The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Whither Cellulosic Ethanol?

Posted by Nate Hagens on August 16, 2006 - 10:25pm
Topic: Alternative energy
Tags: cellulosic ethanol, ethanol, lignocellulosic, vinod khosla [list all tags]

[editor's note, by Prof. Goose] This is a guest post from TLS's friend Don Augenstein (Pomona96 on TOD)

This post presents a perspective on ethanol from lignocellulose by my friend and co-worker, John Benemann. We have worked on, and been immersed in, biofuels and analyses of fuels from biomass processes for over 3 decades. We are to substantial degrees biotechnologists, as well as chemical engineers and have successful processes going today (methane from wastes. You can google Don Augenstein). We have worked long and hard on biofuels for entities including Exxon (long ago), the Electric Power Research Institute, and others. Our carefully considered view, for which we will be happy to provide abundant evidence is that severe barriers remain to ethanol from lignocellulose. The barriers look as daunting as they did 30 years ago. Ethanol from lignocellulose may indeed come to pass. But the odds against are so dismal that a hydrocarbon fueled 200 mile per gallon passenger automobile would be more likely to be developed.

We have been tied up with project work and were not able to participate in the interesting, and extensive Oil Drum discussion regarding Vinod Khosla's views on ethanol from lignocellulose.

Better late than never. I present John Benemann's statement below.

Subj: Vinod Khosla FROM Jbenemann

> TO THE OIL DRUM - drumbeat
>
> I read the presentation of Vinod Khosla and most of the responses. I have some experience in this field, about 30 years of being in the ring of biofuels technology development, with first-row seats, so to speak, on the fights I was not in myself.
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> Re. lignocellulosic ethanol, I am, bluntly, a skeptic. See our abstract, copied below. This is R&D, not something ready for commercial ventures, at least not in any time, or with any risk ratio, a typical venture capitalist would accept. Perhaps Vinod Khosla is not a typical VC, though I have no basis for assuming that.
>
> Much more important, this technology is not ready for policy decisions. It compares with, for one example only, the near-late-lamented Hydrogen Program of the Bush-Cheney Administration. Coming from the same source, talk about curing our addiction to Middle East oil by substituting for it an addiction to Middle America ethanol, has just as much credibility. I note that all long-term R&D (is there any other?) for hydrogen is being terminated next month by the Dept. of Energy.

Of course, the issue is not whether Vinod Khosla is making a wise investment, one that will make him even richer and his investors too, or the opposite is true, or even what the Bush-Cheney administration dictates that our reality will be. The issue is, does the technology work now, can it be made to work in short order, or can we predict when and if it will work with any assurance?

One thing I notice from this entire discussion is an absence of any arguments based on technology. I am among other things a biotechnologist, and very familiar with the associated chemical engineering issues. I would have expected at least some mention of past and recent experiences, of problems, such as needs for extensive feedstock pretreatment or problems with fermentations, about current R&D focus, at least a few citations to the web. Nothing. Neither from Vinod Khosla nor the 360 odd Oil Drum respondents.

The only information presented is that Vinod Khosla has invested in three different technologies. Well, a fair enough investment strategy, but even with a one out of three chance, this is a long shot, even in the long term, by which I mean over 10 plus years, beyond which there are no crystal balls.

I strongly support R&D in this field. Money would be better spent on that than on just one commercial plant. Or even a pilot plant. And, let me hasten to add, that it is perfectly possible to make ethanol from lignocellulosic biomass, it's just extraordinarily inefficient, with EROEI easily determined to be about 1:5. The Soviets had some wood-to-ethanol plants running during WWII, and kept them going afterwards, with at least one going on until the Soviet Union collapsed. Not a pretty technology, without even looking at the energy balance (cheap coal or then-cheap Soviet natural gas to expensive state subsidized ethanol, an economic model now adopted for corn ethanol in the US.)

