Nearly Zero Energy Heritage

Taboo or challenge?

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Abstract – Architectural heritage has been considered as one of highest peaks of Italian culture and its universities as a point of excellence in conservation and restoration. However, they have not been able to fully address contemporary challenges, responding to demands of energy saving and raising of comfort levels. The achievement of NZEB standards in historic buildings, especially those protected by the Ministry of Cultural Heritage, is still considered taboo – if not a dangerous technical drift.

An ongoing project on an 18th Century small listed building is animated by a different spirit; here the traditional conservative approach has been integrated with specialists in energy efficiency. The proposed contribution aims to present an example striving to become indicative of best practice, while highlighting in particular the conflicts concerning material conservation, enhancement of cultural significance and needs for new use, as well as the possibility to overcome some cultural barriers through creativity and innovation.

Keywords – NZEB; cultural heritage; values; energy efficiency; conservation

1. INTRODUCTION

The concerted drive on the part of the Italian government to encourage recourse to energy efficiency measures in building restoration, also with a view to achieving “Nearly Zero Energy Buildings” standards, bestows upon scientific research and technology a fundamental role, especially with regard to cultural and historical heritage. The most advanced dedicated study and experimental field finds itself faced with the double commitment of predisposing and adapting procedures, analysis methods and restoration more suited to the construction and architectural features of historical buildings and to make the actual achieving of virtuous examples possible.

The juxtaposing of the terms “energy efficiency” and “preservation”, to date somewhat distant from each other in the Italian context, must not, nonetheless, be considered as a mere exercise in technical application. Nor are they mere exclusive technological transfer; rather, they stand for the triggering in a slow process of cultural advancing, which requires considerable synergic commitment.

Supported by various financing channels, the culture of Italian architecture heavily involved in restoration and preservation of the country’s historical monument heritage has been set objectives over the past few years which, traditionally, did not belong to its specific sphere of interest [1]. With a co-ordinating role of
multidisciplinary working groups, both organizations appointed to safeguard, and experts in the field of architectural restoration, have intensified study initiatives. The aim has been to draw up guidelines [2] and inform and communicate on their own research activities [3] so as to make other players aware – these latter still somewhat sceptical with regard to such issues.

Over and above scientific studies respecting the *diktat* of their sectorial character, the demand felt today is the opportunity to refer to *best practice* [4]; such may make attitudes and technical methods employed in the field explicit, if the purpose is to improve the thermal behaviour of the historic building and to implement renewable energy sources (which until only a matter of years ago were considered veritable taboos in a restoration project). Various are the players this awareness-making process may be addressed to:

- Owners, be they public (or religious) or private organizations, often oblivious to the most recent scientific issues but interested in “sustainable” management (also financially) of the heritage they are responsible for, as well as the possibility to access financing in the form of incentives and fiscal relief;
- Technicians and professionals. These two categories may, for example, be compelled to undertake permanent professional training programmes offered by dedicated recognized organizations;
- Superintendence officials representing the authorities appointed to evaluate and approve proposed projects on the basis of tried and tested preservation practices.

The opportunity to introduce energy efficiency measures in historic heritage (already completed or in the process of completion) can be an essential basis for convincing owners to invest more in similar intervention. At the same time, the diffusion of case studies could raise awareness among Italian protection organizations so they can authorize technical operations such as insulation and solar panel insertion, without compromising protection and safeguarding of historical material characteristics in buildings dating back to the past. The case study here presented can serve to make owners and technicians aware on several counts: the building is private and listed, with all intervention requiring the approval of the Municipality and the Regional Superintendence of Archaeologies, Fine Arts and Landscape. This case is particularly significant from the point of view of design and decision making process, since energy improvement – not mandatory by regulation – is part and parcel of the restoration and reuse project.

### 2. A PRACTICALLY ZERO ENERGY RESTORATION PROJECT

The very effort to show a practical case study and not only a theoretical example, is one of the basic aims of a restoration and reuse project for a small historical

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1. Up to 65 percent of the total cost of insulation and improvement of glazing systems (for a total amount less than 100,000,00 Euros) from the Ministry of Economic Development.
building boasting unique architectural features and recognized as a listed building protected by the Superintendency of Archaeologies, Fine Arts and Landscape. It is a building of which the history remains scarcely known, even though it occupies a most central position in the city. The property of the Genoese Municipality from 1889 to 2004, it was then purchased by a private concern, which was fully aware of how unique the building and acquisition were. The purchaser then determined to programme a lengthy process (ongoing) of restoration and reuse, including energy enhancement, tending towards the excellent.

The first and foremost purpose of the operation is to instil new life into the building by way of a reuse and preservation project focusing on overcoming the state of abandon the building had been wallowing in for several years, restoring dignity and value to an important urban episode, unveiling its hidden history and opening some parts to the public – in forms and ways compatible with its being private property. Despite the new function, residential (a flat) and offices of a professional activity, the idea came about that it should become an experimental laboratory for processes and technologies for energy saving and seismic improvement – possibly satisfying Nearly Zero Energy Building standards for existing buildings in climatic zone D (Table 1). This approach is quite a novelty since for this type of building it is not required to satisfy technical standards.

Table 1. Italian Zero Energy Building definition for existing residential buildings (2019-2021)

<table>
<thead>
<tr>
<th>Thermal transmittance U (W/m²K)</th>
<th>Maximum primary energy [kWh/m²y]</th>
<th>Share of RES for energy production</th>
<th>Electric energy from PV (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground floor External wall Roof structure</td>
<td>0.29 0.29 0.26</td>
<td>30 50 % (Thermal)</td>
<td>2</td>
</tr>
</tbody>
</table>

In itself the idea embodies more than one challenge:

• the contrast between the features of the historical building, never employed for residential purposes, and the demands of inhabiting in terms of comfort and energy saving;
• the willingness to modify in the least measure possible the material nature of the construction, despite having to insert new installations and equipment;
• the possibility to create a round table comprising different specialists, not always in complete agreement on the same objectives of safeguarding and preservation of existing values both material and immaterial;
• the “sustainability” target of the whole operation from the social, cultural, economic and environmental points of view.
Hence, the interest motives in this initiative are different. Not least of all, the most repetitive nature of going round and round a long process to be subject in itinere to quality checking – similar to the logic of industry.

3. ARCHITECTURAL FEATURES AND HISTORICAL VALUES

The building stands in the centre of the city in an area which over these past two centuries has undergone numerous transformations. Tradition has it that it dates back to 1825, but in reality the sisters of Saint Martha had it built on their land probably at the end of the eighteenth century with a view to using it as a “belvedere”. Evidently the attraction was the building’s spiral staircase in a cylindrical tower on the corner, leading to a flat terrace from which you can enjoy a totally unique 360° view.\(^3\) The building, which is situated in grounds rising above the present level of the access-yielding street, boasts trapezoidal design and three floors above street level and one floor partially a basement. The dimensions as they appear on the building plan are rather unassuming; originally there was merely one room per floor, looking out through large arch openings, devoid of shutters so as to enjoy the view as from a loggia. The vertical structures are stone load-bearing walls.\(^4\) Horizontal edifice shows brick vaults in pavilion shape with lunettes except for the roof terrace – demolished after World War II and rebuilt in reinforced concrete (Figure 1).

Figure 1. BIM Model of the building (west and east façades).

\(^3\) The historical information prior to sale of the building was summarily detailed; lengthy archives research carried out by Santamaria of the State Archives Genoa has led to the revealing of a hitherto unknown history.

\(^4\) A sturdy wall of Middle Ages building characteristics allows us to suppose that the building was erected around some already existent constructions belonging to the city’s very first fortifications. Such a hypothesis is also substantiated by chemical analysis completed on mortar samples removed pursuant to wall coring.
The study on the history of the building and its transformation, especially after the Second World War, was particularly important. It highlights which parts are original, which were added to change the image in keeping with the taste of the time and which are fairly new (1973–1978). The last certainly bear less historical legacy and material value and are, thus, suitable for intervention comprising major modifications.

The first major transformation took place in 1821, when the mayor of that time purchased the property for his own leisure and called upon the municipality architect Carlo Barabino as well as Michele Canzio, the expert scenographer and decorator, to change the external appearance – but not the structure – after a neo-Gothic style. In 1889 the heirs of Marchese Serra sold all his property, including the enormous garden, to the local municipality. Bombing during World War II heavily damaged the roof – later to be replaced by a hollow-core concrete structure – and the outer plastering. Neglect and total abandon, as well as acts of vandalism and squatting, reduced the property to such a deplorable state that in 1973 the municipality commissioned to have the property restored. In keeping with the culture of the era, restoration was of a distinctly reshaping nature: complete external and internal re-plastering with concrete mortar and heavy steel reinforcement in at least one of the two vaulted areas. In 1978 further internal renovations were effected so as to house a small museum, with extensive use of reinforced concrete structures, somewhat detrimental to any attempt to detect seventeenth/eighteenth century origins.

