

Assessment and Optimization of Energy Efficiency

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1. Introduction

In order to pursue the energy goals defined for 2030 and 2050 [1], strong efforts must be made in the assessment and optimization of energy efficiency [2] by researchers, engineers and practitioners working in different sectors, e.g., manufacturing [3,4], industrial systems [5], and non-industrial systems [6]. The rational use of resources represents a key point: all resource categories must be accurately managed to smartly carry out the energy transition [7,8]. Energy efficiency assessment represents the foundation on which to create, build, design and implement optimization strategies. Examples of drivers in this field are represented by data selection, data acquisition, data storage, data analysis, Industry 4.0, digital twin (DT) and key performance indicator (KPI) concepts [9]. Both energy efficiency assessment and optimization represent multidisciplinary challenges where each area can contribute through its distinctive and specific tools. The high specificity and uniqueness of each discipline can make a difference in building a better future. Disciplines of crucial relevance include engineering and applied mathematics exploited in industrial and non-industrial processes. Significant application sectors are hard-to-abate sectors. Key goals are represented by decarbonization and rational use of resources. Decision support systems (DSSs) and expert systems are significant examples of tools that can be exploited to approach these challenges.

This Special Issue presents contributions related to assessment and optimization of energy efficiency, providing an overview of the state of the art of emerging technologies and best practices.

2. Overview of the Published Manuscripts

In the present Special Issue, 22 papers were submitted, of which 10 papers were accepted and published upon completion of the review phase. The main topics tackled by these papers are energy and production efficiency, decarbonization, economic and technological development, and performance evaluation. The following subsections provide an overview of each accepted paper.

2.1. Energy Efficiency, Production Efficiency, and Decarbonization

Ref. [10] tackles the issue of wind energy generation enhancement in bladeless devices. In particular, aerodynamic plates subjected to the von Kármán vortex street are assessed. The study investigates the option to use an oscillating plate downstream of a cylindrical body to produce mechanical energy. The parameters taken into account for optimization are the plate length, plate/cylinder separation, machine damping factor on the power coefficient, and displacement of the blade. A surrogate model is proposed through computational fluid dynamics (CFD) tools. The results obtained prove the significant improvement in performance of bladeless generators.



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In [11], crop production efficiency is investigated. EU countries are considered, and their ability to ensure the economic security of producers (farmers) and of Europe's energy is analyzed. This work is located in the context of the changing political situation where both food security and energy security must be taken into account while maximizing farmers' profit in a market economy. Another research objective is represented by the investigation of the impact of production costs on productivity. The Cash Crop agricultural benchmarking database is exploited, and the data envelopment analysis (DEA) method and stepwise multiple regression are applied. The obtained results show that both crop energy efficiency and farm performance are important challenges in Europe. In addition, a strong correlation between crop economic efficiency and production efficiency is proven.

In [12], the challenge of reclaiming/restoring salt-affected soil is tackled. This challenge is significant due to the limited amount of water available for soil washing. The paper proposes an evaluation and optimization of energy efficiency for reclaiming salt-affected soils through soil electrokinetics (SEK) under pulsed-mode electric field operation. Na^+ , K^+ and Ca^{2+} removal is considered in the control experiments. The obtained results show that it is recommended that the pulsed mode of the electric field is used while reclaiming salt-affected soil.

In [13], energy and production efficiency challenges for polymer processing plants are tackled. The paper exploits a set of tools to prove their analytical capabilities for improving the energy efficiency of polymer production processes. The energy gap method (EGM) is exploited; it is characterized by different levels of specific energy consumption (SEC). The exploited tools are the performance characteristic line for diagnostics (PCLD), the activity-based target from diagnostics (ABTD), and the performance characteristic curve for diagnostics (PCCD).

In [14], road bitumen operational properties are studied. In particular, some modifications are proposed by adding adhesive additives (phenol–cresol–formaldehyde resin, PhCR-F). The study shows that bitumen modifiers produced from non-target coking products of coal can represent new resources in road construction and can increase the depth of decarbonization of the coking industry.

2.2. Economic and Technological Development

Ref. [15] determines which planning directions to choose for the technological development of the oil sector in Mexico and provides related studies. The patent activity of the oil sector is analyzed in order to target the defined goals of the study, aiming to ensure economic sustainability of the oil companies. Currently, the most promising technologies are offshore drilling and production. To reverse the decreasing trend associated with the volume of oil production, research and development activities are crucial; in particular, technological development must not be considered an end but a means to increase the efficiency of the integrated activities associated with the oil companies. The paper proves that the technological component and, more generally, the effectiveness of projects in the energy sector strictly depend on the dynamics of patent generation.

Ref. [16] carries out an economic and technical assessment of the prospects for development of the oil and gas sector in the Republic of Mozambique. This work is located in the context of the global energy transition. The analysis of key gas projects and of patents in the field shows that the integration of carbon capture and storage (CCS) systems and the use of modular solutions can contribute to the improvement in sustainability and investment attractiveness. Based on these assumptions, the important role of the implementation of gas projects in Mozambique is established for the long-term socio-economic development of the country.

Ref. [17] reviews green hydrogen and its contribution to environmental sustainability. Green hydrogen is crucial for the path toward a low-carbon economy, because it allows energy production from renewable sources and without polluting emissions. The work shows that, since 2018, green hydrogen and sustainability have emerged as a consolidated research field. Research mainly focuses on technological efficiency, optimization, and emission reduction, with renewable-based water electrolysis as the dominant pathway.

2.3. Performance Evaluation

In [18], energy and heat consumption in the small consumer sector in Poland is considered for trend analysis and forecasting purposes. Historical data are exploited. The study investigated consumption trends of hard coal, electricity, and natural gas in Polish households from 2006 to 2021. The findings revealed an increasing pattern in natural gas and electricity consumption, together with a decrease in the use of hard coal. In addition, forecasts up to 2027 were generated. Some insights provided by the work indicate that there is a need to increase the use of renewable energy sources and to boost energy efficiency. These goals can be achieved through low-carbon alternatives, enhanced insulation, and smart energy management systems.

Ref. [19] assessed the use of solar photovoltaic radiation as a renewable resource for a region of the Isthmus of Tehuantepec. The goal of the study is to characterize the system's performance based on the location conditions and to prove the feasibility of the installation of these systems in the considered region. Real data were acquired and analyzed. The study advances understanding in the understudied regions with substantial solar potential, such as the Isthmus of Tehuantepec, where wind resource exploitation is prioritized over solar energy by policy.

3. Conclusions

The manuscripts published in the present Special Issue propose innovative pathways associated with energy and production efficiency, decarbonization, economic and technological development, and performance evaluation. Strategic materials and methods are crucial in these topics. The availability of data to be analyzed and systems to be studied is a fundamental requirement. In addition, methodological workflows and tools to analyze data, study the considered processes, and reveal opportunities associated with efficiency improvement and optimization can strengthen the roadmap toward the mentioned challenges.

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Abbreviations

The following abbreviations are used in this manuscript:

ABTD	Activity-Based Target from Diagnostics
CCS	Carbon Capture and Storage
CFD	Computational Fluid Dynamics
DEA	Data Envelopment Analysis

DSS	Decision Support System
DT	Digital Twin
EGM	Energy Gap Method
KPI	Key Performance Indicator
PCCD	Performance Characteristic Curve for Diagnostics
PCLD	Performance Characteristic Line for Diagnostics
PhCR-F	Phenol–Cresol–Formaldehyde Resin
SEC	Specific Energy Consumption
SEK	Soil Electrokinetics

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