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Editorial

Advances in CO_2-Free Energy Technologies

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In today's world, energy demand is increasing, and meeting this demand in an environmentally benign and sustainable manner is the greatest challenge. In order to establish a prosperous, low-carbon economy and sustainable society, innovative technologies for CO_2-free energy are required [1,2]. In order to rapidly devise renewable CO_2-free energy solutions, it is imperative to develop sustainable and efficient technologies enabling the same economic scale as existing processes. Currently, renewable energy technologies, such as wind, solar, biomass, hydro, geothermal, and thermal energy [3], as well as CO_2-free green fuels, including hydrogen, ammonia, etc. [4,5], are widespread. In industries where electrification is a challenge, using hydrogen as an energy source can help reduce CO_2 emissions because it produces no CO_2 when consumed [6]. Hydrogen can be produced via a number of methods, including methane pyrolysis, coal gasification, and steam methane reforming. Additionally, the process of water electrolysis can be used to produce CO_2-free hydrogen [7,8]. Despite this, there is a requirement to develop low-cost CO_2-free hydrogen production technologies in terms of infrastructure and storage. Likewise, ammonia does not release CO_2 upon combustion [9]; switching to ammonia from current fuels of coal and natural gas leads to a significant decrease in CO_2 emissions. Recently, scientists have attempted to produce ammonia using renewable energy sources such as solar and/or wind [10]. Traditionally, ammonia is produced using fossil fuels as raw materials. The utilization of renewable-derived hydrogen for ammonia synthesis at relatively lower temperature and pressure conditions can cause CO_2-free ammonia synthesis [11]. Fuel cells are clean power-generating devices that produce electricity by electrochemically reacting hydrogen with oxygen from the air. Sir William Robert Grove developed the first form of fuel cell technology in 1839 [12]. Since then, research has been conducted with the aim of commercializing large-scale applications of fuel cells [13]. The biggest obstacles to the commercialization of fuel cells are cost and durability. The commercialization of fuel cell technology is hampered by issues with size, weight, thermal management, and water management [14]. In recent decades, enhancing the performance of supercapacitors and batteries has been a priority. It is essential to conduct research regarding the safety, system-level energy metrics, and cost of advanced batteries in order to support the "wireless electrification" process [15]. Energy and power density at a cellular level have been subjected to extensive research. For batteries, supercapacitors, and their hybrids to be widely adopted, challenges in the areas of chemistry, materials, and cell design that affect safety, cost, and the resilience of the power systems must be solved [16]. The development of efficient and affordable CO_2-free clean energy technologies to replace conventional energy systems, which are ultimately necessary for the growth of a sustainable society, is being actively encouraged. This Special Issue on CO_2-free energies collates the various concepts, possibilities, and difficulties associated with the adoption CO_2-free green energy systems.

In this Special Issue, Abbass et al. [17] describe the application of the antlion optimizer algorithm for the maximum power point tracking of a solar array comprising a single module with 20 cells, resulting in an overall 100 W array under ideal conditions. However, in practice, it is impossible to attain the maximum current and voltage from a PV cell. The authors compared the results of the antlion optimizer algorithm with those of conventional approaches. According to their research findings, in the case of solar irradiance was 1000 W/m^2, a maximum power of 91.3 W was attained using the antlion optimizer algorithm in the short time of 0.05 s, whereas the PFA and P&O resulted in 90 W after 2 s and 0.64 s, respectively. The authors also analyzed the efficiency of the antlion optimizer algorithm when solar irradiance decreased to 200 W/m^2 and then reached 1000 W/m^2. In this case, the maximum power achieved using the antlion optimizer algorithm was 55 W at an irradiance of 200 W/m^2, which increased to 91.3 W with an increased irradiance of 1000 W/m^2, whereas values of only 78 W and 82 W were obtained using P&O and FPA, respectively. The antlion optimizer algorithm described in the paper is more efficient than conventional processes such as PFA and P&O. Another research communication published in this Special Issue by Manakhov et al. [18] explored decarbonizing mobility among all electrification versus all hydrogenization. In this study, the authors evaluated the expected demands for low-carbon fuels, such as green and blue hydrogen and low-carbon electricity. According to the authors' conclusions, 366 million tons of hydrogen per year is required for hydrogen mobility. By 2035, this figure is expected to increase to 422 million tons per year, much larger than the currently available hydrogen production capacities. According to the authors' calculations, hydrogen mobility from blue hydrogen will require 4.0 billion tons of CO_2 per annum, which is less than decarbonization of coal-fired plants requiring more than 10.0 billion tons of CO_2 per annum. The authors also calculated the required cost of the fuel and compared various possibilities, including social perception, economic viability, and technical readiness. This study and its results can effectively contribute to future aspects of a CO_2-free sustainable society.

A review published in this Special Issue by Qazi et al. [19] summarized approaches to the utilization of graphene for efficient energy storage and other environmental applications. The authors described the most common synthetic techniques for the production of graphene and its derivatives, in addition to how these techniques affect a material's characteristics. In addition, this paper summarizes the most important applications of graphene and its derivatives, such as CO_2 capture, biomedicine, potential energy storage, and conversion. The authors also highlighted future aspects of the sustainable utilization of graphene and its derivatives, as well as the challenges that must be overcome for efficient and economic industrial-scale applications, promoting the utilization of graphene chemistry and its potential large-scale applications. Another review [20] published in this Special Issue focused on the future of hydrogen as an alternative fuel for next-generation industrial applications. The author summarized recent progress in various hydrogen applications such as hydrocarbon processing, fuel refining, materials, pharmaceuticals, electronics, etc. Additionally, this review emphasizes the current industrialization scenario and describes potential advances, such as speculative scientific breakthroughs, the manufacture of eco-friendly raw materials, potential exploration, and the incorporation of renewable resources. This article also covers the economic effects of using hydrogen as a green resource, challenges regarding the industrial-scale application of hydrogen, and future research perspectives.

In summary, the current Special Issue concisely illustrates the significant challenges associated with developing CO_2-free energy solutions. The guest editors wish to thank the editorial board and all authors for their significant contributions to this field of research.

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