In short, such was the state of affairs at time of building abalienation. The quasi-total absence of documentary material and the evident incomplete unreliable nature of the existing survey encouraged the owner to invest (time and finances) into a long period of analysis and familiarizing. Indeed, this is necessary both to fill a void in urban historiography and to orient and direct the project of reuse, restoration and energy improvement based on the difficult search for a balance between new needs and preservation of the meanings and material values of what the building had been before.

4. INQUIRY THROUGH MULTIDISCIPLINARY COMPETENCES

Given that the bibliographical information was rather summarily reported and in some points contradictory, a private/public archive-oriented inquiry was launched, as well as a concurrent drive to obtain surveys of the building and annexed garden, using different methods (topographic, tape-measured, digital plane photogrammetric, PhotoScan). The superimposition of photo-planes of the prospects with iconographic (1823) and photographic (1926) representations has allowed “reading”, albeit virtual, of the rich decorative apparatus, irremediably deteriorated by neglect and damaged during war bombing (1973) (Figure 2). Despite the absence of original plaster, completely replaced after 1973, the hypothesis of insulating the building from the outside was excluded from the beginning – such a type of intervention being in stark contrast with preservation criteria.

In order to substantiate some hypotheses on developmental stages emerging from archives enquiries (reference is to walls predating the eighteenth century,
the era in which the building was erected, and to the dating of wall and vault creation) a series of tests both archaeological (foundations) and architectural (sample takings of plaster at delicate points submitted for chemical analysis so as to date them) have been carried out, thus comparing direct and indirect sources. Along with testing and digging, there has also been coring, vertical perforations to verify the nature and substance of the ground around the building. Indeed, an early idea shared by owner and technicians alike comprised the option of recurring to geothermal energy to satisfy thermal and electrical needs.

Table 2. Thermal transmittance of the building envelope – current state

<table>
<thead>
<tr>
<th>Ground floor</th>
<th>External Wall ground floor</th>
<th>External wall first floor</th>
<th>External wall second floor</th>
<th>Roof structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.26</td>
<td>1.45</td>
<td>1.65</td>
<td>1.72</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Table 3. Surface and volume – current energy demand

<table>
<thead>
<tr>
<th>Total surface S m²</th>
<th>393</th>
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<tbody>
<tr>
<td>Volume V m³</td>
<td>2150</td>
</tr>
<tr>
<td>Envelope surface Senv</td>
<td>1280</td>
</tr>
<tr>
<td>Surface /Volume</td>
<td>0.59</td>
</tr>
<tr>
<td>Current Global Energy Performance Ep_g</td>
<td>380.25 kWh/m²y</td>
</tr>
<tr>
<td>Current Envelope Energy Performance Ep_env</td>
<td>230.45 kWh/m²y</td>
</tr>
</tbody>
</table>
Since the building has not been used for almost ten years, no environment-oriented monitoring has been applied, nor has it been possible to examine real energy consumption to evaluate thermal behaviour. Materials and stratigraphy of elements allowing heat to disperse have been identified (floor covering, external walls, windows, roofing) to evaluate its related thermal transmittance (Table 2). In keeping with Liguria Regional Law n. 22 (29/05/2007), national Law D Lgs n. 102/2014 and European Directive 2010/31/EU (Table 3), the global energy performance and the energy performance for the envelope indices have been estimated in the current state and before any improvement.

5. ENERGY STRATEGIES: GOALS AND TECHNIQUES

Right from project beginning the owner had expressed the intention to respect the NZEB standards with a global energy performance forecast of around 30 kWh/m²/y. He sought to involve all interested professional parties in the preliminary design process and invited them to make also the architects from the Superintendence aware of such goals.

