Energy rehabilitation of existing, historical, not monumental buildings:

The case of the high performance retrofitting of the CRE in Chivasso

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ABSTRACT: This project deals with a critical issue in building retrofitting that has not been evaluated until now by restoration studies: the compatibility between energy efficiency requirements and the traditional objectives of restoration. An emblematic case of this approach is the ex - Edipower CRE in Chivasso (Recreational Centre for the workers of the Power Plant in Chivasso), a building of the early 20th century that was completely abandoned before the refurbishment. The proposal of TME Architects improves the energy performance of the building (thermal zoning, triple glazing, thin layer insulation, ground pipes, solar greenhouse, PV system) leading the building to the A+ energy classification preserving at the same time its global value.

Keywords: energy retrofitting, historical building, thermal zoning

INTRODUCTION

The town of Chivasso is located on the left bank of the river Po and it is characterized by a temperate climate typical of mid-latitudes, with hot summers and cold winters, similar to that of Turin. In winter, as in the western and southern Piemonte region, a "cold buffer" develops caused by continental air streams which resists to the mild winds that blow at mid-high altitudes such as sirocco. This phenomenon also causes heavy snowfalls.

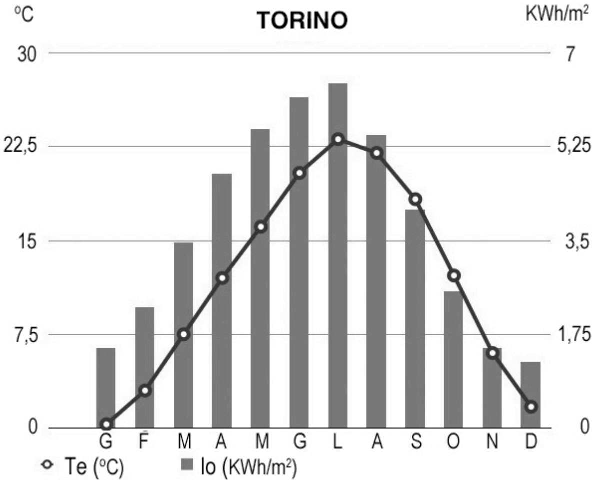

Figure 1: Climate at Chivasso.

The renovation project of the Edipower Recreative Centre at Chivasso was developed in 2010 by TME Architects [1], as a result of a competition by invitation.

The ex CRE was originally built in the early 30's of the 20th century and consisted of 2 simple rectangular floors (plus an underground cellar) of about 200 m² each. The vertical structure was in traditional load-bearing brick walls, while the horizontal slabs were made of wood. The windows were single glazed with a wood frame and traditional, mediterranean blinds as shading devices.

The exposure to atmospheric agents over time led to a complete degradation of building finishes and equipment. Moreover the building was no longer able to meet the minimum performances required by current Italian regulations. These reasons made it impossible to use the building without a complete redevelopment.

Figure 2: The building of the ex CRE at Chivasso just before retrofit.

RESTORATION AND ENERGY EFFICIENCY

The client's request was to have new offices with high energy performances and a guest house in the attic. The image of the existing building had to be saved because it was still considered part of the collective memory for the power plant's workers, as well as for the local community of Chivasso.

The most relevant and common problem to most of architectural restoration projects is matching the need to preserve the building (not in the overall image but for its historical and social value) with the increasing of energy efficiency. For this reason innovative technical solutions for energy conservation and energy efficiency have been used with the aim of saving the historic value of the building. The envelope was therefore restored trying to achieve building performance with standard consumption of a passive building, but ensuring the "complete" reversibility of the restoration. To fit this objective light elements (textile finishing and thermo-reflective insulation), have been used to emphasize the possibility to transform the building image through the time with a simple upgrading of the facades, both in term of exterior finishing as well as of thermal performances. The complete reversibility of the retrofitting is theoretically possible with low costs and simple operations with the exception of the superelevation strictly required by the client and built with conventional technologies.

