

## Editorial: Strategic Supply, Security and Efficiency of Energy Systems using Renewables, Waste and Pollution Minimisation

Petar Sabev Varbanov<sup>a</sup>, Neven Duić<sup>\*,b</sup>

<sup>a</sup>Centre for Process Integration and Intensification - CPI<sup>2</sup>, Research Institute of Chemical Technology and Process Engineering - MÚKKI, Faculty of Inf Technology, University of Pannonia, Egyetem u. 10, 8200 Veszprém, Hungary

<sup>b</sup>University of Zagreb, Ivana Lučića 5, 10000 Zagreb, Croatia  
[neven.duic@fsb.hr](mailto:neven.duic@fsb.hr)

At the 25<sup>th</sup> anniversary of the “Report on Our Common Future” - an important point in turning the world towards a more sustainable future the 7<sup>th</sup> SDEWES (Sustainable Development of Energy, Water and Environment Systems) Conference was aimed at discussing sustainable development of energy, water and environment systems and providing adequate scientific support to the emerging international, European, regional and national challenges. Held in Ohrid, the pearl of Macedonia and a UNESCO world heritage site, this was the first of SDEWES conferences organised outside Dubrovnik, and welcomed more than 200 scientists from around the world – from 45 countries to present research progress and to discuss the state of the art, the future directions and priorities in the various areas of sustainable development. This Special Issue (SI) attempts establishing a novel collaboration of the SDEWES conference with Chemical Engineering Transactions (CET) and builds upon the experience and common values of the conference organisers and CET. The main topics discussed in the articles of this special issue include strategic considerations on energy and water supply and security, process energy efficiency and intensification, use of renewables, pollution reduction and waste management.

### 1. Introduction

Sustainable development is a complex issue and offers a rich field for research and practical actions. The 7<sup>th</sup> SDEWES held in Ohrid 1-7 July 2012 provided a venue dedicated to the improvement and dissemination of knowledge on methods, policies and technologies for increasing the sustainability of development by de-coupling economic growth from natural resources and replacing them with knowledge based economy, taking into account its economic, environmental and social pillars, as well as methods for assessing and measuring sustainability of development, regarding energy, transport, water, environment and food production systems and their many combinations. Sustainability being also a perfect field for interdisciplinary and multi-cultural evaluation of complex system, the SDEWES Conference has become a significant venue for researchers in those areas to meet, and originate, discuss, share, and disseminate new ideas. 7<sup>th</sup> Conference SDEWES 2012 attracted 607 abstracts. Of these 231 papers were selected by the SDEWES 2012 International Scientific Committee, of which 113 archival and 94 conference papers. They were all presented as Oral presentations (Ohrid, 2012). Besides the extensive networking and exchange of ideas at the venues, SDEWES conferences have a comprehensive publication strategy. In addition to Chemical Engineering Transactions, other well-known journals have been collaborating with SDEWES: Energy since the beginning of the conference series in 2002 – for example SDEWES 2011 (Mathiessen et al., 2012) and SDEWES 2009 (Duić et al., 2011), Applied Energy (Duić et al. 2013).

### 2. The main topics of this Special Issue

Twenty three contributions were selected from SDEWES 2012 as candidates for this SI. After a thorough reviewing procedure carried out by the members of the SDEWES International Scientific Committee and

selected world-leading experts, twenty articles have been accepted for publication. The papers reflect all main fields of interest to the SDEWES conferences – they deal with the following topic areas:

- Strategic energy supply and security
- Process Intensification and energy efficiency increase
- Power generation from renewables, wind power
- Pollution detection and reduction
- Clean water supply and water treatment
- Biotechnology and biological treatment
- Waste management and valorisation

The authors are from 18 countries, which demonstrate the world-wide spread of the venue and this SI: Albania, Australia, Croatia, France, Hungary, Italy, Kosovo, Macedonia, Mexico, Qatar, Romania, Serbia, Slovenia, Spain, Switzerland, Taiwan, The Netherlands and the United Kingdom.

