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Corn Wet and Dry Mills Breakout Session

30 x 30 Workshop
August 1 to 2, 2006
L'Enfant Plaza Hotel
Washington, D.C.

Office of the Biomass Program,
U.S. Department of Energy

August 4, 2006

Corn Wet and Dry Mills Session Attendees

Participants:

Dan Benson	George Kervitsky	Larry Russo
Stan Bower	Mike Knauf	Seth Snyder
Mike Bruce	Mike Ladish	Steve Schnurrer
Vincent Camobreco	Steven Lewis	Jim Spaeth
Bill Choate	Rajita Majumdar	George Sterzinger
Bob Dinneen	Pat Mulvihill	Kevin Stork
Mike Fatigati	Thomas Nelson	Mike Tumbleson
Mathew Janes	Cynthia Riley	Gary Welch
Pam Keck	Hosein Shapouri	

Day 1: August 1, 2006

Note: Vote count in blue.

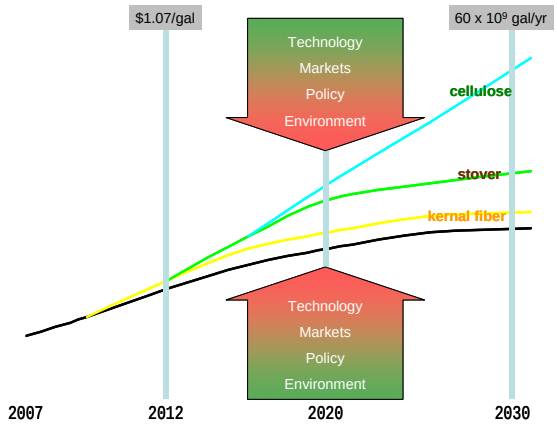
Question 1: Predict volume of ethanol produced from corn in 2012, 2020, and 2030?

***Methodology**: Rapid fire drill around the table*

2012: 7, 7-9, 9-10, 11-15, 12, 12[a], 12-15, 13-14 ……. 7-15 billion gallons
2020: 12-15, 15, 15, 15, 15, 16, 18, 18 ……. 15+ billion gallons
2030: 15, 15, 15-25[b], 20, 20, 25(10-15)[c] ……. 15-25 billion gallons

a – with 2% fiber conversion
b – 25 with the addition of stover
c – 25 if fuel ethanol only, drops to 10-15 after diversion to higher values products

Volume is expected to plateau out in the long term.



Question 2: What are the limiting factors for corn ethanol production growth?

***Methodology**: Worked in five groups of four participants each, voting to identify the major issues*

Broad Factors	Related Issues

Broad Factors	Related Issues
1. What Can You Build? (Resources) This factor especially comes into play in the short term, may be till 2012	• Shortage of materials and labor to build facilities (3) • Serious limitation of "ethanol-capable" contractors (2) • Pace of plant construction will be slow, with couple of years for financing and couple of years to come online • Entire system may have to change to accommodate changes/advancements in part(s) of the process • Financing
2. Farm Economy	• Corn prices, especially in 2008-2009. Good corn prices will fetch a higher ROI, encouraging farmers to plant more and ensuring a supply in future years. (4) • Acreage usage, whether the farmers want to plant corn or other crops like soybean, etc. The farm profitability of ethanol will decide that. (4) • Extent of vertical integration (Is the farmer part of an ethanol coop?). Long-range profitability for farmers would be an incentive. • Price of natural gas used for fertilizer and drying purposes • Losing acreage to development (urbanization)
3. Production Economy (Net Corn Cost)	• Price competitiveness of ethanol with that of other fuels, like gasoline, natural gas, coal-to-liquid, etc. (19) • Limited application of DDGS (high-value coproducts). Extracting protein/burning it will enhance the value and change the economics of ethanol production • Cost of natural gas (3) • Competition with cellulosic ethanol (2) • Cost of waste disposal/handling • Availability and recycling of water
4. Policy	• Renewable Fuel Standard (RFS) mandates (12) • Skilled workforce at mid and upper levels will be needed for later ethanol plants (1) • Global warming (carbon credits, etc.). US does not participate in Kyoto, so ethanol incentive is only from security viewpoint (1) • Infrastructure needs (transportation logistics – getting products to market, etc.) (1) • Cost-sharing for initial plants to alleviate risk (1) • Permits (1) • EU/Worldwise acceptance of GMO corn • Will the new Farm Bill maintain subsidy on corn prices? • Protection from competition with coal to liquid sector • R&D tax credit for companies • Natural gas policy to make its use in fertilizers more advantageous than its use for electricity
5. Other Feedstocks?	• Competition with other starch feedstocks

Question 3. What are R&D needs/priorities to increase production in corn to ethanol facilities?

***Methodology**: Worked in five groups of four participants each, voting to identify the major issues*

Note: The participants felt that there is no critical need for R&D since the industry already has line-up of entities will to put capital into plants and is growing fast. Bottom-line for business is if 15% ROI and 18 month payback is achievable, the business is viable. However, better, faster, cheaper way is always good to increase the business. R&D may help further down in the years. So R&D needs discussion is not what is necessary in the near-term but what might improve the situation in the longer term.

- Organisms for more productive fermentation. The microbe should be robust and AAFCO approved for animal consumption. Also allow simultaneous co-fermentation of C_5/C_6 sugars. (20)
- More high-value products from C_5/C_6 sugars. Technologies are needed that allow for economic recovery of co-products. This is critical to accelerated growth of ethanol industry. (13)
- Energy-efficient distillation/separations (8)
- Cost-effective recovery of ethanol and other products. Currently, 80% of production costs are from ethanol and product recovery. (7)
- C_5 conversion (7)
- Alternate sources of power (5)
- New fermentation processes (Zeachem process, butanol, etc.) (3)
- Utilization of emitted CO_2 (dry ice, liquid CO_2, enhanced energy recovery, …) (3)
- Advanced fractionation technologies (2)
- Oil extraction technologies (1)
- Alternative pretreatment of entire kernel as opposed to fractionation or DDG methodology (corn dry mills)
- Alternate feedstocks
- Accelerate steeping to improve throughput

General Recommendations for OBP

- Rename “Corn Dry Mills” as “Corn Dry Grinding Mills” in all DOE documentation since world over, “corn dry mills” is unanimously referred to mills producing grits for cereals
- The industry works in dry tons not bushels.
- Include the titer of ethanol when reporting yield/production – yield on its own does not tell you the extent of processing required.

Day 2: August 2, 2006

***Methodology**: Worked in 3 groups, one on wet mills and two on dry grinding mills*

Question 1. What are R&D needs, barriers, and success metrics for ethanol production from corn fiber?

Corn Wet Mills Discussion		
R&D Need	Barriers	Success Metric
1. Organisms for C_5/C_6 fermentation (10)	• Robustness • Co-fermentation • FDA/AAFCO-approved residue • Cost for developing the organism	• 90% conversion of C_5s • Rate equivalent to that for glucose • 8% minimum ethanol tolerance • Successful feeding trials
2. Lower cost of enzyme conversion (saccharification of cellulosic glucose)	• Enzyme cost o protein loading o production costs • Fiber-optimized enzyme cocktail. Each enzyme will be substrate specific.	• $0.11/gallon of ethanol for enzyme conversion. Currently, it costs 25 to 39 cents per gallon (this is a rough estimate as integrated plant costs are not understood well).
Maximum expected ethanol from fiber: 5 to 10% increase over the production from starch (10% received the maximum votes) **Feasibility of ethanol from fiber**: Depends on the overall cost of production, i.e., whether it is more economic to process more corn to increase the production or more economic to process the kernel and fiber to obtain maximum ethanol.		
General Concerns: • Lot of investment will be needed to convert fiber into ethanol – will be expensive. A yield of 3/10 gallon per bushel was estimated. As per Pam Keck, a new technology is ready that will increase the yield by 10%, but $5 million of initial investment is needed to try out the technology. • What can be done with residual product – feed it, burn it, or convert to higher value product?		

Corn Dry Grinding Mills Discussion		
Benefits: Taking out the fiber will increase the value of DDG, reduce the volume and may expand the market. Processing of whole kernel is economically feasible since yield increase by 3% will increase the profits. Will require less energy to dry DDG and do away with the need to hammermill, saving costs.		
R&D Need	Barriers	Success Metric
1. Microbes capable of C_5/C_6 conversion for 8 to 10%	• Robustness	• 80 to 100 gm/liter of ethanol

titers	• Industrial-scale quantities • Current technology allows only 5 to 6% conversion	• 40 hours or less for fermentation • Resistant to inhibitors
2. Efficient pretreatment and hydrolysis of corn fiber, including fermentation inhibitors	• What will happen to the syrup? (burned, new co-products, …) • How to use the minerals in the ash? (fertilizer, soil conditioner, etc.) • How much fiber should be left behind to carry the protein in DDG?	• $0.11/gallon of ethanol – enzyme cost • Establish Btu value of syrup as fuel source (syrup can not be used as feed)
3. Identify liquid/solids handling needs that must be considered in equipment design /strategy (understand properties)	• Lack of data on physical properties • High viscosity/complex properties • Lack engineering data on material properties	• Development of data
4. Improved milling and fractionation technologies	• Lack of value for co-products (new applications are required for oil, fiber) • Regulatory approval for food use	• New products (triesters, purified oils, tocopherols, nutraceutical compounds, etc.)
5. Optimization of fiber pretreatment for maximum conversion and minimum costs	• Formation of microbial inhibitors	•
6. Evaluate the 3 different paths for fiber to ethanol conversion for cost comparison – process whole; fractionate fiber and then process; or convert to DDG and then process the fiber;	• Lack of data for cost comparison • Resistance to changes in the mill process • Economics • Co-product quality • Separate streams	• Determining whether maximum yield is more cost effective than grinding more corn (marginal cost for producing ethanol)
Maximum expected ethanol from fiber: 5 to 10% increase in ethanol production (10% received the maximum votes) A 3% increase is expected from cellulose and a further 6% increase from hemicellulose when microbe is available for its fermentation (Pam Keck).		
General Concerns: • Mycotoxin in DDGS is a concern although it will not impact DOE research efforts. • With less fiber, will drying of protein be difficult? • Economically, whether it is worth at all from fiber, although it may eventually lead to bigger things		

