AVIATION FUEL SUMMIT

Track: Feedstock Availability
Session: Carbon and Greenhouse Gases
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Question #1: What crops (here and after including forest crops) are best for production of biofuels for aviation in terms of production capacity?

To start with, it is best to re-word this question as follows: "What feedstocks are best for production of aviation biofuels in terms of volume and quality, in the short and long term?" The key change to the question involves broadening its scope from crops to feedstocks, which include materials that are not crops, such as residues and waste. Feedstock availability for biofuel production is difficult to address thoroughly in isolation of details on the conversion technology under consideration, such as sensitivity to feedstock composition, and size of the biorefinery, which will determine the quantity of feedstock required. Unfortunately, this information varies among the many conversion technologies that are currently under evaluation, and due to the early stage of development of these technologies, it is not clear which of them will emerge as economically viable. Most published studies on cellulosic feedstock availability are very broad in scope, having relevance on a national or regional level, but very little relevance in terms of the need for specific volumes within a certain distance of a specific site. Cellulosic feedstocks can be divided into 1) waste materials, including municipal solid waste (MSW), or garbage, 2) forestry materials, and 3) agricultural materials. Key requirements for a good cellulosic feedstock are (a) adequate volume year-round, (b) adequate quality, and (c) low cost. Each feedstock category is discussed briefly below in relation to these key criteria.

1) Waste Materials

MSW is the most important of the waste materials, and is superior to all other cellulosic feedstocks in terms of all three key criteria, but this has not been recognized in the literature on cellulosic feedstocks. Failure to recognize the significance of MSW as a source of cellulosic feedstock is probably related to lack of a technology to economically clean and separate the cellulosic fraction. However, a company in St. Louis, CleanTech Biofuels (www.cleantechbiofuels.net) has recently solved these problems. The Cleantech technology sterilizes and separates the cellulosic fraction of MSW at a cost of about $20/ton of MSW, while also separating plastic and metal waste streams that generate additional income. Given that MSW typically incurs a tipping fee/disposal cost of $24-$70/ton, with a national average of $34/ton (Table 1), CleanTech cellulosic feedstock can be delivered for zero to ~$20/dry ton, depending on locality and tipping fee, after production and transport costs, and profit for the supplier are accounted for. This is less than half the cost of most other cellulosic feedstocks. Since MSW is generated at a constant rate year-round, its availability is well distributed over time, and infrastructure is already in place for its collection and delivery. According to the EPA, an average of 4.6 pounds of MSW is generated per person each year in the US. It follows that availability and price are most attractive in regions of high population density, specifically the Northeast, Mid-Atlantic and West. However, MSW is readily available in close proximity to all metropolitan areas, regardless of region. The US generates about 251 million tons of MSW annually, and after recycling, about 90 million tons (or 36%) are available as a cellulosic feedstock. Quality of the CleanTech cellulosic feedstock is also superior, because it has less lignin than most other feedstocks, and can be delivered at specified moisture content with low ash levels, and as briquettes or pellets if needed in that format. In summary, cellulosic feedstock generated from the CleanTech process is almost certainly the best feedstock currently available for production of aviation fuels. In addition, use of MSW also reduces the many environmental problems related to landfills.

Table 1. Tipping fees for MSW in 2004 by region.

Region	States	Tipping Fee ($)
Northeast	(CT, ME, MA, NH, NY, RI, VT)	70.53
Mid-Atlantic	(DE, MD, NJ, PA, VA, WV)	46.29
South	(AL, FL, GA, KY, MS, NC, SC, TN)	30.97
Midwest	(IL, IN, IA, MI, MN, MO, OH, WI)	34.96
South Central	(AZ, AR, LA, NM, OK, TX)	24.06
West Central	(CO, KS, MT, NE, ND, SD, UT, WY)	24.13
West	(AK, CA, HI, ID, NV, OR, WA)	37.74
	National Average	**34.29**

2) Forest Material

Forest material includes wood chips of whole trees, material from thinning forests to reduce risks of fire, logging residues, forest product residues like sawdust and bark, and woody crops planted for energy. These materials are available in large quantities in the Northeast, Mid-Atlantic, South, South Central and Western regions, where forest occupies a lot of land. Due to depressed lumber markets related to the current depression in the housing market, cost of wood chips is currently relatively low compared to agricultural feedstocks (about $40/dry ton, delivered). Residues and other related materials are typically less than this. Year-round availability is generally good, because trees can be "stored on the stump". However, moisture content of chips is typically ~45%, which is higher than optimum for certain conversion technologies. In addition, high lignin, and high resin content of softwoods/pines, can be problematic for biological conversion processes. Due to the long time from planting to initial harvesting of woody crops like poplar and willow (5-10 years), this option is considered a mid- to long-term opportunity.

3) Agricultural Materials

The government has wisely capped use of grain such as corn and soybeans to produce liquid fuel. Therefore, these options are not considered here. Other agricultural feedstocks include crop residues, such as corn stover and wheat straw, and dedicated energy crops such as switchgrass, miscanthus and sugar/energy cane. The primary limitation of crop residues (including corn stover), is low density and contamination with soil. Work is in progress to develop one-pass harvesters for grain and stover, which could improve economics. Perennial cellulosic energy crops will have to be planted. Therefore, it is likely to take 3-5 years to establish enough to supply a conversion facility. Costs to establish crops like sugar/energy cane and miscanthus from vegetative material (because they do not produce seed) are high, and may be a major barrier to use of these crops. Annual, high yielding sorghum offers the best near-term opportunity among crops. However, delivered cost of all crops is likely to be $70-$90/dry ton. The Biomass Crop Assistance Program could offset this high cost, but is not in operation yet. Finally, crops are typically seasonal, so need to be stored after harvesting to facilitate year-round delivery. In summary, high cost, delay between planting and full production, storage, and in some cases, harvesting and drying are challenges facing use of agricultural feedstocks for production of aviation fuels.

Question #2: What are the comparative carbon and greenhouse gas implications of the potential biofuel feedstock crops?

Conversion technology (especially type of fuel produced: hydrocarbon vs. alcohol) has a greater effect on GHG emissions than feedstocks. In general, crops are better than wastes or residues because they sequester carbon, and green diesel is better than other fuels because it can be used in the system for hauling and harvesting.