To increase the energy efficiency of the building but also to favour the connection between the building and the park and in order to have a potential winter use of the exterior a winter garden has been designed. The glazed intermediate space (the greenhouse) is visually connected to the exterior and has been added to the south facade, while a new volume on the north side accommodates stairs and lift.

Figure 3: South view of the building after the restoration.

ENERGETIC STRATEGIES

The entire envelope was renovated and both opaque and transparent elements improved their thermal performances to reduce the energy losses through the envelope, but in order to preserve the existing building and easily allow a return to the previous condition a thin multilayer, reflective insulation has been used together with a textile finishing. The two layers (insulation and finishing) have been laid on a double wood frame. The internal distribution is designed to favour the exchange of energy between activities with different thermal requirements and spaces at different temperatures. Continuously used rooms in which higher temperature are requested face south and house the primary activities, while secondary and discontinuous ones face north and the main strategy for winter heating in these rooms is metabolism. At the ground level a small exhibition about the building (history and renovation) has ben located in the north side, while conventional offices face south. On the first floor conventional offices face south while conference rooms face north. The second floor is located in the attic and is used as a guesthouse for visitors of the power plant. In the attic the south facing guest rooms are primarily used in winter, while the north facing ones are primarily used in summer in order to obtain the best inner conditions in each season with the lowest possible energy consumption.

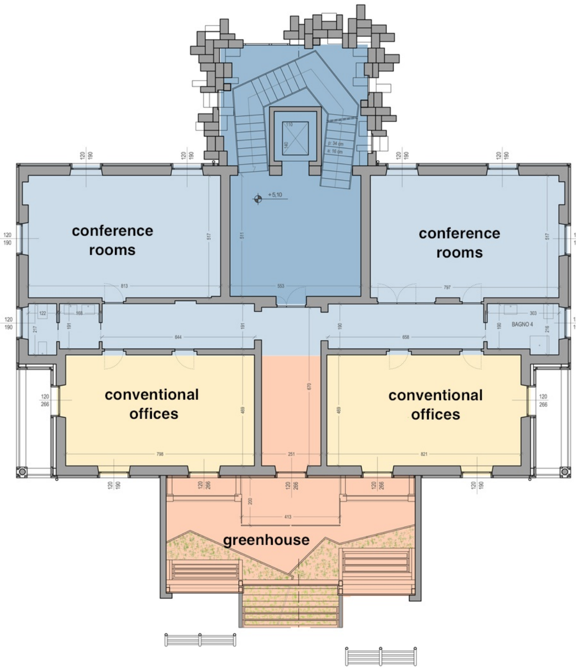

Figure 4: Organization of the activities inside the building (plan of the first floor).

The greenhouse added on the south facade works as a passive heating system collecting solar energy in winter and reducing the heat losses of the adjacent spaces through the walls facing on it. The new added volume on the north side is also unheated and works as a thermal buffer for the building. Corridors and vertical connections are located in this space that is heated only through the heat gains (dispersions) from the walls in common with the other heated rooms.

After the restoration the exterior walls of the building have a high insulation level but the huge existing thermal mass due to the thick brick walls has been preserved; to reduce the thermal bridges the insulation was placed on the exterior side of the envelope. The energy performances of the building have been simulated during the design process using different software that evaluated different aspects: the daylight distribution was simulated with Rafis [2] and Relux [3], the thermal performance in the first stage of the design process with Archisun [4] while a modified version of 5000 Method [5] was used to evaluate the energy efficiency of the greenhouse. The final calculation have been performed using the software EnergyPlus [6]. The described strategies and the technological choices made it possible to reduce fuel consumption from 257 kWh/m^2 year to 8 kWh/m^2 year (heating only). The building has been classified as class A+ in terms of energy performances, according to Italian certification standard.

ENVELOPE DESIGN

The main passive strategies have focused on the design of the building's envelope as a dynamic and selective layer between interior and exterior that can control the interchanges of the energy fluxes.

Figure 5: North view of the building after the restoration.

