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The museum in historical buildings: Energy and systems. The project of the Fondazione Musei Senesi

Michela Rota[a,*], Stefano paolo Corgnati[a], Luigi Di Corato[b]

[a] Dipartimento Energia, DENERG, Politecnico di Torino, Torino, Italy
[b] Direttore—Fondazione Musei Senesi, Siena, Italy

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ABSTRACT

In Italy many museums are located in historical buildings, converted later to this functionality. The insertion of energy systems, for fruition and conservation's needs, happened fairly recently with low attention to environmental sustainability and energy efficiency. "Energy and Buildings" is essential in EU Community Policies aimed at reducing greenhouse gas emissions, at limiting fuel consumption and at encouraging the use of renewable energy sources. The museum buildings can play an important role in this scenario; they should be retrofitted seeking to balance the "passive" energy performance of the building-envelope and the "active" one of the systems. However there are only few cases where energy retrofit have been carried out and few data related to energy consumption and effects after retrofitting.

Fondazione Musei Senesi with Politecnico di Torino have matched these aspects in the research project "The Museum building: Energy, Systems, Safety & Security", aimed at exploring the performance of the whole building envelope and systems for the indoor climate control, with particular attention to energy. The study was carried out on 43 museums using specific tools developed *ad hoc* (self-assessment checklist and a handbook). The project can be a point of reference for different museums widespread throughout the Italian and European territory

1. Introduction

The activity presented is linked to the Project "Siena Carbon Free 2015" [1], which has implemented at the provincial level an energy plan, drawn up a program to perform energy audits in public buildings, give contributions for the construction of photovoltaic plants and for a communication plan to raise awareness on energy and environmental issues. It is aimed at businesses, public bodies and private citizens, and aims to make the Province of Siena the first wide area in Europe with zero emissions of CO_2 by 2015.

"Energy and Buildings" is nowadays one of the essential binomials in the definition of EU Community Policies aimed at reducing greenhouse gas emissions, at limiting fuel consumption and at encouraging the use of renewable energy sources. Around these issues, it has been witnessed the fast development of passive and active technologies, applied to the whole buildings' envelope and HVAC systems, and of rating systems such as GBC LEED® Historic Building [2] now in progress. These topics are more and more frequently applied to the context of the Italian historical buildings, and in particular of the built heritage.

Museums and Cultural Heritage have now the task to adapt themselves at the tendencies for the reduction of greenhouse gas emissions; they should also assume an educational role for citizens and visitors related to energy efficiency and to the diffusion of best practices for sustainability, considering example about what it is applied on historical buildings also in other functional contexts. In a logic of green museum the issue of energy efficiency plays an important role as "the greatest money saver, over time" [3], through the performance improvement and monitoring of systems and through a change of habits in ordinary and extraordinary management of the activities.

However, there are few cases of projects specifically focused in energy efficiency, and above all there are just few real data, even in the scientific literature on energy consumption and on the effects of retrofitting action.

Monitoring and measuring is a central topic and data available about historical buildings and in the museums are still too few and not organized in a systematic way.

* Corresponding author. Tel.: +39 0110904507.
E-mail addresses: michela.rota@polito.it, michela.m.rota@gmail.com (M. Rota), stefano.corgnati@polito.it (S.p. Corgnati), dicorato@museisenesi.org (L. Di Corato).

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Table 1
Steps of the project.

The steps of the project and the people in charge:
Development of the topic to be analyzed and of the methodology (DENERG e FMS)
Elaboration of the self-assessment checklist (DENERG)
Sharing ofthe objectives with the museums' project managers (DENERG e FMS)
Submission of self-evaluation protocol (checklist) to be filledby the Museums (DENERG e FMS)
Data analysis and processing of the results (DENERG)
Presentation of results (DENERG e FMS)
Drafting of the handbook (DENERG)
Preparation of a volume containing the handbook, the self-assessment checklist and the main the results of the project (DENERG e FMS)

2. Objectives and methodology

Fondazione Musei Senesi (FMS) [4] in 2009 set the objective to identify, codify and create a procedure to monitor the museum building. In particular, it has been highlighted the need to increase the awareness on the various "subjects" that work for a museum building, especially in operation and maintenance (but not only), and about performance of systems for indoor climate control.

