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Editorial

Advanced Energy Efficiency Systems in Buildings

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Energy efficiency is becoming one of the key research topics in the energy field and has, therefore, attracted extensive attention in recent research. The ongoing energy situation requires extensive research to develop available solutions that could reduce building energy consumption using advanced technologies. Luisa F. Cabeza et al. [1] performed an extensive review of the published papers' keywords and found that that most of the research is focused on HVAC systems, phase change materials and also information and communication technologies. There is a reduced number of research papers that studies the problem in its entirety, including aspects such as life cycle, investment or greenhouse gas emissions, among others. The authors concluded that the research that focuses on technological aspects lacks an integrated approach considering the links between energy, sustainability or climate change and mitigation. Therefore, to achieve the objectives that focus on building energy efficiency, it is necessary to carry out extensive research that includes the whole scope of the problem and its solutions.

Climate change is producing a deep change in the local climatic conditions and, as a consequence, energy demand in buildings will subsequently vary. F. Mancini and G. Lo Basso [2] analyzed the variation in the demand in different regions in Italy, considering the new climatic conditions. A similar approach for a location with quite different conditions in Poland was performed by H. Bazazzadeh et al. [3]. This type of analysis will become a key research topic in the next few years in order to analyze the energy demand changes and the possible measures that need to be taken; one additional key aspect will be the influence on the energy demand scenario from a local, regional and national approach.

Net zero energy buildings are a key concept to achieve the required energy efficiency objectives and consequent building demand reduction, but the concept is quite broad and further clarification of the requisites and the methods to achieve net-zero energy demand is required. Haleh Moghaddasi et al. [4] performed an extensive analysis of the requirements of the Paris Agreement and found that the existing net zero energy building criteria and definitions clearly differ from each other, but also that the calculation strategies, building requirements and standards usually do differ. As shown, the objective of clearly reducing the energy demand in buildings and simultaneously increasing their energy efficiency requires the extensive attention of policymakers, stakeholders and also researchers in the field. Hossein Omrany et al. [5] performed a detailed bibliometric review of net zero energy building research from 1995 to 2022 and the results proved that the topic presents a certain level of consolidation in the following three major themes: the first theme is buildings' energy conservation, the second theme includes energy storage systems and energy production in buildings and the last theme is the methodological approach.

Control systems, system modelling, artificial intelligence and, generally speaking, information technologies are some of the research topics that aim to develop predictive models, control systems or decision tools, among others. Michael D. Murphy et al. [6] developed a model to evaluate the internal air temperature in nearly zero energy buildings that proved that using this type of system leads to a reduction in the human labor required to simulate internal air temperature in this type of building and, therefore, opens a research topic to extend the model to other buildings typologies. Alice Mugnini et al. [7] presented

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a comparison between physical models and data-driven models for energy prediction models in buildings, proving that both solutions can provide an effective solution, with the physical model being the best in terms of prediction deviation and concluded that the most important problem for data-driven models is the difficulty in properly training the model and data availability. Automatic control systems can be used to provide develop robust and capable technologies that help us to identify the occupancy patters of buildings, making it possible to achieve significant energy demand reductions. Paige Wenbin et al. [8] developed a system that includes a vision-based occupancy technology and equipment usage detection method, driven by deep learning technologies, for demand-driven control systems and proved the capacity of these systems to effectively reduce energy demand. These technologies can be applied for effective building model calibration, as proven by Taehoom Hong et al. [9], who developed a model for a single building. For fast calibration of urban building energy models, Yixing Chen et al. proved the feasibility of applying an automatic calibration strategy that used the 72,000 EnergyPlus (Ludbreg, Croatia) simulation to validate the algorithm and tested the system in 72 large office buildings [10].

The use of renewable energies is one of the most prominent technologies to reduce fossil fuel energy use in buildings and specific research is being carried out in the field of renewable energy-driven net zero energy buildings. Diana D'Agostino et al. [11] proved that geothermal heat pumps are a solution to achieve net zero energy buildings by only using on-site available energy, which includes photovoltaic energy as the electricity generation source. Silvia Soutullo et al. [12] performed a similar approach that analyzed the potential of energy savings in buildings, combining thermal solar energy, geothermal energy and building retrofitting for different locations in Spain, proving that high rehabilitation potentials exist for mid age buildings that were built before novel building codes that aimed to reduce energy demand were approved. An extensive review of the available proposals to achieve net-zero energy buildings using renewable energy systems was performed by Asam Ahmed et al. [13] and the analysis showed that cost-benefit analysis and life cycle analysis are a key part in the development of net-zero energy buildings' design and require further research. Hybrid energy systems, which include several different technologies, including energy storage, different power generators and control systems, can provide a modular solution that can be deployed in remote locations using easily transportable systems, as proven by Umberto Berardi et al. [14]. Fatima Harkouss et al. [15] developed a multi-criteria decision system to design optimal renewable energy sets for net zero energy buildings for different climates and regions. The evaluation criteria included life cycle cost, grind connection or payback period, among others.

As presented in this paper that analyzed the most recent developments in energy efficiency in buildings, energy demand reduction in buildings requires a multidisciplinary approach that involves renewable energy systems, control systems, artificial intelligence, building retrofitting or building policies, among others. Only by combining all these different techniques can the required solutions for energy consumption in buildings be achieved; therefore, extensive research that combines multiple fields must be carried out.

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