Renewable Fuel Niches

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This is the final installment of a three-part series that examines some of the renewable energy options that are presenting themselves as possible contenders to step up as petroleum steps down the depletion curve. The previous installments were:

Renewable Fuel Pretenders

Renewable Fuel Contenders

Today I want to talk about Biofuel Niches. Here is how I would define a **Biofuel Niche**: *A technology that is capable of supplying, long-term, up to 10% of our present liquid fossil fuel consumption, often by utilizing specific, localized synergies.*

This definition covers a great number of possibilities, and I don't pretend that I will even cover a large fraction of them. But I want to cover some specific fuels - like cellulosic ethanol - that I believe can work in a niche. If readers can think of others, let's discuss them. I want to lead off with some of the options I categorized as "Pretenders", and then discuss corn ethanol which I did not discuss in the previous installments.

To reiterate, my views are based on the following expectations: 1). That the average oil price over the next 10 years will exceed $100/bbl; 2). That biomass prices will rise in response to demand, putting a premium on efficient conversion technologies; 3). That these biofuel technologies will eventually have to compete on the basis of oil price and not government handouts. This latter point is key, because it favors those technologies that can decouple from fossil fuel inputs.

Algal Biofuel

I classified this as a pretender based on the fact that technological improvements are needed in order to make algal biofuel economical - yet the hype over algae is mind-boggling. We don't even know if it will work at scale, and yet it is going to be the solution to all our problems? Following my previous essay, I had a discussion with someone involved in testing fuels for the U.S. military. They are optimistic about the future of fuel from algae, but admitted that they were only able to secure algal fuel for testing at the cost of $100/gal! How likely is it that there will be a more than 20-fold decrease in production costs?

Having said that, there are three situations in which I think algae can work. Two of these are niches. The first is a situation in which the oil is produced as a by-product. Algae has a great number of uses in consumer products, and oil can be produced as a by-product of those consumer products. As a hypothetical, assume that algae can be engineered to produce a valuable pharmaceutical. This is certainly not science fiction; the first commercial usage of genetic engineering was to design bacteria to produce human insulin. Imagine instead algae, and oil that is removed during processing. The costs are largely born by the more valuable primary product. The problem of course is that this approach isn't scalable. Imagine again that something like insulin production is the primary role of the algae. If you tried to scale that up to a significant fraction of our fuel usage, you will have thoroughly saturated the market for the insulin. But perhaps if we can pair up a number of primary products with oil algal production, algae can make a contribution to our fuel supply.

The second situation is similar. If algae production is one step in an integrated energy complex, it could work. For instance, I was recently asked to comment on just such an approach by Desert Biofuels, a company in Arizona. Without endorsing their specific approach, this sort of approach may work. (Actually their approach is quite complex and has unique technical risks). But algae can be effective at cleaning up waste water. Imagine algal-cleanup as one step of an integrated complex, and the costs go down substantially.

The only scalable approach I can see is for algae to be engineered to excrete their oil *in situ*. What drives the cost of algae up so much are the difficulties of collecting the algae, separating from water, and then separating the oil from the algae. (Often overlooked is that the oil must be further processed to biodiesel or green diesel). Now imagine a pond of algae in which the oil "leaks" out while the algae grow. The process of collecting the oil would be dramatically simplified. A caveat of course is that engineered algae tend to get out-competed by native strains. The bigger caveat is that this technology doesn't exist, but companies are working on it.

The wild card out there is the Solazyme approach. Think sugarcane ethanol, except instead of yeast producing ethanol you have algae producing oil. The approach is interesting - which is why I mention it - and gets away from many of the problems inherent in trying to produce fuel from algae. Is it more efficient than sugarcane ethanol? I think it's too early to tell. But one poster at The Oil Drum indicated that during a Q&A with a Solazyme representative, he couldn't come close to a believable answer regarding scale-up costs. So while I think this one bears watching, it is far too early to suggest that this will pan out.

For a balanced overview of fuel from algae, see Biotech's green gold?

