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Integrated approach for sustainable development of energy, water and environment systems

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ABSTRACT

The Conferences on Sustainable Development of Energy, Water and Environment Systems (SDEWES) at the beginning of the 21st century have become a significant venue for researchers to meet, and initiate, discuss, share, and disseminate new ideas in various disciplines of sustainable development. In 2002, the first conference was organised in Dubrovnik, Croatia and since then, 10 more successful conferences were realised. Following the success of international conferences in Dubrovnik, the organizing committees decided to organize the main conference and regional conferences all over the world in even years. In 2016, the second regional SDEWES conference, namely the 2nd South East European Conference on Sustainable Development of Energy, Water and Environment Systems, was held June 15–18 in Piran/Portorose, Slovenia while the 11th SDEWES conference was organised in Lisbon, Portugal on September 4–8. There were 10 special sessions dedicated to various sustainability topics organised in both conferences.

This special issue is based primarily upon a collection of 35 papers selected from among 538 scientific contributions presented at the 2nd SEE and 11th SDEWES Conferences. Moreover, this editorial summarises SDEWES published articles that have addressed and identified problems or provided the background for the research that is reported in the current special issue. The main topics of the selected papers address sustainable combustion technologies, renewable energy sources and sector integration, including the integration of renewable technologies in the urban environment, the integration of heat, cold, electricity and fuel production in buildings and industrial applications, heat exchangers and heat exchanger networks, the development and integration of energy storage for concentrated solar power plants, and sectorial integration of bioenergy resources and biorefineries with a particular focus on system integration for efficient and low-carbon systems.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Our Common Future, Report of the Brundtland Commission, 1987

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

1. Editorial introduction to special issue of the 11th SDEWES and 2nd SEE SDEWES conferences

The Brundtland Commission clearly expressed the goal of sustainable development and the necessity to understand, accept and acknowledge the needs of future generations for normal life and development. 30 years after, the set of 17 Sustainable Development Goals (SDGs) and 169 targets which are to be achieved by 2030 delineates an inclusive agenda to address the challenges and complexities of sustainable development. The Sustainable Development of Energy, Water and Environment Systems (SDEWES) conference series with presented papers, special sessions, panels, debates and publications, meetings and

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networking ensures that a wide range of technical and other solutions are provided that will stimulate actions in areas of critical importance for humanity and the planet.

Protecting the "Mother Earth's" climate and combating climate change is just one of the 17 SDGs but one of the most crucial for long term sustainability of life on the planet in its current form. Almost all countries in the world have achieved agreement to cut the emissions of greenhouse gasses and hold the increase in the global average temperatures to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. The Paris Agreement entered into force on 4 November 2016, thirty days after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55% of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the Depositary.

Actions following the agreement should reduce the risks of global warming and climate change and ensure that most of the places in the world will not be hit by its impacts, while the planet, humanity and life as we know will continue to exist. Fossil fuels and industrial processes are the primary sources of anthropologic CO_2 emissions that have remained at about 34 Gigatons in 2016 [1]. The stability in global CO_2 emissions for the last three years is promising that humanity will soon bend the curve of increasing CO_2 emissions that must be reduced rapidly thereafter to attain carbon neutrality by mid-century. Advances in and diffusion of efficient energy conversion technologies and integrated energy management approaches are critical in meeting the reductions that are deemed necessary.

The Conferences on Sustainable Development of Energy, Water and Environment Systems (SDEWES) at the beginning of the 21st century have become a significant venue for researchers to meet, and initiate, discuss, share, and disseminate new ideas in various disciplines of sustainable development. In 2002, the first conference was organised in Dubrovnik, Croatia and following the new approach for even years, the 2nd South East European (SEE) Conference on SDEWES took place from June 15–18 in Piran/Portorose, Slovenia while the 11th SDEWES Conference took place in Lisbon, Portugal from September 4th to 8th 2016. The 538 contributions that were presented in the scientific programme of these conferences have broadened the wealth of pioneering knowledge in these disciplines with a particular emphasis on system integration for efficient and low-carbon systems.

