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Editorial

Energy Efficiency in Buildings and Innovative Materials for Building Construction

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1. Introduction

The main topics of this Special Issue regard energy efficiency in buildings and the use of innovative materials for design and retrofitting to pursue this goal. In developed countries, energy consumption in buildings comprises 20–40% of total energy use, which is above industry and transport in the EU and the USA. For this reason, energy efficiency strategies have become a priority in energy policy, with new regulations and certification schemes, including minimum requirements. This could be achieved by means of different approaches, among which energy saving in buildings will be essential in order to make a sustainable energy future possible. In Europe, the new Clean Energy for All Europeans package also outlines specific measures for the building sector, with considerable potential for gains in energy performance. Among the measures, it is worth mentioning the boost in renovation for more energy-efficient buildings, as well as improved monitoring of buildings' energy performance so as to reduce costs.

2. Energy Efficiency in Buildings and Innovative Materials for Building Construction

In light of the above, this Special Issue was produced to collect the latest research on energy efficiency in buildings by means of innovative and sustainable materials for building construction. There were 23 papers submitted to this Special Issue, and 14 papers were accepted (i.e., a 61% acceptance rate). When looking back to the Special Issue, various topics have been addressed, mainly focusing on energy performance, considering the building envelope and the plant, and on materials' behavior and characterization. In particular, seven papers are more focused on the first topic, concerning the study of the building envelope and plant, while the other eight are more on materials.

Papers [1–3] are focused on simulation techniques for the evaluation of the energy performance of buildings. For example, Sabina Jordan [1] and her colleagues conducted a parametric study of the influence of the occupant behavior on the energy performance of an office building provided with radiant ceiling panels for heating and cooling. They used TRNSYS, and they concluded that specific human activities influence the annual energy use a small amount and their effects often counteract. Cristina Cornaro and her colleagues [2] made a comparison of two different procedures for energy dynamic model calibration—manual and automatic—using the IDA ICE tool. They built up an automatic calibration procedure and compared it to standard manual calibration for an office building located in Rome, Italy. They found that, although both methods require high expertise from operators and showed good results in terms of accuracy, automatic calibration presents better performance and consistently helps with speeding up the procedure. Lastly, Amirreza Fateh and colleagues developed a dynamic energy model of a single zone building, considering external and internal radiation using Matlab/Simulink. They validated the model with data from the literature and then used the same model to evaluate the effect of an added layer of PCM material on the energy consumption. They found a slight reduction of energy consumption for the model with PCM with respect to the one without PCM.

Two more papers focused on upgrading the energy performance of historic buildings in Sweden [4] and a stadium in Greece [5]. The paper [4], authored by Paulien Strandberg-de Bruijn, Anna Donarelli and Kristin Balksten, evaluates the insulation capability of an hemp lime render compared to a lime render for historic buildings in Sweden. They carried out experimental activity on full scale walls, one renovated with hemp lime and the other one just with lime. They conclude that hemp can improve the insulating characteristics of the lime render, keeping the same appearance of the original external wall, preserving the heritage values, and allowing the building to comply with modern standards, increasing thermal comfort and reducing energy use. In Reference [5], the authors present a roadmap for the energy upgrade of the Pancretan Stadium located in Crete, Greece. Using active and passive solutions, such as the replacement of old openings, the introduction of a PV plant and of an open loop geothermal system, and the installation of energy-efficient lighting and a building energy management system, they could reach an annual energy saving percentage that exceeds 83%. They also improved the RES penetration at 82% versus the annual energy consumption.

Papers [6,7] deal with energy-efficient plants. In particular, Chengchu Yan, Qi Cheng and HaoCai [6] propose an optimal design method to optimize the design of a chiller plant, quantifying uncertainty and reliability. Their method optimizes the chiller capacity and chiller number to minimize the total life cost of the plant. The method is applied to a 50-storey office building in Hong Kong. Their results show that the life-cycle total cost obtained with the novel optimization method is reduced by 26% and 11.4%, respectively, relative to those from uncertainty-based and conventional design methods. Paper [7] presents the results of field tests of nine conventional shallow-depth geothermal heat pump systems and eight medium-depth geothermal heat pump systems carried out in China. The experiment allowed analyzing the energy performance of heat pump systems, as well as the heat transfer performance of ground heat exchangers. A comparative analysis between the two kinds of heat pumps shows that the outlet water temperature of the deep borehole heat exchangers (DBHE) in the medium-depth heat pumps can reach more than 30 °C with heat extraction, which is much higher than that of shallow-depth heat pumps. This high temperature of the heat source can produce great energy-saving effects.

