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An Assessment Method for Certified Environmental Sustainability in the Preservation of Historic Buildings. A Focus on Energy Efficiency and Indoor Environmental Quality in the Italian Experience of GBC Historic Building

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Abstract: Environmental sustainability certification represents a strategic opportunity for improving energy efficiency, environmental quality, rational use of resources and design innovation in historic buildings, allowing greater transparency on energy uses and environmental management. To address these aspects, the Green Building Council of Italy has developed a new rating system, GBC Historic Building®, derived from the most diffused environmental sustainability assessment method worldwide (i. e. Leadership in Energy and Environmental Design - LEED®), in order to evaluate the sustainability level of restoration, rehabilitation and adaptation of historic buildings built before the end of World War II. This manuscript focuses on how this innovative assessment method addresses energy issues and indoor environmental quality aspects throughout the different thematic areas, introducing the new category “Historic Value”, distinctive of this protocol, aimed at improving the knowledge on the historic building and to support a sustainable approach in the restoration process.

Keywords: deep renovation, historic value, energy retrofit, indoor environmental quality, rating system

1 Introduction

In recent years, the European Commission has decided to set up a specific legislative framework to cut CO_2 emissions, to increase the share of renewable sources and to enhance energy and environmental performances. Particularly, European Directives 31/2010/EU [1] and 2012/27/EU [2] have shown the big potential to achieve energy savings and CO_2 emissions reduction through the refurbishment of existing buildings and the construction of new low-energy buildings [1]. As the matter of fact, approximately 35 % of the building stock is more than 50 years old [3], more than 40 % of the European residential buildings have been constructed before the 1960s [4] and more than 50 % before the 1970s [5]. European households are responsible for 68 % of the total final energy use in buildings, mainly related to heating, cooling, hot water, cooking and appliances [4]. Furthermore, existing buildings in EU are responsible for 40 % of final energy consumption [6] and for 36 % of CO_2 emissions [3]. The large proportion of existing dwellings has an important role for reducing energy bills and costs, as well as for improving energy efficiency and human comfort [1]. Considering the lowest rate of new buildings construction, 2% in United States [7] and 3% in Europe [8], energy efficiency in existing buildings is one of the greatest opportunities towards a sustainable future. Particularly, in the case of historic buildings (both traditional and listed buildings), the intervention should respect their historic values, balancing the needs for energy efficiency, human comfort, heritage preservation and long-term sustainability. Considering energy efficiency as an effective mean rather than an added restriction for protecting the cultural heritage [9] can lead to a conjunction between the culture of environmental sustainability and the wealth of knowledge of the restoration practice [10]. In this context, environmental sustainability certification is a key issue for improving energy efficiency, indoor environmental quality, rational use of resources and design innovation, allowing greater transparency during design and construction phases and on environmental management of buildings, while preserving their cultural identity. This article introduces the Italian experience for the development of a sustainability rating tool named GBC Historic Building®, which was released in 2014 and is currently available for the Italian building sector. Specifically, this manuscript is concerned with how this innovative assessment method addresses energy issues and indoor environmental quality aspects throughout the different thematic areas.

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2 Historic value and environmental sustainability: an assessment method

2.1 Motivation and development of the tool

Since the multiple factors and stakeholders involved within a restoration process, the understanding and delivery of cultural values represent an important asset for decision-making about what and how to preserve, and what the priorities and potential threats to consider are [10]. To this regard, environmental sustainability assessment methods offer an effective model and structure in terms of reliability and transparency that can be adopted in the historic field as well. This understanding, together with the great potential regarding the historic building stock to be renovated at a the Italian and European level [11], has led the Green Building Council (GBC) of Italy, an Italian non-profit organization that promotes sustainability in building design, construction, and operation, to develop a new rating system, namely GBC Historic Building® (GBC HB) [12]. GBC HB is therefore a voluntary and third-party assessment method and certification tool for orienting and assessing restoration, rehabilitation and adaptation processes of historic buildings built before the end of World War II towards sustainability goals. The tool is based on the existing rating system Green Building Nuove Costruzioni e Ristrutturazioni (LEED NC 2009 Italia) [13], the Italian adaptation of the LEED® rating system for new construction and major renovation, i. e. LEED® Building Design and Construction: New Construction (v3) (LEED BD+C) [14]. Although applicable to existing buildings, neither LEED NC 2009 Italia nor LEED BD + C included specific requirements addressing historic and cultural values in the renovation process, highlighting the lack of tools and guidelines dedicated to this topic within the building sector. Therefore, a pool of experts in the green building practice and in the restoration field (both from the academic field and the wider construction sector) was therefore put together by the GBC of Italy, activating the Technical Advisory Group 'Historic Building' (TAG HB) that worked alongside with the technical and certification group of the Italian organisation.

The development process started with the analyses of two existing rating tools, which, together, constitute the basis and structure of the new protocol, i. e.:

- Green Building Nuove Costruzioni e Ristrutturazioni (LEED NC 2009 Italia, version 2011), the existing Italian adaptation of LEED® Building Design and Construction: New Construction (v3) (LEED BD+C), which was previously developed by the GBC of Italy in order to better align with Italian statutory framework. This tool is applicable to existing buildings as well, but does not consider historic values as part of the sustainability goals;
- LEED® Building Design and Construction: New Construction (v4), the newest born in the LEED 'family' [15]. The TAG looked into this new version as soon it was released at the end of 2013, in order to evaluate the possibility of integrating new credits or new approaches into GBC HB, in order to start preparing the Italian tool for a future alignment with the most recent international version.

The development process comprised an assessment of preliminary case studies through the existing LEED NC 2009 Italia in order to highlight applicable (also with modifications and/or integrations) and non-applicable credits [16]. Alongside with the investigation above, the TAG HB defined a list of priority topics related to the heritage field, which have been translated into the LEED 'language' in order to develop measurable criteria to be used for the assessment of preservation and sustainability level of interventions, while aligning with the original tool. This research has led to the definition of a brand new credit category, namely 'Historic Value' (HV), which does exist in GBC HB only, aiming at collecting all the objectives related to the fulfilment of preservation principles within the building process, with particular attention to the acknowledgement of historic values as sustainability criteria.