In previous SDEWES Conferences in Dubrovnik, Prof. Carvalho et al. [2] had defined the outlook for a new post carbon society and the main features of future energy systems. According to this outlook, future energy systems will be based on renewable energy sources (RES), buildings as positive power plants, smart grids and electric vehicles, and energy storage. In addition to numerous distributed renewable energy solutions and opportunities, a crucial issue for achieving the post carbon society and decarbonised economy at least cost, least entropy production and exergy destruction is the integration of sectors, processes, energy production and consumption. Integration allows many RES forms to be combined with different storage options and enhances the flexibility of system operation through digitalisation, advanced use of information and communications technology (ICT) and artificial intelligence.

The 35 papers in this special issue address key topics in the field of energy conversion and management and also sustain the series of scientific contributions that head towards realizing this future outlook and achieving many of the SDGs. The main topics of the selected papers address sustainable combustion technologies, renewable energy sources and sector integration, including the integration of renewable technologies in the urban environment, the integration of heat, cold, electricity and fuel production in buildings and industrial applications, the integration of heat exchangers and heat exchanger networks, the development and integration of energy storage for concentrated solar power plants, and sectorial integration of bioenergy resources and biorefineries. This editorial is organised into these main groupings and their connections to previous SDEWES papers. As the fourth special issue of SDEWES in *Energy Conversion and Management* interlinkages between those in the current and previous special issues [3–5] are emphasised.

2. Sustainable combustion technologies

The dependence of the world's energy production on fossil and alternative fuels, and related environmental pollution, remain among the greatest challenges today. The use of novel alternative fuels and new efficient combustion technologies for sustainable utilizations of energy production is essential to achieve a smooth transition to low carbon energy technologies. In this context, a special session at SDEWES 2016 on "Sustainable Combustion" was organised by Prof. Vujanović and Prof. Costa and the current SDEWES special issue brings several papers on combustion science and technologies from that session.

Among greenhouse gas emissions, methane takes an important place due to its high global warming potential. In the current special issue, Bargiel et al. [6] concentrates on the negative environmental impact of natural gas released during failures of transmission and distribution networks, especially in cases of remotely located pressure letdown stations. In such cases, information about system malfunction is not immediately reported to the dispatching centre. The aim of their study was to address this problem by providing small-scale local electric supply using abundantly available natural gas from a distribution network as an energy vector, in order to enable installation of relevant communication technologies. This work represents the continuation of a project whose initial phase was reported in a previous SDEWES special issue [7], where the preliminary computational model of the thermoelectric generator (TEG) fired with natural gas was established based on mass and energy balances. Simplified models are useful in early stages of design, but in order to include all relevant flow phenomena and its influence on spatial distribution of physical quantities that are necessary for the design of a prototype, computational fluid dynamics (CFD) should be employed [8]. In the present work of Wang et al. [8], a CFD model of a vertical configuration of a TEG generator was generated in order to perform sensitivity analysis of design parameters on the solution and to provide a set of design parameters for the optimization procedure. Subsequent optimization was done using response surface optimization method. The objective function was maximizing the temperature difference over the generator surface and the constraint was put on maximum hot side temperature of thermoelectric generator module. The Central Composite Design has been used as the Design of Experiments type. The non-parametric regression has been used for the response surface generation and Non-linear Programming by Quadratic Lagrangian (NLPQL) method has been utilized as the optimization algorithm. As a result, three candidate points, represented by a set of optimum values of the design parameters, have been identified and are currently under consideration in the project phase of prototype testing. The final choice of the optimum configuration will also take into account economic issues related to the quantity of material per type and the resulting cost of production.

Coal power plants emit large quantities of NO_x and SO_x into the atmosphere. NO_x can be reduced by employing gas aftertreatment technologies, such as selective catalytic reduction [9] or selective non-catalytic reduction [10], whilst SO_x can be reduced by wet or dry desulphurization process. Dry desulphurization process generates large quantities of sulphites compared to wet desulphurization process. Sulphites are susceptible to reemitting SO_2 to the atmosphere [11], so the disposal process of desulfurization residues is not suitable. As indicated previously by Mikulčić et al. [12], the use of alternative raw materials could be one of the measurements in an effort to reduce CO_2 emission in the cement industry. Examples of these alternative raw materials include semi-dry flue gas desulfurization residues from coal-fired power plants. Unfortunately, sulphites also degrade the cement quality and lead to costs of landfill disposal. The work carried out by Castro et al.