### **2.1 Strategic energy supply and security**

The first article in this SI was a Plenary lecture and discusses the key strategic issues of “Integration of Energy and Resource Flows” (Klemeš and Varbanov, 2013). The authors Jiří Jaromír Klemeš and Petar Sabevar Varbanov are from Centre for Process Integration and Intensification - CPI<sup>2</sup>, University of Pannonia, Veszprém, Hungary. Industrial and agricultural have been under considerable pressure to cope with the population development and growing demands. This requires a large and continuously growing supply of energy and water delivered mostly from reserves of natural resources. This paper reviews the main trends in the flows of energy and water supply, paying attention also to the concept of virtual water (Čuček, et al, 2012), and draws conclusions for directions of possibly promising future research and development efforts as e.g. full life time evaluation (Nemet et al., 2013) and performance monitoring under uncertainties (Manenti, 2007). The authors conclude that the main emphasis of future research should be on constructing and optimising a combined energy and water supply strategies following a strict principle of sourcing them as close to the use locations as possible (Perry et al, 2008).

The second contribution on energy strategy comes from Slovenia and is authored by Branko Kontić with the title “Strategic environmental consideration of nuclear power through comparative evaluation of energy options” (Kontić, 2013). The paper considers the comparative evaluation of energy supply options. The author evaluates the options from strategic planning and assessment points of view, emphasising multi-objective decision making, starting from environmental considerations. The study is reported to be based on the analysis of 296 selected worldwide studies of the sustainability of Renewable Energy Sources and other technologies as presented in IPCC report from 2011. The study concludes that nuclear power looks better than other options when evaluating the broader environmental context of the technologies.

### **2.2 Process Intensification and energy efficiency increase**

In the second part of this SI, Adelaida Andoni and Rutger van Santen, present the work titled “Propenal Hydrogenation on Silver Surface - A Theoretical Approach” (Andoni and van Santen, 2013). They have investigated whether H<sub>2</sub> takes part in the reaction as molecules or dissociates on silver. Small clusters of silver atoms are considered in the study by checking first their stability by theoretical calculations. Next, adsorption of H<sub>2</sub> was allowed to estimate whether the adsorption energy is exothermic. It is reported that adsorption of hydrogen on rhombic silver cluster yielded negative value of the adsorption energy suggesting that hydrogen can dissociatively be adsorbed on small particles and step surfaces as well.

An interesting work on improving the efficiency of fossil fuel utilisation is presented by Risto V. Filkoski, Lidija Joleska Bureska and Ilija J. Petrovski in the article “Assessment of the Impact of Under-Fire Air Introduction on the Pulverised Coal Combustion Efficiency” (Filkoski et al., 2013). The objective was to analyse the effect of the air redistribution on the flow field, temperature profiles and combustion efficiency, in a pulverised coal-fired utility boiler. The change has been planned via an under-fire air (UFA) introduction through ports located at the bottom of the furnace. Computational fluid dynamics (CFD) modelling technique is used for evaluating the aerodynamic behaviour of the gas-solids mixture, combustion efficiency, temperature profiles and concentrations of combustion products in a furnace of a utility boiler of 225 MWe power plant. The simulation results are compared with a test matrix of measurements at various operating conditions. The authors report that the comparison between the computed and the measured temperature profiles, as well as the energy loss due to inefficient combustion, shows satisfactory compliance. The analysis of the results concerning the near-burner regions indicates the occurrence of intensified swirl and improved combustion efficiency, as under-fire air flow rate was increased.

One possible route for reducing carbon footprint of energy supply is the use of renewables such as geothermal sources (Manenti et al., 2013). Done Tashevski and Dame Dimitrovski wrote the article

“Optimization of Binary Co-generative Thermal Power Plants with SOFC on Solid Fuel” (Tashevski and Dimitrovski, 2013). They declare that the purpose of the paper is to provide insights into the problem of optimising co-generative power plant employing a high temperature solid oxide fuel cell running on solid fuel. By this they aim for high efficiency modern power systems placing emphasis on using lignite as the most abundant fuel in Macedonia. The optimisation procedure is based on a model validated against simulation results and similar plants from literature sources. A comparison is made between binary co-generation power plant with and without fuel cell, in relation of the efficiency and environmental benefits.

