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Revisiting cooling energy requirements of residential buildings in Portugal in light of climate change

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ABSTRACT

Since climate data for building energy simulation have recently been refreshed with 1971–2000 observational data and theoretically influenced by a conservative approach of climate change, benchmarks for cooling energy requirements for residential buildings are discussed for a set of 30 regions in Portugal, mainland and islands, as a contribution to the next revision of Portuguese building thermal code (DL 118/2013). The main conclusion is that gain utilization factor correlates with average external air temperature for summer season by a logarithmic function. The benchmark for gain utilization factor plays an important role in defining cooling energy requirements. A set of recommendations are suggested: (i) using the gain utilization factor as an index to evaluate the overheating risk, thus, for values above a defined threshold cooling energy needs could be neglected for primary energy demand quantification; this measure may encourage designers to integrate passive cooling systems; (ii) defining a national roadmap based on technological advances of shading solutions for benchmark parameterization of the west equivalent collecting area by unit of floor area starting from 0.065.

1. Introduction

The recast of the Energy Performance of Buildings Directive (EPBD) [1] requires that European Member States set minimum requirements for the energy performance of buildings and building elements (Article 4), in order to fill the existing gaps resulting from the difference between energy performance requirements and those that are cost-optimal, taking into account initial investment and running costs throughout building life time, typically 30 years for residential buildings. Most of the studies regarding cost-optimal energy requirements identified heating related elements, such as thermal insulation of building elements, ventilation heat recovery or type of heating supply systems, as dominant factors (e.g. [2–5]). For southern European countries, cooling energy is a significant part of the overall primary energy demand, which increases in a global warming scenario. For example, considering the Portuguese mainland, Aguiar et al. [6] have estimated an increase of 19–24 kWh/m^2 for the annual cooling energy load. In Portugal, the EPBD transposition for national building thermal code included a large revision of climate data used for building energy simulation [7]. The new data considers the most conservative scenario of climate change in the 5th Assessment Report of Intergovernmental Panel on Climate Change (IPCC), which is the emission scenario RCP 4.5 (Representative Concentration Pathways) [8], implying that, during summer, the average external air temperature ranges from 20.1 °C, in northern coast regions and islands (Açores and Madeira) to 25.3 °C, in southern inland regions, while the data currently used for building thermal code ranges from 19 to 23 °C. Therefore, the 1–2 °C of increase is enough to influence the calculated cooling energy needs.

For residential buildings under dry Mediterranean climates, the most common strategies for preventing excessive cooling energy loads are: (i) prevention of heat gains by efficient solar shading, solar orientation and thermal insulation, (ii) increasing building thermal inertia and (iii) ventilation during nocturnal periods [9]. Other strategies exist but are applied only in non-traditional buildings [10,11], such as earth-to-air heat exchanger, evaporative cooling, solar chimney, green roofs and green facades [12], constituting passive cooling systems. Achieving a cost-optimal level of the aforementioned building elements for cooling is not straightforward as it is for heating. For example, for heating, the increase of thermal insulation thickness is always beneficial and, therefore, the sum of the investment and operating costs reaches a minimum for a specific thermal insulation thickness. Taking into

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