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Editorial

Advancements in sustainable development of energy, water and environment systems

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ABSTRACT

The integration of sectors for more sustainable systems and processes provide a multi-disciplinary research domain to which researchers are contributing with intense motivation in the context of urgency for addressing global climate change. The 26 papers in the current special issue of the 12th Conference on Sustainable Development of Energy, Water and Environment Systems represent a pursuit of excellence for leading related advancements. This editorial contains a review of these advances with a focus on the themes of effective valorisation of bioenergy resources, energy-water nexus in wastewater treatment processes, optimized local energy supply for efficient and clean systems, solar energy technologies for the energy transition, and technologies for efficient combustion and electric transport. Other themes are alternative and cross-cutting technologies for the energy system in addition to analyses of thermal energy recovery and heat transfer. Significant contributions under these themes relate to biomass residues and biogas upgrading processes, novel renewable energy and performance comparisons in the wastewater sector, efficient micro-cogeneration, polygeneration and load-sharing approaches, clustering techniques in district heating networks as well as hybrid and concentrated solar power systems. Control strategies for latent energy storage, aging processes in battery packs, engine knock occurrence and coupled numerical engine modelling, fuel blends with nanoparticle additives, utilization of flue gas, soot formation in plastic waste pyrolysis, high altitude wind energy systems as well as exergy analyses for heat and cold recovery and reverse electrodialysis are other key contributions. The advances are expected to enable more sustainable energy conversion and management processes in a time when an integrated approach is nothing less than essential to maintain a coherent and liveable Planet.

"An integrated approach is essential for a sustainable energy future" *[Energy Technology Perspectives 2017 – Catalysing Energy Technology Transformations, IEA]*

1. Editorial introduction to the special issue of the 12th SDEWES Conference

There is increasing recognition that a sustainable energy future depends on an integrated approach [1]. Such an understanding is crucial for a society that is urgently called upon to reach net-zero carbon dioxide (CO_2) emissions by mid-century as a vital prerequisite to sustaining the coherency of life on Earth. The required pace of action to reach this target implies halving gross anthropogenic CO_2 emissions every decade and doubling the share of renewable energy in the primary energy spending of the energy system even more rapidly [2]. In this race against time, the acceleration of scientific interactions and their influence on guiding policy decisions becomes ever more important.

Since the beginning of the 21st century, the Conferences on Sustainable Development of Energy, Water and Environment Systems (SDEWES) have become a significant venue for researchers to meet and originate, discuss, share and disseminate new ideas in support of sustainable development. Based on the initiation of the conference series in 2002 in Dubrovnik, Croatia, researchers have contributed to advancing an integrated approach to effectively address sustainability challenges. During this time, scientific interactions were further accelerated through annually organized main conferences and regional conferences in even years while over 1,300 papers were published in partner journals. Within the progression of the conference series, the 12th SDEWES Conference was organized again in the home venue of Dubrovnik from October 4–8, 2017. In total, 525 scientists, researchers, and experts from 57 countries and 6 continents were actively engaged in a programme with 570 presentations, 12 special sessions, 2 special events, 4 invited lectures, and 2 panels.

The contributions of the 26 papers in this virtual special issue represent the multi-disciplinary nature of the research domain that is involved in integrating sectors for more sustainable energy, water and environment systems. The novel contributions also extend the scientific and technological advances in earlier special issues of the SDEWES Conference series in *Energy Conversion and Management*. These previous contributions are based on the 8th SDEWES Conference [3], 9th SDEWES Conference [4], 10th SDEWES Conference [5], and both the regional 2nd South East European and 11th SDEWES Conferences that were organized the same year [6]. As a continuation of the productive partnership with *Energy Conversion and Management* as one of the partner journals, the contributions in the present special issue for the 12th SDEWES Conference build upon the wealth of knowledge that is encompassed in the vibrant research work of participants in the SDEWES Conference series.

This editorial provides a review of the main advances that are put

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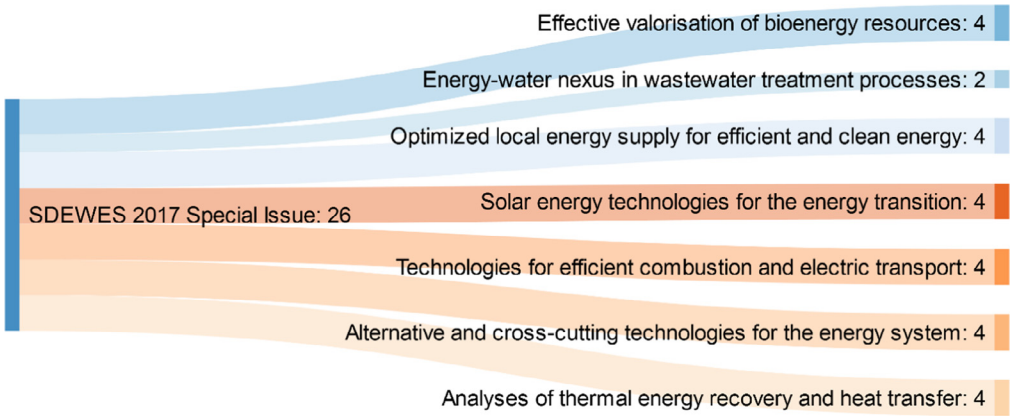

