energies

MDPI

Editorial

Environmental and Energetic Valorization of Renewable Resources

Attilio Converti

Department of Civil, Chemical and Environmental Engineering, Polytechnic School, Genoa University, Via Opera Pia 15, 16145 Genoa, Italy; converti@unige.it

Abstract: This Editorial provides an overview of the 13 papers published in the Special Issue *Environmental and Energetic Valorization of Renewable Resources* belonging to Section B: Sustainable Energy of the *Energies* journal, five being review papers and the remaining being scientific articles.

Keywords: carbon dioxide capture; electricity; contaminated soil; biosurfactant; biomass; fuel cell; food waste; pyrolysis; hydroelectric plant; power generation

1. Introduction

The serious environmental impact associated with human activities and the progressive depletion of fossil fuel resources is seriously affecting sustainable development, so in the absence of global political strategies for a change of course and effective technological therapies, the future of the next generations may be at risk. The quantity of waste that is produced annually and globally by various industrial segments and by normal human activities is huge, and often their treatment is either not carried out or is carried out inappropriately. Even when this happens, their energy value is often overlooked, with one forgetting that they are valuable alternative energy resources. Therefore, technologies capable of combining environmental and energy aspects should be further developed.

The purpose of this Special Issue of the *Energies* journal, as can be seen from its own title, was to provide an overview of the current technologies for the "Environmental and Energetic Valorization of Renewable Resources", including the treatment of different types of waste and byproducts (biomass of various kinds, industrial wastes, urban solid wastes, agro-industrial wastes, etc.), the possible recycling of resources, and/or energy recovery. Special attention was also paid to technologies devoted to solving energy and environmental problems such as, but not limited to, (a) Gas to Power technologies, i.e., highly efficient and environmentally friendly energy production through fuel cells, (b) Power to Gas technologies, i.e., the production of hydrogen or other fuels through electrolytic cells, (c) the reduction of carbon dioxide emissions through systems in which the two previous technological categories are combined with traditional systems and/or renewable sources, and (d) traditional waste treatments including biogas production, soil remediation, gasification, and pyrolysis.

2. Review Papers

To allow the reader to have the widest possible vision on these topics, many of them were the subject of in-depth review papers. In the first one, da Silva et al. [1] reviewed the main in situ and ex situ methods for soil bioremediation, as well as their current properties and applications, as an economically viable alternative way to restore polluted areas. The characteristics of each class of pollutants were discussed in the first section, while the second one dealt with current bioremediation technologies and their main uses, followed by a comparative analysis of their respective advantages and disadvantages. Finally, the application of surfactants and biosurfactants as well as the main trends in the bioremediation of contaminated soils was addressed.

Aiming at a rational recovery of food waste, Wang et al. [2] reviewed, in the second review paper, oriented fermentation processes, which have strong application prospects due

check for updates

Citation: Converti, A. Environmental and Energetic Valorization of Renewable Resources. *Energies* **2021**, *14*, 8440. https://doi.org/10.3390/en14248440

Received: 3 November 2021
Accepted: 6 November 2021
Published: 14 December 2021

to a high efficiency, strong robustness, and high-value products. Lactic acid fermentation stood out due not only to natural microbial breeding during collection, transportation, and storage, but also because lactic acid bacteria can survive extremely acidic environments. The industrial use of Continuous Stirred Tank Reactors, which are characterized by a good mass and heat transfer, but by a relatively low solid concentration, was compared to that of Leach Bed Reactors that can separate the hydraulic retention time and solid retention time but that suffer easy clogging that hinders a continuous operation. Performing the hydrolysis and acidogenesis simultaneously in a single-stage fermentation process to make the operation simpler and increase productivity was also compared to the two-stage process that enables accurate control and high purity. The authors concluded that the industrialization of food waste fermentation requires further improvement and a green development of the downstream processes for product separation and recovery, because the actual technologies, including precipitation, distillation, extraction, adsorption, and membrane separation, are too expensive and/or consume a large amount of chemicals and energy and need extensive post-treatments.

