Introduction to Renewable Energy – Biomass

Captured solar energy from biological systems currently plays a large role in human society through agriculture and small-scale domestic use. Expanding the use of biomass for large-scale energy services could help reduce the greenhouse gas intensity of the energy system. Because photosynthesis captures CO_2 from the air, the resulting carbon based feedstock can be processed and utilized in a similar manner to fossil fuels with lower net emissions of CO_2.

Biomass energy conversion could take advantage of many existing waste streams, but would also likely involve the cultivation and conversion of dedicated energy crops. The naturally low efficiency conversion of solar energy to biomass leads to large requirements of land, water and nutrients. Lifecycle cost, energy, and greenhouse gas emission considerations such as fertilizer production, harvesting, and feedstock transportation are barriers to the widespread use of energy crops. Increases in the yield of energy crops for given energy, water, and nutrient inputs would decrease the associated lifecycle costs. Research utilizing modern biotechnology could increase efficiency with respect to each of these inputs.

Research enabling more efficient and lower cost conversion methods could also benefit biomass energy. Thermochemical conversion systems designed for fossil fuels could be adapted to accommodate biomass feedstock, or new systems designed to take advantage of the unique properties of biomass could be explored. Biological conversion systems have the potential for higher efficiency and lower cost as our understanding and control of these organisms increase.

GCEP has one final project in the renewable energy/biomass area that is coming to an end.

Professors Spormann and Jaramillo have a project entitled "Integrated Electrochemical-biological Systems for the Production of Fuels and Chemicals from CO_2" that began in 2015. This ambitious project aimed to bring together biological organisms and electrochemical devices to make fuels and chemicals from CO_2, water and electrical current. Electrochemical synthesis of small molecules, such as H_2 or formate, is becoming a promising route for converting electrical energy into chemical energy using catalytic materials based on transition metals, metal sulfides, and metal phosphides, among others. However, these processes are currently most efficient for 2-electron reduction steps rather than for producing multi-carbon transportation fuels and industrial chemicals, e.g. hydrocarbons, alcohols and ketones. Certain microbial organisms have the capacity to synthesize C4-C6 and higher multifunctional organic compounds from simple C1 and H2 precursors at high selectivity, thus opening the unique opportunity for a novel combined microbial-electrochemical platform for sustainable fuels and chemical production. This research explored the potential and limitations of operating microorganisms in a combined, efficient electrochemical system; designed catalysts for compatibility with microbial systems; and engineered microbes for compatibility with selected electro-catalytic materials. The researchers have developed an integrated bioelectrochemical platform for selective production of organic compounds from CO_2. They observed long-term stability of H_2 production using transition-metal-based cathodes, such as, NiMo, CoP, and MoS_2. This integrated system used *Acetobacterium woodii* and has established a platform for using different species that use H_2 and reduce CO_2. In these experiments the researchers demonstrated production of acetate and methane at high selectivity, rate, and stability, which sets a starting point for producing a range of industrially relevant chemicals. Producing high value organic chemicals based on an electron supply, biocompatible cathodes, electricity, CO_2 and microorganisms is the ultimate goal. Follow-on projects will be aimed at overcoming issues associated with maintaining high selectivity of the electrochemical catalyst over time, pH instabilities, and abiotic CO_2 formation in the middle compartment that interferes with microbial activity.