This objective was translated into the activities of the research project "The Museum building: Energy, Systems, Safety & Security" unrolled by Energy Department of Politecnico di Torino in synergy with FMS. The project was developed involving 43 Museums on the territory of Siena, playing an experimental activity, aimed at exploring the energy performance of the whole building system.

To this aim it was necessary to develop useful tools for the survey, in order to highlight in a systematic manner the critical issues related to building energy systems and to suggest actions to:

- improve energy performance;
- minimize consumptions and cost (in terms of raw materials and economic aspects);
- minimize environmental impacts;
- start a process towards the "green museum".

The above table highlights the steps of the project (Table 1).

The main aspects covered by the project concern the development of a self-evaluation checklist, useful to defining the *status quo*, a methodology for data analysis and a report of the results of the survey.

In the last part of the present paper, the structure of the handbook is presented: written as support for institution managers and owners of museums to create a common language addressed to building energy efficiency and as guideline useful to take more appropriate actions from the very early steps of a retrofit project.

2.1. Checklist for a preliminary museum energy assessment

It has been developed an evaluation form (checklist) for the collection of energy systems and data of the Museums. This survey tool, developed specifically for the museum's assets, was implemented after meetings with the museums' staff involved in the project. The checklist allows managers of the museums, through a self-assessment, to monitor and evaluate the status quo of their institutions with reference to energy efficiency of the whole museum building, in order to establish an adequate path for planning a retrofit activity. The checklist is presented with closed questions yes/no or opened in limited number; there are also spaces for notes to specify some aspects.

The topics of the survey are divided into sections and include:

Table 2
The size of the buildings.

	1–500 m^2	501–1000 m^2	1001–2500 m^2	No answer
Museums	20	6	6	3
Total Museums	34	34	34	34

- general information;
- information on the building envelope;
- functional and dimensional parameters of the rooms;
- detailed info on the energy systems (thermal plant, HVAC systems, electrical equipment, lighting. . .);
- types of contracts for operation and maintenance of the building;
- indications related to safety & security aspects.

The survey was initially performed on 43 Museums; the final analysis was processed on 34 Museums. In fact, during the data processing it has been chosen not to include in the analysis the Scientific Museums, since it was impossible to get energy and systems information to that kind of museum, because they are often placed inside wider buildings. The information collected, later presented, can be summarized in terms of analysis onto three different levels:

- Comparison between museums: the direct comparison of the data characterising the analyzed museums.
- General trends for each analyzed topic (for example, for the item 'management of the museum': for 15/34, direct management of the owner; for 18/34, management entrusted by the owner to another entity). Summary table for the evaluation of energy data. For this analysis, the attention is paid to items more specifically related with energy efficiency, as the volumes and dimensions of the museum building, the data about fuel and electricity and consumption and costs.

2.2. The application and results of the museum energy assessment checklist

2.2.1. General information

"The Fondazione Musei Senesi brings together about forty museums in a unified system that offers invaluable evidence of the Sienese cultural identity. This immense cultural wealth is made even more precious by the fact that the museums are often housed in monumental buildings of major architectural interest and are linked by geographical proximity and historical continuity to the contexts where they were created, presenting a paradigmatic example of eco museum. The collections preserved in the Sienese museums embrace in this way the entire civilization of the Land of Siena (and more) from its Etruscan origins to the modern day, in the most diverse forms of art-historical, archeological, scientific, natural, and anthropological holdings. They offer an extraordinary way to experience the area" [4].

In particular, the museums are mainly housed in buildings in which the original use was different; they were built for residential purpose, as palaces and homes (11/34), castles, farm buildings or schools or religious complex. The buildings were built mainly between the twelfth century and 1900 (29/34), in some cases with different layers of construction that took place over time. The feedback for the current condition of conservation of the buildings is positive in 90% of cases. The size of many museums is lower than 500 m^2 (20/34) (see Table 2). Only 6/34 museums have an area higher than 1000 m^2, it follows that these are mainly buildings of small and medium size. 18/34 Museums holds other functions within the building, including municipal offices, libraries managed by the City Council or University or private homes and offices; this last aspect has a direct consequence in terms of system's