2.2 Recognition of historic value as a sustainability parameter

In terms of sustainability, it is necessary to design intervention on historic buildings closely to the monumental heritage they carry and without compromising the real and potential wealth in the context in which we are asked to get involved. If sustainable development is the «development that meets the needs of the present without compromising the ability of future generations to meet their own needs» [17: 41], this 'potential' has to be kept in order to make future generations to benefit from it. This process depends on multiple interdependent dimensions: environmental, economic (long term), social, and, above all, cultural. Therefore, restoration, as the «[...] methodological moment in which a work of art is appreciated in its material form and its historical and aesthetic duality for its transmission to the future» [18: 6], becomes a sustainable 'action' itself, thus assessable through tools and methods pertaining to the sustainability context (such as LEED) [10]. Humanity has always dealt with the issue of maintaining, repairing, restoring and/or adapting to new uses to respond to the continuously changing needs [19]. In the past few decades, the relevant literature in the architecture technology field has extensively highlighted that the behaviour of pre-industrial humanity could be called 'sustainable', as it was particularly focused to the consumption of raw materials and energy. It is often noted that re-gaining such behaviour could represent, today, a step towards a sustainable approach to development. Actually, it is incorrect to speak about sustainability of pre-industrial humanity, because the use of techniques that allow an effective economy of resources is not motivated by the attribution of value to the resources themselves, but by their mere economic determination as a scarce resource. It is possible to speak of sustainability in the modern sense only when the sustainable action has the goal of preserving the resource whose value is recognised for future generations. These are two very distant goals: in the past, preservation of resources stemmed out from their shortage at the time and because of a recognised short-term economic potential within them; on the contrary, today, the preservation of resources is the result of their expected shortage in the future, although their preservation in the present may turn out to be economically unfavourable. Therefore, the concept of 'environmental sustainability' qualifies as maintenance (intended as preservation) with respect to an already existing potential (or a balance between already existing potentials) whose environmental value is recognised. The concept of 'cultural sustainability' qualifies as maintenance (intended as preservation) with respect to a pre-existing construction (or a balance between pre-existing construction) whose cultural value is recognised. It is then possible to assert that restoration, in the modern sense, identifies a sustainable action, from a cultural point of view, with respect to existing heritage, whose cultural value is recognised. To this regard, GBC HB is an innovative tool that, in addition to answering the needs of the market to create the conditions for high levels of health and well-being for users and the reduction of consumption of non-renewable resources, sees restoration as the first sustainable action that concerns the existing building whose cultural value is recognised. It is precisely the holistic approach, typical of all LEED rating tools, that the new rating system seeks to achieve, maintaining and transmitting the building in both its physical form and the cultural values it represents to future generations.

The choice of restorative actions is founded on a series of principles developed from the late nineteenth century up to the latter half of the twentieth century. All the preservation principles largely shared in the practice of restoration (such as minimum intervention, authenticity, reversibility and compatibility, as they appear in the Venice Charter of 1964) [20], were extensively integrated in the new topic area HV, to give a useful guide to designers for planning their intervention on historic constructions. For a wider sustainability and for not compromising the authenticity of the subject (in both its tangible and intangible dimensions), the activity must be carried out following the principle of minimum intervention, in order to preserve the material, restore the image, and functionally renovate the asset. Even structural improvements or integrations must be designed under this perspective, without introducing elements that are not strictly necessary. The principle of reversibility of the project's works has been embedded in the new HV area as well, with the purpose of allowing future generations, who may potentially avail of different and more advanced technologies than our own today, to get involved with a greater degree of preservation and in a more respectful manner than the current approach. The principle of compatibility, which ultimately concerns the durability of the work for posterity, was declined in a range of applications: from the ways in which the asset can be used, to the materials used for the restoration of architectural surfaces, and to techniques used for structural consolidation. The attention given to the durability of the restoration is also confirmed by the importance given to the scheduled maintenance plan. All the principles of restoration discussed above have found a place in the new topic area HV, though dedicated new prerequisite and credits, as discussed in the following sections.

3 A new assessment method

3.1 Field of application

GBC HB is applicable to the building stock constructed before the end of World War II, at the beginning of the post-war reconstruction activity and the rise of the industrialization of the building process in Europe. Being «[...] material testimony having the force of civilization» [21], this part of the stock is mostly characterised by pre-industrial building process (in terms of phases, tasks and operators), pre-industrial materials and construction techniques (spontaneous and local), and technical elements mostly made through pre-industrial processes. The existing building undergoing the assessment must have been built before the end of World War II (or after World War II if pre-industrial features are recognised) for at least 50 % of the existing technical elements measured in square meters of the front surface calculated without considering voids (windows and doors). In case the building was built before the end of World War II for a portion of less than 50 % of the existing technical elements, the project can be assessed through the already existing rating systems pertaining to the LEED 'family' of rating tools. In addition, it is to be noticed that the protocol can be used for projects seeking restoration, rehabilitation or adaptation processes, which must entail a major renovation, defined as action which involves significant elements of HVAC systems and the renewal or functional reorganization of interior spaces, considering the possibility of a building envelope performance improvement consistent with the preservation of cultural, architectural and construction features. The new tool has therefore a wide applicability to the Italian building sector, as historic buildings constructed before the end of World War II and in need of major renovations are more than the 30 % of the existing building stock [12].

