Sustainability assessment of historic buildings: lesson learnt from an Italian case study through LEED® rating system

Paola Boarin\textsuperscript{a}, Daniele Guglielmino\textsuperscript{b}, Anna Laura Pisello\textsuperscript{c*}, Franco Cotana\textsuperscript{b}

\textsuperscript{a}Department of Architecture, University of Ferrara, via della Ghiara 36, 44121, Ferrara, Italy.
\textsuperscript{b}Green Building Council Italia – Piazza Manifattura 1, 38068, Rovereto, (TN), Italy.
\textsuperscript{c}CIRIAF – University of Perugia, via Duranti 67, 06125, Perugia, Italy.

Abstract

Environmental certification is a key issue for improving energy efficiency, minimizing energy consumption and allowing greater transparency on energy uses in buildings. If sustainability of the building process is an already consolidated issue for new constructions, as well as for existing buildings, for traditional and historic buildings a dedicated consideration still must be carried out, due to the major complexity of the variables to be taken into account. This paper deals with the criticality of applying LEED® Italia rating systems for New Construction and Major Renovation to the case study of an ancient stable located in correspondence to a Middle Age fortress in Perugia, Italy. This gap analysis process shows the weakness of existing tools when applied to the historical context, by highlighting the need of a new assessment framework in case of restoration and preservation processes. GBC Historic Building™, a new rating system that GBC Italia is now developing, offers the opportunity to combine framework and criteria of the International LEED® standards and the specific knowledge of the restoration and preservation theory and practice. The case study highlights possible modifications and integrations of the existing LEED®/GBC topics, with the ultimate purpose of bridging the gap between energy efficiency, environmental sustainability and cultural heritage preservation.

Keywords: historic building; energy efficiency in buildings; International rating system; energy retrofit; restoration; LEED protocol.

1. Introduction

Existing and historic buildings represent a significant asset in Italy, also due to their cultural and architectural value. The improvement of existing buildings’ performance, by means of deep renovation or operational strategies, is also a priority set by the European Community. In order to achieve this goal, appropriate tools capable of leading operators in the building industry are needed, such as LEED® (Leadership in Energy and Environmental Design) \cite{1}, a set of rating systems for design, construction, operation and maintenance of green buildings. In 2010, the Italian Green Building Council (GBC Italia) developed a local version of one LEED® rating system for New Construction and Major Renovation named LEED® Italia. Although LEED® Italia is applicable to interventions of deep renovation of historic buildings, it does not include specific issues related to a sustainable valorization of the historical and
cultural aspects that this particular segment of the built environment might have. Thus, GBC Italia decided to develop *GBC Historic Building™* [2], a new LEED®-based rating system for the voluntary certification of the sustainability level in restoration, recovery and integration of historic buildings, with the ultimate purpose of recognition, enhancement and transmission to the future of cultural heritage in its usefulness, historic interest and significance. In this paper, the contribution to the new rating system development is assessed through an applied analysis on a real case study consisting of a historic building located in central Italy.

2. Methodology: through GBC Historic Building™ rating system

*GBC Historic Building™* is applicable to “historic buildings”, meaning constructions that are worthy of consideration as “material witness having the force of civilization” [3]. In this regard, buildings that may fall within the scope of *GBC Historic Building™* must be built before 1945 that, conventionally, represents in Europe an important and deep change in the building sector in terms of materials, techniques and technologies given the industrialization of construction process. In order to verify critical aspects of the LEED® Italia rating system for New Construction and Major Renovation in case of historic heritage, a gap analysis process has been done through the application of the existing protocol to some preliminary case studies (one of which is presented in this paper), in order to evaluate its (i) relevance and applicability in case of different levels of the restoration process, in order to define strengths, weaknesses, opportunities and threats and (ii) possible modifications and integrations of the existing structure and contents, according to existing LEED®/GBC topics.

3. Case study

3.1. Description of the building

The case study building is an ancient stable in the complex of Sant’Apollinare Medieval Fortress in Perugia, Italy. The building, after renovation, will become an International research center where offices and meeting rooms will be located, to support the research around biomass plants and new energy technologies, which are already implemented in the same Abbey construction complex [4]. The building is characterized by two floors of 140 m² and one underground floor used as cellar and storage area. The original stone structure was completely preserved, together with the wood paving and ceilings. A project of external insulation layer was permitted by the Architectural Preservation Office, given that the ancient configuration of the building had a cement plaster as most external layer.

3.2. Major renovation design

The major renovation intervention consisted of the design of (i) a new high performing envelope, according to the prescription of the Architectural Preservation Office, (ii) efficient HVAC plants, in order to take advantage of the prototype plant producing energy for heating and cooling, (iii) effective strategies to reduce the use of potable water.

