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Inside POET: A Conversation with the World's Largest Ethanol Producer

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On July 17th I spent some time on the phone with POET's VP of Science and Technology Dr. Mark Stowers. (I was invited up for a visit, but I couldn't swing that just now). Dr. Stowers is in charge of company R&D, which includes corn and cellulose to ethanol, as well as the investigation of novel processes for utilizing waste to power their facilities.

Joining us on the call was Matt Merritt, POET's Media Relations Specialist. We covered a lot of ground on the call. Along with the environmental impact, key interests of mine in assessing fuels of any kind are the energy inputs – what kind, how much – and the related topic of logistics. I probed the energy inputs in some depth, as I consider that critical when considering long-term commercial feasibility.

First a bit of background on POET. They are the largest ethanol producer in the world, producing more than 1.5 billion gallons of ethanol each year from 26 production facilities across the country (each with its own nuances, I was told). They recently started up a 20,000 gal/yr pilot-scale cellulosic ethanol plant, which uses corn cobs as feedstock. Plans are to commercialize the process in 2011. They have named this effort Project Liberty.

My questions and Mark's answers below are paraphrased, but as I told them if they spot anything that I got wrong they can notify me and I will correct it. The format below includes questions, answers, and comments from me. Where the comment was part of the interview, it will appear as a prelude to a question or a comment in the follow-up as "RR: Comment.... Mark's answers will appear as "MS: Comments..." To distinguish from additional comments I might interject, I will indicate those with *[RR: Comment...]*

I first voiced my skepticism that cellulosic could ever make a huge impact, due to logistical issues and energy requirements. That was going to be a major thrust of the interview, but I started off with a related comment/question.

RR: Conditions in Texas have been really dry. We have had over a week with temperatures exceeding 100 degrees each day. There are a number of corn fields near my house, and the fields appear to be dead. How are conditions up north?

MS: Actually this will probably be one of the best years ever. We got rain when we needed it. Corn grew 6 inches overnight recently. In Sioux Falls right now the temperature is 70 degrees.

RR: OK, let's move on to your process. Can you start by walking me through your cellulosic ethanol process?

MS: Our cellulosic process is based on corn cobs. We have harvested 25,000 acres over the past couple of years. We are currently still trying to work out harvesting and storage. The yield of cobs is 0.65 tons/acre, and we can collect them commingled with grain with a modified combine. Or we can collect them with stover coming out of the back of the combine. The bulk density for cobs is higher than for stover, and that makes them easier to separate. We store at the farm field edge currently and can collect over the following 6-9 months. We make sure sufficient stover is left on the field for erosion control and nutrition. We are focused on cobs because the bulk density for cobs is better than for stover, and cobs have 16% more carbohydrates than the stover. We believe that there is a nationwide potential for 5 billion gallons of ethanol if all cobs are collected and converted.

RR: OK, I am going to walk through some numbers here. As you may know, I have been skeptical about the potential of cellulosic ethanol to scale very well. I feel that there are niches in which it will work, but I don't think it works well as a large scale solution.

As you mentioned, average cob yields are 0.65 bone dry tons (1300 pounds) per acre. I have a reference that says the heating value of cobs is about 7900 BTU/lb *[RR: Mark agreed that this was correct]*. So the total BTU value of the cobs on an acre is about 10 million BTUs/acre, which is also the energy content of 135 gallons of ethanol (ethanol has a heating value of 76,000 BTU/gal). That would seem to be an upper limit on a hypothetical perfect conversion process that could capture 100% of the BTUs. But of course enzymatic processes are not going to convert lignin, and there will be some inefficiencies. My guess is that you probably need 20 pounds or more of cobs to produce a gallon of ethanol (as opposed to 10 pounds for a perfect conversion process), putting the actual yield at around 65 gallons per acre. I saw someone (not POET) who recently claimed cellulosic from corn cobs would increase per acre yields by about 110 gallons per acre, but based on the BTU value I don't think that's possible.