Question 2. What are R&D needs, barriers, and success metrics for ethanol production from corn stover?

Corn Wet Mills Discussion		
R&D Need	Barriers	Success Metric
1. Evaluate the next best feedstock	• Complex as it will vary because of geographic availability of the feedstock	• Profitability • Knowledge base
2. Compatible pretreatment processes for cleaning, grinding, and traditional chemical treatments	• New terrain – processing cost is unknown • Abrasiveness	• Synergistic economics with other plants • 15%ROI
3. Assess whether gasification possible as fuel to displace natural gas. (Gasification fits better for electric cogeneration and chemical processing)	•	•

Corn Dry Grinding Mills Discussion		
R&D Need	Barriers	Success Metric
1. Require new infrastructure with separate methods for pretreatment (for starch, herbaceous, wood, etc.), hydrolysis, fermentation and downstream recoveries. (Stover will not be good alone and some flexibility/optionality will be needed in feedstocks	• Cost • Limited existing markets for DDGS	Marginal costs are competitive with • $/gallon of ethanol • $/ton DDGS • $/million Btu
2. Evaluate various biomass, including stover, for existing plants such as Gatty and Fischer-Tropsch	• Costs • Pretreatment • Value of co-products	• $1.07 to $1.50
3. Optimization of pilot-scale plants – should kernel plants stay as is or have new ones that combine kernel/stover processing	• Separate stover and kernel plants will involve two plants and probably reduced value • Combined stover/kernel	•

	processing will require co-processing technologies	

Question 3. Is DDGS a limiting factor on future growth of corn ethanol?

Overall, DDG will not limit the growth of alcohol market. However, some R&D needs were identified as below:

R&D Needs:

- Optimize DDG combustion systems since the floor price of DDG is equal to that of fuel.
- Develop technologies for protein and oil extraction from DDG. This will help in applications of DDG – feed for monogastric livestock (w/o fiber), protein human food and polymers. For use as feed, it is extremely important that the feed be of consistent quality/composition – an important criterion for buyers for quality control purposes.
- Pelletizing DDG for no-stick flowability. This will enable easier transportation.

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Appendix: Agenda for Corn Wet/Dry Mill Breakout

AGENDA Day 1 (10:45 – 3:40) What role does grain milling play in contributing to meeting national and OBP goals for biofuel production?

Introductions - Facilitation - Housekeeping- Personal Goals (10:45 – 11:00)

Bottlenecks and Limits (11:00 – 12:00)

At some point there is a practical volumetric limit to grain-based ethanol production. What are the limiting factors?

Business as Usual	Single Plant Limit
New Business Model	National Limit

← LUNCH

Internal Technologies and Practices (12:20 – 1:45)

What are the technology and/or practices barriers to improve the performance of starch to ethanol?

← BREAK

External Raw Materials and Existing CoProducts (2:00 – 2:30)

What factors associated with raw materials and co-products limit or contribute to the practical volumetric limit?

Institutional & Policy Change (2:30 – 3:20)

What changes (institutional and/or policy) need to occur in order to increase the practical volumetric limit?

Report Out Briefing 3:20 – 3:40 Plenary *3:55- 5:30 Day 1 Results*

AGENDA Day 2 (8:00 – 12:00) How is other biomass (corn fiber/stover, cellulose, …) incorporated into the milling industries to boost production of ethanol?

Welcome Day 2 - Housekeeping (8:00 – 8:10)

Corn Fiber Technologies and Practices (8:10 – 9:00)

What retrofit technologies and/or practices would need to be installed to convert fiber in existing operations (new operation)?
How much could this contribute?
What are the R&D needs?
What about policy?
What price of conversion makes this “interesting”?

Corn Stover Technologies and Practices (9:00 – 10:15)

← BREAK

What retrofit technologies and/or practices would need to be installed to convert stover in existing operations (new operation)? Etc…

Cellulose Technologies and Practices (10:15 – 11:30)

What retrofit technologies and/or practices would need to be installed to convert cellulose in existing operations (new operation)? Etc…

Report Out Briefing 11:30 – 11:45

Actions /Parking Lot /Exit 11:45 – 12:00 *12:15 Lunch* Plenary *1:30- 3:45*