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Editorial

Energy Production from Biomass Valorization

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This Special Issue of *Energies* contains successful submissions [1–6] relating to the subject area of "Energy Production from Biomass Valorization". The composition of residual biomass, its low cost, and its abundance make it a realistic option for the production of the energy required for the sustainable development of human society [7]. Renewable energy production has received increasing interest and will play an important role in our pursuit of achieving a carbon-neutral future. In this context, producing energy from renewable sources is a major requirement for decreasing the dependence on fossil resources and thus alleviating the current threats related to climate change [8]. In that direction, biomass valorization offers infinite possibilities in terms of producing renewable energy to satisfy the increasing demand of today's industry and meet the requirements of a carbon-neutral post-petroleum society and contribute to energy and environmental sustainability [9]. As reported by Holm-Nielsen and Ehimen [10], energy production from biomass materials is especially favored over production from fossil-based feedstocks in order to provide a carbon-dioxide-neutral energy system.

The generation of residual biomass materials, such as agricultural and forest residues, by-products from food- and wood-processing industries, and domestic and municipal wastes, is continuously increasing as a consequence of the increase in the demand for food, materials, and services driven by human population growth [11]. In this context, efficient strategies should be developed for the valorization of large amounts of generated waste [12,13]. Using these waste streams as raw materials to produce energy is a rational valorization strategy. Recovering energy with a reduced carbon footprint [14] is possible through different routes, such as thermal conversion via gasification [15], pyrolysis [16], or combustion [17], hydrolysis and fermentation to ethanol [18], bioconversion to other liquid biofuels [19], or anaerobic digestion to biogas [20]. Despite the immense efforts being undertaken to implement economically feasible techniques to convert residual biomass into advanced energy carriers, developing novel valorization approaches of commercial relevance is still a major requirement.

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A Short Review of the Contributions in This Special Issue

This Special Issue contains six original research articles that cover different aspects related to biological, thermal, and catalytic routes for the conversion of various types of biomass feedstocks to renewable energy. Research results dealing with forest residues, food waste, wheat straw, and herbaceous materials are presented. Original research results relating to biomass valorization technologies, such as gasification, anaerobic digestion, pyrolysis, and combustion, are discussed.

The first article in the collection investigates the efficiency of a batch boiler and the emissions of harmful substances during the combustion of several wood types, all with a volatile content above 74%. Among the investigated materials, the pine wood sample had the lowest moisture content of about 10%, while the beech wood sample had the highest, corresponding to 12.5%. On the other hand, birch and beech wood samples showed the lowest ash content, i.e., below 1%. The results showed that fuels with a higher volatile content ignited faster and burnt more intensely, probably due to their lower density. The net calorific value of each fuel was also analyzed and determined to be approximately 16 MJ/kg [1].

The next two articles consider ash behavior during the combustion of pellets produced by an agro-industry. In the first article, the design of the blends and the results of the experimental tests are presented [2]. In the second article, the chemical characterization of sintering and deposition are investigated [3]. In these studies, wheat straw and maize stalk are selected to be blended with forestry wood in an agro-industry dedicated to animal feed production, and the results are compared to those of using 100% forestry woody pellets as the reference fuel. Accordingly, different pellets (blends of woody and herbaceous biomass) were produced and tested in a fixed-bed reactor in order to study their combustion behavior. Additionally, it was demonstrated that agro-industries could produce blended pellets that will fulfill the ISO 17225-6 standard concerning non-woody pellets for the energy market [2]. In the following study, eight different pellets (one woody and seven blends of woody and herbaceous biomass) produced by an agro-industry were therefore tested for investigating possible challenges that might hinder the establishment of these agropellets within the energy market [3]. After a deep analysis of the behavior in terms of the sintering degree and deposition, it was concluded that these biofuels were technically interesting to be burned in adapted boilers under appropriate operating conditions.

In the next study by Charvet et al. [4], the characterization of the operation of a cylindrical brick kiln during regular wood carbonization cycles is investigated. Relevant process parameters were monitored along with the yields and/or composition of the main products (carbonization gas, charcoal, and charcoal fines) to evaluate the mass balance of the process. It was found that the bulk of the kiln, operated at temperatures below 300 °C, greatly limited the quality of the charcoal due to the generation of significant quantities of by-products (e.g., partially charred wood, charcoal fines, permanent gases, and liquids), which have little or no commercial value. For some of those by-products, applications can be found; however, for others, no uses are identified. The partially charred wood can be reused in the process, and the charcoal fines can be marketed (mainly for briquette manufacturing). However, gases and liquids are currently discharged into the atmosphere and soil, which has a significant impact on the valorization of woody biomass. Hence, modifications in the carbonization process are still needed to improve efficiency, charcoal quality, and environmental acceptance to sustain this activity related to wood waste management [4].

Regarding anaerobic digestion, the impact of anaerobic co-digestion on the valorization of food waste alone and with wheat straw pellets is investigated at different organic loading rates (OLRs) to maximize energy production in the form of biogas [5]. The predominance of bacterial and archaeal communities and their roles in the thermophilic anaerobic biodegradation of these two different biomass sources were determined [5]. A novel genomic analysis method was used in the assessment of microbial diversity. It was found that both hydrogenotrophic and acetoclastic methanogens played crucial roles during the co-digestion of a carbon- and a nitrogen-rich substrate achieving specific methane productions up to 520 NmL CH_4 per 1 g of volatile solids (VS) at an OLR of 7.0 gVS/L/d [5].

In the last article featured in this Special Issue, gasification, a relevant approach to producing gaseous fuels from biomass, is applied to the residual biomass taken from eucalyptus [6]. In that study, the effect of the addition of steam or oxygen during gasification is investigated. The results showed that the addition of steam or O_2 during the air gasification of residual biomass improved the gas quality, overcoming some of the barriers in conventional air gasification technology.

The content of this Special Issue shows the immense potential of biomass valorization as a sustainable alternative for producing energy. However, the development and implementation of economically feasible valorization techniques to convert biomass into valuable fuels, products, chemicals, and materials remain crucial. The huge availability of different biomass sources (e.g., agricultural and forest residues, livestock manure, domestic and industrial wastes) poses a challenge to the research in the area. Developing novel technologies that efficiently produce energy and suit the different available materials is a top priority.

The guest editors of this Special Issue acknowledge all of the contributing authors. The articles in this Special Issue show recent advancements in the area of energy production from biomass valorization. Significant challenges still remain, and a continuation of the current efforts in the development of technologies of commercial relevance is expected in the immediate future.

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