The vertical opaque envelope has been isolated using a thin thermo-reflective multilayers (infra-red insulation) material of 2 cm thickness made of 14 different layers (combination of polyester, metal, polyethylene foam and polyester reinforced with a wire mesh), reaching a R-value of 6,1 m^{2}K/W equivalent to 25 cm of conventional insulation. The exterior finishing was made of black polyethylene textile, normally used in agriculture as a wind protection and sun breaker. Also the roof has an high thermal performance (U=0,13 W/m^{2}K). It has been designed as an isolated-ventilated roof to reduce heating loads during the winter, but also the cooling loads during the summer. The insulation is made of conventional 10 cm of mineralized wood fiber plus the thermo-reflective multilayers, infra-red insulation described above.

The new volume on the north side was designed as the new entrance to the building. Its facade resembles a structure of basalt stone and the color magenta hides an insulated enclosure made of blocks of cellular concrete, characterized by a good thermal transmittance (U=0,30 W/m^{2}K). This north side volume works as a buffer space protecting the less heated rooms. This volume has few openings to reduce the heat losses at a minimum. The two loggias facing east and west, made of decorated cement, have been restored and are visible through the new textile finishing. Old single glass windows have been replaced with new ones with wood frame equipped with triple low-e glass and Argon gas into the air gaps with an equivalent U_w value = 1,13 W/m^{2}K. The shading system is made of external venetian metal louvers.

THE GREENHOUSE AS A CLIMATIC FILTER

The new added south facing volume was designed as a bioclimatic greenhouse. It has the characteristics of an intermediate space located between the envelope and the outside environment acting simultaneously as a barrier and a connection. It can be defined as a climatic filter able to control and modulate the energy gains and losses (heat, light and air). It is composed of three volumes with different inclinations due both to energy and architectural issues.

The side walls are opaque and made of cellular concrete blocks U=0,30 W/m^{2}K to ensure good insulation but also a good effective, internal thermal mass, while the transparent surfaces have an aluminium frame (interrupted thermal bridge) equipped with double low-e glasses filled with Argon gas (U_g=1,1 W/m^{2}K). The roof of the greenhouse is made of opaque insulated panels with a U=0,30 W/m^{2}K. The greenhouse has a positive effect on the energy balance of the building (winter heating) as well as to the architectural image.

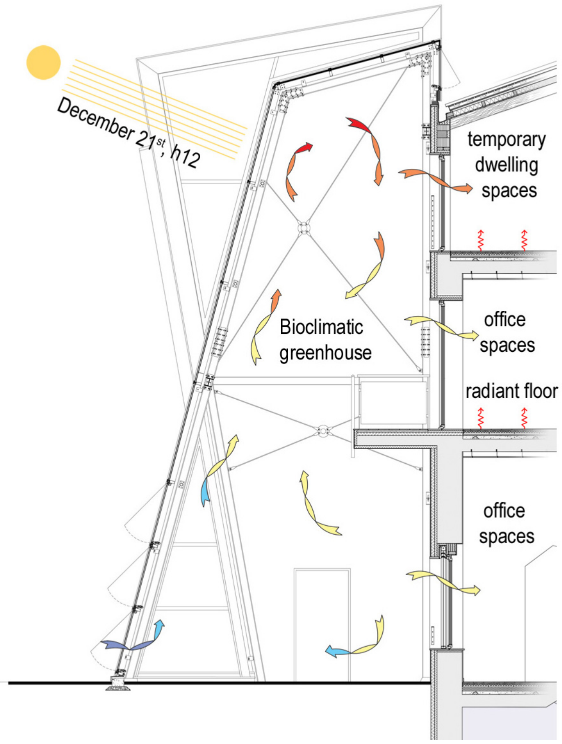

Figure 6: Schematic section and functioning of the greenhouse in winter.