3.3. Energy analysis

The stable heating, cooling and hot water requirement were evaluated through a dynamic simulation engine (EnergyPlus), by taking into account the final designed configuration of the façade materials and occupancy of the building. Therefore, the estimated energy consumptions correspond to the post-retrofit
scenario, given that the actual situation sees the building as a non-occupied area, without energy requirement. The ex-ante scenario took into account the non-insulated façade and roof structure. The post retrofit façade is a 4-layer structure that was described by EnergyPlus simulation engine [4]. The final calculated transmittance value of the two layer masonry (before-retrofit) was 1.448 W/m²K, calculated as prescribed in BS EN ISO 6946. The post-retrofit value corresponded to 0.269 W/m²K. The dynamic simulation was run from January 1st to December 31st. The temperature setups were 20°C and 26°C for winter and summer, respectively.

3.4. “Innovation in design” key elements

Given the scientific value of the building, particular attention has been paid to the implementation of several innovations in design. Specific focus was dedicated to reduce the cooling needs of the building through passive techniques. To this aim, innovative reflective clay tiles were elaborated by the authors with the cooperation of an industrial company. The prototyped tile is a cool roof solution specifically developed for historic buildings, with about 15% higher reflectance than traditional clay tiles and the same visual appearance, in order to be accepted by the Architectural Preservation Office [5]. This solution helps achieve several benefits in the GBC Historic Building™ categories of Sustainable Sites, Energy and Atmosphere and Innovation in Design. In fact, the tile is still a prototype applied for the first time in a real historic building case study. Additionally, the Solar Reflection Index (SRI) determining the cooling potential of the surface [6] corresponds to 67, when the value suggested by the LEED® protocol for sloped roof is 29. The same coating was also used for part of the external paving of the building, contributing to the same credit. The overall surface of the area was covered by cool natural and local materials, such as tiles and natural local reflective gravel typologies, which granulometry has been optimized in order to maximize the cooling potential. The final SRI value of this permeable stone natural paving is more than 45.

4. Discussion

4.1. Principal originalities of the new protocol

GBC Historic Building™ arised as an innovative tool based on the comparison and the union of two different cultures: the sustainability criteria of the LEED® standard and the knowledge of the restoration world, for which Italy hold positions of excellence in the International scene. With the purpose of improving sustainability goals in the building’s deep renovation process and to enhance cultural instances within the new evaluation system, a new topic called “Historic Value” has been introduced in order to collect all the specific issues related to the preservation practice. This new area is integrated to the well-established LEED topics that deal with sustainability of the sites, water efficiency, energy saving and performance optimization, materials and waste management, indoor environmental quality, both during construction and operation phases.

4.2. Energy efficiency and architecture preservation

One of the innovative aspects of GBC Historic Building™ is the consideration of energy efficiency as an opportunity to preserve and protect historical buildings, and not necessarily a change to its original content to be avoided. The new rating system recognizes the relevance of whole building energy performance evaluation, required to analyze energy needs for heating and cooling, lighting, DHW and process energy through a simplified calculation model or dynamic energy simulation [6]. The approach
implemented in this study is the dynamic simulation, that allowed to define the variation of heating and cooling requirement with varying boundary conditions such as weather data, occupancy, etc. The main energy efficiency passive intervention consisted of the implementation of a performing external insulation layer over the opaque envelope and of cool roof solutions for historic buildings, where both energy efficiency practice and the purpose of preserving architectural heritage are successfully combined. The possibility to study the thermal-energy dynamics of the buildings also facilitated the integration of innovative solutions, suitable for applications in historic buildings, main purposes of *GBC Historic Building™*.

5. Conclusions

The experience of the case study of an historic building located in central Italy has highlighted some innovations and methodologies to save energy, useful for the development of *GBC Historic Building™* prerequisites and credits. In particular, the case study presented in this paper contributed to the investigation around the applicability of “Sustainable Sites”, “Energy & Atmosphere”, and “Innovation in Design” issues while respecting the prescription of the Regional Architectural Preservation Office. Moreover, the energy analysis has highlighted the need of audit activities to be integrated in the building evaluation process, a set of procedures that will be developed and integrated within the new topic “Historic Value”.

References


Biography

**Paola Boarin.** Architect, Ph.D., research fellow and lecturer at Department of Architecture, University of Ferrara, Italy. Chair of the Technical Advisory Group “Historic Building” for GBC Italia.

**Daniele Guglielmino.** Architect, Ph.D., LEED® AP™ O+M, BD+C. Founder Member of IBPSA Italian Chapter. Vice Chair of Technical Advisor Group EA of Green Building Council Italia.

**Anna Laura Pisello.** Engineer, Ph.D. in Energy Engineering from University of Perugia, visiting scholar at Columbia University and CUNY. Her research interests focus building energy efficiency.

**Franco Cotana.** Engineer, Full Professor of Applied Physics at University of Perugia, Italy. Director of the CIRIAF. His research interests lie in renewable energy systems, green chemistry, building physics.