In the third review paper, Marchelli et al. [3] focused their attention on the literature regarding the production of renewable energy or materials by the low pyrolysis of agricultural lignocellulosic residues and water hydrolysis of wool residues from sheep husbandry, which are produced in large quantities and whose disposal is often costly and challenging for farmers. The authors demonstrated that both processes may be fruitfully integrated, as their products, namely a C-rich biochar suitable for soil amending and a N-rich fertilizer, can be flexibly mixed to produce fertilizers thanks to the achievement of a balanced and tunable C/N ratio and the enhancement of mechanical properties. Finally, coupling with other industries would allow for a return of biomass waste to the field, following the principles of circular economy.

Barelli et al. [4] discussed enzymatic biofuel cells as a promising solution to generating electricity from biological catalytic reactions thanks to the excellent intrinsic properties of enzymes as biocatalysts, despite the great concerns in terms of the long-term stability and high power output. The review covered a wide range of applications, moving from miniaturized portable electronic equipment and sensors to integrated lab-on-chip power supplies and from advanced in vivo diagnostic medical devices to wearable devices. Its main objective was to assess the performance of enzymatic biofuel cells based on flow designs, which are considered of great interest for powering biosensors and wearable devices. Different enzymatic flow cell designs were analyzed, highlighting their performances in terms of power output and long-term stability and emphasizing new promising fabrication methods for both electrodes and cells.

In the last review paper, Moliner et al. [5] analyzed and discussed data on thermochemical plants in Southern Italy fed with solid biomass, considering the biomass availability and potential together with a cost-benefit analysis and using technology development and economic indicators. Of the almost 64,000 units distributed in eight regions, only 53 were classified as plants for electricity production or cogeneration plants, the rest being thermal units for heat production. Calabria proved to be by far the largest producer of electricity from biomass, followed by Apulia; on the other hand, regarding thermal production, Campania and Calabria stood out, while Basilicata, Molise and Abruzzo generated the highest amounts per capita. The authors concluded that the area is far from fully exploiting its biomass potential, that bioenergy can be remarkably competitive considering the relatively low capital costs and the wide availability of low-cost biomass, and that new applications and markets for sub-products (i.e., char, ash) would help in lowering the still not competitive economic indicators.

3. Scientific Articles

The remaining eight papers of the Special Issue dealt with experimental studies devoted to the solution of specific problems related to the selected topics. Belotti et al. [6] focused on predicting future streamflows as a key step in electricity generation in countries

with large hydroelectric plants. To analyze the forecasting capability of models regarding monthly seasonal streamflow series, they considered six versions of a special class of Neural Networks, i.e., the unorganized machines, and addressed the extreme learning machines (ELM) as the combiner of a neural-based ensemble. A comparison was done utilizing two linear approaches, four artificial neural networks, and four ensembles. The results of tests conducted at five hydroelectric plants, using horizons of 1, 3, 6, and 12 steps ahead, indicated that unorganized machines and ELM ensembles performed better than linear models.

In their experimental study, Ghiara et al. [7] considered metallic interconnects of a solid oxide fuel cell stack made up of Crofer22APU and coated on the air side with Co-Mn base spinel. Stacks were field-operated in reformed natural gas for up to 20,000 h, and one interconnect was studied for each of them by sampling and preparing a cross-section in the inlet and outlet positions. The characterization of samples by Scanning Electron Microscopy-Energy Dispersive X-Ray spectroscopy allowed one to follow the evolution of the interconnect at the air side. Chromia-based thermal grown oxide formed at the ferritic stainless steel/coating interface and solid-state diffusion of Cr and Fe occurred from metal to coating. Microstructural features evolving over time were also quantified.

Galiwango et al. [8] investigated the kinetic and thermodynamic parameters of the non-isothermal combustion of date palm waste as a potential low-cost energy source. A thermogravimetric analysis showed a major peak of volatiles degradation in the temperature range 127–138 °C with an average percentage mass loss of 68.04, 62.97, 59.26, and 65.57% for rachis, leaflet, fibers, and their composite. While the Flynn–Wall–Ozawa method allowed estimating for these parts activation energies of 158, 164, 169 and 157 kJ mol^{-1}, the Kissinger–Akahila–Sunose one was the best suited to describe chemical equilibrium, with average Gibb's free energy variations of 90.3, 186.5, 99.3, and 178.9 kJ mol^{-1}, respectively. Positive enthalpy values confirmed an endothermic pyrolysis reaction. All tested models, including the Starink one, showed a minimal difference between the activation energy and enthalpy. According to the authors, the high energy content and volatile matter combined with low energy barriers make date palm waste a potential candidate in a biorefinery.