Analysis of combustion emissions has been performed by Ene Barbu, Gheorghe Fetea, Romulus Petcu, Valeriu Vilag and Luminita Dragasanu. Their contribution is “Afterburning Installation of 2xST 18 Cogeneration Power Plant – Investigations on Combustion and NO<sub>x</sub> Emissions” (Barbu et al., 2013). The paper presents an investigation of a cogeneration power plant in Romania, focused on afterburning installation flow and NO<sub>x</sub> emissions. The authors report obtaining an experimental burner with 30 % reduction in NO<sub>x</sub> emissions than the one of existing the power plant.

A study on the performance improvement of wind towers is presented by John Kaiser Calautit, Ben Richard Hughes and Saud Ghani in the article “Numerical Investigation of the Integration of Heat Transfer Devices into Wind Towers” (Calautit et al., 2014). The study evaluates the incorporation of heat transfer devices inside the passive terminal of a wind tower unit attempting to optimise the cooling duty of the device. Computational Fluid Dynamics (CFD) was used for developing a wind tower numerical model and simulating the air flow patterns associated with the device and a test room. The results reported in the paper indicate that the average internal airflow rate can be reduced following the integration of vertical and horizontal heat transfer devices – by 4 % and 8 %. This was accompanied by an up to 15 °C reduction of the air temperature.

### **2.3 Power generation from renewables, wind Power**

An interesting contribution on the use of wind for power generation is the article “Modelling, Simulation and Analysis of Full Power Converter Wind Turbine with Permanent Synchronous Generator” (Kabashi et al., 2013), authored by Skender Kabashi, Gazmend Kabashi, Ali Gashi, Kadri Kadriu, Sadik Bekteshi, Skender Ahmetaj and Kushtrim Podrimqaku. The paper focuses on modelling and simulation of a full scale converter wind turbine with permanent magnet synchronous generator and the impact on the Kosovo power system operation. The authors' conclusion was that the wind farm does influence the transmission system but all requirements of the Grid Code relating to the wind farm connection were satisfied.

In the article “Comparative Assessment of a Horizontal Small Wind Turbine with Ball and Magnetic Bearings on the Starting” (Rosales et al., 2013), Pedro Rosales, Jesus Cerezo, Gisela Montero and Alejandro Lambert describe a mathematical model of a horizontal wind turbine of 500 W with a NACA 2418 airfoil type during the start-up condition for two proposed systems. The first considers a wind turbine system where the friction moment is given by ball bearings. The second proposes the replacement of the ball bearings by magnetic bearings. The magnetic bearing has the features of non-mechanical contact, non-mechanical friction, minimizing the damping in the wind turbine. The results under a wind speed of 8 m/s show that there is an increase in power by 7.2 % generated by the wind turbine with magnetic bearings and other additional benefits.

### **2.4 Pollution detection and reduction**

Terrestrial and underwater pollution sources present a serious problem affecting human health, biodiversity, tourism, fishery, and other environmental issues. Andreja Abina, Uroš Puc, Pavel Cevc, Anton Jeglič and Aleksander Zidanšek in the article, “Terrestrial and Underwater Pollution-source Detection Using Electromagnetic Multisensory Robotic System” (Abina et al., 2013) study the potential use of high-resolution electromagnetic (EM) sensors to detect polluting waste ashore and underwater. They propose a multisensory system. Low frequency sensors in the kHz region are based on electromagnetic induction (EMI) approach, whereas high frequency sensors in the MHz and GHz regions are based on ground penetrating radar (GPR). The authors report that the designed multisensory system has the capability to discover, map and interpret waste from various materials in different environmental conditions with the option of the objects' size and shape reconstruction as well as waste classification.

The wastewater treatment plant utilised in the metropolitan area of Turin is connected to the Po river near the town, in an area that has been considered very critical for potential eutrophication phenomena. This necessitates very high nitrogen removal rate of the plant. To identify potential beneficial modifications, Deborah Panepinto, Giuseppe Genon and Andrea Borsarelli examined the water treatment line and sludge system in their article “Improvement of Nitrogen Removal in a Large Municipal Wastewater Plant” (Panepinto et al., 2013). They propose two fundamental technological solutions to improve the nitrogen removal. The first one, to be implemented in the waste water treatment system, requires modification only

of the biological treatment tanks. The second solution consists in devising a system of autotrophic anoxic removal of nitrogen operating on the internal recycle, with the adoption of a fixed specialised biomass bioreactor on the recycle flux that is very rich in ammonia nitrogen, and poor in organic carbon.

