

Building Energy Audits—Diagnosis and Retrofitting towards Decarbonization and Sustainable Cities

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Abstract: A collection of twelve papers published in *Energies*, in a Special Issue on “Building Energy Audits-Diagnosis and Retrofitting”, was bound together and published in 2021, focusing on the built environment. The aim was to systematically collect and analyze relevant data for obtaining adequate knowledge on the energy use profile of buildings, and was extended for the sustainability assessment of the built environment. To date, all papers have been very well received, attaining a total of 97 citations and over 15,300 views. The papers addressed historic and various building types, baselines for non-residential buildings from energy performance audits and from in-situ measurements, monitoring and data analysis, assessment of indoor environmental quality, model calibration and verification of energy savings, along with an urban audit and rating method for assessing the sustainability of the built environment. Following on from the success of this Special Issue, the decision was made to reopen and extend it to include papers related to decarbonization and sustainability, at building, city, region, and national scales. This Editorial reviews the performance of the first Special Issue and outlines the second volume on Building Energy Audits-Diagnosis and Retrofitting Towards Decarbonization and Sustainable Cities, as a Special Issue in *Energies*.

Keywords: building and HVAC energy audits; survey; diagnosis; inspections; energy performance; energy efficiency; energy conservation; implementation and verification; baselines; energy use intensities; carbon use intensities; gap analysis; benchmarking; building stock modeling; decarbonization; sustainability assessment



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1. Introduction

Buildings, and the related construction industry for manufacturing major building materials (e.g., steel, cement, glass), use about 130 EJ (or 35%) of the global final energy [1]. As a result, the carbon emissions from building operations have peaked at about 10 GtCO₂ (or 28%) of total global energy-related CO₂ emissions that are linked to climate change. Taking into account the additional impacts from the building construction industry, this is estimated to reach about 38% of the total global energy-related CO₂ emissions [1].

In response, under the auspices of the United Nations and the historic Paris Agreement, countries throughout the world have committed to aggressive efforts for energy conservation and a reduction in carbon emissions, in order to limit climate change and its negative impacts. For example, the European Union aims to be climate-neutral by 2050—an economy with net-zero greenhouse gas emissions. The buildings sector is at the center stage, as a main contributor to these efforts, to transform buildings from being part of the problem to become part of the solution. In this direction, there is a commitment to net-zero carbon building stock by 2050. This involves reducing energy consumption through higher energy efficiency and using environmentally friendly energy carriers, like renewables, for power generation and at the building site.

However, the success of these efforts will depend on the success of handling the main challenge for renovating the existing buildings stock. In this vein, it is estimated that by 2030, the direct CO₂ emissions from building operations should be cut by half and indirect

emissions from power generation should drop by about 60%. This implies that emissions from the building sector should drop by ~6% per year from 2020 to 2030 [1]. To help interpret the magnitude of this effort, consider that the global energy sector CO₂ emissions decreased by about 6% during the COVID-19 pandemic [2], while CO₂ emissions are again on the rise and, currently, significantly deviate from the targets of the Paris Agreement.

2. Understanding the Built Environment

In the European Union, about 75% of the building stock is energy inefficient, since the buildings were constructed before the introduction of the strict requirements, according to the energy performance of buildings directive. As a result, cities use large amounts of energy and natural resources and have serious, detrimental environmental impacts, including high greenhouse gas emissions. Auditing and collecting information about existing buildings, infrastructures and the built environment are necessary for implementing effective renovations and planning large-scale strategies.

At the building scale, information can be used to assess measures for higher energy efficiency and lower emissions, improve indoor environmental quality, for better and healthier living and working conditions. At a larger scale, understanding of the building stock can support efforts towards decarbonization and address sustainability issues in cities, regional and national buildings stocks.

Building audits, in one form or another, can be used to systematically collect the necessary data, in order to gain adequate knowledge and a better understanding on the operations, energy use and prevailing indoor conditions of buildings. The data can be used to identify, quantify and prioritize renovation measures for reaching higher energy efficiency, lowering emissions and improving indoor environmental quality. Findings can also be used as input during building certification and studies for assessing the cost effectiveness of renovations. At larger scales, the data can be exploited to develop performance baselines and benchmarks, methods and tools, for understanding the building stock, in order to facilitate the decarbonization and sustainability assessment of the built environment, assess and improve the outdoor environment and the well-being of area residents, among others.

2.1. The First Special Issue

The first Special Issue, on “Building Energy Audits—Diagnosis and Retrofitting”, addressed several of these subject areas. A total of 12 articles were published online in the open access journal, *Energies*, and the article reprints were collected in a bounded volume, published in early 2021 [3]. Among them, eleven contributions were research papers [4–14] and one was a review paper [15], referenced in the order of their individual publication. In terms of the geographical distribution for the affiliations of the 54 contributing authors, they originated from seven countries, including Czech Republic, Greece, Italy, Korea, Poland, Spain and Sweden. All papers have been very well received by the scientific and technical community, so far securing a total of 97 citations and over 15,300 views, since the first paper publication, at the end of 2019.

2.2. The Second Special Issue

Continuing on the previous success, the new edition will include similar topics of interest, but not be limited to:

- Methods and tools for building energy audits, surveys, diagnosis, inspections, assessment;
- Non-destructive testing, measuring, monitoring and analysis of data;
- Energy efficiency and conservation measures;
- Calculation, measurement and verification of energy savings;
- Model calibration and gap analysis;
- Energy performance contracts and certificates, risk analysis and assessment;
- Benchmarking energy use and carbon intensity, baselines and breakdown for end-uses, financial assessment, cost analysis;
- Case studies and lessons learned from the field.

These will expand the topics of interest to place more emphasis on city, regional and national scales, related to decarbonization and sustainability issues that will also address, but will not be limited to:

- Auditing, monitoring and assessing decarbonization and sustainability efforts;
- Facilitating audits, inspections and data collection, using information from smart systems, remote data collection and virtual audits;
- Exploiting automated processes, using novel methods to collect and process data for large-scale built environments, from geographic information systems (GIS) and global earth observations (GEO), among others;
- Quantifying energy and carbon savings, from renovations of large portfolios and building stocks;
- Presenting cities case studies, large-scale assessments and lessons learned.

3. Conclusions

The buildings sector continues to have a major impact on energy consumption and emissions that influence global efforts to mitigate the impacts of climate change. On the other hand, buildings are also becoming part of the solution for a decarbonized economy, transforming them from energy sinks to prosumers, with minimum operational and embodied energy and carbon emissions. Building audits can provide profoundly necessary and valuable data, for understanding, quantifying and optimizing the role and operation of the built environment at different scales. Along with novel methods and tools, this knowledge can help overcome the existing complexities and navigate towards decarbonization and sustainability.

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

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