Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 111 (2017) 397 – 406

Energy Procedia

8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

Refurbishing an existing apartment block in Mediterranean climate: towards the Passivhaus standard

Agata Consoli[a], Vincenzo Costanzo[b], Gianpiero Evola[a*], Luigi Marletta[a]

[a] *Dipartimento di Ingegneria Elettrica, Elettronica ed Informatica, University of Catania, Viale A. Doria 6, 95125 Catania, Italy*
[b] *School of Construction Management and Engineering, University of Reading, Whiteknights, PO Box 219, Reading, Berkshire, UK*

Abstract

The Passivhaus standard, although widely appreciated in cold regions, is seldom regarded as a reference in the energy renovation of existing buildings in warm countries. This paper evaluates the effectiveness of a series of strategies for the energy refurbishment of an existing apartment block in Southern Italy, based on dynamic energy simulations. The paper aims to show that, in warm Mediterranean areas, a building refurbishment must not be oriented towards an excessive insulation level. Conversely, if aimed to comply with the Passivhaus standard, the renovation must look above all at those strategies that mitigate the energy needs for space cooling and improve thermal comfort in summer.

Peer-review under responsibility of KES International.

Keywords: Refurbishment; Apartment block; Mediterranean climate; Passivhaus; Thermal comfort

---

1. Introduction

Since its origin in the late 1980's, the application of the Passivhaus standard [1] has focused on new constructions located in cold climates, such as those of Central and Northern Europe. As a consequence, the key concepts of this standard were the envelope superinsulation, the airtightness and the use of ventilation systems with performing heat recovery. The standard requires to achieve energy needs for space heating lower than 15 kWh m^{-2} y^{-1}, and total primary energy needs (heating, domestic hot water and electrical appliances) below 120 kWh m^{-2} y^{-1}. All the surface-averaged energy figures refer to the net liveable area. Moreover, air infiltrations must be less than 0.6 h^{-1} at a

---

* Corresponding author. Tel.: +39-95-7382421; fax: +39-95-7382496.
E-mail address: gevola@unict.it

Peer-review under responsibility of KES International.
doi:10.1016/j.egypro.2017.03.201

pressure difference of 50 Pa. So far, the application of this standard proved to be so successful in achieving the proposed goals, as to give raise to the *Zero Energy Building* concept, introduced in the EU Directive 2010/31 [2] and implemented in several new buildings within the EU countries [3]. However, its dissemination overseas and for warm climates proved to be questionable, and thus still deserves accurate research. To this aim, the Passive-On project resulted in the publication of guidelines for designing Passive Houses in Southern Europe [4]. In this context, a further limitation is introduced, i.e. to keep the sensible energy demand for space cooling below 15 kWh m^{-2} y^{-1}. Furthermore, space cooling has to be included in the calculation of the total primary energy needs, and a lower air tightness is allowed (1 h^{-1} at 50 Pa) if the ambient temperature does not drop below 0°C.

Within this research stream, some authors studied how to cope with potential overheating issues and increased cooling energy needs for mild-to-warm climates. As an example, Figueiredo et al. [5] carried out an extensive simulation study for optimizing the design of new buildings in terms of both thermal comfort and energy needs based on an existing well-performing detached house in Portugal. Sameni et al. [6] and Sassi [7] investigated overheating problems in existing UK flats designed to accomplish Passive House standards, finding that it is possible to achieve Passive House goals just by naturally ventilating the building.

Badescu et al. [8] assessed the feasibility of Passive Houses in Southern Hemisphere countries located at reversed latitudes and with similar climatic conditions of typical EU countries, by adapting the construction details of a prototype passive building built in Romania. Again, they found out that the thickness of thermal insulation may be decreased in warm climates like in South America and New Zealand, thus allowing for capital cost savings and construction simplifications. On the other hand, Schnieders et al. [9] simulated the performance of a reference two-floor detached house built in Hannover in very different climates, from the very cold city of Yekaterinburg in Russia to the hot-humid city of Abu Dhabi in the Emirates. This work is worth of attention because it highlights that specific construction details are needed to meet the Passivhaus requirements, even if in Abu Dhabi it is not possible to keep the sensible energy demand for space cooling below 15 kWh m^{-2} y^{-1}. Finally, Attia and Zawaydeh [10] investigated on passive and active design strategies for an existing apartment in Jordan, with the aim of reaching a zero energy retrofit. Their results showed that the NZEB objective is too ambitious, having a 30-year payback time.

A step forward in this sense is made in this paper, where an existing multi-storey apartment block, located in the Mediterranean climate of Catania, is modelled in EnergyPlus. The aim is to provide suggestions about possible refurbishing options to comply with the extended Passivhaus requirements for Southern Europe.

Nomenclature

A	net surface of the building (m^2)
COP	Coefficient of Performance (-)
E	electric energy need (kWh $year^{-1}$)
EER	Energy Efficiency Ratio (-)
ITD	Intensity of Thermal Discomfort (°C h)
n	air change rate for natural ventilation or infiltration (h^{-1})
Q	thermal energy need (kWh $year^{-1}$)
PE	primary energy need (kWh m^{-2} $year^{-1}$)
PER	primary energy ratio (-)
r	solar reflectance (-)
T_{op}	operative temperature (°C)
U	thermal transmittance (W m^{-2} K^{-1})

2. Methodology

2.1. Calculation of final and primary energy needs

As highlighted in the previous section, one of the requisites for a building to comply with the Passivhaus standard is that its overall primary energy consumption does not exceed 120 kWh/year per unit useful surface. The overall