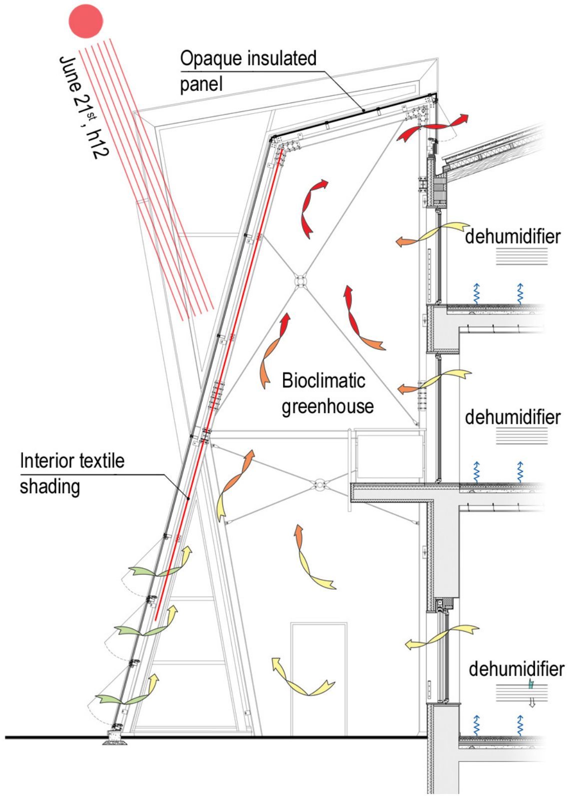

Figure 7: Schematic section and functioning of the greenhouse in summer.

The south facing surfaces with different inclinations allows to control the undesired solar radiation during the summer. The two side volumes are projecting and have been designed to guarantee a good self shading during the summer and to have significant solar gains in winter. The greenhouse acts as a heat producer and this function is integrated in the general architectural strategy of energy transfer from the south (warmer) to the north (colder). This strategy of temperature zoning in the different spaces and for the different activities allows a dramatic reduction in the energy consumption. The retrofitting of the building produced a reduction of about 15,4 tons of CO_2 per year (equivalent to about 6.000 litres of diesel) with reference to the former condition. To guarantee an adequate functioning of the greenhouse and to control potential overheating during the summer appropriate strategies have been adopted in order to modulate solar gains and improve interior ventilation. An interior textile protection has been designed to reduce sunlight penetration in summer and to prevent both overheating and glare. North facing openings (of about 9 m^2) located on the top of the greenhouse and south facing openings at the bottom of the greenhouse (of about 12 m^2) guarantee significant cross ventilation powered by the stack effect (about 8,5 m) and eliminates the overheating risks also during the warm and sunny Italian summer.

Figure 8: Interior view of the greenhouse.

ACTIVE ENERGY SYSTEMS

To cover the electricity needs of the building a photovoltaic field was installed on the roof of the building. It is monitored to evaluate the instant and seasonal performance and it can provide a peak load of 10 kWp with 60 panels of 175 W each.

The heating and cooling are generated through a heat pump of deep geothermal exchange, floor radiant panels and a dehumidification system, as well as through the contributions of the solar gains collected by the greenhouse. The building functioning is controlled by a home automation system that opens windows when necessary, activates the dehumidification system, etc.

CONCLUSION

After one year the test of the building performances shows that the measured energy transfer through the exterior wall was higher than expected due to the unconventional use of the thin infrared insulation. In fact the use of a textile finishing is not as efficient as a opaque wall and the air movement in the back of the textile finishing was higher than expected.

Figure 9: Thin insulation used in the retrofitting.

The greenhouse is working greatly and no overheating problem has been recorded last summer. The windows sealed required openings to guarantee the desired humidity in winter too because of the reduced ventilation (close to 0), while the HVAC equipment required a certain time to be correctly set. The client was satisfied both by the global image of the building and by its energy performance. The resolution of thermal bridges was difficult and in some cases it was impossible to solve completely the thermal discontinuity and to save at the same time the existing mouldings and decorations on the facades.

The renovation of existing buildings to obtain high energy performances is complex and requires particular attention in the design of details, nevertheless in most cases the final result can be comparable to the ones of a new building. Today energy requirements do not easily fit with the necessity of conservation of existing building, on the other hand it is not possible to imagine a use of an old building for different use and with new comfort requirements without a transformation that should be compatible with the building itself. The ex CRE at Chivasso represents an example of preservation through transformation in which the energy objectives have been reached together with the architectural ones.

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