Energy and Buildings 95 (2015) 39–46

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Are the Best Available Technologies the only viable for energy interventions in historical buildings?

Daniele Milone[a], Giorgia Peri[a,*], Salvatore Pitruzzella[b], Gianfranco Rizzo[a]

[a] *Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici (DEIM), Scuola Politecnica dell' Università degli Studi di Palermo, Palermo, Italy*
[b] *Dipartimento di Architettura, Scuola Politecnica dell' Università degli Studi di Palermo, Palermo, Italy*

ARTICLE INFO

Article history:
Available online 7 November 2014

Keywords:
Energy efficiency
Preservation
Energy refurbishment

ABSTRACT

Worth aged buildings represent among the existing buildings a special case when it comes to their energy refurbishment. Unfortunately, the available technologies for building components characterized by high level of thermal performances show, not rarely, a limited compatibility with the architectural integrity of the building. In other words, the so-called Best Available Technologies, which are effectively adopted to optimize the building energy performances, in case of buildings to which a certain artistic, historic and/or architectural merit is recognized, i.e. heritage houses, might determine such kind of conflicts. This situation may lead to the selection of "non-invasive" but less performing building and plant elements.

To check the effectiveness of these less performing technologies, we investigated the energy performance of two different refurbishment configurations of the building envelope of a heritage house: a "Best Available Technology" scenario, in which interventions assumed consist of using the Best Available Technology for energy saving; and an "Allowed Best Technology" scenario, in which interventions assumed consist of using technologies that, although not the best available ones, are anyway "allowable" according to the cultural heritage preservation requisites and rules. A cost-based comparison between these two configurations was also made. Results of this comparative analysis are reported here.

1. Introduction

The energy consumption for space heating and cooling of buildings, as it is well known, represents a significant part of the energy balance of a country [1–4]. To reach the ambitious EU goals of reducing the buildings' energy consumption, Member States are called for adopting more incisive and binding measures for the energy rehabilitation of the building stock.

Apart from this general concern, countries with noteworthy cultural heritage are asked for paying particular attention to energy consumption of historical buildings, since the energy demand of such buildings represents a not negligible part of the whole building stock demand [5,6]. In Italy, for example, approximately 70% of buildings (data based on ISTAT Census 2001) were built before the release of the first law (released in 1976) establishing limits for the energy consumption in the building sector; therefore, it is likely that a certain part of this large amount of buildings might be classified as heritage houses, despite a specific statistical analysis is not currently available. As a matter of fact, several buildings in Italy are under the protection of the Superintendence of Artistic and Cultural Heritage that intervenes when modifications of such buildings are proposed.

The energy consumption of historical buildings in the EU is currently estimated at more than 200 kWh/m^2 year [7]; despite such a high energy use, indoor conditions provided to occupants are often scarce and generally tolerated only because of the cultural and environmental worthiness of such constructions.

While this issue seems to only marginally interest discontinuously occupied historical buildings (such as museums, for example), it is particularly significant for historical buildings that are used for residential, working and commercial purposes, which represent, actually, the greatest part of the historic buildings stock.

These continuously occupied buildings are supposed to be generally more energy consumer [8] since they are called for providing good quality indoor conditions [9,10]. In fact, people living and working in this kind of buildings do require suitable indoor conditions in terms of thermal, acoustic, visual and IAQ performances [11] comparable to those of modern buildings.

Despite such a high energy consumption, however, the EU Directive 2002/91 on the energy performance of buildings [12], expressly

* Corresponding author. Tel.: +39 091 238 61923; fax: +39 091 484425.
E-mail address: peri@dream.unipa.it (G. Peri).

http://dx.doi.org/10.1016/j.enbuild.2014.11.004
0378-7788/

excludes *buildings and monuments officially protected as part of a designated environment or because of their special architectural or historic merit*, from both the procedure for energy certification and possible interventions of energy retrofitting, when *compliance with the requirements would unacceptably alter their character or appearance* (article 4, paragraph 3). That is, for this kind of buildings Member States are allowed not to take the necessary measures to meet the minimum energy performance requirements. Such a position is substantially confirmed in the recent EU directive 2010/31/EC [13] in which the possibility of the energy rehabilitation is extended also to buildings that may be defined as historical, but as long as their historical identity and quality is not compromised by invasive interventions (article 4, paragraph 2, decreto-legge 4 giugno 2013, n. 63) [14].