And we, in the U.S., even made butanol from seaweed harvested off San Diego during WWI, in a major industrial enterprise that was set up in a few months, a perfect example of necessity as the mother of invention, and showing how fast we can do something when we need to, for our survival. But extrapolating from making explosives for war to transportation fuels for civilians driving SUVs is more than a bit of a reality stretch. I like the analogy of this being the difference between going to the Moon and Mars, another Bush-Cheney vision, I must note. Of course, we still haven't figured out why to go to the Moon, aside from the feel-good factor.

Bottom line, making ethanol from lignocellulosics is a technical issue, actually many separate technical issues: can we really make 60 or 80 or 100 gallons of ethanol per ton of biomass, can we really ferment pentoses outside the laboratory, will we have a positive energy balance and not run this on fossil fuel as we do corn ethanol? And, coming to the details, can we really use commercial enzymes, or the same fermentation vessels that are used in the corn ethanol business, or do we need to go to very, very expensive contained fermentations. And at the end, do we get a high enough ethanol content in the fermentation beer (above 10%) to have a reasonable distillation cost? And, finally, can we put it all together, starting with the necessary pretreatment of lignocellulose (and what kind at what cost?). Actually, some applications for particular, minor, biomass waste resources, could make ethanol now at food processing plants, breweries and such, but this is not what Bush-Cheney or Gates-Khosla are promoting, to bring up another "venture" investor's name.

Not that Vinod Khosla lacks information - his semi-public presentations on the topic

earlier this year (I saw one of the power point presentations) provide some technology background, which, perhaps not too surprisingly, was almost exactly what was presented just before (or even on) January 31st in the briefing papers for White House, to support the "oil addiction" talk in the State of the Union speech. Another great example of sales of good sounding policy first, supporting facts to be provided later, a well used modus operandi. And now the Bush-Cheney administration has reshaped the federal government funding priorities for biomass R&D, to support their ethanol from lignocellulosics visions.

However, these visions of tens of billions of gallons ethanol per year from biomass must, by all reasonable analysis, be considered a distant possibility not an imminent accomplishment, as is being portrayed. That is the bottom line.

Of course, reasonable researchers will argue about where exactly we are and when and how can we could get there. As one close colleague told me, all the technical problems I talk about (see attached abstract) are actually viewed as "opportunities" by the R&D community. I agree, but there is now the belief that with current high ethanol prices, we have the means to this end at hand. After all, if for the past 25 years we were almost there, according to the National Renewable Energy Laboratory and others working on this. It stands to reason that with ethanol prices two or three times that high we must now be in clover. Right?

Well that is the rub of it. Wrong. We aren't any more "there" or in clover than before. Yes, we can shave down some of the assumed costs to reach such low, low costs, but the assumptions are still there, only slightly closer to reality. Need I point out that there is only one pilot plant operating, Iogen in Canada, at a quarter of initially announced capacity? That is all we really can, and actually need, say about the commercial status of this technolgoy.

Thus jumping on this bandwagon and joining in the suspension of disbelief, which seems to pervade public discourse, outside some participants of this esteemed Peak Oil blog, is premature.

There is more to this argument, however, than just the issue of whether there is real technology (real could be defined, loosely and very charitably as less than $10/gallon of ethanol, or about a $100/mmBtu liquid fuel). The most important question is: what is a better way to use our billion plus ton per year potential biomass resource (and I stress potential, also not real, maybe one or two hundred million tons are real): conversion to ethanol or use for other purposes? Would it not be better to use surplus and waste wood, crop residues, or energy crops (another whole subject) to heat our homes, using wood pellets or even gasification to make heating oils?

And if we really want ethanol from crops, and I would favor some, 10%, to 20%, of our use if ethanol is economically or energetically feasible, would it not be better to grow high starch crops (requiring lower fertilizer inputs than corn)? Then we can make ethanol the way we know how, while using part of the crop residues for the process heat, rather than coal or natural gas. That should be an improvement what we are doing now, the corn to ethanol fiasco.

Well Vinod Khosla is probably correct, as I read him, that there is nothing that can be done about the world as we find it, and the function and reward of capital is to serve the system as is, not as it should be. And when I ask, do we want to drive our SUVs or

freeze in our homes, that is rhetorical, as I do realize that the question is becoming irrelevant, the "we" will include only those who can do both, and they won't really care, any more than any other ruling class has, about those that can't heat their houses or drive their cars.

