Sustainable Energy Technologies for Energy Saving and Carbon Emission Reduction

The world energy consumption has been predicted to increase by 48% by 2040 in the face of the continuous economic development and expansion of world population [1]. Fossil fuels were expected to remain the dominant energy source in the energy supply system in the next few decades [2]. Meanwhile, to have a likely chance of keeping the global temperature change below 2°C in comparison with pre-industrial levels, the Intergovernmental Panel on Climate Change (IPCC) [3] indicated that global greenhouse gas (GHG) emissions must be cut by 41-72% relative to 2010 levels by 2050. What makes the GHG mitigation challenging is that most of the GHG emission is currently accounted for by energy-related emissions, especially, by the combustion of fossil fuels. The dilemma between the roaring energy demand and threatening global warming is urging the worldwide exploration of energy saving methods, alternative energy sources, and GHG mitigation measures. Simply speaking, the relevant technologies could be largely categorized as sustainable energy technologies (SET), despite a more comprehensive definition requires the coherent consideration of social, economic, and environmental aspects, that is, energy security, economic competitiveness, and environmental sustainability, respectively [4].

The role of SET in addressing the potential energy-related issues could not be underestimated and a diverse cluster of SET has been attempted, developed, improved, and even put into practical applications. Some of the prevalent topics in the area of SET include (1) the optimal use of renewable energy sources (e.g., solar, wind, biomass, and geothermal) that involves the

efficiency improvement in energy harvesting, conversion, and storage, and the design of their compatibility and integration with existing energy systems and end-user systems for a sustainable consumption and production, (2) sustainable heating and cooling systems that are assisted by the renewable energy sources or have specific energy saving configurations or designs, (3) the incorporation of hydrogen and fuel cell technologies with automotive, portable, and stationary platforms and corresponding optimization in all levels (i.e., material, device, and system), (4) CO_2 mitigation, capture and storage technologies ranging from low carbon solutions, to various CO_2 capture and storage techniques, and electrochemical/photosynthetic conversion and utilization of CO_2, and to carbon market frameworks such as carbon tax and emission permits, (5) sustainable development of urban systems and their networked infrastructure that aim to optimize building energy efficiency, waste management and recycling, urban transport, and urban ecosystem and biodiversity management, (6) optimal energy management and conservation strategies that encourage the expansion and adoption of SET, and facilitate the implementation of sustainable urban systems and infrastructure, (7) the development of smart-grid that is resilient, reliable, affordable, flexible, and sustainable, and could potentially incorporated with the various renewable energy sources, and (8) sustainable waste treatment and management technologies (e.g., gasification and pyrolysis) with a special focus on the design of the chemical processes for enhancing the efficiency of waste treatment and the production of energy (e.g., syngas and biogas) and high-value chemicals (e.g., fertilizers, geo-polymers, and absorbents, building materials, etc.).

The 15th International Conference on Sustainable Energy Technologies (SET 2016) took place in Singapore from 19th to 22nd July 2016, hosted by the National University of Singapore

(NUS), in collaboration with the World Society of Sustainable Energy Technologies (WSSET), American Institute of Chemical Engineers Singapore Local Section (AIChE SLS), and Campus for Research Excellence and Technological Enterprise program (E2S2-CREATE). This conference provides an excellent platform for scientists, industrialists, and politicians around the world to discuss recent technical and scientific advancement and review future directions and priorities in the area of sustainable energy technologies. 11 out of 211 high-quality submissions from over 30 countries or regions in SET 2016 are selected to be included in this SET 2016 special issue of Applied Energy after a rigorous, regular peer-review process. The accepted papers cover the most of the topics as just mentioned earlier and represent some of the recent technology and knowledge developments in the area of SET.

The work of Ibrahim Dincer and Canan Acar [5] comprehensively discusses the concept of smart energy systems and its potential in addressing global energy-related issues. It summarizes some essential requirements for a transition to smart energy systems and evaluates and compares several smart energy systems with respect to their efficiencies, environmental performance, and energy and material sources. It identifies that fossil fuels are not desirable in smart energy systems while geothermal is attractive because of its great potential in cleaner technology usage, renewability, and multigeneration. The study by Jingyong Cai *et al*. [6] investigates the operating performance of a novel dual source multi-functional heat pump (DMHP) system under different working modes using both experimental and simulation methods. It demonstrates that the DMHP system could be applied in the building sector to save energy and reduce the carbon footprint. It also discusses the component-based exergy loss ratio for potential future optimization of the system. The study by Erdem Cuce [7] experimentally and numerically analyzes the thermal