Endosulfan is a toxic organochlorine pesticide, environmentally persistent, banned and restricted in many countries. For phytoremediation purposes, it was previously observed that the presence of *Ocimum basilicum* decreased the concentration of endosulfan in experimentally-polluted soil by 37 % after 30 days. To study the possible mechanism, Maricela Ramirez-Sandoval, Saé Muñiz-Hernández and Jesús Bernardino Velázquez-Fernández in their article “Mechanisms of Phytoremediatory Effect of *Ocimum basilicum* L. and its Rhizosphere Exposed to Different Concentrations of the Organochlorine Pesticide Endosulfan” (Ramirez-Sandoval et al., 2013) evaluate the effects of endosulfan on the activity of glutathione S transferase (GST) of *O. basilicum* and that of microorganisms from rhizosphere. After exposure to the pesticide endosulfan in *O. basilicum* and its rhizosphere, observations suggest that phytostimulation and phytotransformation could be involved as possible mechanisms of the phytoremediatory effect of *O. basilicum*.

## 2.5 Clean water supply and water treatment

Dew water is obtained by passive condensation of water vapour from air. Its production can be significantly improved by using specific materials and particular geometry. Daniel Beysens, Filippo Brogini, Iryna Milimouk-Melnychouk, Jalil Ouazzani and Nicolas Tixier in their article “New Architectural Forms to Enhance Dew Collection” (Beysens et al., 2013) present new shapes for dew collectors and their water yields are compared with those of a 1 m<sup>2</sup>, 30° inclined planar condenser used as a benchmark. The experiments were carried out in Pessac (SW France), about 45 km from the Atlantic Ocean, during the summer and fall of 2009. The authors report that the conical shapes produced 30 % larger yields than the benchmark based on experiments and numerical simulations. This was followed by two new form types: egg-box and origami. The egg-box shape yields 9 % more water than the benchmark nearly independently of the dew yield. In contrast, the origami shape gives yields 150 % larger than the benchmark for events with high dew volumes and can show 400 % greater yields for low dew volumes.

Sorption characteristics of partially soluble hydrocarbons (Toluene, Naphthalene and Xylene) on various adsorbent materials have been investigated by Meenakshi Arora, Geoff W. Stevens in the article “Groundwater Remediation in Cold Regions” (Arora and Stevens, 2013) at 40 °C to facilitate the development of a permeable reactive barrier (PRB) for treating oil-contaminated surface and sub-surface water in cold regions. Inverse modelling has been applied using the computer program CXTFIT to determine the variable parameters, axial dispersion coefficient and porosity. The authors report that their model has been able to accurately predict the column behaviour.

Javier Uche, Amaya Martinez and Beatriz Carrasquer in their article “Water Demand Management from an Exergy Perspective. Application to a Spanish River” (Uche et al., 2013) analyse water demand management options to assess the monetary losses associated with demand deficits in a region. The cost of diverse water demands priorities were evaluated. The cost to achieve a hypothetical Demands Ideal Scenario (DIS) in which water demands are absolutely covered was also considered. The assessment was performed using the Physical Hydromonics (PH) methodology, based on exergy, which evaluates the available energy contained in a water flow, including both its physical and chemical features. The reported results show that the present priority order when supplying the water demands has the lowest Cost to Guarantee Demands (CGD) that include those derived from the use of water technologies to provide the remaining water.

## 2.6 Biotechnology and biological treatment

Aleksandra Djukić-Vuković, Ljiljana Mojović, Svetlana Nikolić, Jelena Pejin, Sunčica Kocić-Tanackov and Katarina Mihajlovski studied lactic acid and biomass production from distillery stillage - a by-product of bioethanol industry. Their article is titled “Distillery Stillage as a New Substrate for Lactic Acid Production in Batch and Fed-batch Fermentation” (Djukić-Vuković et al., 2013). Their fermentation strategies for lactic acid production on distillery stillage were applied. The appropriate initial sugar concentration in the stillage was determined and various fermentation strategies were studied. The most efficient sugar conversion for the batch configuration was attained with initial sugar concentration of 55 g/L. Enhancement in lactic acid productivity (up to 1.80 gL<sup>-1</sup>h<sup>-1</sup>) and a very high number of viable cells (108 CFU/mL) were achieved in fed-batch fermentation.

