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Special Issue: Renewable Energy Communities and Thermophysical Systems for Sustainable Regional Energy Transition (Selected Papers from the Milis Study Day on Energy Communities)

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Editorial

In recent years, the global transition toward low-carbon and decentralized energy systems has significantly accelerated the development of Renewable Energy Communities (RECs) as an emerging model for regional energy management and sustainable energy governance. In this frame, the integration of renewable energy, energy reduction, and energy recovery provides a solid framework for achieving a future free from fossil fuels, summarized in the "3R for 4F" concept. By promoting local renewable energy utilization, distributed generation, collective self-consumption, and coordinated participation among multiple stakeholders, RECs have increasingly become an important component of the European energy transition framework. At the same time, the growing complexity of modern energy infrastructures has highlighted the critical role of thermophysical optimization, thermal management, energy storage enhancement, and advanced transport phenomena in improving the operational efficiency and engineering feasibility of distributed energy systems.

This Special Issue, entitled *Renewable Energy Communities and Thermophysical Systems for Sustainable Regional Energy Transition (Selected Papers from the Milis Study Day on Energy Communities)*, brings together selected contributions presented within the framework of the "Study Days on Energy Communities for Territorial Development" organized in Milis (Oristano) on February 16, 2026, together with several complementary studies addressing related developments in energy engineering and engineering thermophysics. **The collected papers reflect the multidisciplinary nature of contemporary energy research, linking RECs, distributed energy optimization, thermal storage enhancement, porous media transport, and integrated thermal process systems within a common perspective of sustainable regional energy transition**.

The issue opens with the contribution from Marialaura Di Somma and co-authors, which investigates **the coordinated management of distributed RECs through flexible load coordination, battery storage scheduling, and shared energy optimization**. The study proposes a operational framework aimed at enhancing shared renewable energy utilization while maintaining user comfort and reducing electricity costs. Beyond the technical optimization aspects, the work also discusses the evolving European and Italian regulatory framework supporting the deployment of REC systems.

The following contribution, authored by Raffaello Possidente and co-authors, focuses on **the techno-economic assessment of a Renewable Energy Community implemented in the municipality of Pattada, Italy**. By combining municipal photovoltaic generation with distributed residential participation scenarios, the study evaluates the energy balance and economic feasibility of shared electricity utilization within a local REC framework. The results demonstrate the practical relevance of distributed renewable systems for improving local energy self-sufficiency and supporting regional energy planning strategies.

Subsequently, Guglielmina Mutani and colleagues extend **the analysis to integrated digital decision-support**

systems. Their contribution integrates geospatial analysis, energy modelling, and operational assessment tools to develop a multi-objective framework for the design and optimization of RECs. The study highlights the importance of digital platforms and spatially explicit planning methodologies for improving self-consumption, self-sufficiency, and coordinated renewable energy deployment at the regional scale.

The work by Farid Mechighel and collaborators further explores **transport phenomena in anisotropic porous systems**. Their study analyzes the influence of permeability anisotropy, porous layer thickness, and inertial effects on flow structure and heat transfer behavior in partially filled channels. The paper offers a detailed thermo-hydraulic analysis that contributes to the understanding of heat transfer enhancement mechanisms in complex porous thermal systems.

The following contribution by Yibao Zhao and co-authors investigates **a thermally regulated electrochemical–membrane integrated system for hydrazine-containing wastewater treatment**. By combining electrocatalytic oxidation, membrane separation, structural reliability analysis, and thermal regulation strategies, the study illustrates the growing integration between thermal process engineering and environmentally oriented treatment technologies.

The Special Issue concludes with the contribution by Muna Hameed Alturaihi and Faez Abid Muslim Abd Ali, which investigates **a passive photovoltaic thermal management system based on the combined utilization of paraffin phase change material, porous metal foam, and ternary nanoparticles**. Through transient numerical simulations employing a Galerkin finite element framework, the study evaluates heat transfer enhancement, phase transition behavior, and photovoltaic performance under realistic operating conditions. The results demonstrate that the incorporation of metal foam and ternary nano-enhanced phase change material significantly accelerates thermal energy dissipation, increases latent heat utilization, reduces photovoltaic operating temperature, and improves electrical conversion efficiency. The study highlights the potential of advanced thermal storage materials and porous structures for enhancing the performance and reliability of next-generation solar energy systems.

Taken together, the papers collected in this Special Issue demonstrate that future sustainable regional energy systems increasingly rely on the integration of distributed renewable generation, thermophysical enhancement, digital optimization, and coordinated engineering design. Rather than focusing on isolated technologies, the contributions collectively emphasize system-level integration as a key pathway toward resilient, energy-efficient, and sustainable energy infrastructures.

As guest editors, sincere appreciation is extended to all authors for their valuable contributions, to the reviewers for their careful evaluations, and to the editorial team for their continuous support throughout the preparation of this Special Issue. It is hoped that this collection will provide useful insights for future research on RECs, engineering thermophysics, and sustainable regional energy systems.