To satisfy the demand for renewable sources, a geothermal heat pump, applicability of which had been previously verified with archaeological essay and vertical coring in the soil, will produce thermal and electrical energy. The latter exceeds the required quota of 50 % (Table 1) and reduces CO₂ emissions to 5 kg/m²/y (compared to an estimate which could be around 150–200 kg/m²/y in the current state). This technology certainly impacts less on the existing buildings – if compared to solar energy powered panels, which are often incompatible with the preservation of architectural features. A small surface of pavement photovoltaic panels, respecting regulation requirements, could be installed on the flat roof terrace – hidden from view. Since the application of this technology on historic buildings is a controversial issue, it will be necessary to set out by verifying the attitude of the interested safeguarding organs. In any case, historical and archival analysis has revealed that the re-construction of the flat roof in reinforced concrete dates back to 1973; none of this particular part of the construction, unfortunately, had been spared WWII bombing. A heat pump will power floor radiant panel heating; this intervention previews the removal of flooring and subfloor – both renewed in 1973 and not original. A mechanically driven ventilation installation to check inside comfort conditions (relevant humidity, overheating) and domotics installation to check inside comfort (plants and dimming of windows) have also been previewed. Another criterion shared by the project group, as well as by the client, is the minimum interference between new channelling and the new vertical and horizontal wall structures, entrusting to the new dividing walls (conceived with “dry-stone wall” technologies) the role of net restraint. Vertical passages will be reduced to a minimum number, examining a technical “loop”, required for the installation of a new lift.5

5 The lift will be installed in a type of wall-surrounded cavity and hence will not be visible on the ground floor, where the single vaulted area will remain completely empty – as it was originally.
The horizontal flat structures (floor and ceiling) remain within the limits of transmittance laid down by regulations (previewed U-values equal to 0.20 W/m²K): the interspace between ground floor slab and soil, completed in 1973, will be filled with mineral insulation material while the flat terrace structure, in a poor state of preservation and devoid of historical architectural value, will be demolished and rebuilt with a light insulated steel structure. Windows and external opening will be replaced: the existing ones were added after 1973, hence lacking in any documentary historical value as well as proving to be quite ineffective, while the new ones will have low-emissive double-glazing, respecting the minimum requirements of technical legislation (even lower, between 1.2 and 1.4 W/m²K).

Despite efforts made regarding maximum enhancement and preservation of material authenticity, there emerge some conflicts evidently opposing demands, especially in applying of internal wall and brick vault insulation. The external walls and the brick vaults of the ground and first floors were, in fact, built in the 18th century, as is evident from historical archival examination: the bearing structure in irregular stone is still original, while the cement plaster finishing outside and inside are completely new (reconstruction in 1973). Another constraint of a material nature (the choice being the client's) concerns the type of insulation to be used. To adapt to the material characteristics of the historical construction (stone, brick and lime mortar) it is preferred to use compatible materials of the same mineral origin (insulating panels based on calcium silicate hydrates or lime-based thermo-plaster with cellular glass aggregates to replace internal cement plaster dating back to 1973), even though their thermal performance is less efficient than synthetic insulators (expected external wall U-values between 0.36 and 0.41 W/m²K, counterbalanced by the low U-values of windows and flat floors). To insulate the vaults and solve existing thermal bridges, a double system will be used: passive (inserting mineral insulation in the empty space between the extrados of the vaults and the wall) and active (in the form of heating supplying resistance above the vault cornice).

6. CONCLUSIONS

The experience conducted to date with this small project of reuse and restoration is by no means devoid of the complex problems which must be faced when working on the historical heritage, but it is significant for the fixing of the procedure and involvement of all interested parties. The latter include the architect and archaeologist working in the Superintendence and in charge of the authorization process. From the first design phase and decision making process, what can be underlined as a meaningful approach is a logic of “compensation” and “balancing” concerning different values (restoration and NZEB standards in primis), which also means striking a balance between conservation and transformation. Original materials, elements and architectural forms, which have been afforded a historical and “witness” value, will be preserved and appreciated; recent construction elements (1973–1978), mainly in concrete and reinforced concrete, will be replaced with more compatible and, in thermal terms, even more efficient, enhancement materials. The creative attitude typical of the architectural
design process will also involve technical equipment (i.e. PV floor) in co-operation with thermal engineering.

Other in-depth considerations will follow this first project phase, especially in the choice of the most appropriate materials and technologies, with not only financial but also environmental evaluation assessment. Indispensable will be both the phases of executive planning and delivery, which should feature a highly qualified workforce. Nevertheless, the real success of this intervention cannot be decreed before complete execution and verification by way of annual monitoring during ensuing management stage.

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8. REFERENCES