MS: Yes, I think that 110 gal/acre number looks too high. The 20 pound number you came up with looks approximately correct. We can get 85 to 100 gallons per ton with our process but operate mostly in the high eighties and low nineties at present. We are drying and burning the lignin for fuel, but in addition to the cellulose we are also converting the hemicellulose to ethanol.

[RR: OK, so 85 gallons per ton is equal to 55 gal/acre, and 100 is 65 gal/acre - which is the number I had worked out. Incidentally, I think the difference between a skeptic and a cornucopian is that the skeptic will look at that range and say "OK, realistically speaking they probably get 85 gallons/ton on a good day, and they think they can push it to 100 gallons if they continue to push the envelope." The latter will claim matter-of-factly that their yields are at least 100 gallons/ton.]

RR: OK, I did not know you were converting the hemicellulose. What is the percentage of cellulose and lignin in the cobs?

MS: The cellulose plus hemicellulose is upwards of 60%. Lignin is about 15%.

RR: One of the keys to success for a cellulosic ethanol process is to increase the concentration of ethanol in the crude product. Historically this has been in the 3-4% range for cellulosic ethanol, and I don't believe that will be commercially practical. The energy required to purify a solution in that range would be comparable to the energy contained in the ethanol. *[RR: Of course with waste heat or very cheap BTUs, you might be OK to do it anyway]*. So can you discuss the sorts of ethanol concentrations you are getting?

MS: First of all, I agree with your comments on ethanol in the 3-4% range. While we have not

released information on our cellulosic ethanol titers, they are lower than those for corn ethanol. On the other hand we have some of the highest corn ethanol titers in the business; we can achieve greater than a 20% ethanol solution from corn. But we are better than the 4-5% range for our cellulosic process. Also, there is sufficient energy in the solid waste stream and the liquid stream to provide more than enough energy to power our cellulosic process.

RR: Don't you have problems with the enzyme activity diminishing at higher ethanol concentrations?

MS: We do not see enzyme activity as a rate limiting step with respect to ethanol tolerance.

RR: Beyond the energy required to process the cellulosic ethanol, there is the fuel required to gather and transport the corn cobs. Along those lines, one of my readers wondered about the radius to the plant in which the logistics are still economical. His comment was that he heard that shipping costs for cobs are twice as costly as the grain because they are so bulky.

MS: We can go out to a 25-35 mile radius; about the same as corn.

[RR: I suspect if you did the analysis for cobs by themselves, collecting cobs and transporting them from 35 miles away might not be worth the fuel value of the subsequent ethanol produced.]

RR: Do you have a feel for how many BTUs is required to produce a BTU of cellulosic ethanol?

MS: We have some idea of those numbers, but haven't released them. *[RR: I think he said they are waiting for more results from their pilot plant, and they are working on getting better numbers.]*

RR: Another question from a reader: "Will they contract with producers and what will the terms be?" I think I know the answer to this, because I read an article yesterday in which Poet spokesman Nathan Schock said that this hasn't been fully determined. *[RR: Here is the article: Iowa plants to offer farmers cash for corn cobs.]*

MS: Nathan was correct; we have contracted with some farmers for fall harvest but we don't know where the economic sweet spot for everyone involved is going to be.

RR: I would think you would hold those numbers close anyway, or all farmers will be holding out for the highest published price.

MS: Yes, that is a key point.

RR: (I asked if another reason for focusing on cobs over stover was related to concerns about soil depletion. I also incorporated another question from a reader): "Ask POET what they think of cellulosic from corn stover. They seem to say that stover has too many collection and handling problems (dirty, low density, etc), and that is one reason they are concentrating on cobs only. Many others assume corn stover will be the primary source of cellulosic feedstock."

MS: We don't have to leave all stover in the field necessarily over soil depletion issues; we have just chosen to focus on cobs. How much one can remove depends on soil type, location, and tillage practice. Cobs take those variables away.

RR: Is your ethanol purification compatible with existing corn ethanol infrastructure? I would think that with a higher water concentration you could go into your corn ethanol distillation

system, just at a lower feed location.