Irina Mladenoska and Aco Dimitrovski have performed primary and secondary screening of several wild types of microorganisms, living in spoiled food and oily waste, as potential lipase producers in the article “Microbial Production of Lipases on Media Containing Vegetable Oil Waste: Process Development” (Mladenoska and Dimitrovski, 2013). In this work a process for microbial production of lipases, from

isolation of wild type microbial producer to optimisation of cultivation conditions for its growth and lipase production have been presented. Media containing sunflower oil waste as a carbon source have been used. One microbial strain showed superior performance in the primary screening and was chosen for further examinations. The authors conclude that a process for application of industrial oily waste waters as raw materials for production of lipases could be developed based on the study.

The Ma bamboo (*Dendrocalamus latiflorus* Munro) covers 152,300 ha in Taiwan, roughly 7.2 % of the overall forest area. Chun-Han Ko, Ya-Nang Wang, Fang-Chih Chang, Chih-Yuan Lee, Wen-Hua Chen and Wen-Song Hwang in the article "Energy Analysis of Bioethanols Produced from *Dendrocalamus latiflorus*" (Ko et al, 2013) evaluated the energy and mass balance of using Ma bamboo as a feedstock for bioethanol production. Processes included acidic steam explosion, alkaline steam explosion, bleached, unbleached kraft pulps, enzyme hydrolysis, and simultaneous saccharification and fermentation (SSF) for fuel ethanol production from bamboo were studied accounting for the energy consumption and generation. Authors reported that post-fermentation residues had high heating values.

### **2.7 Waste management and valorisation**

Irene Garcia-Diaz, Felix A. Lopez, Francisco J. Alguacil, Juan P. Bolivar and Manuel Gazquez in their article "Valorization of Two Inorganic Industrial Wastes for Manufacturing Sulfur Polymer Concrete" (Garcia-Diaz et al., 2013) aim to evaluate the valorisation in sulphur polymer concrete (SPC) of two hazardous waste materials – phosphogypsum (PG) and non-dissolved ilmenite mud (MD), to be utilised in the manufacture of building materials. SPC has strong advantages over Portland cement concrete – quick hardening and reaching the required characteristics in only 24 h, very low water permeability, and exceptional resistance to acid and salt agents, which allows its use in extremely aggressive environments. This material also allows the utilisation of large amounts of sulphur from worldwide oil refineries and metallurgical industries and can also be used as a stabilizing agent for waste.

Large amounts of waste toner cartridges are being generated from printing on an everyday basis. Waste toner cartridges contain heavy metals, plastics, as well as residual toxic toner powder, and have been characterised as hazardous waste. Therefore the management of waste toner cartridge content presents a significant issue in environmental protection. Aleksandra Anić Vučinić, Dinko Vujević, Kerim Mujkić and Mateja Novak in the article "Recycling of Waste Toner in the Republic of Croatia – An Environmentally Friendly Approach" (Anić Vučinić et al., 2013) presented a study of the possibility of recycling and reusing waste toner cartridges, with special emphasis on the reuse of the residual toner powder. To decrease the explosive properties of the residual toner powder, the material was mixed with calcite. After performing analyses of the mixture it was found that the mixture cannot be disposed of on landfill sites as inert waste material, since the value of the total organic carbon content (TOC) has found to be above the limit prescribed by the law. It was found that the mixture of residual toner powder, which contains 10 % of calcite, is an excellent bitumen additive, since it improves its application properties.

### **3. Conclusions**

This Special issue, devoted to the Conference on Sustainable Development of Energy Water and Environmental Systems – SDEWES 2012, provided an overview of several topics related to the sustainable development. The Guest editors believe that the selected papers and addressed issues would be of interest to the readers of this journal. The Guest editors would like to thank all reviewers who have made most valuable contribution by reviewing, commenting and advising authors.

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