In addition to the regulations on the buildings' energy performance, in Italy historical buildings are also disciplined and preserved by regulations on cultural and landscape heritage [15] that define possible interventions and methodologies for their conservation.

The assessment of the compatibility of a new element with a historic building is an issue that has largely been debated in the field of the architectural conservation [16].

In case of occurrence of an energy retrofit of a heritage house, for example at owner's request, one would be pushed toward the adoption of the "Best Available Technologies" (BAT) due to their performances, but unfortunately these technologies, not rarely, are characterized by a limited compatibility with the architectural integrity of the building, it is emblematic, for example, the case of solar collectors aimed at producing hot water or electric power which could be hardly used in a heritage house. In such a case, it may therefore result necessary the selection of "non-invasive" but less performing building and plant elements, whose effectiveness should however be checked both from an energy and economic point of view.

With the aim of investigating the potential for energy performance improvement of these "non-invasive" solutions for the energy retrofit compared to that of the "invasive" ones, we selected, as an emblematic case, a building belonging to the category of heritage houses and compared two different energy rehabilitation scenarios: a "Best Available Technology" scenario, in which interventions assumed consist of using the Best Available Technology for energy saving; and an "Allowed Best Technology" (ABT) scenario, in which interventions assumed consist of using technologies that, although not the best available, are anyway "allowable" according to the cultural heritage preservation requisites and rules. A cost-based comparison between these two configurations of the building envelope has been also carried out.

2. The selected building

In this section, after briefly describing the building under consideration, an energy performance analysis of the case-study in its current state is reported. It represents the baseline scenario which the two hypothesized scenarios are compared with.

2.1. Description and characteristics

For the study presented here, we have selected a historical building located in the historic center of Ragusa, in the South coast of Sicily, that is named "Palazzo Battaglia". The building belongs to a climatic zone characterized by 1324 Degree Days (DD) and by a design outdoor temperature of 0.0 °C; the building is situated at a height of 502 m over the sea level.

The construction with a quadrangular layout dates back to XVIII century. The palace was seriously damaged during an earthquake happened in 1693 and reconstructed in 1727, in Baroque style. It consists of three floors plus one located between the ground and the first floor, with a number of apartments of 3, 2 and 2, respectively. Fig. 1 reports a building view from the outside along with some details of the façades. The entire structure is composed of *tufo* stones which are combined with mortar. The horizontal parts of the structure of both the ground floor and the floor, positioned between the ground floor and the first one, stand on barrel vault and cross vaults made of limestone elements, support stones and lime subfloor, on which the stone flooring stands. In the first floor, the horizontal structures are in double wood warping with the vault made of canes and gypsum with support of stone and gypsum; the same typology has been used for the horizontal part of the attic floor, where, anyway, at the end of fifties a deep structural intervention generated a hollow space made of wood and Sicilian pan tiles.

Fig. 1. Main perspective and details of some façades of the historical building selected for the application.

This building has been selected because it represents a typical example of the building stock of this part of Sicily. Also the interventions that make interesting the building during the time, can be considered as typical of the story of such kind of buildings.

2.2. Energy performance

The assessment of the energy performance of our case-study in its current state, which represents the baseline scenario, was carried out using one of the national available software based on the Italian standard UNI-TS 11300 [17], that is the Italian standard for the evaluation of the energy demand for space heating and cooling of buildings, a transposition of the international standard ISO 13790 [18].

The heating system was omitted in the simulation and only the thermo-physical characteristics of the building envelope (opaque and glazed elements) were considered. Hence, the primary energy demand was calculated assuming the presence of electric space heating devices [19,20]. Figs. 2 and 3 illustrate, using synthetic technical sheets, the opaque and glazed elements that are present in the baseline scenario, respectively.