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36th International Conference on efficiency, cost, optimization, simulation and environmental impact of energy systems (ECOS 2023) – Advancing sustainable energy systems

1. Editorial

The global energy transition requires innovative solutions to improve efficiency, reduce environmental impacts, and integrate renewable energy sources. The 36th International Conference on Efficiency, Cost, Optimization, Simulation, and Environmental Impact of Energy Systems (ECOS 2023), held in Las Palmas de Gran Canaria, Spain, provided a dynamic platform for researchers and professionals to present cutting-edge advancements in energy system design, optimization, and sustainability.

Following the recommendations of the Chairpersons and Session Monitors, the Selection Committee identified a set of high-quality papers for archival publication in Energy. After a rigorous peer-review process, a total of 27 papers were selected, representing significant contributions from ECOS 2023. These studies cover key areas such as thermoeconomics, renewable energy integration, the hydrogen economy, and energy system optimization, offering valuable insights into the challenges and opportunities of the energy transition from technical, economic, and environmental perspectives.

2. The Future of thermoeconomics

One of the main highlights of this special issue is the dedicated section *The Future of Thermoeconomics,* which gathers studies addressing the evolution and future applications of exergy-based methodologies for energy system analysis, resource accounting, and sustainability assessments. In his work, Tsatsaronis provides an in-depth review of the theoretical foundations of exergy analysis, highlighting areas for further methodological improvements [1]. Similarly, Frangopoulos and Dimopoulos offer a historical perspective on thermoeconomics and suggest new research directions that could enhance the applicability of this discipline in modern energy systems [2]. Lazzaretto et al. expand on these themes by proposing advancements in exergoeconomic methods, extending them to optimization strategies that better integrate sustainability and cost-effectiveness [3]. Meanwhile, Favrat broadens the traditional scope of thermo-economic analysis by incorporating environmental and sustainability considerations, proposing an expanded framework for assessing the long-term viability of energy systems [4], and Reini and Casisi explore how exergy cost theory can be integrated with cumulative resource accounting to enhance sustainability assessments, with the aim of creating more robust thermoeconomic models [5].

Contributing further to this discussion, Valero-Capilla et al. discuss how thermoeconomics can evolve beyond industrial cost minimization towards cumulative resource accounting and sustainability evaluations, providing a broader theoretical framework to assess the real economic impact of energy systems [6]. From a complementary perspective, Sciubba proposes a reconciliation between exergy analysis, thermoeconomics, and the cost of environmental externalities, emphasizing the need to include external environmental and social costs in energy analyses [7]. Together, these contributions show the importance of thermoeconomics as a relevant tool for evaluating the economic and environmental impact of modern energy systems.

3. Energy system optimization and sustainability

Several studies in this special issue focus on the optimization of energy systems through advanced computational approaches. One study introduces a hybrid optimization algorithm to enhance district heating and cooling networks, proposing a Bayesian optimization-based approach that improves energy efficiency and operational costs [8]. Additionally, researchers explore nonlinear multi-phase optimization methods for improving energy distribution systems and industrial processes, demonstrating the potential of these strategies in large-scale networks [9].

Another study assesses the impact of forecasted heat demand on the optimal scheduling and real-time control of multi-energy systems, highlighting how accurate forecasting techniques can significantly enhance system reliability and operational efficiency [10]. In parallel, a systematic approach to energy planning and infrastructure design is presented, identifying typical district energy configurations and their optimal operation [11].

4. Renewable energy integration and storage

The integration of renewable energy sources and energy storage technologies is a central theme in this issue. One study proposes an innovative solar-wind cogeneration system for sustainable power and freshwater production, integrating microbial desalination cells, humidification-dehumidification, and reverse osmosis technologies to enhance system performance [12]. Another paper examines the feasibility of latent heat thermal energy storage integrated with heat pump

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systems, providing new insights into their potential for increasing the efficiency of heating systems [13].

In the field of thermal energy storage, one study investigates the techno-economic implications of methanol-based thermochemical energy storage for district heating applications, demonstrating its potential as a scalable solution [14]. Similarly, an alternative approach to thermal energy generation is presented through an evaluation of sodium-water reaction heat sources in district heating systems [15].

5. Hydrogen economy and green fuels

Several studies analyze the hydrogen economy, focusing on its production, distribution, and integration into multi-energy systems. A comprehensive exergetic life cycle assessment of green hydrogen production identifies key efficiency factors and environmental impacts associated with different production pathways [16]. In a related study, a comparative analysis explores the techno-economic feasibility of CO_2 and water as heat carriers for long-distance heat transport from geothermal sources, providing critical insights into their potential role in energy transmission [17].

Further contributions include an assessment of hydrogen supply chains in island energy systems, presenting dynamic bi-objective optimization models that balance cost minimization and greenhouse gas emissions reduction through real-world case studies [18]. Additionally, a study on refinery decarbonization presents a holistic approach that integrates atomic, energy, and exergy flow analyses to advance carbon footprint reduction strategies in the refining industry [19].

6. Advancements in power generation, cooling systems and district energy planning

Several papers explore advancements in power generation and cooling technologies. For example, one study provides an exergoeconomic analysis of supercritical CO_2 cycles, examining their efficiency and economic viability as a sustainable alternative for power generation [20]. Another research effort compares different methodologies for predicting wet cooling tower performance in concentrated solar power plants, demonstrating how AI-based models can improve operational accuracy and efficiency compared to traditional Poppe models [21].

A study focusing on renewable energy planning presents a rationale for selecting suitable locations for offshore wind energy farms, with a case study on the Canary Islands assessing site selection criteria based on techno-economic and environmental constraints [22]. Another research investigates the potential use of the renewable exergy return on investment (RExROI) metric, discussing its implications for the optimization of renewable energy resources [23]. Additionally, a system-level analysis compares different low-carbon heating and cooling solutions for residential applications, optimizing configurations of heat pumps, electric and hydrogen-driven boilers, and thermal storage solutions to achieve the best techno-economic performance [24].

7. Environmental impact assessment and life cycle approaches

Environmental impact assessments and life cycle methodologies play a fundamental role in evaluating the sustainability of emerging energy technologies. One study in this issue examines the environmental impact of perovskite solar cells, highlighting critical concerns related to their material composition and long-term sustainability [25]. Another contribution explores the role of energy system layout strategies and sector coupling in multi-criteria energy planning, demonstrating how these approaches contribute to more sustainable energy infrastructures [26].

A further study introduces ROSMOSE, a web-based decision support tool developed to facilitate the design and optimization of osmotic energy systems. This tool enhances energy recovery efficiency by integrating advanced modeling and optimization techniques [27].

8. Conclusion

The selected papers in this special issue demonstrate the depth and breadth of research presented at ECOS 2023, showcasing cutting-edge methodologies and technologies that are driving the global energy transition. By integrating theoretical advancements, numerical modeling, and experimental validation, these studies provide valuable guidance for policymakers, engineers, and researchers striving to develop more efficient, cost-effective, and environmentally sustainable energy systems.

We extend our sincere appreciation to all the authors for their high-quality contributions, to the reviewers for their rigorous evaluations, and to the editorial team at Energy for their unwavering support in bringing this special issue to fruition. We hope this collection of research serves as a source of inspiration for future innovations and fosters continued collaboration in the pursuit of a sustainable energy future.

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