Bustamante et al. [9] conducted a detailed technical analysis of small-scale solar–biohybrid power generation systems using Rankine (steam turbine) and Brayton (gas turbine) cycles. Thermodynamic models were developed to characterize the state of working fluid and select the most suitable solar collection technology for individual power generation systems. The authors used the net capacity factor of power generation and utilization efficiencies of solar and biogas energy as parameters to evaluate energy generation and select the best configuration. They demonstrated that the steam turbine system had a better global efficiency (67.7%) but lower electricity generation efficiency (5.6%) than the gas turbine one (55.7 and 27.0%, respectively) and concluded that the method used in this study could also be applied to investigate and optimize other small-scale hybrid renewable energy generation systems.

Mendes da Silva Santos et al. [10] investigated a new formulation of low-cost, biodegradable, and nontoxic biosurfactant from *Candida sphaerica* UCP 0995 produced in a bioreactor on an industrial waste-based medium, using a central composite rotatable design for optimization. The best results, namely a 25.22 mN/m reduction in surface tension, a biosurfactant yield of 10.0 g/L, and a critical micelle concentration of 0.2 g/L, were achieved in 132 h at an agitation speed of 175 rpm and an aeration rate of 1.5 vvm. Analyses of the purified biosurfactant by chemical methods, Fourier-Transform Infrared Spectroscopy, and Nuclear Magnetic Resonance suggested the glycolipid nature of the biosurfactant, which showed no cytotoxicity in the colorimetric methylthiazolyldiphenyl-tetrazolium bromide (MTT) assay, remained stable for 120 days at room temperature, and showed tolerance to wide ranges of pH, temperature, and salinity, thus being suitable for application under extreme environmental conditions. Bioremediation tests performed to check its efficacy in combination with the microbial producer for removing oil indicated that it is a promising agent for contaminated soil bioremediation.

To advance in the field of fuel cells that are able to convert fuel chemical energy into electrical energy, Squizzato et al. [11], using Scanning Electron Microscopy, Energy Dispersive X-Ray Spectroscopy, X-Ray Diffraction, and Brunauer–Emmett–Teller (BET) plots, compared the structural features of $La_{0.6}Sr_{0.4}MnO_3$ (LSM) nanofibers prepared by electrospinning with those of LSM powders with an identical composition prepared by the self-combustion citrate-based procedure. Nanofibers showed a higher surface area and reactivity, better catalytic performance at 800 °C, and lower presence of strontium oxide on the surface than powders. The methane conversion achieved with LSM nanofibers (73%) compared well with that obtained with powders at 900 °C (50%).

Ferrari et al. [12] investigated the Facilitated Transport Membranes (FTMs) as a novel membrane technology to reduce the energy demand and cost for carbon dioxide capture in a cement plant. A new process employing FTMs was simulated and applied to a real clinker production plant in Italy (Colacem, Gubbio) and compared with other carbon capture technologies. The results showed that the FTM technology can be competitive with other technologies despite the need for steam to use the membrane. The authors concluded that, despite the benefit in terms of a specific emission compared to the more established absorption with the liquid amines process, further improvements on membrane performances are needed in order to also gain an economic advantage in carbon capture in the cement industry.

Finally, Lemanowicz et al. [13] studied saline soils with surface mineral layers contaminated by the waste produced by a soda plant in Poland, in terms of the activity of selected enzymes, pH, clay content, total organic carbon and nitrogen, total exchangeable bases, electrical conductivity, $CaCO_3$, and concentration of available phosphorus. Based on the enzyme activity, they calculated the enzymatic pH indicator, resistance index, resilience index, relative changes, and time index. The research showed that the activity of enzymes and their indexes make it possible to conduct long-term monitoring and identify the processes in soil.

