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Review of bioclimatic architecture strategies for achieving thermal comfort

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ABSTRACT

The residential sector consumes a significant amount of energy worldwide. Therefore, it is important to study, analyse and implement bioclimatic architectural systems that contribute to the reduction of energy consumption while considering the possible construction solutions offered at both passive and active levels. The present study conducted a comprehensive analysis that was stratified into three large blocks. The first block examined the concept of bioclimatic architecture. The second examined the bioclimatic architecture construction strategies as a function of each climate zone with the objective of achieving the greatest climate comfort level within a specific building. Fourteen climate zones were established and recommended according to the possible strategies that would facilitate reductions in energy consumption. The third block analysed the principal scientific research trends in this field and highlighted the use of vernacular architecture strategies, experimentation with bioclimatic architecture construction, application of innovative bioclimatic architecture strategies, promotion of bioclimatic architecture, use of bioclimatic architecture in urban planning, inclusion of bioclimatic lessons in study plans and development of energy saving technologies to support bioclimatic architecture. The extensive review described in this paper allowed us to conclude that certain bioclimatic architecture strategies that have been adopted in specific countries could be exported to other areas with similar climates because they were proven to be good functional design strategies that resulted in large energy saving measures (each in its corresponding climate) related to solar protection, humidification or temperature increases.

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1. Introduction

Human health and comfort have been perceived as the most important parameters during evaluations of indoor environments. Developing countries are limited by extreme environmental conditions, out-dated construction techniques and scarce financial resources and therefore struggle to adopt costly technologies aimed at achieving improved interior environments [1]. Any analysis of the role of energy in architecture is faced with serious limitations due to the lack of such studies in the architectural literature. An awareness of these limitations will enable one to understand why architects have paid little attention to the interaction between form and energy and a bioclimatic focus in contemporary architecture [2]. The construction sector plays an important role in the European economy, as it generates nearly 10% of the gross domestic product and provides 20 million jobs that are concentrated among small and medium-sized businesses [3]. The intense building construction activity, the need to conserve energy and the establishment of environmental protection policies all indicate a need for more reasonable building design practices [4]. The heating and cooling of a space to maintain thermal comfort are an energy intensive process that represents up to 60–70% of the total energy consumption in non-industrial buildings [5]. The concept of energy efficiency in buildings refers to the amount of energy required to achieve the desired environmental conditions while minimising energy consumption [6]. Heating, ventilation and air conditioning (HVAC) are the largest energy consumers in buildings [7]. Ekici and Aksoy [8] listed the parameters that affect building's energy requirements as follows: physical–environmental parameters (daily exterior temperature, solar radiation and wind speed and direction) and design parameters (shape factors, surface transparency, orientation, thermal–physical construction material properties and distances between buildings). The term bioclimatic (or sustainable) architecture refers to an alternative method of constructing buildings in which the local climate conditions are considered and diverse passive solar technologies are used with the aim of improving energy efficiency [9]. The term solar passive technologies refers to heating or cooling techniques that passively absorb (or protect, e.g. natural hats) the sun's energy and contain no moving parts [10]. Bioclimatic design employs appropriate technologies and design principles based on a reflexive focus on the climate and environment

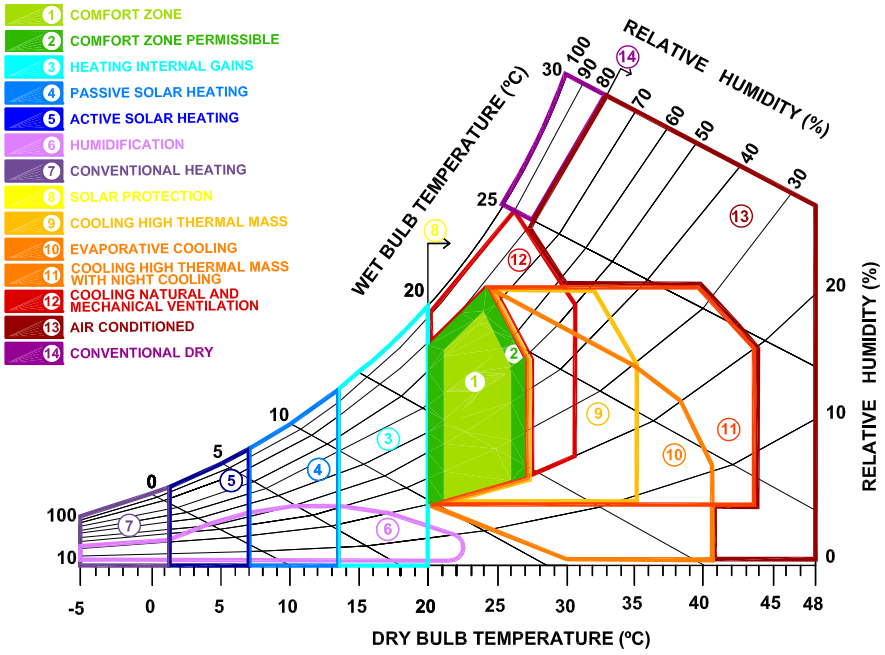

Fig. 1. Psychrometric chart adapted from Givoni [30].