

Buildings Energy Efficiency and Innovative Energy Systems

Vítor Leal 

Department of Mechanical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal; vleal@fe.up.pt; Tel.: +351-938480810

1. Introduction

The use of energy in buildings is at the crossroads between comfort and productivity requirements, passive and active technological options, and health and environmental consequences. This energy end-use sector accounts for 36% of the final energy consumption and about 39% of the total greenhouse gas (GHG) emissions, making it the largest sector responsible for GHG at the world level [1].

It is well known that the energy use in buildings can be hugely reduced by adopting stricter energy efficiency measures, mostly at the levels of the envelope design and thermal insulation, heat recovery at ventilation, and by adopting renewable-based heating and cooling [2,3]. While building codes and practices have steadily been moving in a forward direction, there is still room for more innovation—be it to achieve more effects or for better cost-efficiency.

Yet, energy in buildings cannot be decoupled from issues such as behavioral attitudes, sociological aspects such as cold homes/fuel poverty, impacts on health/indoor temperature requirements, integrating buildings into cities, or even how policies for buildings are designed and evaluated. This justifies why this journal issue took a comprehensive approach to the theme of Energy Efficiency and Innovative Energy Systems in Buildings. It was announced in March 2020 and was open to topics such as:

- Energy efficiency and performance metrics;
- Performance assessment of the existing stock;
- Integration and synergies with on-site renewables;
- Innovative design strategies;
- Innovative technological solutions;
- Maximization of electric demand-response potential;
- Financing instruments for energy efficiency actions;
- Rebound effects and behavioral issues;
- Non-energy benefits of actions;
- Retrofit strategies and case studies.

2. Publication Statistics

The issue received a total of 15 submitted articles, of which 12 were accepted and published after each passing an independent peer-review process.

Table 1 shows the authors' list in alphabetical order, together with their first affiliation institution and country of the first affiliation institution. It contains 21 authors from institutions in Europe and Asia. The number of authors ranged between two and six, with an average of 3.17 authors per article.



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Table 1. List of contributing authors and affiliations.

Author	First Affiliation	Country of Affiliation Institution	References
Arewa, A.	School of Energy, Construction and Environment, Coventry University	United Kingdom	[4]
Ahmed, A.;	Institute for Future Transport and Cities, Coventry University	United Kingdom	[4]
AL-Dossary, A.	Architectural Engineering Department, King Fahd University of Petroleum and Minerals (KFUPM)	Saudi Arabia	[5]
Almeida, M.	LEPABE, Faculty of Engineering, University of Porto	Portugal	[6,7]
Azevedo, I.	INEGI, Institute of Science and Innovation in Mechanical and Industrial	Portugal	[8,9]
Baik, Y.	Department of Architectural Engineering, Seoil University	Republic of Korea	[10,11]
Caratella, K.	Institute for Future Transport and Cities, Coventry University	United Kingdom	[4]
Ferreira, P.	ALGORITMI Research Centre, School of Engineering, University of Minho	Portugal	[12]
Granadeiro, V.	INEGI, Institute of Science and Innovation in Mechanical and Industrial	Portugal	[6]
Kim, D.	Architectural Engineering Department, King Fahd University of Petroleum and Minerals (KFUPM)	Saudi Arabia	[5,10,11,13]
Leal, V.	DeMec-Faculty of Engineering, University of Porto	Portugal	[6–9,14,15]
Lee, W.	Department of Architectural Engineering, Seoil University, Korea	Republic of Korea	[13]
Lim, T.	Department of Architectural Engineering, Seoil University, Korea	Republic of Korea	[10,13]
Lima, F.	Faculty of Engineering, University of Porto, rua Dr. Roberto Frias, Portugal	Portugal	[12]
Machado, J.	CIN—Corporação Industrial do Norte, S.A., Portugal	Portugal	[6,7]
Mateo-Garcia, M.	Faculty of Computing, Engineering and the Built Environment, Birmingham City University, UK	United Kingdom	[4]
Mendes, A.	LEPABE, Faculty of Engineering, University of Porto, Portugal	Portugal	[6,7]
Ortiz, D.	Faculty of Engineering, University of Porto, Portugal	Portugal	[8,15]
Souto, T.	CIN—Corporação Industrial do Norte, S.A., Portugal	Portugal	[6,7]
Teixeira, R.	Faculty of Engineering, University of Porto, Portugal	Portugal	[14]
Yim, W.	Department of Industrial Management, Seoil University, Korea	Republic of Korea	[11]

Concerning the topics addressed, they spanned through most of the field, as can be seen in Table 2. Three articles were focused on policy design, while heating technologies, special paints, and daylight and cooling attracted two articles each.

Table 2. Distribution of the articles per topic.

Subtopic	Number of Articles	References
Policy design	3	[5,12,13]
Heating technologies	2	[6,7,10,12]
Special paints	2	[1,2]
Daylight and cooling	2	[7,11]
Connection energy-health	1	[3]
Hybrid technologies	1	[8]
Building renovation	1	[14]

3. A Short Review on the Contributions in This Issue

From the technological perspective, four articles were published.

