Technology to Achieve New Goals for U.S. Ethanol Industry

Commercial Ethanol Technology and Research Workshop
Decatur, Illinois
October 29, 2008
Delta-T Corporation Overview

• Founded in 1984, headquarters in Williamsburg, Virginia
• Track record of innovation in ethanol technology
• Major stakeholder in existing ethanol industry
• Technologies that can be applied to many feedstocks
• 25+ plants in operation, numerous projects in progress
• Since July 2007, a subsidiary of Bateman-Litwin, an international oil, gas and energy EPC contractor
### 33 Plants in the US & Canada

<table>
<thead>
<tr>
<th>STATE</th>
<th>CITY</th>
<th>NAME</th>
<th>CAPACITY</th>
<th>ONLINE</th>
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<tr>
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<td>2009</td>
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<td></td>
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<td>Terra Grain</td>
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</table>
Ethanol Technology World Wide
Robust, Industrial Grade Design and Build

- Plants exceed nameplate
- Guaranteed at 350 days/yr – exceeded in operations
- Long life expectancy
- Flexibility in operations
- Upgradeable, Customizable
- Lower maintenance costs
- Financeable. Proven.
Ethanol Market Indicators

- Ethanol consumption continues to outpace new supply
- Ethanol imports continue to rise
- Ethanol lowers price at pump – with or without incentives
- Midrange fuel blends (E20, E30, E40) have been tested favorably for emissions performance and compatibility in standard vehicles
- Consumer acceptance of E85 growing rapidly
- Automakers committing to more FFV’s
- Transportation and logistics facilities are quickly being added to handle new supplies coming into the marketplace
Top 10 Crude Oil Import Sources vs. U.S. Ethanol Contribution (Gasoline Equivalent)
EISA 2007 Perspective from Industry

• Delta-T and our competitors assessing cellulosic ethanol for decades

• Conventional ethanol plants can meet overall objectives of Bill – Reduced GHG and Fossil Fuel Inputs, Increased Domestic Production

• Incremental steps to commercialized cellulosic ethanol to happen first at existing ethanol producers

• Legislative Support is important to finance projects, continue growth

• Do definitions in Sec 201 of EISA 2007 impede commercially viable and proven technologies, ongoing agricultural development, job creation, and energy trade balance?
The Energy Independence and Security Act of 2007

OVERALL EISA GOALS
Energy Independence & National Security
Reduction in GHG Emissions and Carbon Footprint

- Increase domestic fuel production
- Reduce fossil fuel inputs
- Reduce emissions
- Increase use of other renewable feedstocks
- Minimize impact on food prices and resources
- Plants, infrastructure have to be financed and built
The Energy Independence and Security Act of 2007

DELTA-T TECHNOLOGY GOALS

- Increase production capacity
- Decrease energy use in production
- Reduce or eliminate fossil fuel inputs
- Increase utilization of renewable feedstocks
- Reduce GHG emissions and carbon footprint
- Sustainable agriculture markets, Food and Fuel
- Financeable Projects, Manageable Risk

*Industry goals and EISA 2007 objectives are a match!*
Grain to Ethanol Technology Advancements

• Corn Fractioning Systems - Food, feed and fuel production

• High Efficiency Drying - Integrated closed loop (Delta-T)

• Biomass Energy, Power and CHP

Potential to reduce fossil fuel inputs to zero, carbon footprint to net negative with power export to offset coal

• Utilization of industrial emissions and non-fossil fuel sources for process energy and power

• Ongoing process integration & continuous improvement

*Corn to ethanol can be as efficient as sugarcane to ethanol with implementation of low risk, proven technologies, food accounting*
Fossil Energy Inputs for Ethanol

Fossil Energy Use (BTU / mmbtu)

Gasoline: Continuous improvements, low-risk proven technologies
Corn Ethanol: Many of the same technologies in corn ethanol required here
Cellulose Ethanol (Projected)
DST – Dry Separation Technology

PERICARP / BRAN
Protective covering of kernel

GERM
Germ contains corn oil, most valuable part of the corn. Increasingly preferred in food markets.

ENDOSPERM
Contains nearly all of the kernel starch (used for ethanol) and protein for animal feed.

TIP CAP
Attachment point of kernel to the cob.

- Separates corn into germ, bran and endosperm
- Reduces energy required for production
- Germ - high quality feed or for food production (corn oil)
- Bran - feed and combustion value, small food market
- More ethanol per facility and higher protein animal feed products.
- Significant profit enhancement and risk mitigation

Only starch is converted to ethanol!
## Energy Savings Implications

<table>
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<th>Process</th>
<th>Current Base Case*</th>
<th>Expected with DST™</th>
<th>Energy Savings</th>
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<td>19,640</td>
<td>1,960</td>
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<tr>
<td>Dryer</td>
<td>13,440</td>
<td>8,900</td>
<td>4,540</td>
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<tr>
<td>Total</td>
<td>35,040</td>
<td>28,540</td>
<td>6,500</td>
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</tbody>
</table>

* Design basis numbers based from mass and evaporative loads, not operations

All values in BTU/gal UDA, assumes 100% dried feed with solubles (DDGS)
High Efficiency Drying (HED)

- Barr-Rosin Ring Dryer that uses no combustion gases in feed drying chamber
- 90% Dryer Emissions Reduction
- Produces nearly pure steam - condensed in the evaporator to recover the energy and water
- Can run on solid fuel – woodchips, coal, non-fermentables, other waste streams
- Reduced Fire Risk – No / very low oxygen in drying chamber
- Does require some process water treatment capacity
- 2 in operation – China, Wisconsin
Dry Mill Plant Energy Breakdown

