Innovations in Bioenergy

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Bio-energy with carbon capture and storage (BECCS) is a popular topic of discussion in the field, as utilization of this technology can potentially result in negative emissions. Hamilton *et al.* report that the use of ethanol and CCS technologies are 204-416% better at reducing CO2 emissions than using petroleum as an energy source, and using electricity and CCS technologies is 329-558% better at reducing CO2 emissions than using petroleum as an energy source[x]. These percentages would vary according to which crop was used in the production of each energy source. Aside from carbon capture, the technologies such as anaerobic digestion can be used in wastewater treatment plants along with combined heat and power capacity in order to increase biogas production[xi].

Research frontiers for Sustainable Bioenergy

There are still various research questions that remain in the field of bioenergy. Advances in biotechnology allow researchers to modify the genomes of crops in order to make them more resilience to factors such as changing climates or pests, and increase crop resilience. Genetic engineering tools such as CRISPR enable researchers to make modifications to the biomass genome that would allow for the crops to have increased resiliency to disease, drought, climate change, and other undesirable environmental conditions. This is vital for ensuring a reliable supply of biomass that is needed for bioenergy to be utilized in long durations. Engineering the metabolic pathways of microorganisms that produce fuel precursors is another method to increase the yield of useful products. For instance, Wang *et al.* demonstrate that *C. Saccharoperbutylacetonicum* (which are butanol producers) have autolysin enzymes that results in self-destruction of the cells, and makes long term fermentation difficult thus negatively impacting production[xii]. Therefore, deleting these enzymes allows for optimized production. Such modifications are often necessary when producing energy sources on an industrial scale.

Additionally, other researchers are developing tools to allow for and support sustainable decisions. Researchers from Argonne National Lab (ANL) and Pacific Northwest National Lab (PNNL) have developed the Biomass Assessment Tool (BAT) to identify locations in the US that meet lab, biomass productivity, and carbon dioxide co-locating criteria in order to scale up the production of algae based fuels[xiii]. A tool such as BAT is useful in improving biomass yield and production efficiency to help make bioenergy production more economically feasible.

The 2019 Bioenergy Sustainability Conference aimed to create a platform for the sharing of groundbreaking research in the field. The conference was comprised of three sessions: (1) Advances in Integrated Assessments of Bioenergy Sustainability, (2) Integrated Systems, Designing Sustainable Bioenergy Systems, (3) Research us9sons: