**Carbon and Greenhouse Gas Emissions of Biomass Processing Techniques for Aviation Fuel**

David Palubin and Pratap Pullammanappallil,
University of Florida

There are many options on the horizon for the production of jet fuels from alternative sources. However, determining the practicality and the degree of improvement of these alternatives requires analysis of lifecycle carbon and greenhouse gas emissions, or "well to wake" emissions. The most viable forms of alternative jet fuel are derived either from oils of algae, halotrophs, jatropha, and other oil plants, or from Fischer-Tropsch treated products of plant/animal waste. These fuels have the same properties as kerosene and can be used as “drop-in” fuels without special modifications to aircraft.

Because the carbon released from the combustion of biofuels must be sequestered by plants in the formation of the fuel, combustion does not result in net $CO_2$ emission over the whole life cycle. Other contaminants may be released however, such as small amounts of particulate matter, $NO_x$, or $SO_x$. However, the amounts of most contaminants released by biofuels such as biojet are generally much lower than the amount released by jet fuel refined from crude oil.

This is not to say that the biojet life-cycle is completely carbon neutral. $CO_2$ and other greenhouse gases are released during transportation and processing. Also, the plants responsible for these fuels can require a large amount of land area for commercial fuel production. The conversion of this land to make it suitable for fuel crop growth may itself result in significant carbon and GHG emission. The impact of land use change processes can be reduced by using plants with high oil content per hectare and plants that can grow in areas not suitable for other crops. This has led to the common belief that algae is the feedstock of the future for aviation fuel, due to its high oil content and ability to thrive in otherwise unusable environments.

With algae and other oil producing plants, the process of conversion to jet fuel is as follows. First, the oxygen from the oils must be removed. Once the oxygen is removed, the molecule is thermochemically "cracked" or isomerized into synthetic parrafinic kerosene. Typically the process requires temperatures of 600-700F, pressures of 40-100atm, and times from 10-60 minutes in the presence of hydrogen. These conditions require energy to maintain, resulting in increased greenhouse gas emissions for the overall process. However, over the total life cycle, GHGs from energy inputs during hydroprocessing are lower than the amount of GHGs that would be released from comparable amounts of jet fuel from crude sources.

According to Wong[1], the total greenhouse gas emissions of Fischer-Tropsch (FT) treated biomass have the lowest GHG profile for conversion to jet fuel. According to this lifecycle analysis data, Biomass to fuel using a Fischer-Tropsch process produced about 1/5 of the greenhouse gases of conventional crude oil to jet fuel processes. However, this analysis did not include land use change GHGs, which would increase the emissions slightly. Also, there is some variability in the amount of processing necessary to create synthetic parrafinic kerosene from biomass. Biomass is composed of a variety of different molecules and sizes, some of which require much more processing than others. A variety of end products are produced by FT, including branched chain molecules and molecules of different carbon backbone lengths. Many of these can be separated out and sold as value products. Generally these FT fuels are produced from waste plant material, which does not require any land use change. However, current supply of available waste material is not great enough to supply US fuel requirements. In the future, supply of plant biomass for FT fuel should increase.

It is important to note that while the conversion process of biomass to fuel may be energy intensive, renewable energy from the biomass can be used to power the reaction. During the initial stages of biomass treatment, some of the material is converted to char in an exothermic process that can be used to generate electricity. The char can then be used as fertilizer to replenish nutrients in soil depleted by biomass production. Also, some waste biomass that cannot be easily converted using Fischer-Tropsch methods could be transformed to methane via anaerobic digestion. Using some of the biomass to power conversion of the rest to fuel reduces the need to use GHG releasing petroleum products to accomplish the same ends. Much of the emissions from biomass processing can be overcome in this way.

---

[1]Wong et al (2008) Analysis of lifecycle greenhouse gas emissions of alternative jet fuels. http://www.aci-na.org/static/entransit/sunday_joint_fuels_wong.pdf . Accessed 08-26-2009