The other 8 out of the 14 published papers are focused on materials and components for energy saving in buildings, concerning thermal, hygrothermal, acoustic, environmental and mechanical properties of innovative materials. Seven of the eight papers study materials for the opaque part of the building envelope, one of them is instead concerned with the transparent envelope and, in particular, on the glass edge sealing of Vacuum Glazing Systems.

Paper [8], authored by Z. Saghrouni, D. Baillis, N. Naouar, N. Blal and A. Jemni, studies the thermal properties and the microstructure of composite materials based on mortar combined with *Juncusmaritimus* fibers. It shows that the increasing the *Juncusmaritimus* fiber content in the mortar induces increased porosity of the mortar composite and reduction in thermal conductivity, thermal diffusivity, and density, resulting in an efficient thermal insulation material.

A mixture of waste rubber particles of different sizes and concrete [9] was investigated by J. Guo, M. Huang, S. Huang, and S. Wang, in terms of mechanical and thermal insulation properties and microstructural analyses of the rubberized concrete. Results indicate that the uniaxial compressive strength of rubberized concrete was reduced, while the peak strain was gradually increased, and thermal insulation properties were improved with an increase in rubber content and decrease in rubber particle size. In addition, the interfacial adhesion between the matrix rubber and the aggregates was weak, seeming to be a key factor in reducing the strength of rubberized concrete.

In Reference [10], the authors S. Bouzit, S. Laasri, M. Taha, A. Laghzizil, A. Hajjaji, F. Merli, and C. Buratti, performed the characterization of natural gypsum sampled from two Moroccan regions in terms of mineralogical, microstructure, thermal, mechanical, and acoustic properties. The samples have almost the same mineralogy and very good thermal properties; are able to ensure integrity in construction, especially regarding thermal insulation, fire protection, bulk density, high water content and porosity; and are low-cost in the market. The acoustic absorption coefficients were comparable to the ones of conventional cement plasters, while very good sound insulation performance was achieved.

Z. Slimani, A. Trabelsi, J. Virgone, and R. Zanetti Freire [11], analyzed the behavior of a wood fiber insulation material subjected to non-isothermal loading under a vapor concentration gradient by means of both experimental and modelling approaches. They found a good agreement between modelling and experimental data, although the prediction can be improved during the transient phase, and highlighted the limits of a purely diffusive thermal transfer model. The evolution of the thermal and moisture profiles with time suggests that the adsorption of water vapor occurs together with the redistribution of liquid water within the envelope.

Dobrosława Kaczorek, in her paper [12], conducted various experiments on the moisture buffering capacity of a series of walls assembled with hygroscopic materials. The research confirmed some results of previous work, in which it was suggested that there is a mutual influence of one layer on the other, indicating that the multilayer walls have a hygric behavior difficult to assess. Software tools such as Wufi plus could help, and, for this reason, a comparison of the simulated variables with the measured ones was presented. The author concludes that, despite the discrepancies between simulated and measured values, the tool can be used to help designers in the choice of materials to improve the moisture buffering effect.

The environmental, energy, and economic performances of the external thermal insulation composite system (ETICS), using agglomerated insulation cork board (ICB) or expanded polystyrene (EPS), were investigated by J. Silvestre, A. Castelo, J. Silva, J. de Brito, and M. Pinheiro, in Reference [13], as insulation material for energetic renovation of the building envelope during a 50-year study period. A comparison between ETICS using ICB and EPS, for the same time horizon, is also presented. Results showed that ETICS with ICB is environmentally advantageous, both in terms of carbon footprint and of non-renewable primary energy, the production stage of ICB being less polluting and the EPS U-Value being low. When comparing ETICS with reference solutions, the latter perform better only in the economic dimension and for energy consumption which fulfils less than 25% of the heating and cooling needs.

Finally, in Reference [14], authored by J. Kim, Y. Kim, and E. Jeon, the transparent part of the envelope was studied, focusing on the optimization of the glass edge sealing process the fabrication of Vacuum Glazing, using microwaves to seal glass edges. The study was carried out using the Box–Behnken method of response-surface analysis, based on three factors and three levels. Results showed that edge sealing is possible when minimization of the step height is carried out; a predictable regression equation was derived for the step height of edge sealing, and the main-effect analysis was performed for the step height.

3. Future on Energy Efficiency in Buildings

Research on energy efficiency in buildings and innovative materials for building construction is in further development, and is of great interest in relation to the targets of energy saving and environmental impact reduction. More high-quality research is expected in the near future, and, therefore, other Special Issues on these topics could be organized periodically in order to update the state of the art.

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