And a final question, should we, including our venture capitalists, foist on to other countries, let me give India as an example I know of personally, our simultaneously myopic energy policy and visionary technology focus? The answers to this and the prior questions are apparent, they hardly need to be answered, but they are not being sufficiently asked.

So I sincerely wish Vinod Khosla all the success in his enterprises. I hope they work for him and his investors, and for all of us. However, I am not enthusiastic about the free enterprise tail enabling -- or even able to enable -- this preordained policy dog to wag. Bluntly, we should not put our trust and future in ethanol from biomass saving the day. No more than in to that prior canard that H2 would save the day after tomorrow (remember those GM ads so long ago, was it last year, saying that todays' toddlers would get their H2 cars for high school graduation?). And remember all the venture capital that went into those hydrogen companies? Anyone into financial forensics? But that is not our problem.

OK, as I said, reasonable people can argue the merits of this case, but these merits, particularly the technical nitty gritty, have not been argued to the extent necessary in this forum, neither by Vinod Khosla nor the many who responded to this blog. I hope to add to knowledge, in a minor way, by pointing this out, and some of the technical issues, and suggesting that ethanol from lignocellulosics is not something we should count on, any more than most of the other 1970s ideas and technologies being re-floated (biodiesel from algae being a personal favorite of mine).

Yes, biofuels are and will be very important, we are already doing some things, and need to do much more. Much work is required, in many areas, from anaerobic digestion to crop production, and including R&D on lignocellulosics to ethanol. Maybe we will get the proverbial breakthroughs. But multiple barriers must be overcome, and betting the farm on just this one ticket, on only ethanol from switchgrass and such, is foolish in the extreme. And that is, what I am afraid, the Bush-Cheneys are now attempting and the Gates-Khoslas accomplishing. This single rathole could easily consume most biofuels funding and, most likely, nothing real will be accomplished.

Another victory for the fossil-nuclear energy companies?

John Benemann

The following abstract is to be presented August 29th at the Conference on Biofuels and Bioenergy: Challenges and Opportunities, Univ. British Columbia, Vancouver, Canada (see www.task39.org).

ETHANOL FROM LIGNOCELLULOSIC BIOMASS - A TECHNO-ECONOMIC ASSESSMENT

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Proposed lignocellulosic-to-ethanol processes envision a pre-treatment step, to liberate cellulose and hemicelluloses from lignin, followed by a hydrolysis step, to convert the carbohydrates to simpler sugars, and then a yeast or bacterial fermentation step, to yield ethanol, followed by ethanol recovery (distillation, drying). Some steps might be combined, such as in acid hydrolysis (combining pre-treatment and saccharification) or in a simultaneous saccharification-fermentation process. After five decades of intensive R&D, currently only a single pilot plant (Iogen Corp. in Canada) is operating, reportedly producing about one million liters of ethanol per year, though well below its planned capacity.

An independent analysis identified many problems with the currently proposed processes, including the relatively high costs of biomass delivered to commercial-scale plants (which would need to be 200 million liters per year output, or greater, for economics of scale), the problems with pretreatment, the low rates and yields of sugars from enzymatic cellulose hydrolysis, the resulting low sugar and ethanol concentrations, and the overall high energy consumption of the overall process. In addition to not tolerating high ethanol concentrations, genetically engineered organisms developed for combined hexose-pentose fermentations are subject to contamination, which will require prohibitively expensive containment systems.

Even ignoring, as most studies do, such major problems, and using available corn stover and enzymatic hydrolysis, the currently favored biomass resource and process, our techno-economic analysis estimated a cost of ethanol twice as high as that of ethanol from corn. Forest residues and wastes, biomass crops, and municipal wastes are even less promising. The conclusions of this assessment are that none of the existing processes are ready for commercial applications in any foreseeable time frame and that continuing fundamental and applied R&D is required. Some opportunities may exist for near-term applications of cellulose conversion technologies to some specific, modest-scale, agricultural wastes.

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