MS: A cellulosic plant will be a bolt on to an existing corn ethanol plant. But we will have a better efficiency if we don't intermingle the streams with corn ethanol because we don't want to get things like lignin in our corn ethanol distillation train. So it is better to have separate distillation trains. The infrastructure will be more of what you see in common (utilities, logistics in and out, etc.).

RR: Why not just use the cobs to produce steam for the corn ethanol process? Have you done comparative studies on that?

MS: We are doing that today as well. We are using other renewable biomass to fuel a solid fuel boiler at Chancellor, South Dakota. This is a 100 million gal/yr facility. We are also using landfill gas in a multi-purpose boiler.

RR: What is the quality of the methane from your digestor? Do you have to clean it up?

MS: We have two applications for our biogas. One is for overall energy, and the other is fuel for the dryers. We are just finishing up our 3rd month of operation. The boiler that we have developed can handle the biogas that is produced.

RR: How many engineers are working on Project Liberty?

MS: Between the lab and pilot plant, we probably have 25 scientists and engineers.

RR: Is your pilot unit fully integrated? Is the pilot process fully connected?

MS: We are completely integrated from cob collection through ethanol production and recycle streams. We have a 24/7 operation with 4,000 data points collected. The pilot plant has been running since about Nov 18, 2008.

RR: One of the things that I strongly believe is that if the corn ethanol industry is ever going to break free from endless subsidies, you have to get the fossil fuels out of the process to the greatest possible extent. The sugarcane ethanol producers are more immune to the ups and downs of fossil fuel prices because of the large role bagasse plays in providing fuel for their process. So it feels like you are headed down the right path here, even though natural gas prices aren't exactly a pressing concern for ethanol producers right now.

However, it might be that you have enough waste energy to fuel your process, but most of the BTUs are used up in the conversion, leaving very little ethanol. So in a case like that the question becomes, "Are you left with a small net amount of ethanol, or a **very** small net amount of ethanol? "

[RR: For example, if you had one BTU of biomass, and consumed 0.9 BTUs to produce 0.1 BTU of liquid fuel, you could say that you have gotten the fossil fuel inputs out, but you have produced very little fuel and were very inefficient with the utilization of the BTUs. In that case you could ask if there might have been a better use for that BTU of biomass.]

MS: The energy from our waste streams should be sufficient to power the 25 million gal/yr cellulosic plant and nearly power the 50 million gal/yr starch plant next door.

[RR: To me this was the most significant statement he made during the interview. If an added benefit is that you are also powering your corn ethanol plant with the energy produced from

the cellulosic process, you have a very powerful synergy. But I admit that I have a bit of a hard time with this one. I would like to really dig into the energy balance, because it doesn't seem to me like there are enough BTUs. If I go back to my analysis of 10 million BTUs/acre available from the cobs and you back out 65 gallons of ethanol produced from the cobs, that would only leave you with about 5 million BTUs per acre to power both a cellulosic plant and a corn ethanol plant. If I make a couple of reasonable assumptions, it looks to me like they are assuming only 30,000 BTUs of energy input per gallon of ethanol production. This seems on the low side, but is perhaps reasonable when the ethanol yields from the cobs are on the low end of the range - leaving >30,0000 BTUs/gal for running the process.]

RR: When you are out front with a technology, there are always risk factors. What are some of the risk factors that you have identified that might keep you from meeting your goals?

MS: First is the absence of a market for cellulosic ethanol. The blend wall from E10 really limits the cellulosic market.

RR: OK, that's market risk. How about technical risk?

MS: We must have farmers and equipment manufacturers engaged; we need a solution in which both sides can make money. We need programs early on to help biomass collectors overcome the risk. How many cobs can you get in a truck? The logistics become important. There is also the issue of inventory management. The annual supply of cobs for a 25 million gal/yr cellulosic plant would require a silo the size of the Empire State Building. We need to decentralize this, and we need as high a throughput into the reactor as possible.

RR: Gentlemen, that's about all the questions I have, although I will probably come up with 10 more when I am writing this up.

MS: Feel free to contact us for any followups.

RR: Thanks guys. Appreciate you taking the time.