regulation impact of green walls directly grown with climbing plants. It demonstrates the effects of green walls with the climbing vegetation of *Hedera helix* on reducing internal wall temperature under different sky conditions. The vegetation type, plant intensity, and orientation dependence of the thermal regulation feature of green walls is also highlighted. Muhammad Burhan *et al*. [8] investigate the development of a compact, concentrated photovoltaic (CPV) for rooftop operation. In this work, the CPV system is enhanced by employing a master-slave configuration for the control of CPV trackers field and a cost effective but highly accurate solar feedback sensor. The system could meet the low cost and fewer hardware requirements for potential rooftop deployment on commercial and residential buildings. They also extend the CPV system to a CPV-hydrogen system whose hydrogen production performance is also explored. The study by Junjie Zheng *et al.* [9] contributes to the understanding of the kinetic performance of the formation process hydrate-based gas separation (HBGS) process in a stirred tank reaction. It specifically considers tetra-*n*-butylammonium fluoride (TBAF) as the promoter because of its high thermodynamic promotion on hydrate formation. It shows that the HBGS process could be operated at near ambient temperatures by using TBAF as the promoter. It also explores the relationships between experimental pressures and temperatures and gas uptake. The study by Hisu-Po Kuo *et al.* [10] considers the integration of bio-oil production and grading in a fluidized bed pyrolyser. It studies the influences of gas fluidization velocity towards the physical and chemical properties of the graded oils and sheds light on the underlying mechanisms affecting the bio-oil production and grading in a fluidized bed pyrolyser. Jingxin Zhang *et al*. [11] explore the concept of a novel compact three-stage anaerobic digester (TSAD) for improving the overall efficiency of food waste treatment of methane production. The TSAD consists of three separate vertical components, i.e., high-solids hydrolysis, acidification, and wet methanogenesis,

respectively, and allows optimal pH conditions to be applied to each component. Compared to traditional one-stage and two-stage anaerobic digesters, the TSAD generally has a higher methane yield, volatile solid reduction rate, and buffering ability, and a more diverse bacterial community. Bokkyu Choi *et al*. [12] develop a 1 kW-class electrochemical reactor for hydrogen production using bipolar plates. They introduce a new electrode fabrication method based on the particles containing active materials, conductive materials, and binders and studies the electrochemical and hydrogen production performance of the reactor by varying the current density at an ambient temperature. Their findings are valuable for proposing the methods of stack assembly and large-scale applications in the future. Wangliang Li *et al.* [13] propose a high-solid two-stage co-digestion process with the ability of treating food waste, chicken manure, and horticultural waste in one reactor. Specifically for the two-stage process, food waste and chicken manure are co-digested in the first stage, while the digestate of the first stage is transferred to the second stage for co-digestion with grass. This two-stage process achieves higher biogas yield and shorter digestion duration. This work also studies the influences of the volatile solid mass ratio among the three types of waste and the duration of the first stage towards the performance of the two-stage process. Eloka-Eboka and Inambao [14] study the energy production and carbon sequestration potential from four strains of microalgae, i.e., *Chlorella vulgaris*, *Dunelliela*, *Scenedesmus quadricauda*, and *Synechococus spp*. They specifically explore the relationship between the atmospheric CO_2 removal and the production of lipid by the microalgae, and compare various factors such as biomass productivity, cellular concentration, pH values in lipid content, hydraulic detection time, and, the ratio of CO_2 absorption to desorption among the forces strains of microalgae. This work shows that *Dunelliela* is most effective in carbon sequestration, while *Chlorella vulgaris* has the highest

lipid productivity. This work shed lights on the optimization of microalgae cultivation in terms of carbon sequestration and bioenergy production. The study by Sutton *et al*. [15] studies the heat storage performance of two salts ($CaCl_2$ and $LiNO_3$) when they are combined with vermiculite to form a salt in matrix (SIM) for thermochemical storage which is characterized by high energy density, and low material cost and toxicity.. This work highlights that the utilization of salts may be poor when they are applied in practical applications because the high affinity of the hydrated salt to water vapor prevents the penetration of moisture into the bulk of the storage medium. The performance of the system could not be improved by the attempts such as changing the orientation of reactor and adjusting the flow regime of mist and dry air.

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