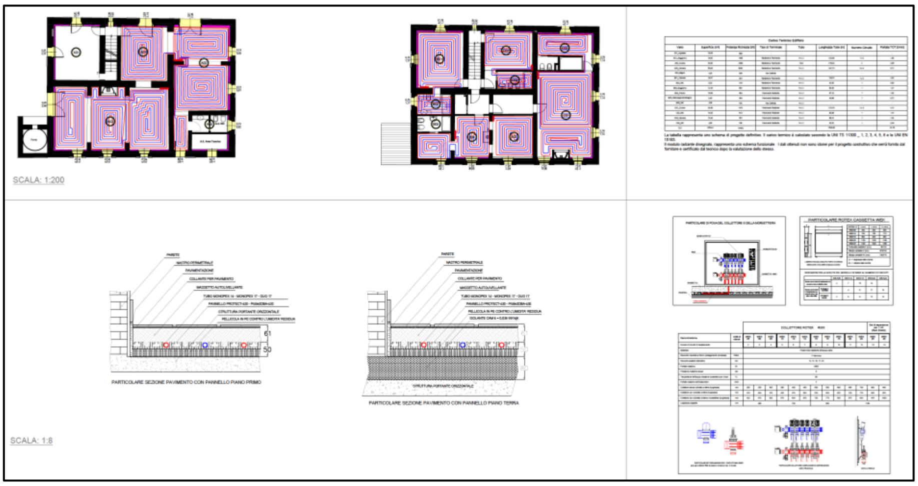

Fig. 7. Layout of PV module and of the electrical single-line diagram of the photovoltaic system and the wall box

4. Comparative energy analysis

Very interesting, is to understand how much overall energy the building manages to save and how many kWh per year are saved thanks the new configuration of the proposed plants.

To do this, the two energy class outputs reported by the building certificate are reported.

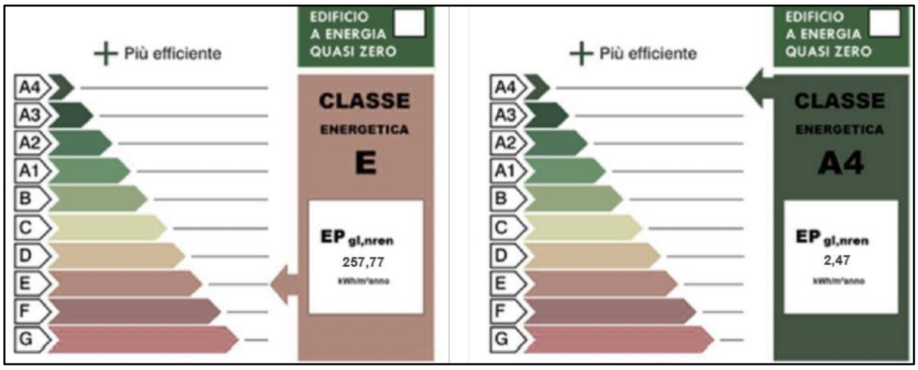

Fig. 8. Pre and post intervention – energy consumption

What can be observed is that the certified energy consumption is significant, going from 257,77 kWh/m^2 to 2,47 kWh/m^2 in a calendar year.

This implies that there was an energy saving of 255,30 kWh/m^2 per year, equal to 70.207,50 kWh for the entire building in one year. Transforming this value into tons of oil equivalent (TOE), the result is even more significant, as it is talking about 57,57 TOE per year (the transformation was calculated by converting the standard cubic meter of methane gas).

5. Conclusions

As can be seen, the ecological transition and the reduction of building consumption today absolutely must take place with a series of targeted and combined interventions, but it is of fundamental importance to combine passive interventions with active ones (photovoltaic generators and thermal solar system). Of fundamental importance is a good design of the building which must be envisaged today as an integrated structure of mixed systems including electrical engineering and advanced IT (monitoring of consumption through devices that detect consumption in real time, management of consumption profiles through apps on devices such as smartphones and more and home automation integrated between climatic conditions and building).

The case of study, transposed to the state of Kosovo, would allow significant savings in energy and carbon dioxide emissions, in fact more than 138 tons of CO_2 are saved per year. It would be very interesting to do an economic analysis of the following case, but for now it must be underlined that the intervention has considerable costs and that at this moment it could not be addressed without subsidies from the state. After all, the ecological transition is a collective need and it is good that the community participates in it.

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