Cellulosic Ethanol

I see two major problems with the scalability of cellulosic ethanol. First, the logistical challenges of getting a lot of biomass into the plant is going to limit the size of the plant. As I pointed out in an essay on Coskata, to run their proposed plants would take the equivalent of over a million trees per year. In terms of rail cars, this is over 1 per hour, 24 hours a day, 365 days a year in and out of the plant to dump the biomass. And bear in mind that this is really a gasification to ethanol plant, with higher forecast yields than a conventional cellullosic process (i.e., a real cellulosic plant of this size would require even more biomass).

But beyond that, the ethanol that is produced from the cellulosic process is at a far lower concentration than that of corn ethanol. That means big energy inputs in order to make pure ethanol.

A good niche application for cellulosic ethanol could be a situation in which there is a lot of waste heat available near a point source of biomass. Generally, there isn't a lot of high quality waste heat that would contribute a lot to the steam needs of a cellulosic ethanol plant. But picture something like a cogeneration unit near a collection point for woody waste. The waste is being collected and is coming in anyway for disposal, and the heat output from the cogen unit may improve the economics.

Another alternative could be if there is another very cheap source of steam around that can't be better utilized. If you had a lot of coal in the same location as a lot of biomass, again a cellulosic process might work (but I would argue that depending on the source of biomass, gasification might be a more efficient solution here).

Hydrogen

While not generally considered a biofuel, I discussed hydrogen in my "Pretenders" piece so I will address it here as well. In my opinion, the most interesting realistic option for hydrogen is as energy storage for excess power. For instance, let's say you have a neighborhood in which most houses have enough solar panels to produce excess electricity at mid-day. Once the batteries are charged, what else can you do with that excess electricity? If it can't be diverted to someplace that has a need, then it may make sense to electrolyze water to produce hydrogen. This is not a very efficient process, and not something you would do under normal circumstances, but in this case it could be the best storage option.

Once the hydrogen is produced, it could either be used to fuel stationary fuel cells for the neighborhood when the solar panels aren't producing, or it could be compressed and used to fuel hydrogen combustion engines.

Corn Ethanol

A niche, you say? Aren't we producing 10 billion gallons of corn ethanol already? True, but I am talking about something that could actually stand on its own in the long run - unsubsidized - and still make a decent net contribution to our energy supplies. In that case, producers might still be able to sell 10-15 billion gallons of ethanol a year and make a profit, but the distribution pattern would be different. In a state with ample rainfall and rich soil, corn ethanol may be able to stand unsubsidized by making and consuming the ethanol locally. Corn ethanol may be a fine solution for Iowa (although E85 is not even cornering the market in Iowa, where it should be in its optimal market). Stretching it beyond a local solution is where the economics start to break down and the scheme only works with subsidies.

Here are some examples of what I am talking about. When corn ethanol is produced far from corn supplies - like in California - the economics became difficult due to the cost of shipping the corn to the plant. I talked about that in 2006, when I warned of the potential problems of Pacific Ethanol's plans to do just that. They filed for bankruptcy earlier this year.

Another example is when ethanol is produced from a state in which ethanol's energy balance is poor (e.g., parts of Nebraska, due to corn's irrigation requirements) and then shipped to California. If you look at the USDA's most recent paper on corn ethanol's energy balance (the one in which they used creative accounting), you can see from Table 2 that Nebraska's energy inputs for growing corn are about 20,000 BTU/bushel above the Midwest average. (By comparison, Iowa's are 11,000 BTU/bushel under the Midwest average). This has the overall impact of actually causing Nebraska's net energy from producing ethanol to be negative unless one adds a BTU credit for co-products. With such a marginal energy balance (and I haven't even mentioned the Ogallala Aquifer) it hardly makes sense to produce ethanol in the drier regions of Nebraska. It makes even less sense to then spend more energy shipping that ethanol far from the point of origin.

Conclusion

Those are some of the major niche applications I see, but there are certainly others. What corn ethanol could be for Iowa, sugar beet ethanol may be to the EU and palm oil may be to Malaysia: Local solutions. The key to success for any of these is not to try to scale something that should operate in a niche. When we attempt to do this, we open up a can of perpetual subsidies in order to force something that doesn't fit, and often get unintended consequences in the process.