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Simplified assessment method for environmental and energy quality in museum buildings

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ABSTRACT

In the contemporary age, the museum is dealing with unexpected challenges, related to the transformation of social structures, educative methods and cultural diffusion. Close to traditional structure, educational centers, amusement spaces, bookshops, conference rooms, shops, and restaurants arise. Refurbishment, restoration, and conversion of heritage buildings into exhibition spaces involve a series of conservation risks. Environmental and energy quality depends on achieving the right balance among several parameters, such as: public enjoyment, human comfort, communications, preventive conservation, energy consumption, and safety precautions. The research presents a simplified evaluation method for assessing the environmental and energy quality of museum buildings. It is structured in three phases:

1. Environmental performance evaluation considering the needs of preventive conservation and human comfort;
2. Energy performance evaluation;
3. Assessment of the environmental and energy quality, considering the integration between the previous evaluations.

The tool has been applied in fifty European museums, to compare environmental and energy performance and identify the most common problems, weaknesses, and vulnerabilities. The method suggests a strategic and repeatable approach for balancing care, enhancement, and energy efficiency of cultural heritage.

1. Introduction

The idea of "museum buildings" has changed substantially over the last 40 years, opening new and urgent problems related to conservation and enhancement of cultural heritage, environmental quality, human comfort, energy efficiency, and safety for users, buildings and collections. Over the time, the definition of the museum as a "static place", intended to preserve, protect, conserve, and display the heritage [37], has been replaced by a "dynamic vision" of transmission and dissemination of knowledge [39]. The Centre George Pompidou in Paris (1972), which represented an experimental laboratory in constant evolution [27], marked this fracture. Its conceptual and technological fracture with traditional museums was so strong to introduce the idea of the "museum in the Post-Pompidou Age" [23] characterized by a dual function of contemplation (aesthetic dimension) and transmission (cognitive dimension) of cultural values [56].

New disciplines came to be part of the museum, in addition to the traditional ones of research, preservation, restoration, display, management, and storage [37]. Marketing, communication, semiotics, didactic, cultural and social entertainment became essential for the economic and cultural development of the institutions [44]. New theories of psychology and pedagogy of the heritage produced the idea of "dynamic museum", in which the visitor is the primary protagonist of the perceptual experience [41]. This situation emphasized the role of cultural learning, showing the gradual transformation from the "transmission model", characterized by a linear communication, to the "cultural model", distinguished by reiterated and circular processes [10]. These theories have developed an international shared notion of "museum", as "[...] *non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and*

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its environment for the purposes of education, study and enjoyment" [39].

These changes also lead architectural modifies. Alongside the traditional functions, new activities for education and tourist entertainment arise. They include workshops, play zones, conference rooms, bookshops, libraries, restaurants, cafeterias, and shops specialized in merchandising [20,23,25,43]. The required renovation comprehend dimensional expansion, space modifications, introduction of new functions, visit reorganization, renewal of the exhibitions, plant upgrade, implementation of security, elimination of architectural barriers, and improvement of energy efficiency. So, the museum building and its environment must adapt to this change, physically, socially and anthropologically. These issues are more serious in existing buildings, where the refurbishment and the conversion into exhibition spaces according to a "modern vision", normally, involve several conservation risks [15,33,43].

The main problems regard energy and environmental items because conservation of heritage, human comfort and energy efficiency are closely interrelated [14,15]. The needs for artwork conservation and human comfort are opposite [3,13,49]. Care of collection and building requires the control of light, air temperature, relative humidity, pollutants, pests, display mounts and poor handling. On the contrary, human comfort requires level of light, temperature and relative humidity not always compatible with the safeguard. Large flows of people and new activities related to the "dynamic vision" of the museum intensify these problems: display systems, presence of laboratories (i.e. restoration and photography), areas with high concentrations of people (i.e. didactics rooms, bookshops, shops and atriums), cleaning, and maintenance activities generate microclimatic instability and indoor pollutants. Similarly, food areas (shops, restaurants and cafes), gardens, and specific activities (tanning, taxidermy, and embalming) may involve risks of pests and pollutants. The museums moreover must face the challenge of climate adaptation and reduction of greenhouse gas emissions [11]. Therefore, it becomes necessary to limit indoor fluctuations and pollution produced by free access and, at the same time, to guarantee appropriate comfort levels and sustainable management procedures. Usually, this balance is achieved by mechanical systems. This thesis is supported by different theories. First, Drdacky and Galova [26] looked at the diffusion of cultural tourism, which generates new problems linked to the growing of attendances. Cassar [14], Padfield [50] and Padfield–Borchersenm [51] consider the severe microclimatic conditions required by museum standards, easier reachable with artificial lighting and HVAC. Peters [54] strengthens this idea, arguing that the enlargement of heritage categories requires different indoor conditions, available only by active measures. Cassar [14] takes into account also the loan constraints imposed by foreign museums. This situation generate different energy and environmental problems. The active measures require lower costs and time than bioclimatic strategies [5] but, at the same time, they directly affects sustainability and climate mitigation [6] and involve high energy consumption and high costs for the management [15]. On the contrary, the energy and environmental potential for museum regeneration is high: Tombazis [61] estimates a total energy conservation of 30–50% using a correct building design, and staff training. In addition, the energy and environmental retrofit, certainly preserving the value and the historical characters, promotes the economic growth of the building values and, in case of more extensive intervention, the social regeneration of urban districts [43]. Finally, the museums should assume an educational role for citizens and visitors related to environmental sustainability and energy efficiency [15].

2. Research aims

The paper presents a simplified evaluation method for assessing and comparing the environmental and energy quality (EEQ) of museum buildings. It has been developed to support the decision-making community (public administrations, government department responsible for monument and artistic treasures, museum authorities and staff, conservators, owners, and curators) to identify in easy way: faults, poor performances, conservative risks, and technological inefficiencies. It is an easy and accessible *corpus operandi* to: (i) assess the energy and environmental quality of museum buildings; (ii) identify the possible risks; and (iii) plan a deeper audit for defining the most appropriate interventions.

The evaluation method neither mean to be exhaustive or definitive, but simply aims to serve as a reference for technicians and conservators that require clear and easy procedures to operate. It could be useful especially for institutions with poor economic or management resources.

3. Methodology

The EEQ assessment is based on the "performance indicator system" method: the rating is established indicating the presence or the absence of a particular element (presence = 1; absence = 0). The final score identifies a "qualitative performance indicator" (QPI), permitting a quick and easy comparison among different institutions. The definition of the QPI considers all the aspects with an impact on EEQ: (i) heritage conservation, (ii) human comfort, and (iii) energy efficiency. A cross-disciplinary approach has been developed starting from the study of standards, best practices, policies, guidelines, techniques, procedures, and tools already made at local, national and international level in these fields. Due to the complexity of the museum buildings, normally, scientific literature and existing tools analyze in detail only one aspect. Generally, the environmental evaluation concerns the opposite needs of heritage conservation and human comfort, while the energy assessment regards mainly the existing buildings (not historic, listed or museum buildings). For this reason, the present methodology considers a strong relationship among these three disciplines.

The EEQ assessment is structured in the following phases (Fig. 1):

- Environmental performance evaluation considering the needs of preventive conservation and human comfort ("envQPI");
- Energy performance evaluation of building envelope, HVAC, renewable sources, management procedures, and energy policies ("enQPI");
- Assessment of environmental and energy quality, considering the integration between the previous evaluations ("total EEQ").

The results obtained are consequence of the opinions of the team group involved in the work and do not represent the effective calculated performances of the building and systems.

The assessment of the environmental factors that may affect heritage preservation and users' comfort is an essential step in establishing a correct approach to conservation management [48]. The present procedure integrates museums standards [6,16–18,40], guidelines [7,14,15,33,36,49,64], policies [45,58] and reference literatures [13,22,59,60] on preventive conservation and human comfort. The basis of the risk assessment surveys are the GCI's guideline [7], the ICCROM's framework [36], and several museum's guidelines [14,15,33,45,49,64]. These books has been selected for their international reputation in museum assessment. The "environmental QPI" covers 70 categories of analysis,