Biofuels and Feedstocks: A Commercialization Outlook

Jim Lane, Biofuels Digest

Of all the hydrocarbons and simple sugars that can be made from biomass, or recovered from fossil reserves, gasoline, diesel and natural gas remain the most important end-products and are likely to remain so for some time to come. Into that mix comes the advent of biofuels, and in recent years the arrival of what are variously termed “second-generation” or advanced biofuels.

Though markets for intermediates and fuels such as methanol, propylene and ethylene are considerable, range into the billions, as high as $25 billion in the case of propylene, the market for gasoline is measured in trillions of dollars, not billions. According to the Energy Information Administration, global liquid fuel consumption in 2008 was 85.43 million barrels a day at a US refiner averaged cost of $94.68 per barrel, or $2.95 trillion.

The biofuels market today is small - no more than $40 billion, or less than two percent of the total liquid fuels market, and not much more than the market for ethyl propylene. Talk about biofuels is all out of proportion to its market size.

Biofuels have four basic economic drivers: energy independence, climate change remediation, economic development, hedging, and the search for fuels that are lower in cost or in price volatility.

These are linked. As US House Speaker Nancy Pelosi said in urging her colleagues to pass the climate change bill: “remember these four words for what this legislation means: jobs, jobs, jobs, and jobs.” Pass it they did.

The science of biofuels — the growing of biomass feedstocks and the conversion of biomass to power and fuel depends on a turbulent, fast-changing set of technologies. We have seen manifest changes in the projected yields per acre of candidate feedstocks, the efficiencies and yields in conversion from biomass to fuels, and the cost of components and systems.

There are numerous competing approaches including transesterization, fermentation, acid hydrolysis, enzymatic hydrolysis, the Fischer-Tropsch process, gasification and pyrolysis to name a few. The outlook for the industry depends, then, not only of the future of feedstocks, but the future of the conversion technologies.

The future of policy is a factor as well. We have seen biofuels mandates constructed in Germany and then watered down, and the same in England. We have seen a great upheaval around the issue of “food vs. fuel,” as nations debate the optimal division of land between food production and feed production. To some extent, the debate is a canard, for "food" in the sense of vittles at supermarkets available for purchase is the complex result of both food crop and energy inputs. There are but five cents of corn in a $4.20 box of Kellogg's Corn Flakes.

In addition, ideas about the markets for biomass are changing. Bioplastics, feed and nutraceuticals are under discussion at advanced biofuels companies like Virent, Solazyme, PetroAlgae, and Coskata. Fuels of the future will compete for feedstock with the green chemicals of the future that will also use those feedstocks, made by companies that also have interest in carbon footprint amelioration.

The outlook for biofuel demand, at this time, is generally controlled by national mandates — such as the Renewable Fuel Standard in the United States which mandates 36 billion gallons of biofuels by 2022, and the Renewable Transport Fuel Obligation in the UK. Mandates have been established in numerous European countries, as well as smaller mandates in some Asian countries, such as an E10 and B5 mandate in India and an E3 mandate in Japan. Brazil, which does not have a biofuels mandate, distributes ethanol at a heavy discount to gasoline and ethanol has now passed gasoline as the dominant fuel in that country.

The outlook for biofuels technology is much clearer now than in the past. Today, the vast majority of biofuels — primarily in the US, Brazil, Argentina and Western Europe — are produced from food crops such as corn, sugarcane and soy using fermentation into alcohol or transesterization into biodiesel oil.

However, numerous pilots and demonstration projects for conversion of cellulose and waste residues (agricultural, forest, municipal and animal) are underway or under construction. Producing ethanol via enzymatic hydrolysis are Iogen in Canada, plus Range Fuels, KL Energy, and ZeaChem in the United States. Qteros and Mascoma will produce ethanol from cellulose using a proprietary microbe. BlueFire Ethanol will produce simple sugars and ethanol from landfill waste and ag residues using acid hydrolysis. Coskata and Range Fuels will produce ethanol from cellulose using gasification. Dynamotive will produce bio-oil and bunker fuel from residues using fast pyrolysis. Virent, Amyris Biotechnologies and LS9 will produce a drop-in replacement for diesel fuel ("green diesel") from sugarcane using proprietary, genetically modified microbes.

All these projects, which range from 10,000 gallon per year pilots to 100 Mgy commercial demonstrations, are expected to be in the market by 2011, and are producing from 40 to 135 gallons of fuel per ton of biomass (Biofuels Digest). Where does this leave us in terms of commercial viability?

A key question is the long-term value of carbon credits. At an emission price of $30 per ton of CO_2, this adds about $33 cents per gallon to gasoline. Here is usually a premium for gasoline of 10 percent above the crude oil price (NYMEX 2009). So a world of $100 oil will leave us with a long-term "break-even" target of $2.94 for wholesale biofuels. That's $118 to $397 per ton of biomass. If oil or carbon credits go north of $100 per barrel and $30 per ton, that changes the outlook.

Companies like Coskata are guiding their investors on the basis of $1 per gallon wholesale, for renewable fuels. So there is plenty of margin to work with in a future that has a significant role for biofuels.

Two limiting factors are the amount and price at which biomass can be sustainably recovered. The US Department of Energy estimated that 1 billion tons of biomass can be sustainably harvested in the United States – that's enough for 40 to 135 billion gallons of fuel, or between 20 and 70 percent of US fuel consumption today. Europe has less land and biomass available in comparison to fuel consumption, while Latin America and Africa have enough raw biomass that they could conceivably become energy self-sufficient given enough capital and time.

One wild card is the question of algae. PetroAlgae has been reporting a haul of 60 tons of biomass per acre per year at its Fellsmere pilot plant. By contrast, corn farmers in the US average 4.2 tons of biomass per acre. Although algae requires more labor and supervision than, say, corn or soybeans, the prospect of converting up to 40 percent of the biomass to fuels and the remaining 60 percent to feed, power and intermediates for the production of renewable chemicals and nutraceuticals, is a potential disruptive force in the fuel and feed markets. Further, algae, though water-intensive, does not require the use of arable land. Aurora Biofuels is targeting "$1.30 at the gate" as its wholesale production cost for algae biodiesel by 2013, and though production volumes are not expected to exceed 1 percent of the US fuel supply before the late 2010s, the prospect of algae fuels at parity is a real one.

Other high-yield feedstocks are under investigation and trial, particularly research on jatropha, camelina, switchgrass and miscanthus. These have yields in the 200-700 gallon per acre range, well below algae but generally superior to first-generation feedstocks. For now, sugarcane ethanol has the lowest cost of mainstream biofuels feedstocks, with yields in the 500-800 gallons per acre range.

Though the economics of biofuels appear to be improving, the use of large tracts of land for energy crops has raised questions about the impact on food prices, carbon-storing fallow land, and sustainable development. Significant work is underway to measure the impact of energy crops on global land use and crop prices, with a special focus on the impact on overall emissions. The US EPA and the state of California both attempted an analysis of international indirect land use change from biofuels, but the results divided the scientific community regarding the robustness of available data on land use change.

The mandates that are in place – 10 percent biofuels by 2020 in Europe and around 15 percent in the US by 2022, plus the E10 mandate in India and the majority market share enjoyed by ethanol in Brazil, suggests that biofuels will command 10 percent or more of global market share in the early 2020s. That's north of 100 billion gallons per year. If land use change issues are resolved (such as with a rapid expansion in high-yield algae production), fuel producers prevent waste residues from becoming high-price commodities, capital markets recover to supply more than $250 billion in plants and equipment, and the pilot-scale technologies prove out at commercial scale, the outlook is rosy indeed for bioenergy.