3.2 Structure of GBC Historic Building

GBC HB follows the same structure and process of the already existing LEED tools, but in addition it promotes a shift towards the inclusion of historic values as sustainability criteria through the new topic 'Historic Value'. The protocol is structured in the following categories:

- Historic Value (HV) (20 points available): it pays close attention to the principles of restoration and operations required at the different stages of the restoration process, while improving the overall environmental performances. This new category does exist in GBC HB only and it is not present in any of the other LEED/GBC protocols;
- Sustainable Sites (SS) (13 points available): it encourages strategies for regenerating damaged areas, minimizing retrofit and building impacts and promoting alternative transportation;
- Water Efficiency (WE) (8 points available): it stimulates a smarter use of water and its preservation, considering indoor, outdoor and specialised uses, as well as promoting water metering;
- Energy and Atmosphere (EA) (29 points available): it approaches energy performance improvement from a holistic perspective, considering energy efficiency as a protection tool;
- Materials and Resources (MR) (14 points available): it minimises impacts associated with the extraction, processing, transport, maintenance and disposal of materials, as well as the embodied energy;
- Indoor Environmental Quality (EQ) (16 points available): it aims to achieve high standards of indoor air quality and thermal comfort for the occupants;
- Innovation (ID) (6 points available): it rewards design solutions that are distinguished by the characteristics of innovation and environment performance exceeding the protocol's requirements within the restoration-related process;
- Regional Priority (PR) (4 points available): it encourages design teams to focus on environmental characteristics that are unique and specific to the region in which the building is located, through the achievement of credits across the protocol that are associated to specific climate conditions and environmental needs.

All topic areas are made by prerequisite(s), which are mandatory, and credits, which are voluntary and rewarded with points. The distribution of scores across thematic areas and their associated prerequisites and credits, like other LEED protocols, is focused on the effects of each credit on environment and human health, compared to a set of impact categories related to environmental, economic and social benefits. Although credit categories in the LEED BD+C group are always the same, prerequisites and credits (and, therefore, the amount of achievable points) can vary in order to better address specific challenges related to different projects and end uses (commercial, schools, retail, core and shell, and healthcare). Following the same principle, besides the integration of the brand new category HV, which exists in this protocol only, GBC HB has a different allocation of points across the credit categories [21]. Table 1 compares the distribution, number of points and credit weighting across thematic areas in LEED NC 2009 Italia and in GBC HB.

An extensive review has been undertaken within the TAG HB concerning the adaptation and integration of the existing rating tool LEED NC 2009 Italia in order to address sustainability concerns in restoration works [22]. In this regard, Table 2 lists:

- all prerequisites and credits included in each thematic areas;
- the maximum number of points achievable per credit;
- the type of credit (new, revised with minor or major changes, or confirmed compared to LEED NC 2009 Italia);

Table 1: Comparison between the allocation of points and weightings for each topic in LEED NC 2009 Italia and GBC HB.

Topic	LEED NC 2009 Italia		GBC HB	
	Points per Topic	Topic Weightings [%]	Points per Topic	Topic Weightings [%]
Historic Value (HV)	Not existing in this tool	Not applicable	20	18.2
Sustainable Sites (SS)	26	23.6	13	11.8
Water Efficiency (WE)	10	9.1	8	7.3
Energy and Atmosphere (EA)	35	31.8	29	26.4
Materials and Resources (MR)	14	12.7	14	12.7
Indoor Environmental Quality (EQ)	15	13.6	16	14.5
Innovation (ID)	6	5.5	6	5.5
Regional Priority (RP)	4	3.6	4	3.6
Total	110	100 %	110	100 %

Table 2: Summary of credits per category for GBC HB.

Prerequisite/Credit	Points	Type of credit	Exemplary performance	Regional Priority (PR)
	HISTORIC VALUE (HV)			
Prerequisite 1 – Preliminary analysis	Mandatory	New	Not eligible	Not eligible
Credit 1.1 – Advanced analysis: energy audit	1–3 points	New	Not eligible	Eligible (c)
Credit 1.2 – Advanced analysis: diagnostic tests on materials and deterioration	2 points	New	Not eligible	Not eligible
Credit 1.3 – Advanced analysis: diagnostic tests on structures and structural monitoring	2–3 points	New	Not eligible	Not eligible
Credit 2 – Project reversibility	1–2 points	New	Eligible	Eligible (m)
Credit 3.1 – Compatibility of the new use and open community	1–2 points	New	Eligible	Eligible (m)
Credit 3.2 – Chemical and physical compatibility of mortars	1–2 points	New	Not eligible	Not eligible
Credit 3.3 – Structural compatibility	2 points	New	Not eligible	Not eligible
Credit 4 – Sustainable construction site	1 point	New	Eligible	Not eligible
Credit 5 – Scheduled maintenance plan	2 points	New	Not eligible	Eligible (s,c)
Credit 6 – Specialist in preservation of buildings and sites	1 point	New	Not eligible	Not eligible
	SUSTAINABLE SITES (SS)			
Prerequisite 1 – Construction activity pollution prevention	Mandatory	Confirmed	Not eligible	Not eligible
Credit 1 – Brownfield redevelopment	2 points	Major revision	Not eligible	Not eligible
Credit 2.1 – Alternative transportation: public transportation access	1 point	Minor revision	Eligible	Not eligible
Credit 2.2 – Alternative transportation: bicycle storage and changing rooms	1 point	Minor revision	Eligible	Not eligible
Credit 2.3 – Alternative transportation: low-emitting and fuel-efficient vehicles	1 point	Minor revision	Eligible	Not eligible
Credit 2.4 – Alternative transportation: parking capacity	1 point	Minor revision	Eligible	Not eligible
Credit 3 – Site development: open spaces recovery	2 points	Major revision	Eligible	Eligible (s,c)
Credit 4 – Storm-water design: quantity and quality control	2 points	Major revision	Not eligible	Eligible (c)
Credit 5 – Heat island effect: non-roof and roof	2 points	Major revision	Eligible	Not eligible
Credit 6 – Light pollution reduction	1 point	Confirmed	Not eligible	Not eligible
	WATER EFFICIENCY (WE)			
Prerequisite 1 – Water use reduction	Mandatory	Confirmed	Not eligible	Not eligible
Credit 1 – Water-efficient landscaping	1–3 points	Major revision	Not eligible	Not eligible
Credit 2 – Water use reduction	1–3 points	Confirmed	Eligible	Not eligible

(*continued*)

Table 2: (*continued*)

