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Editorial

Advances in the Optimization of Energy Use in Buildings

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Buildings are responsible for about 40% of final energy consumptions and 30% of total energy-related CO_2 emissions [1]. Approximately 35% of these buildings are more than 50 years old, and almost 75% of them have low energy performance [2]. While the energy efficiency of new buildings has improved over time, existing buildings still offer significant potential for energy savings through modest energy retrofits (up to 60%) or major renovations (between 50% and 80%) [3,4]. For this reason, in recent years, reducing energy needs in the building sector and achieving decarbonization have been defined as priorities in various national and international policy plans, legislative acts, and regulatory documents. Notably, the European Union has issued a series of directives to promote the energy transition by enhancing energy efficiency and mitigating climate change in the construction sector. These policies include a roadmap for reducing energy consumption in new constructions and retrofitting existing buildings [5], measures to encourage building renovations [6], and the integration of renewable energies [7,8]. The net-zero scenario has set ambitious goals to be reached for 2030 [9], which involve a 25% reduction in energy consumption, a decrease of over 40% in the use of fossil fuels, and a phase-out of biomass. These objectives can be pursued through various actions [10]:

- Improving the energy performance of the building envelope;
- Selecting efficient appliances, lighting, and air conditioners;
- Utilizing efficient and clean energy systems, such as heat pumps or district energy;
- Increasing the use of renewable energies;
- Enhancing building flexibility in order to adapt to changing energy demands.

By implementing these actions, the building sector can significantly contribute to achieving a more sustainable and environmentally friendly future.

In this context, further research is essential in order to explore innovative methodologies and technologies aimed at minimizing building energy requirements. Several typical systems can contribute to this goal, such as renewable energy sources, smart grid concepts, energy storage technologies, and smart control techniques (like demand–response mechanisms) [11]. However, it is crucial to consider that reducing energy needs cannot be isolated from other important factors, including economic aspects, occupants' thermal comfort, building design considerations, and the operational limits of technologies that are employed. Given the complexity of factors involved, many analyses in this field can benefit from adopting a multi-objective optimization approach. By considering multiple objectives simultaneously, it becomes possible to strike a balance between various goals and find solutions that are more well rounded and sustainable. Additionally, building standards and regulations play a pivotal role in this domain. When combined with assessments like energy modeling tools, certifications, and green rating systems [11], they offer comprehensive support, guidelines, and instructions for designers and building engineers. These measures ensure the health and well-being of building occupants [12], maintain consistency in construction practices, and promote environmental protection [13]. By adhering to these standards and leveraging assessment tools, professionals can create buildings that are more energy-efficient, environmentally friendly, and user-friendly.

This Special Issue aims to gather scientific contributions focused on enhancing energy efficiency in buildings, particularly emphasizing the optimization of energy usage while considering various constraints, such as economic, architectural, technological, and human comfort factors.

Different contributions were collected. First, Seminara et al. [14] concentrated on building performance evaluation as a crucial aspect in designing sustainable buildings. They proposed a sequence for assessing building performance from a United Kingdom perspective. The authors reviewed various evaluation methods, exploring their relationships, developments, and associated tools. They also emphasized the significance of post-occupancy analysis, highlighting its pivotal role in improving building efficiency while taking into account users' needs and feedback.

Furthermore, Qiu et al. [15] addressed appropriate operation mechanisms to achieve a correct energy conservation design project. They focused on the optimization and control of chilled water pumps, which are essential components in building cooling systems. The authors proposed a simple and feasible approach based on similarity/affinity laws and pump performance curves. The method was tested on a real cooling system in a battery factory, demonstrating the high accuracy of results (a flow rate estimation error less than 2% and a frequency estimation error less than 1 Hz), significant energy-saving effects (20%), and improved water grid operation conditions (a grid pressure difference reduced by 1.4% and a flow rate reduced by 2.6% compared to pre-intervention conditions).

Moreover, Malatesta et al. [16] explored the inter-relationship between energy systems, home energy demands, and occupant practices. The authors discussed the dynamic interaction between technology, consumers, and policies in creating sustainable and effective energy solutions to address the climate emergency. The review highlighted various personal and social barriers that limit the widespread adoption of renewable energy systems. The authors proposed a framework that can be used to re-evaluate the design of home automation and energy management systems, considering the impacts of different human lifestyles and routines to optimize the use of renewable energies.

Finally, Romano et al. [17] focused on deep-energy zero-emission renovation by enhancing circularity processes for water and energy resources in order to optimize their management within urban districts. They established a method used for evaluating the potential to reduce energy consumption and CO_2 emissions related to water usage and distribution in buildings. This calculation approach was applied to an established urban social housing district in Rome. By implementing a combination of interventions to reduce and control water consumption, in alignment with the green city approach, it was possible to effectively carry out a substantial energy retrofit of the existing building stock. This outcome could significantly help to mitigate the fundamental causes of climatic changes.

These contributions collectively provide valuable insights and solutions for improving energy efficiency in buildings based on a wide range of factors to ensure more sustainable and effective energy use.

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