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Simulating building thermal behaviour: the case study of the School of the State Forestry Corp

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Abstract

The building thermal performance plays a fundamental role in reducing the national energy consumption, especially considering that the majority of the existing structures were built before energy efficiency was a concern at all. The paper presents the case study of the School of the State Forestry Corp in Sabaudia (Italy).The aim is to simulate the thermal behaviour both in stationary and dynamic conditions, and to identify the most appropriate action to improve the building energy efficiency, ensuring occupants' thermal comfort during the year. The results clearly show that considerable thicknesses of insulating material do not represent an advisable retrofitting in summer.

Keywords: heat transfer; buildings; dynamic simulation; TAS software; economical assessment.

1. Introduction

Buildings account for approximately 40% of energy consumption in the European Union (EU), 63% of which is attributed to the residential sector. Thus, it has become a relevant environmental issue, especially if we consider that buildings constitute a major pollution source: CO_2 from residential buildings represents the fourth largest source of greenhouse gases (GHG) emissions in the EU, contributing to 10%. The average energy consumption in Europe has recently reached 200 kWh/m^2/year [1-8].

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Nomenclature	
CFD	Computational Fluid Dynamics
EP_{DHW}	total primary energy consumption for domestic hot water (kWh/m^2/year)
EP_{GL}	global energy performance indicator for winter heating (kWh/m^2/year)
EP_W	energy performance indicator for winter heating (kWh/m^2/year)
Φ_{int}	heat flux entering the system
Φ_{out}	heat flux leaving the system
Φ_{source}	heat flux of an eventual heat source
Φ_{stock}	stored heat flux

Reducing the energy demand and exploiting Renewable Energy Sources (RES) represent a reachable target in the built environment so that building sustainability is a fundamental tool to provide healthy and comfortable indoor conditions, limiting the impacts on Earth's natural resources. Since the majority of existing structures were built before energy efficiency was a concern at all and most of them will be in function at least until 2025, retrofitting the existing building stock has a large potential for improving energy performance and decreasing pollutant emissions [9].

Energy renovations have positive implications and benefits not only in GHG emissions reduction and energy savings, but also in social and financial aspects, e.g. fuel poverty. In this scenario, the updated version of the Energy Performance of Buildings Directive (EPBD) has been recently published by the European Commission and focuses on the need for the Energy Efficient Retrofitting (EER) of existing buildings. EER is aimed at reducing the total energy demand, simultaneously ensuring the required levels of occupants' thermal comfort, and encompasses several actions, such as installation of thermal insulation, limitation of thermal bridges, and use of mechanical ventilation with heat recovery. Accordingly, all the aspects starting from the design phase need to be optimized in order to comply with the current regulations. Practical and scientific solutions have been proposed: an awareness campaign with the occupants identifying simple actions in order to significantly decrease the end-use energy consumption; optimization of energy systems, including the integration of renewable solutions; control and monitoring systems, allowing controlled blackouts during specific moments of the day [2, 4, 5].

The role and importance of energy efficiency has been also underlined by the Directive 2012/27/EU, which establishes a common framework of measures for achieving the Union's 2020 headline targets and requires each Member State to identify reference case studies for minimum energy performance. Furthermore, since buildings owned by public bodies represent a considerable share of the building stock, renovation strategies need to be investigated for this sector. This becomes even more important if we consider that the average efficiency of public bodies' buildings is 50%, where the amount of primary energy losses reaches 6.5 Mtep (figure 1) [7, 10].

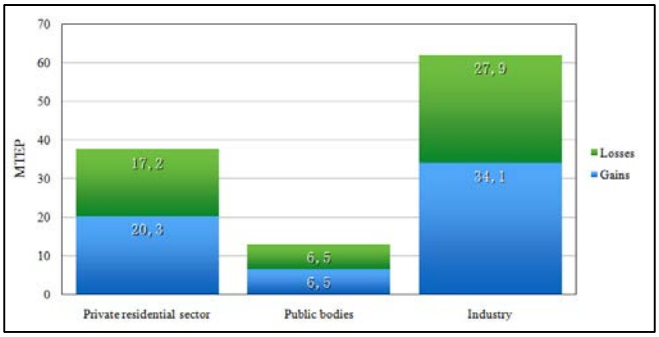

Fig. 1: Share of losses and gains in the private buildings, public bodies' buildings and industry [10]

Energy saving regulations originated in cold climates, where the fundamental concern is to reduce the winter energy consumption for space heating and to prevent heat loss through the building, having a stationary behaviour