

## HUMAN-DRIVEN ENERGY EFFICIENCY IN HISTORIC BUILDINGS

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### 1. Introduction

In Europe, historic buildings constitute about 14% of the total building stock; however, in several historic cities this percentage could dramatically grow, up over 50% [1]. In Italy, for example, about 30% of buildings (around 12.5 million) dates from before 1945 [2]. These data, coupled with the current replacement rate of existing buildings by new-built, which is under 3%, highlights the importance of individuating suitable solutions for the energy retrofit of historic buildings [3]. Despite this necessity, until today the majority of energy-related standards in Europe exempted this category of buildings from respecting the energy performance prescriptions [4]. This, because the European culture of historic evidences' preservation conceives the protection of cultural heritage as its "material" conservation, which theoretically requires to leave the object (in this case the building) as the history left it [5]. For this reason, the implementation of the most common energy-retrofit measures (such as envelope insulation or windows' substitution) on historic buildings is not always possible nor allowed. There is thus the necessity of individuating and experimenting energy retrofit solutions that could balance the necessity of preserving them as material evidences, but also reducing their environmental footprint and adapting them to the current standards of liveability, wellbeing and comfort. In fact, their persistence is strictly related to their usability, accessibility and suitability for human activities. Based on these considerations, one of the possible solutions is to explore the potential of human-driven energy efficiency. In fact, buildings' energy usage is strictly related to their operation by humans. Moreover, intervening on the building operation does not require any "material" intervention, avoiding any damage to the historic evidence and, in some cases, contributing to historic materials and decorations conservation. This paper introduces a methodology called BIOSFERA (Building Intelligent Operational Strategies For Energy Retrofit Aims), which investigates the potential of energy saving and indoor environmental conditions enhancement by acting only on how the building

is operated by building operators and occupants. Moreover, the results obtained in a first pilot study will be critically analysed considering the potential impact that the adoption of the methodology in a broader scale could have in economic, environmental and social terms.

## **2. Methodology**

The presented methodology follows a pre-test post-test design and it is articulated in three subsequent phases called Diagnosis, Intervention and Control. The Diagnosis phase has the objective to hypothesize the potential of energy saving and indoor environmental enhancement by characterizing building operators' energy-related management, quantifying the building energy consumptions and related costs, assessing the building's indoor environmental conditions and acquiring energy-relevant information (about behavior and comfort) from building occupants. The second phase, Intervention, is addressed at elaborating actions to ameliorate the building operation by building operators and occupants pursuing three objectives: lower the building's energy consumptions, enhance comfort perception and behavior of occupants and ameliorate or solve indoor environmental critical situations related to artworks' conservation. The third and final phase, Control, defines the potential, previously hypothesized, so it is dedicated to the definition of the Intervention impact on the building's energy consumption, on occupants' comfort perception and behavior and on indoor environmental conditions in relation to artworks' conservation.

## **3. Results and Findings**

The first pilot study in which the methodology was applied showed promising results, both in terms of energy saving (all case studies saved between 10% and 30% seasonally) and behavioural change towards less energy wasting habits. The behavioural change was assessed both directly (by asking occupants about their perception of behavioural change towards specific energy-relevant building interfaces like thermostats or artificial lights) and indirectly (repeating some behaviour-related questions that were previously asked during Diagnosis). Moreover, the energy savings did not impact or even ameliorated occupants' thermal comfort. Also, in terms of engagement, participants of the pilot study appreciated the adopted communication means.

## **4. Discussions and Conclusions**

This research demonstrates that a human-driven energy retrofit has a great potential from multiple points of view. First, because based on the pilot study, the zero-costly (or almost zero) implemented strategies can bring similar or even higher energy savings than those expected from other energy retrofit measures in historic buildings (e.g. substitution of heating and cooling systems).

Second, because involving occupants and building operators at the same time allowed to detect previously unexplained reasons of energy waste and chronic environmental discomfort causes. Third, because the fact that a notable percentage of iconic historic buildings (like those taken into account on the pilot study) are owned or ruled by public administrations, offers the possibility of involving citizens as active characters of a sustainable management of the cultural heritage, as strongly claimed by the Faro convention [6]. These results encourage a broader reflection on the role that the energy sector, and particularly this kind of initiatives, could have in helping to preserve the liveability and sustainability (environmental and economic) of historic buildings. Anyway, the approach proposed by the BIOSFERA methodology could easily be adopted also on other building typologies and be coupled with other “material” energy retrofit measures, in order to reduce the risk of rebound effects subsequent to these interventions [7]. In fact, unexpected increases of energy demand after energy retrofit interventions are quite frequent and could be efficiently addressed by nearing the improvement of the building energy performance with adequate operation practices.

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