In “PoDIT: Portable Device for Indoor Temperature Stabilization: Concept and Theoretical Performance Assessment”, Leal and Teixeira present a novel system for indoor temperature stabilization, using phase-change materials and especially for decreasing the maximum indoor temperature of buildings without air conditioning during summer and/or during heatwaves. The results showed that the device could lead to nearly a 3 °C

reduction in the maximum room air temperature, with natural convection, while adopting a fan to impose forced convection at the surfaces of the device can lead to temperature attenuations in excess of 4 °C [14].

In “Thermal and Energy Performance Assessment of the Prefab Electric Ondol System for Floor Heating in a Residential Building”, Lee et al. compared water-based “Ondol” radiant floor heating systems with electricity-based ones. They found significant differences in the cost and in the surface temperatures between the two systems [13].

In “Heating Performance Analysis of an Air-to-Water Heat Pump Using Underground Air for Greenhouse Farming”, Lim et al. assess, with measurements, the heating performance of an air-to-water heat pump that used underground air as a heat source for greenhouse farming during the winter. They show that AWHP (air-to-water heat pump) can save more than 70% of the total heating costs compared with a conventional air heater [10].

Another article, also with T. Lim as the first author (“Evaluation of Daylight and Cooling Performance of Shading Devices in Residential Buildings in South Korea”), addresses the issue of the daylight and energy performance of shading devices in the Korean context, comparing Venetian blinds, horizontal louvers, light shelves, and egg-crate solutions. They found that egg-crate shading was the most proper shading device to block sunlight and reduce energy use [11].

A group of articles dealt with the issue of performance evaluation of special paints. In “Thermochromic Paints on External Surfaces: Impact Assessment for a Residential Building through Thermal and Energy Simulation”, Grandeiro et al. study the impact of using thermochromic paints in the external façade of residential buildings. They show that energy savings of up to 50.6% could be reached if the building is operated in conditioned mode. Conversely, when operated in free-floating mode, optimally selected thermochromic paints enable reductions up to 11.0 °C during summertime and an increase up to 2.7 °C during wintertime [6].

In “Total Solar Reflectance Optimization of the External Paint Coat in Residential Buildings Located in Mediterranean Climates”, Souto et al. analyze the relevance of carefully choosing the total solar reflectance (TSR). They show that carefully chosen TSR values lead to better indoor thermal temperatures if the buildings have no mechanical heating or cooling or to energy savings of up to 32% if they do [7].

AL-Dossary et al. wrote an article on the “Study of Design Variables in Daylight and Energy Performance in Residential Buildings under Hot Climates”. It covered optimization of including window-to-wall ratios (WWR), external shading devices, and types of glazing and showed the importance of tailoring these options for each building/climate combination [5].

Policy design attracted three articles. In “A Review of the Measures and Instruments to Promote Efficiency and Renewable Energy in Domestic Water Heating”, Ortiz et al. reviewed and systematized the technical measures and policy instruments that can be used to promote energy efficiency and the use of renewable sources for domestic hot water. A matrix showing the applicability of policy instruments per technical measure was derived, enabling policymakers to better choose articulated measures and policy instruments for their policy packs [8].

D. Ortiz was the first author of another policy design article, “Energy Policy Concerns, Objectives and Indicators: A Review towards a Framework for Effectiveness Assessment”. It assessed the policy evaluation practices regarding the public policies on energy, with a focus on the metrics: concerns, objectives, and indicators. The concerns and objectives were organized into four categories: institutional, environmental, economic, and social. For every category, detailed and condensed concerns were identified, resulting in 15 core indicators [15].

A third paper on policy design was authored by Azevedo and Leal: “Decomposition Analysis of the Evolution of the Local Energy System as a Tool to Assess the Effect of Local Actions: Methodology and Example of Malmö, Sweden” [9]. In it, the authors propose the use of decomposition analysis to assess the effect of local energy-related actions

towards climate change mitigation and thus improve policy evaluation and planning at the local level. The proposed methodology, including the quantification of the specific effect associated with local actions, is demonstrated with the case study of the municipality of Malmö (Sweden) in the timeframe between 1990 and 2015 [9].

The topic of the connection between the energy use and the building's occupants was dressed by Lima et al. through a review article: "A Review of the Relation between Household Indoor Temperature and Health Outcomes". The review established that, overall, inadequate indoor temperatures are associated with poor health status, whereas energy efficiency measures have been associated with improved indoor temperatures and the occupant's health, namely regarding cardiovascular, respiratory, and mental health disorders. The review also highlighted the need for more empirical studies with an extended timeframe [12].

Finally, the most important and timely issue of retrofitting was addressed by Ahmed et al. in the article "Integrated Performance Optimization of Higher Education Buildings Using Low-Energy Renovation Process and User Engagement". This article seeks to critically evaluate the low-energy renovation process and the role of user and stakeholder engagement in the strategic implementation of low-energy retrofit technologies for performance improvement of higher education buildings. A new renovation process and user engagement framework was developed. The findings suggest that there is a direct relationship between retrofit intervention, improving energy performance of low-carbon buildings, and the comfort of occupants, with technologies and strategies also appearing to have various impacts on user satisfaction [4].

The topics of the field not covered with strict focus include nearly and net-zero energy buildings and buildings considered as clusters/communities (low carbon or net-zero energy communities). There is also ample room for further innovation at the level of heating and cooling technologies, especially those based on renewable energy sources, as well as the forecasting and mitigation of the impacts of climate change on buildings and cities.

Conflicts of Interest: The author declares no conflict of interest.

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