Fig. 1. Distribution of papers across the themes of the SDEWES 2017 special issue.

forth by the 26 papers in the virtual special issue [7] with a particular focus on providing a broader perspective of their interlinkages with other publications that have originated based on the SDEWES Conference series. The editorial is organised into seven themes that connect the 26 papers in the current special issue with other recent research advances stemming from the SDEWES Conference series. The seven themes include effective valorisation of bioenergy resources, energy-water nexus in wastewater treatment processes, optimized local energy supply for efficient and clean systems, solar energy technologies for the energy transition, and technologies for efficient combustion and electric transport. The themes continue with alternative and cross-cutting technologies for the energy system and analyses of thermal energy recovery and heat transfer. Fig. 1 provides the distribution of the 26 papers across the main themes while subthemes are provided in subsequent sections.

2. Effective valorisation of bioenergy resources

An integrated perspective into the valorisation and evaluation of bioenergy resources has been upheld in the pioneering studies of SDEWES researchers. Among related studies, Miedema et al. [8] had compared scenarios for biomass gasification to produce syngas to provide 1% of the natural gas needs of the European Union (EU). The results had indicated that the transport of biomass has a significant impact on energy efficiency and the energy ratio. Both metrics involved a boundary that includes the use of external fossil inputs and places emphasis on optimized supply chain design.

The necessity to enable an efficient and environmentally benign process of utilizing energy resources is similarly valid for bioenergy resources. Other recent studies underlined the necessity to valorise bioenergy resources in the right place and right demands. For example, Pfeifer et al. [9] had considered the use of cellulose biomass based on short rotation coppice and the pruning of fruit trees in 30% of the idle agricultural land in Croatia as a feedstock for biomass driven combined heat and power plants (CHP) with installed capacities of up to 15 MW_e. In another study [10], short rotation coppice based on poplar was considered as an option for biomass co-firing to satisfy 10% of the fuel supply in two coal-fired power plants in Portugal. The results of scenarios indicated the significance of subsidies and/or carbon allowances for improving economic viability.

Mikulandrić et al. [11] had developed an approach for the modelling of a co-current fixed-bed biomass gasifier under changes in operating conditions. The model was based on a dynamic artificial neural network with network re-training to predict both process temperature and the composition of syngas. Rosengart et al. [12] had developed a predictive model to evaluate the costs for an ultrafiltration plant to avoid membrane bio-fouling during the clarification of fermentation broth, which was applied to a case for lactic acid production. Gaida et al. [13] had recognized the absence of full-scale control strategies for biogas plants that digest agricultural residues or solid waste in contrast to the advancement of such controllers for anaerobic digestion in wastewater treatment plants, which have relatively more consistent substrates and a higher degree of automation.

Özdenkçi et al. [14] had investigated the sectoral integration of the value chain of biorefineries with multiple sources to produce multiple products to gain flexibility against changes in the feedstock or product demands, which is a shortcoming in singular approaches. The concept was evaluated based on a novel hydrothermal process to convert lignocellulosic biomass into lignin and syngas or bio-oil. Medina-González et al. [15] had developed a multi-criteria, multi-scenario approach to enable different raw material flows to be managed in a sustainable way in the presence of uncertainties.

In aspects of evidence-based tools to support policies that involve bioenergy, Kos Grabar Robina et al. [16] had implemented a novel survey method to address the need to improve data quality for the consumption of solid biofuels in South East European countries. A ranking approach was put forth in Stefanović et al. [17] using multi-criteria analysis in which composting of organic residues and the recycling of inorganic waste was found to be environmentally benign options in waste management.

2.1. Utilization of biomass residues for energy and products

The stock of knowledge in the field of bioenergy is extended in this special issue based on novel scientific contributions for biomass combustion and pyrolysis processes. Among previous recent studies of SDEWES researchers, Branco and Costa [18] had analysed the combustion of wheat straw and rice husk in a drop tube furnace based on particle burnout and particular matter concentration under four classes of particle sizes. The results for these agricultural residues included ramifications for the operation of industrial equipment since particles above 800 μm had a negative impact on particle burnout. Mymrin et al. [19] had characterised the mechanical properties of utilizing the waste of high-strength kraft pulp production as an input for construction material. Tamošiūnas et al. [20] had modelled the chemical process of reforming glycerol as a residue after producing biodiesel into synthesis gas through the use of thermal plasma technology. The process was found to have an energy efficiency of 51% and specific energy requirement of 59.2 kJ per mol of synthesis gas while these values varied according to the ratio of steam to glycerol and plasma torch power.

Clearly, the principles of a circular economy are motivating researchers in investigating the uses of resources that were previously identified as wastes in alternative processes that can save energy, water and materials. In this special issue, Moço et al. [21] investigate the combustion characteristics of pulverized grape pomace under operating conditions that are representative of its utilization in a wall drop tube