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A high performance home in the Mediterranean climate: from the design principle to actual measurements

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Abstract

Experience developed in the northern European countries led, in the last decades, to standard and shared procedures for the design and construction of passive houses and similar high performance buildings. These approaches are specifically developed for cold climates, therefore cannot be directly applied to the Mediterranean climate, where substantially different climatic conditions must be challenged.

The design and early monitoring of a customized zero energy house, located in Sicily, is proposed as an exemplary case study for the future generation of high performance and nearly-zero energy buildings in the Mediterranean area. The key role played by the control of heat gains, and the correct use of thermal mass is highlighted, showing similarities and differences with passive houses built in the North Europe. The measurements of energy and environmental performance of the building show the effectiveness of the response of the adopted design approach to the specific climatic conditions.

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1. Introduction

A passive solar approach to the design and construction of buildings has been extensively adopted since the ancient times, as pointed out by the study of vernacular architecture [1]. However, it was only in the 1988 that the first formally defined passive protocol was established under the name of "Passivhaus", by Bo Adamson of Lund

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University, Sweden, and Wolfgang Feist of the Institut für Wohnen und Umwelt. In September 1996 the Passivhaus-Institut was founded, in Darmstadt, to promote and control the Passivhaus standard. The very first Passihaus building was eventually built in 1991, in Darmstad, Germany, i.e., the Darmstadt-Kranichstein Passive House [2].

The focus of the Passivhaus standard is on the reduction of energy needs for heating, and this may be achieved by applying a proper building orientation and shape, an adequate thermal insulation of the building envelope, and by airtightness and mechanical ventilation with heat recovery [3]. The Passivhaus certification method was, indeed, originally developed for countries with a continental climate (e.g. Germany), where the major challenge is to contrast the low outdoor temperature and to wisely exploit the internal and solar heat gains, while providing adequate indoor air quality levels. Cooling and dehumidification are usually less important in this climate, especially for residential buildings.

Other similar certification methods exist in parallel to the Passivhaus, especially in central Europe, such as Minergies (Switzerland and Liechtenstein) and Casaclima (Bolzano province – Italy). These certification methods share with the Passivhaus standard, the emphasis on the reduction of the energy need for heating, as have mainly been applied in cold climates. The technologies and the overall energy concept developed to comply with the Passivhaus, Minergie and Casaclima certification methods in the continental climate, might, nevertheless, not necessarily be effective in other climates.

In the last years, however, the Passivhaus certification method tried to extend its applicability to warmer climates, under the Passive-on Project [4]. The current major technical requirements to comply with the standard are:

- Energy need for space heating lower than 15 kWh/m^2 per year
- Energy need for cooling and dehumidification lower than 15 kWh/m^2 per year
- Primary energy for all domestic applications (heating, hot water and domestic electricity) lower than 120 kWh/m^2 per year
- Air tightness at 50 Pa (n_{50}) lower than 0.6 air change per hour (ACH).

The Botticelli project, a single family detached house located in Sicily (Italy), was conceived to assess the possibility to extend the passive house concept to the Mediterranean climate. It is a living lab, inhabited all year long and designed on the basis of a new approach. Sensors and logging equipment have been installed and optimized to monitor its energy and comfort performance under different operational conditions [5,6]. The early monitoring results show the effectiveness of the adopted design approach in addressing the specific climatic conditions.

2. Building principles in the mediterranean climate

The Mediterranean climate - Csa/Csb under the Köppen climate classification [7] - is a particular variety of subtropical climate. The lands around the Mediterranean Sea form the largest area where this climate type is found. The majority of the regions with Mediterranean climates have relatively mild winters and very warm summers. Because most regions with a Mediterranean climate are near large bodies of water, temperatures are generally moderate with a comparatively small range of temperatures between the winter low and summer high (although the daily range of temperature during the summer is large due to dry and clear conditions, except along the immediate coasts) [8]. Under the Köppen-Geiger system, “C” zones have an average temperature above 10 °C in their warmest months, and an average in the coldest between 18 to −3 °C. Areas with this climate receive almost all of their precipitation during their winter season, and may go anywhere from 4 to 6 months during the summer without having any significant precipitation [8].

Building cooling is the most challenging issue in the Mediterranean climate, due to the strong solar radiation and to the high ambient temperature. The large daily range of temperature during the summer provides, nevertheless, a considerable potential for nigh-time ventilative cooling [9,10]. Figure 1 reports a brief summary of key weather data in Catania, as an example of Mediterranean climate.