Prerequisite/Credit	Points	Type of credit	Exemplary performance	Regional Priority (PR)
Credit 3 – Water metering	1–2 points	New	Eligible	Eligible (s)
ENERGY AND ATMOSPHERE (EA)				
Prerequisite 1 – Fundamental commissioning of building energy systems	Mandatory	Confirmed	Not eligible	Not eligible
Prerequisite 2 – Minimum energy performance	Mandatory	Minor revision	Not eligible	Not eligible
Prerequisite 3 – Fundamental refrigerant management	Mandatory	Confirmed	Not eligible	Not eligible
Credit 1 – Optimize energy performance	1–17 points	Minor revision	Eligible	Eligible (m)
Credit 2 – Renewable energies	1–6 point	New	Eligible	Eligible (s)
Credit 3 – Enhanced commissioning	2 points	Minor revision	Eligible	Not eligible
Credit 4 – Enhanced refrigerant management	1 point	Confirmed	Not eligible	Not eligible
Credit 5 – Measurement and verification	3 points	Confirmed	Not eligible	Not eligible
MATERIALS AND RESOURCES (MR)				
Prerequisite 1 – Storage and collection of recyclables	Mandatory	Confirmed	Not eligible	Not eligible
Prerequisite 2 – Demolition and construction waste management	Mandatory	New	Not eligible	Not eligible
Prerequisite 3 – Building reuse	Mandatory	New	Not eligible	Not eligible
Credit 1 – Building reuse: maintaining existing technical element and finishing	3 points	Major revision	Not eligible	Eligible (c)
Credit 2 – Demolition and construction waste management	1–2 points	Minor revision	Not eligible	Not eligible
Credit 3 – Materials reuse	1–2 points	Minor revision	Eligible	Eligible (s)
Credit 4 – Building product environmental optimization	1–5 points	New	Eligible	Eligible (m)
Credit 5 – Regional materials	1–2 points	Minor revision	Eligible	Not eligible
INDOOR ENVIRONMENTAL QUALITY (EQ)				
Prerequisite 1 – Minimum indoor air quality performance (IAQ)	Mandatory	Major revision	Not eligible	Not eligible
Prerequisite 1 – Environmental Tobacco Smoke (ETS) control	Mandatory	Confirmed	Not eligible	Eligible (s,c)
Credit 1 – Indoor air monitoring	2 points	Major revision	Not eligible	Not eligible
Credit 2 – Minimum outdoor air delivery assessment	2 points	Major revision	Not eligible	Not eligible
Credit 3.1 – Construction indoor air quality management plan: during construction	1 point	Minor revision	Not eligible	Not eligible
Credit 3.2 – Construction indoor air quality management plan: before occupancy	1 point	Minor revision	Not eligible	Eligible (m)
Credit 4.1 – Low-emitting materials: adhesives and sealants, cement-based materials and timber finishes	1 point	Minor revision	Not eligible	Not eligible
Credit 4.2 – Low-emitting materials: paints and coatings	1 point	Minor revision	Not eligible	Not eligible
Credit 4.3 – Low-emitting materials: flooring systems	1 point	Minor revision	Not eligible	Not eligible
Credit 4.4 – Low-emitting materials: composite wood and agrifiber products	1 point	Minor revision	Not eligible	Not eligible
Credit 5 – Indoor chemical and pollutant source control	1 point	Major revision	Not eligible	Not eligible
Credit 6.1 – Controllability of systems: lighting	1 point	Minor revision	Not eligible	Not eligible
Credit 6.2 – Controllability of systems: thermal comfort	1 point	Minor revision	Not eligible	Not eligible
Credit 7.1 – Thermal comfort: design	1 point	Minor revision	Not eligible	Eligible (m)
Credit 7.2 – Thermal comfort: verification	2 points	Minor revision	Not eligible	Not eligible
INNOVATION (ID)				
Credit 1 – Innovation in design	1–5 points	Confirmed	Not eligible	Not eligible
Credit 2 – GBC HB® Accredited Professional	1 point	Minor revision	Not eligible	Not eligible
REGIONAL PRIORITY				
Credit 1 – Regional priority	1–4 points	Minor revision	Not eligible	Not eligible

- the list of credits eligibile to the extra point for exemplary performance (i. e. a performance achieved by the project that is largely exceeding the threshold required in eligible credits), in regard to the Innovation category (ID);
- the list of credits eligible to the Regional Priority (PR) category, for projects located in coastal areas (s), continental areas (c) or mountain areas (m).

Prerequisites and credits could be related to the design phase or the construction phase, depending on their impact on the process and the type of verifications needed. Each prerequisite and credit include a set of requirements whose achievement has to be demonstrated by the project team by completing information forms and/or providing documentation from the project and/or the site.

The maximum score achievable by the GBC HB project is 110 points, divided into 100 points across HV, SS, WE, EA, MR and EQ, and 10 points for ID and PR. The sum of the achieved points defines the level of certification attainable by the project, i. e.: i) "Certified", from 40 to 49 points; ii) "Silver", from 50 to 59 points; iii) "Gold", from 60 to 79 points; iv) "Platinum", from 80 to 110 points. The certification process is entirely managed by the GBC of Italy which covers both the role of standard setter, i. e. they define the process steps and technical contents, and of certification body. External Accredited Verification Bodies help the GBC of Italy with design and construction verifications (including site visits) during the process. After construction is completed and all inspections have had positive outcomes, the certification can be awarded. A certificate is produced by the GBC of Italy and the building can also be awarded with a plaque (optional) to be exhibited in a publicly accessible space. Fees are payable to the GBC of Italy for registration, certification and production of certificate and plaque.

