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Cleaner energy for sustainable circular economy implementations: Integrated energy, water and environment systems

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A B S T R A C T

This is the first Virtual Special Issue (VSI) of Cleaner Energy Systems. It contains research articles originating from some of the papers presented at the 16th Conference on Sustainable Development of Energy, Water and Environmental Systems (SDEWES), which was held both onsite and online in Dubrovnik, Croatia, from 10 to 15 October 2021, related to the scope of Cleaner Energy Systems. The main target of this VSI, which is in line with the conference goals, is to cover topics that focus on preventing the generation of waste while increasing efficiencies in the use of energy, water, resources, and human capital. The articles in this VSI present extended developments as follow-ups from the conference papers. The treated topics are central to making energy systems cleaner – heat transfer and heat exchanger efficiency, Heat Integration and District Heating, policies for promoting the use of renewable energy, and energy efficiency of buildings.

1. Overview of the VSI

Waste heat utilisation is a major opportunity for increasing energy conservation and efficiency. It fits well with the circular economy principle, representing direct energy reuse. In recent years, the optimised integration of low-grade waste heat has been investigated with renewed interest, resulting in significant methodology developments and many case studies. A 3-year project was finalised in 2021 to integrate heat exchangers in the petrochemical industry for waste heat utilisation (Zeng et al., 2021) from the perspectives of advanced heat exchanger development, such as compact heat exchangers embedded in advanced Heat Integration procedures.

A Printed Circuit Heat Exchanger (PCHE) is a special compact heat exchanger with advantages such as small volume, high heat transfer performance, and lightweight. These features make it suitable for application to a wide range of pressures and temperatures (Ma et al., 2022). Both two- and three-dimensional simulations of supercritical natural gas flow distribution in a plate of PCHE, as well as the thermal-hydraulic performance of the channels, were studied by Wang et al. (2022), investigating the maldistribution of the gas within the channels. The standard turbulence model k-ε model was applied, and the meshes were generated by ANSYS ICEM software. When two- and three-dimensional simulations are compared, the results showed that the mass flow rate differences are from 0.25 % to 4.52 %, and the difference of the sum of flow nonuniformity is 0.24, which indicates that the developed two-dimensional model can satisfy the accuracy and calculation efficiency from the engineering perspective.

Xu et al. (2022) focused on the simulation of a PCHE with tens of thousands of mini-channels using the homogenisation method, elastic and elastic-plastic finite element analysis methods to understand the thermal deformation behaviour, thermal stress and strain characteristics. They found out that the macroscopic thermal deformation gradually decreased from the hot side to the cold side and also observed the obvious thermal stress concentration around the junctions between the PCHE core and the cover plate.

For the Heat Integration in the energy system, Cunha et al. (2022) explored the economic and environmental benefits of utilising distant excess heat sources to satisfy the demand for a district heating network in Portugal. Two options were studied – pipeline transportation and portable thermal stores. The EMB3RS platform (EMB3Rs, 2021) was applied to find the balance between heat supply and demand. The cost parameters in the study were obtained from the EMB3RS platform knowledge base. The results showed that the pipeline could save 17.25 €/MWh_{th} compared to the portable thermal storage, and also 10.8 % benefit is achieved on the decarbonisation aspect.

With the fast development of renewable energy technology, the policy support of renewable energy adoption should be further strengthened. The financial institutions should also provide stronger financial support to further drive industrial upgrading. However, there are always barriers to be faced by the adopters of novel technologies.

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Mehta et al. (2022) studied the legal and economic aspects of the energy policy of Kyrgyzstan to analyse the current barriers to implementing renewable energy projects and future development-promoting strategies. The current Feed-in tariff (FIT) calculation methodology was investigated. It was suggested that the government should change the focus from hydropower to other types of renewable sources, e.g., solar, wind, and geothermal. Meanwhile, the low FIT for renewable energy (0.030 €/kWh) and the very low price of the grid electricity supply (about 0.01€/kWh) significantly reduce the interest of the potential investors. The insufficient awareness of the newly developed renewable energy technologies contributes to the development barriers and related strategies should be implemented to tackle these main issues.

Natural ventilation can significantly save energy in favourable climates and building types, but in cold weather with strong wind, it can lead to significant heat loss. Some related studies focused on developing a ventilator that can automatically adjust the opening of the ventilator according to the mechanical principle (Wang et al., 2021), while another way is to detect the opening and closing of a window by real-time monitoring and detection based on computer vision and deep learning (Tien et al., 2022). This method can remind the users to close the window and thus reduce the unnecessary load for the heating. The model was tested on different data curation, labelling, and training methods. Among the four proposed models in this study, the development of Model 4 focused on recognising the opening gap of the window rather than the entire window. And this detection method has the highest F1 score, which is used to judge the model's accuracy. It also has the highest correct detection rate (85.93 %).

2. Conclusions

The Editors of this VSI have worked hard to bring more contributions to the cause of Cleaner Energy Systems as a starting journal. The topic coverage is important and timely, from the novel heat exchanger network development, Heat Integration, clean energy policy and energy saving. The journal enters its second year with a credible portfolio of high-quality articles, and the authors in this VSI deserve credit for their valuable contributions to the starting journal.

The Guest Editors would like to express their heartfelt appreciation to both the authors and the reviewers for their hard work. The new journal year will bring further challenges. In addition to lower pollution, a new dimension of sustainability was revealed by the events in the outgoing year 2022 – the security of the supply of services and resources. It has to be integrated with a high priority alongside the already traditional objectives of pollution and health impact minimisation.

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