4. Conclusions

The results of the papers included in this Special Issue clearly confirm the huge environmental and energetic potential of renewable resources, which justifies the great efforts made in this field by both scientific and editorial worlds.

Funding: This research received no external funding.

Acknowledgments: The author is grateful to all authors, reviewers and editors involved in this Special Issue, who allowed its successful publication.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Da Silva, I.G.S.; de Almeida, F.C.G.; da Rocha e Silva, N.P.M.; Casazza, A.A.; Converti, A.; Sarubbo, L.A. Soil Bioremediation: Overview of Technologies and Trends. *Energies* **2020**, *13*, 4664. [CrossRef]
2. Wang, Q.; Li, H.; Feng, K.; Liu, J. Oriented Fermentation of Food Waste towards High-Value Products: A Review. *Energies* **2020**, *13*, 5638. [CrossRef]
3. Marchelli, F.; Rovero, G.; Curti, M.; Arato, E.; Bosio, B.; Moliner, C. An Integrated Approach to Convert Lignocellulosic and Wool Residues into Balanced Fertilisers. *Energies* **2021**, *14*, 497. [CrossRef]
4. Barelli, L.; Bidini, G.; Pelosi, D.; Sisani, E. Enzymatic Biofuel Cells: A Review on Flow Designs. *Energies* **2021**, *14*, 910. [CrossRef]
5. Moliner, C.; Arato, E.; Marchelli, F. Current Status of Energy Production from Solid Biomass in Southern Italy. *Energies* **2021**, *14*, 2576. [CrossRef]
6. Belotti, J.; Siqueira, H.; Araujo, L.; Stevan, S.L., Jr.; de Mattos Neto, P.S.G.; Marinho, M.H.N.; de Oliveira, J.F.L.; Usberti, F.; de Almeida Leone Filho, M.; Converti, A.; et al. Neural-Based Ensembles and Unorganized Machines to Predict Streamflow Series from Hydroelectric Plants. *Energies* **2020**, *13*, 4769. [CrossRef]
7. Ghiara, G.; Piccardo, P.; Bongiorno, V.; Geipel, C.; Spotorno, R. Characterization of Metallic Interconnects Extracted from Solid Oxide Fuel Cell Stacks Operated up to 20,000 h in Real Life Conditions: The Air Side. *Energies* **2020**, *13*, 6487. [CrossRef]
8. Galiwango, E.; Al-Marzuoqi, A.H.; Khaleel, A.A.; Abu-Omar, M.M. Investigation of Non-Isothermal Kinetics and Thermodynamic Parameters for the Pyrolysis of Different Date Palm Parts. *Energies* **2020**, *13*, 6553. [CrossRef]

9. Bustamante, M.; Engeda, A.; Liao, W. Small-Scale Solar-Bio-Hybrid Power Generation Using Brayton and Rankine Cycles. *Energies* **2021**, *14*, 472. [CrossRef]
10. Mendes da Silva Santos, E.; Alvares da Silva Lira, I.R.; Moraes Meira, H.; dos Santos Aguiar, J.; Diniz Rufino, R.; Germano de Almeida, D.; Casazza, A.A.; Converti, A.; Sarubbo, L.A.; Moura de Luna, J. Enhanced Oil Removal by a Non-Toxic Biosurfactant Formulation. *Energies* **2021**, *14*, 467. [CrossRef]
11. Squizzato, E.; Sanna, C.; Glisenti, A.; Costamagna, P. Structural and Catalytic Characterization of $La_{0.6}Sr_{0.4}MnO_3$ Nanofibers for Application in Direct Methane Intermediate Temperature Solid Oxide Fuel Cell Anodes. *Energies* **2021**, *14*, 3602. [CrossRef]
12. Ferrari, M.-C.; Amelio, A.; Nardelli, G.M.; Costi, R. Assessment on the Application of Facilitated Transport Membranes in Cement Plants for CO_2 Capture. *Energies* **2021**, *14*, 4772. [CrossRef]
13. Lemanowicz, J.; Gawlińska, K.; Siwik-Ziomek, A. Impact of Technogenic Saline Soils on Some Chemical Properties and on the Activity of Selected Enzymes. *Energies* **2021**, *14*, 4882. [CrossRef]