4 The challenge of energy retrofit and indoor environmental quality improvement in historic buildings

The topic of energy retrofit and indoor environmental quality improvement in historic buildings has a strong interdisciplinary nature, linking preservation, energy efficiency and human comfort together. Similarly to other LEED protocols, in GBC HB the energy and environmental retrofit is focused on the building level, but considering the main effects on district level as well. The energy and indoor environmental 'issue' adds up to 40.9 % of the points available. It is directly and indirectly addressed in different areas, i. e.:

- in the new Historic Value (HV) category, where the historic building's energy diagnosis is suggested for understanding the current energy behavior of the building, in order to inform any design and intervention strategy;
- in the topic Sustainable Sites (SS), where attention towards the urban heat island effect reduction and the efficient illumination system contributes both to indoor and outdoor comfort and energy consumption reduction;
- in the topic Energy and Atmosphere (EA), where great attention is given to the improvement and optimization of the building energy performance, to the commissioning of building systems, to the integration of renewable energy sources, the management of refrigerants, and to the measurement and verification of energy consumption during operation;
- in the topic Indoor Environmental Quality (EQ), where the attention is focused to the improvement of the overall indoor environmental quality through air quality control and upgrading, controllability of lighting and thermal control systems, and the design and verification of thermal comfort conditions. These strategies have a direct impact on energy consumption due to energy systems choices.

The following paragraphs provide more context to the points highlighted above, addressing energy issues and indoor environmental quality aspects throughout the different thematic areas listed above, though relevant prerequisites and credits.

4.1 Area Historic Value (HV)

The accurate identification of thermal performance and environmental behavior of a historic building is a key requirement for ensuring an appropriate energy assessment and for identifying possible modifications or operational solutions for improving its performance [23, 24]. The prerequisite included in the HV area concerns preliminary analysis necessary to identify the historic value of a building through the study of its architectural features (i. e. structures, materials, construction techniques) and its transformations across the time (multiple construction phases, different uses, on-going deterioration processes, etc.). Particularly relevant is the requirement of providing preliminary information on existing building services, in use or not, in order to understand how active systems affect thermal comfort conditions, to identify obsolete devices that should be replaced and existing cavities that could be reused and repurposed.

An appropriate energy and environmental evaluation allows the optimization of the energy performance and to foster environmental sustainability, preserving and enhancing the positive qualities of an historic building. Moreover, energy-related retrofit actions based on an incorrect understanding of the original energy behavior can cause serious physical damage and possible legal claims. Therefore, an accurate energy audit is the first step to identify the suitable energy-related retrofit intervention for a historic building and this requirement was included in HV credit 1.1. The European Commission defines the energy audit as «[...] a systematic procedure to obtain adequate knowledge of the existing energy consumption profile of a building [...], identify and quantify cost-effective energy savings opportunities and report the findings» (2, art 3). The legislative framework emphasizes its role to identify energy inefficiencies, to reduce energy inputs and to define potential measures for improving energy efficiency and human comfort [2]. As recommended by literature [25] and American standards [26], the procedure asks for different types of energy audit according to the analytical level to be obtained: i) "walk-through audit", a visual inspection for assessing the general energy quality and highlighting inefficiencies and savings potentials during a short-term visit (one-day audit); ii) "standard audit", for quantifying the energy loses linked to a specific problem; and iii) "simulation audit" based on deep inspections and dynamic simulations of the building energy performance. Each level of analysis requires data collection and elaboration of results progressively more complex and refined. This protocol considers the real energy audit as a foundamental step for knowing the energy performances of the building. There are several Non Destructive Testing (NDT) that can be used to support the building energy audit, in order to understand complex fluid dynamics phenomena, to characterize materials and structures, to control the manufacturing processes, and to improve the design and the fabrication of products [27, 28]. In HV credit 1, GBC HB includes a progressive set of achievements to understand the building's energy behavior, starting with the "walk-through audit". This credit includes also on-site measurements and NDT to quantify energy use and performances of the building envelope and building services. Particularly, infrared thermography (IRT) is suggested to reveal the most important thermal anomalies related to structural features, building materials and energy problems. Progressing from the requirement of an energy audit and as a second step, HV credit 1.1 suggests the use of IRT to detect the presence of thermal bridges, non-homogeneous components and behaviours (different thicknesses, traces of arches or other components, low performances, different materials, etc.), damages of the building envelope (decay, cracking in the plaster, presence of moisture, water percolation, air leakages from windows and cracks, etc.) and malfunctioning of installations and systems (missing of insulation on boilers, high consumptions, malfunctioning, etc.). As a third step, the Heat Flow-Meter (HFM) measurement is suggested in HV credit 1.1 to determine the thermal transmission properties, both thermal transmittance (U-value) and thermal resistance (R-value) of representative parts of the building envelope. This test is to be performed *in situ* and under actual thermal conditions to avoid many inaccuracies related to databases determination or analytic calculation. Overall, the use of NDT suggested in HV credit 1.1 allows to collect qualitative and quantitative data on the building's thermal behavior in order to define more appropriate actions for the energy-related retrofit and improvement of indoor thermal comfort conditions.

Although not primarily addressing energy and IEQ matters, reversibility (addressed in HV credit 2) and compatibility (addressed in HV credit 3.1, 3.2 and 3.3) criteria should guide design choices for the energy and environmental retrofit, in order to avoid historic values to be undermined though the process.

With a wider view to the construction site, HV credit 4 aims at reducing the negative impacts of environmental and boundary conditions that could potentially affect the building components and surrounding communities, by adopting renewable energy sources during renovation as much as possible and reducing impacts produced by the use of restoration techniques. Lastly, the implementation of a scheduled maintenance plan (HV credit 5) is considered as a tool for guaranteeing the maintenance of the building, in order to reduce the energy costs on a long-term period.

4.2 Area Sustainable Sites (SS)

The topic Sustainable Sites addresses the environmental aspects associated with the place where the historic building sits, focusing on environmental concerns related to building landscape, hardscape and exterior building issues. The fundamental aspects responsible for the improvement of the liveability and the quality of the urban environment that have an impact on the energy issue are related to: i) enhancement of public and alternative transport; ii) recovery of high-permeability open spaces; iii) reduction of the "urban heat island effect" phenomena, by using passive techniques with low aesthetic impact; iv) rationalization of the illumination system, reducing the intensity of light pollution.

