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Editorial: Electricity-bioenergy hybrids: Solutions for improving the resource efficiency of biomass conversion

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Editorial on the Research Topic
Electricity-bioenergy hybrids: Solutions for improving the resource efficiency of biomass conversion

Modern bioenergy is a necessary component to achieving a net-zero emissions energy system. Bioenergy is especially important for the transport sector, and it can also provide renewable heat for industry, as well as low-carbon flexibility and security of supply for the power sector during clean energy transitions.

Sustainable biomass is also a limited resource that should be used as efficiently as possible. In addition to energy efficiency, biomass conversion processes should aim to achieve high carbon efficiency to minimize the need for land and to maximize the yields to bio-based products. Carbon efficiency can be significantly increased by using electricity as a co-energy source in biomass processing. This can be achieved either directly with electrical energy or indirectly through the use of electrolytic hydrogen.

This Research Topic is focused on solutions that can be used to improve the carbon and overall resource efficiency of biomass conversion with electricity as a co-energy source. In addition, concepts where biomass is used as a carbon source for the production of electrofuels or electrochemicals instead of carbon dioxide are included.

The published contributions cover several key aspects for the progress of these technologies, including processes that can use electricity in a flexible way to optimize process economics, or that can increase overall efficiency of the process with the help of electric heating.

Regarding concepts that can switch between "enhanced" and "biomass only" operation modes, Habermeyer et al. conducted a techno-economic analysis showing that the hybrid concept achieved 53% carbon efficiency compared to 35% of the biomass only concept. However, the higher carbon efficiency was achieved at a cost of higher production cost based on the Finnish day-ahead market.

Putta et al. applied an economic criterion to optimise the distribution of additional electrical energy between the gasifier and the electrolysis unit. Adding electricity to the gasifier *via* electric heaters was shown to be always beneficial, and the optimal amount of energy added to the gasifier was about 37–39% of the energy of the biomass feed.

In the case of biogas, Marchese et al. investigated the opportunity to utilise the full potential of biogas and digestate waste streams derived from anaerobic digestion processes available at the European level to generate synthetic Fischer–Tropsch products focusing on the wax fraction. Utilizing the full biogas plants' carbon potential available in Europe, a total of 10.1 Mt/h of Fischer–Tropsch fuels and 3.86 Mt/h of Fischer–Tropsch waxes could be produced, covering up to 79% of the global wax demand.

Gantenbein et al. analysed three different power-to-methane process chains with grid injection in two scales regarding their investment and operation cost. A significant efficiency increase was achieved by integrating the heat of catalytic methanation reaction with the high-temperature electrolysis; however, investment cost has to decrease below 1000 €/kWel to obtain economically feasible production cost of biomethane.

Focussing on methanol, Poluzzi et al. presented a techno-economic comparative analysis of three flexible power and biomass plants based on different gasification technologies with an ability to operate with and without hydrogen addition from electrolysis. Methanol breakeven selling prices were found to range between 545 and 582 €/t using 2019 reference Denmark electricity price curve for the studied concepts.

Melin et al. presented a novel selective and flexible process concept for the production of ethanol with electricity and lignocellulosic biomass as main inputs. Additionally, the CO2 emissions and economic feasibility were assessed. The overall energy efficiency was calculated at 53–57%, and carbon efficiencies were above 90%. The lowest levelized cost of ethanol was 0.65 €/l, at biomass cost of 20 €/MWh and electricity cost of 45 €/MWh and production scale of approximately 42 kt ethanol per year. The levelized cost was found to be competitive with the current biological route for lignocellulosic ethanol production.

Using process level carbon and energy balance models, Jafri et al. showed how different CCUS approaches can benefit fourteen different biofuel production pathways. From a combined carbon, cost and climate perspective, although commercial pathways deliver the cheapest biofuels, the emerging pathways were found to provide large-scale carbon-efficient GHG reductions.

Finally, Mesfun et al. investigated the integration of a molten carbonate electrolysis cell (MCEC) in biofuel production pathway based on sawmill by-products. The MCEC replaces the water-gas shift step of a conventional syngas conditioning process and enables increased product throughput by as much as 15%–31%. Depending on the process configuration and steam-methane reforming technology, biofuels can be produced to the cost range 140–155 €/MWh in the short-term.

We would like to thank all the authors and reviewers for their contribution to this Research Topic. Together they have covered a broad spectrum of relevant aspects that are key to continue with the development of electricity-bioenergy hybrids.

Author contributions

IH: Writing.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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