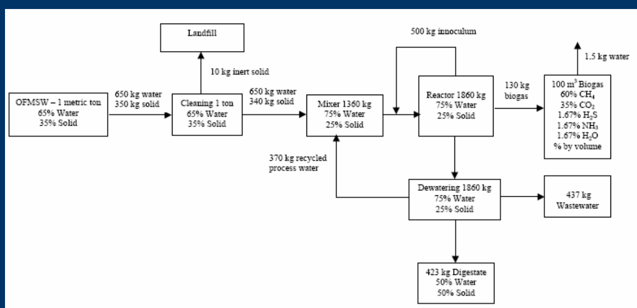
Short Contact Time Reactor Fischer Tropsch Synthesis for the Production of Clean Fuels from Anaerobic Digestion Biogas

Scott M. Kaufman and Professor Marco J. Castaldi
Earth Engineering Center, Columbia University

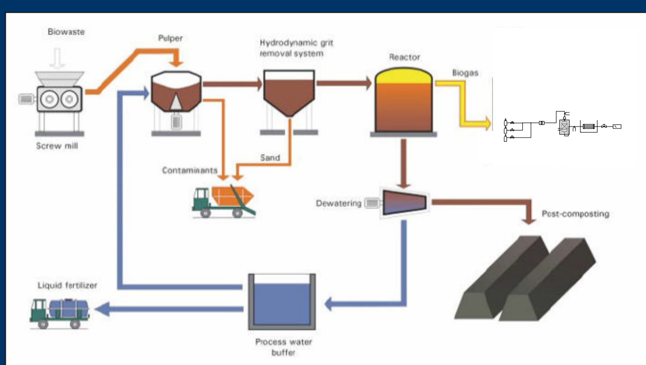
Anaerobic Digestion → SCTR Fischer Tropsch

Background

Anaerobic Digestion (AD) is the controlled process of decomposition of organic wastes in the absence of oxygen. Among the products are digestate (a compost-like substance that can be used as a soil ammendment) and methane gas, which can be used as a direct fuel for combustion of as a feedstock for further processing. The material balance is as shown below:



Source: Karena Ostrem, Columbia University Master's Thesis. Professor Nickolas Themelis, advisor.



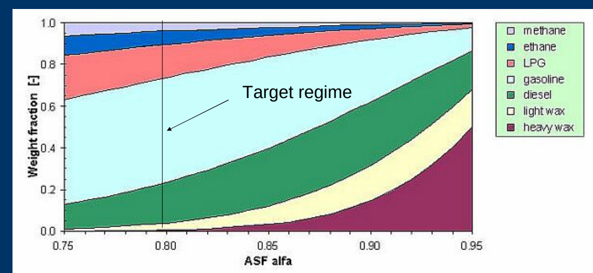
Source: *An Introduction to Anaerobic Digestion of Organic Wastes*
http://www.remade.org.uk/Organics/organics_documents/IntroAnaerobicDigestion.pdf

Research Goal – Create Green Transport Fuels from AD Biogas

A course of study focusing on the combined use of anaerobic digestion and Fischer Tropsch would address several problems. Firstly, the use of AD helps avoid the tremendous problems associated with sending organic waste to landfills. Second, the biodiesel produced in the FTL process would provide a clean, domestic source of liquid fuel that could continue to be used within the current transportation infrastructure. Third, the use of AD and FTL in agriculture would allow farmers to successfully deal with the large volumes of organic waste produced on farms in the U.S. and alleviate the associated environmental problems.

Background

The Fischer Tropsch gas to liquids (FTL) process, developed in Germany in the 1920's, takes syngas (a mixture of carbon monoxide and hydrogen which can be easily reformed from biogas) and converts it into long-chain hydrocarbons that are subsequently converted into 'green diesel' in a post-processing step. The FTL process has the additional advantage of being highly exothermic, and the large amounts of heat produced can be used for combined heat and power (CHP) applications.



The Basic Fischer Tropsch Reactions

•$CO + 2H_2 \rightarrow -(CH_2)- + H_2O$ $\Delta H = -165$ kJ/mol

20% of chemical energy released as heat
Temp 200-250 °C
Pressure 15-40 bar

•Iron-based catalysts show high WGS activity, so H_2/CO ratio is adjusted in FT reactor

$CO + H_2O \rightarrow CO_2 + H_2$ $\Delta H = -42$ kJ/mol

Short Contact Time Reactors – are more compact than the traditional industrial scale reactor. They tend to use precious metal catalysts such as platinum or rhodium supported on monolithic structures (ceramic or metal) or wire gauzes. The advantage (other than their compact size) is that they offer a higher throughput using a smaller amount of catalyst as well as lower energy and capital costs. In this project, we are setting up a short contact time reactor to convert syngas to clean liquid hydrocarbon fuels.

Experimental

The reactor we have set up combines N2 (as a carrier gas), CO and H2 , all of which are sent through a flowmeter that will manage flow rates into the reactor. A thermocouple is placed before the syngas mixture enters the reactor, which is housed in a furnace mounted vertically in our lab. The precious metal catalyst is mounted in a monolith,. Gas passes through the reactor, then to a condenser and on to analysis in a TGA and GCMS.