Although not directly addressing energy aspects, but the wider topic of climate-change, the group of credits related to alternative transportation (SS credits 2) encourage multimodal transportation choices or, otherwise, reduced motor vehicle use, thereby reducing greenhouse gases, air pollution and other environmental and public health harms associated with motor vehicle use. Particularly, these credits encourage the diffusion of public and alternative transportations (low-emitting and fuel efficient vehicles) and associated spaces (i. e. bicycle storage, changing room, etc.).

SS credit 3 concerns previously saturated or paved spaces, or altered historic gardens. This topic is strongly related to the reduction of urban heat island effect (SS credit 5) that occurs when cities replace natural land cover with dense concentrations of pavement, buildings and other surfaces that absorb and retain heat. This effect increases energy costs (e. g. for air conditioning), air pollution levels and heat-related illness. Different strategies can be done to reduce this effect such as: to plant trees and other vegetation, to integrate small green infrastructure practices into grassy or barren areas, vacant lots, and streets or to build green and cool roofs. The credit considers a range of intervention options, which include non-roof and roof surfaces; for the latter, the project can consider either high-reflectance roofs or green roofs (or a combination of both), options that can be integrated in historic contexts [29] and can promote product innovation in the building industry.

Lastly, the reduction of light pollution (SS credit 6) is another proposed action to improve the sustainability of the building while reducing its overall energy consumption. The credit addresses both indoor and outdoor lighting, defining different requirements in relation to the different lighting zones. Attention is paid to high performance luminaires as well as on lighting design, especially in cases of high historic value where outdoor illumination is integrated to enhance the building and highlighting its aesthetic dimension.

4.3 Area Energy and Atmosphere (EA)

One of the innovative aspects of GBC HB is to consider energy efficiency and energy retrofit process as a practice for guaranteeing the protection of historic buildings [9] and not necessarily a change in the original material consistency. For this reason, the topic Energy and Atmosphere is based on the principle of building performance improvement compared to a reference building, considering all energy uses. The traditional approach based on the adaption to pre-defined and fixed energy performance levels, for building components or for the building as a whole, was avoided because it could not promote a positive improvement of their overall performance. In this holistic approach, any improvement is an important step towards the energy consumption and greenhouse gases emissions reduction and towards the improvement of human comfort. On the contrary, a narrow vision considering the replacement of single building elements with new ones with higher performances (windows, as a relevant example) could potentially lead to critical situations in terms of thermal comfort, formation of condensation or to a possible alteration of the balance with the surrounding historic environment.

Through the Legislative Decree 311/2006 [30], the Italian law imposes minimum requirements for the energy refurbishment of new and existing buildings, both related to the whole energy consumption or to the thermal performance of each single building element undergoing refurbishment (i. e. roof, windows, walls, heating system, etc.). However, the same Legislative Decree exempts listed buildings from this requirement, as it would not be possible do make a distinction *a priori* between those that can actually allow some improvement from those that would be undermined in their cultural value by such changes. To overcome this problem, GBC HB allows design projects to choose between two different paths related to energy performance assessment of the historic building and included in EA prerequisite 2 and EA credit 1:

- a simplified procedure (prescriptive procedure) for energy performance assessment according to calculations in steady conditions, suggested by national standards mentioned in the Italian Legislative Decree [31–33], obtaining at least an improvement of 5 % of the initial energy consumption; or
- a dynamic energy simulation of the whole building (performance procedure), obtaining at least an improvement of 3 % basing on the ASHRAE American standard [26].

In both cases, the protocol considers the percentage of energy improvement compared to a baseline building defined for the historic environment and includes all forms of energy consumption, i. e. winter heating, summer cooling, ventilation, hot water production, illumination and process, and energy production, i. e. from renewable energy sources.

EA credit 1 is highly projected towards the performance procedure (awarding up to 17 points against the maximum 3 points for the prescriptive procedure), as energy simulation models can help comparing alternative retrofit interventions, avoiding strategies or technological solutions that can have negative effects on the building. The currently available tools for assessing energy performance of buildings can be static or dynamic. Each software uses specific algorithm for calculations, has different input mode and can produce different typology of output. In general, the more powerful and complete the software, the more detailed and precise the input. Simpler software can produce an energy assessment in steady regime considering a limited number of factors. Generally, they are used for energy labelling in order to compare different performances in standard condition of use. They simulate the real building's performances only partially, as they have standard heating period, pre-defined data for internal and external air temperature and they do not consider periodic changes of temperature and data managing. Such software are not suitable for complying with the performance procedure, where dynamic simulation software are more suitable, as they analyse contributions of thermal inertia of walls in detail, variability of the outside temperature, solar radiation, natural ventilation and users' management. Detailed data have to be used for both describing climatic conditions, geometry and building properties. In both cases, the challenge is to build a model that represents the real building. As a result, their applicability on historic buildings requires adjusting the inputs appropriately to obtain results close to experimental data and this requires a tight collaboration between heritage preservationist and building physicists. Particularly, many authors considered the calibration of a building simulation model a fundamental to predict the effects of energy preservation measures [34, 35]. Calibration techniques include iterative revisions of the initial model, driven by identified discrepancies [35], which are corrected based on evidence and expert's knowledge [36]. Certainly, a dynamic software is better than other tools for assessing energy performance of historic buildings and this is why EA credit 1 is more oriented towards this option.

Besides the considerations towards energy performance, the area 'Energy and Atmosphere' includes other possible design and management strategies affecting energy effficiency, namely:

- energy commissioning of systems (fundamental in EA prerequisite 1 and enhanced in EA credit 3), moving also towards the envelope's commissioning as a technique for improving the knowledge and respect for the historic surfaces;
- refrigerant management (minimum in EA prerequisite 3 and enhanced in EA credit 4);
- integration of renewable energy sources (EA credit 2) produced either on-site or resulting from certified off-site green energy production, when a local integration is not possible for reasons related to the historic context the building sits within;
- measurement and verification of consumption during operation (EA credit 5).

4.4 Area Indoor Environmental Quality (EQ)

The achievement of high standards for thermal comfort and indoor air quality for occupants in historic buildings has to balance the requirements for the protection and enhancement of cultural heritage. Very often, the presence of decorated surfaces or high artistic and historic value does not allow the inclusion of HVAC terminal units or substantial intervention on technical elements. For this reason, this topic is structured in two alternative paths, respectively related to: i) the preservation of historic architecture or ii) to the optimization of thermal comfort and indoor air quality for occupants. This dual approach allows the design proposal to respect the historic environment and to protect surfaces and high-quality materials and, at the same time, to achieve the highest levels of comfort and indoor air quality by exploiting the potential offered by boundary conditions. Therefore, if special boundary conditions are recognized for the building (and this is typically done at the beginning of the design process and confirmed at the moment of the registration of the project to the certification with GBC HB), the group of credits in the EQ category must be pursued consistently on either of the two paths.

The whole area EQ is dedicated to the achievement of high indoor environmental quality, but a prerequisite and a number of credits produce an impact on energy efficiency as well. The possible design and management strategies in this area are related to: i) the improvement of the indoor air quality; ii) the indoor pollution control; iii) the hazardous materials reduction; and iv) the control of indoor visual and thermal comfort conditions for occupants. The improvement of indoor air quality concerns the maximization and control of ventilation in order to guarantee suitable airflow rates (EQ prerequisite 1 and credit 2). In case any ventilation duct is to be integrated in the building to achieve the targeted objectives, the reuse of existing cavities is suggested, in order to avoid any loss of material from the building fabric, thus preserving the historic values to the maximum extent. Controllability and reduction of indoor pollutants are effected through:

- the management of indoor air contaminants, where environmental tobacco smoke is banned from all indoor environments and outdoor spaces up to 8 meters from all entrances, windows and intake ducts (EQ prerequisite 2);
- the control of indoor airflows for mechanically or naturally ventilated spaces according to pollutants concentration monitoring (EQ credit 1);
- the reduction of the use of materials emitting volatile organic compounds (VOC) (EQ credits 4), addressing finishes, preservatives, coatings and all other treatments that are usually put in place in preservation-related activities and that can affect the indoor environment even after occupancy;
- the minimisation of contaminants from outdoors through building accesses and their production indoors (EQ credit 5).

The implementation of an Air Quality Management Plan (EQ credit 3) is considered a specific tool for controlling the indoor air quality during construction phases and before occupancy, thus reducing air quality related issues that can occur due to construction and restoration/rehabilitation processes.

Alongside with the approaches mentioned above, controllability of systems for achieving visual and thermal comfort are fundamental aspects to improve occupants' health, well-being and productivity, and optimising energy performances while preserving the historic building (EQ credits 6). Special attention is given to thermal comfort, both during the design phase, though an appropriate design of HVAC systems and building envelope (EQ credit 7.1), and during the occupancy phase though verifications of indoor environmental parameters and the installation of permanent monitoring system to ensure that building performance meets the desired comfort criteria (EQ credit 7.2).

4.5 Areas Innovation (ID) and Regional Priority (RP)

The Innovation area is not addressing energy efficiency and indoor environmental quality of historic buildings directly, but it promotes innovative and sustainable building practices and strategies during the restoration process and rewards design and construction excellence in case of performance that greatly exceeds those required by the credits within the other categories. In fact, up to 5 points are allocated for exemplary performance across eligible credits (see Table 2). The intention is to promote progressively a shift towards increased practices and outcomes though project, process and product innovation in order to produce a positive impact on the building sector.

As the successful achievement of some credits can be more important in some areas than in other (for instance, the reduction of water consumption in dry climate zones), some credits across the rating system have been identified for each of the three climate zones groups of the Italian territory, i. e. costal, continental and mountain areas. If achieved, these credits are rewarded extra points for Regional Priority (RP) because of their importance for reducing environmental impacts at the local level. As example, EA Credit 1 “Optimize energy performance” is eligible to one extra point in the Regional Priority category for cold zones.

5 Future development and case studies

The protocol has been first released in 2014 and it is currently undergoing a pilot period for its validation through the application to real case studies in Italy, which will contribute to the tool's implementation for the local market, before the evaluation of a potential international applicability beyond national boundaries. In fact, GBC HB is currently available for the Italian market only, but future activities could evaluate its applicability at a European level, where it can potentially have a wide impact. A possible methodology to be investigated for the international adaptation could be the Alternative Compliance Paths (ACPs), an approach currently used by the U.S. Green Building Council for projects outside U.S. ACPs are additional options or approaches to the credits that address unique project needs, making the tool more flexible and applicable for projects outside the specific geographical and legislative context targeted by a rating system.

After collecting the feedback from the first two registered case studies (a rural house in the countryside of the Province of Cuneo and a palazzo in the city centre of Turin, both in the North of Italy), which helped the validation of some new credits within GBC HB, the GBC of Italy has seen the registration of other 5 pilot projects willing to achieve full certification. Among them, two have already been certified and achieved the Gold certification. One project is an old stable positioned inside the Sant'Apollinare Medieval Fortress, a Benedictine fort situated 20 km south-east from the city of Perugia (Italy) and repurposed as a university building with offices, laboratories and conference rooms of an interuniversity research center working on the sustainable development of the built environment [37]. The other pilot project is the MEIS, the National Museum of the Italian Jewish Culture and of the Shoah, to be placed in a former prison in the historic centre of the UNESCO city of Ferrara, Northern Italy. The building, built in 1912 and abandoned in 1992, will host an exhibition space, a library and educational spaces and will be funded by the Italian Ministry of Cultural Heritage and Activities and Tourism. As soon as the other three projects will be verified, the GBC of Italy, together with the TAG HB, can retrospectively review the achievement of this first edition of GBC HB and, possibly, suggest some amendments and/or integrations to fine-tune the protocol.

6 Discussion

The first case studies and the subsequent pilot period allow for some initial assessments of the effectiveness of the GBC HB tool for the Italian market.

In the last decade, the extreme slowdown of the economy has cut total profits by more than half in the Italian construction sector, triggering a gradual but steady market transformation, with residential renovation becoming one of the three main drivers of development. Following a trend that is common to many other mature economies, the Italian construction sector seems increasingly tied up to the intervention on existing buildings. The growth registered in this sector has significantly affected indirect public intervention, enacted through a system of incentives. It is estimated that about 60 % of investments in existing residential retrofits were subject to tax subsidies. Such taxonomic approach applied to the construction sector, however, can be seen in the assessment of interventions on existing buildings. The "qualitative" assessment of the intervention cannot be guaranteed only by energy performance certificates or earthquake risk reduction confirmed by the shift to a lower risk category, but it must also be documented by a wider understanding of all those values that the building, particularly the historic ones, can express, whether of cultural and/or service nature. It is necessary to point out that one of the main objectives, the indicator of the building's structural and/or energy performance, is primarily intended to inform and guide decision-making for buyers and/or users (tenants) as a result influencing their economic value, making buildings with better performance and lower energy consumption more interesting on the housing market. On the other hand, it is to be highlighted that historic buildings have typically a higher average economic value than the rest of the built environment (at least in Italy), by virtue of externalities such as the location, proximity to main public services and/or the particular features of each building, or on account of factors that are intrinsic to the artefact itself. In this economic environment, characterised by a short-term vision, actions supported by private capital seem, for now, directed solely to maximizing profits in a purely speculative dimension (exploitation of incentives, enhancement of location revenue using subdivisions, elevations, changes in land use, etc.), even before the medium-long term achievement of performance targets. In the context of the work on historic buildings, in addition to the essential and preventive critical approach and where the pre-existing stock allows for it, it would be vital to provide and implement all the necessary measures to ensure a relevant sustainability level. To this regard, GBC HB defines possible interventions on the artefact to preserve its identifying features from the preliminary stages of the project. Today, energy-efficient constructions, along with earthquake risk reduction required by the most recent requirements at various institutional levels, must be combined with other goals oriented to a wider environmental sustainability. The critical evaluation of compatible and effective project solutions in practice, identified among those available today, highlights the real possibilities of success of flexible and adaptable voluntary certification protocols for specific areas of intervention on existing buildings.

In Italy, actions supported directly by public capital that almost exclusively involve existing buildings (often subject to protection measures) seem, instead, focused on a longer-term vision. It is no coincidence that the first two registered cases for the application of GBC HB are owned by public agencies. The sector, notably influenced by the recent earthquakes that in the past decade have struck the Italian territory several times (L'Aquila 2009, Emilia 2012, Central Italy 2016), could easily be the main reference for voluntary certification that, similarly to GBC HB, are focused on the historic building heritage. The main barriers that may justify a still insufficient impact in the Italian market do not seem to be consistent with the early extra costs associated with the registration and the certification of the protocol or to the difficulties in complying with some of the credits. On the contrary, they are actually due to the extreme fragmentation of the process that has always characterized the public sector, in particular in the last two decades. These include project phases that fall within the responsibility of design groups that change multiple times throughout the process, unnecessary lengthy time between the planning and execution of works and frequent changes of the client's representatives, factors that seem representing the main obstacles to the protocol's application to public interventions. However, the Italian Ministry of Environment and Protection of Land and Sea, through the Ministerial Decree of December 24, 2015 [38], has recently introduced and adopted minimum environmental criteria related to the offer of services for the design of new construction, the renovation and maintenance of buildings and for the construction site design and management. The so-called 'Minimum Environmental Criteria' (also known as CAM, in Italian) show general guidelines aimed at directing public authorities towards a rationalization of consumption and purchases and at providing "environmental considerations" related to the different phases of competitive bidding procedures. From the viewpoint of reducing environmental impacts, these are aimed at qualifying submissions and supplies throughout the service/product life-cycle. Specifically, the document prepared for the construction sector and based on already existing voluntary certification protocols (such as the LEED NC 2009 Italy protocol mentioned several times in this paper, or another Italian voluntary assessment method called ITACA, although not extensively used), identifies CAMs that public administrations must include as objectives for competitive bids in the construction field (for both works and services). This approach fits into the context of implementation of directive 2014/24/EU [39] on public procurement rules aimed at encouraging competitive bidding based on the criterion of the most economically advantageous bid, with the allocation of a higher technical score related to the environmental and social performance of products and services. The flexibility that the instrument seems to have in the strong fragmentation of the process, identifying specific criteria for each of the different stages, could be the determining factor for a significant impact on the market. Voluntary certification schemes, now firmly established within new construction, but still not very common in the transformation of existing buildings, with very few cases regarding historic buildings, will be called upon in the near future to adapt to the new target and, especially, at the highest level of flexibility defined by the legislation. Most probably, they will be closer to the logic followed by CAM systems for the building industry to adapt and update itself faster and more efficiently. Systems developed from the LEED structure are not only consciously improving energy performance, but also include wider issues within their structure (from site and water management sustainability) and are sure to be advantaged in the adaptation process [37].

7 Conclusions

In preparation for the increasingly urgent need to adapt historic buildings to new uses by upgrading their overall performances, the transparent process of third-party certification could represent a valuable strategy for orienting the building sector towards a sustainable market transformation. To this regard, this paper has introduced the experience conducted in Italy for the development of a sustainability rating tool named GBC Historic Building, the first and only voluntary and third-party assessment method and certification tool born to tackle the issues connected to the integration of environmental sustainability objectives within the restoration process. GBC HB was born to tackle the issues connected to the integration of environmental, energy efficiency and indoor environmental quality objectives within the restoration process. The tool's aim is to support stakeholders to plan building process and phases in an effective and holistic manner, pursuing a conscious and sustainable restoration process that will allow the historic building to remain a source of cultural identity while meeting today's needs. In particular, this paper has highlighted how the new tool was structured upon the existing LEED-based rating systems used in Italy at the time of the development and how it incorporates energy efficiency and indoor environmental quality considerations in order to meet European and Italian legislation's requirements without undermining the building's cultural value.

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