- Grain Drying: 38%
- Evaporation: 25%
- Distillation/Dehydration: 28%
- Cleaning/Inefficiencies: 3%
- Fermentation: 0%
- Mash Preparation/Cooking: 6%
Waste Heat Reuse Effects

HED™ Plant Energy Breakdown

- Grain Drying: 38%
- Distillation/Dehydration: 28%
- Energy Reduction: 24%
- Evaporation: 2%
- Cleaning/Inefficiencies: 2%
- Fermentation: 0%
- Mash Preparation/Cooking: 6%
HED +DST Technology

Energy Consumption: 21,000 BTU/ Gallon
Biomass Energy, Power, CHP

- Biomass boilers – solid fuel and fluidized bed
- Biodigestion to biogas
- Gasification to producer gas / syngas
- Combined Heat and Power (CHP)
- Gas or Steam powered turbines
- Use of Landfill Gas and other Industrial Emissions
- Corn fractions can be used as energy source

Reduce fossil fuel use, increase capacity, reduce GHG

All are Incremental Steps to Cellulosic Technology
Grain Handling → Corn Fractioning

Ethanol Plant

Starchy Endosperm

Bran

Germ

Oil extraction or expelling

Oil

Corn oil

Spent Germ

Steam to turbine or ethanol plant

Biomass Boiler, Biodigestion, Gasification

Cobs, Ag residues, Woodchips, MSW

Syrup, Stillage

Catalysis to alcohol

Ethanol storage

Steam (energy) from nat gas boiler

Power (grid)

Fuel Ethanol

High Protein Distillers Grain

Power

Hi protein syrup

Option 1 Blend

Dryer HED option

Wetcake HPD or HPDS to regional livestock feedlots

Dried HPD or HPDS to storage

Power (grid)

Steam/Gas powered turbine
## Conventional Biofuels - Corn Availability

### Domestic Sources and Uses of Corn

<table>
<thead>
<tr>
<th>Market Year</th>
<th>Production</th>
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<th>Feed</th>
<th>Exports</th>
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<td>2007</td>
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<td>2,750</td>
<td>1,782</td>
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</table>

Food, feed and export use at or above 10 yr averages in 2007

U.S. Corn Output has risen by 70% per lb of fertilizer since 1970’s
What should be done with a US corn bushel?
Exportable and domestic food, feed and fuel

2010-2013 Scenario

• At projected 15 billion bushels (85 mm acres, 175 bu/acre yield):

• All other corn markets at or above 10 year averages – no “food vs. fuel” or indirect land use implications

• 6 BB bu of corn for ethanol = 17 BB gal ethanol, 54 mm tons feed
• Market value of products = $50 billion
• Displaces 500 million bbl imported oil = $65 billion

Net swing of over $100 billion to US revenues, compared to non-value added whole corn feed export and crude oil imports
Export Demand for Corn and Grain-fed Meat

U.S. Corn Availability

Grain for US Ethanol, China Meat, vs. US Corn Production 1995-2007 (million tonnes of grain)
Advanced and Cellulotic Biofuels Definitions

**Advanced Biofuel** - renewable fuel other than ethanol derived from corn starch, derived from renewable biomass, achieves a 50 percent GHG emissions reduction. The definition of advanced biofuels include cellulosic biofuels and biomass-based diesel. 50 percent GHG emissions reduction requirement may be adjusted to lower percentage (but not less than 40 percent) by EPA if determined the requirement is not feasible. (Cellulosic biofuels that do not meet 60 percent threshold, but do meet 50 percent threshold, may qualify.)

- Corn ethanol singled out (almost entire U.S. industry)
- Wheat, sugarcane, other grain crops qualify (?)
- Corn to ethanol companies are major stakeholders in industry and first to implement new technologies
- Existing plants can be upgraded to achieve quantified targets
- Bill written at peak of anti-corn-ethanol publicity campaign
Delta-T Technology - Advanced Biofuels

• Wheat, small grains – three plant designs, two plants in operation
• Milo (Grain Sorghum) – based on economics, good in dry climates
• Sugar, Sweet Sorghum – partnership with Arkel, Alfa-Laval in 2007
• Cassava – plant in operation, mixed feedstock with molasses
• Bio-and Iso-Butanol – current designs could be modified

CONVENTIONAL PLANT UPGRADES UTILIZED in ADVANCED BIOFUELS:
• Grain and sugar technology is similar
• Cellulosic biomass combustion and gasification (for heat, power, CHP)
• Corn fractioning similar to debranning and dehulling for other grains – improves efficiency and co-product values
• Biodigestion to biogas for energy / power (could also be catalyzed into cellulosic ethanol)
Delta-T Technology – Cellulosic Biofuels

20 YEARS of R&D – NO COMMERCIAL IMPLEMENTATION TO DATE

Sugar Platform
• Pretreatment, Acid or Enzyme Hydrolysis
• Yeast Fermentation, C5 Sugars, Co-products recovery
• NREL standard is enzymatic hydrolysis with byproduct combustion

Bugs
• Microbial breakdown and fermentation to alcohol

Gasification
• Thermal Gasification to SynGas (CO and H₂)
• Building block to Ethanol and other chemicals
• Existing, densely accumulated, low cost feedstocks
Delta-T Technology – Cellulosic Biofuels

- Partnerships, Project focused
- Continuous improvement vs. “Next generation”
- Leverage experience and track record in finance, permitting, project execution, startup support and staff training

CONVENTIONAL PLANT UPGRADES UTILIZED in CELLULOSIC BIOFUELS:
- Cellulosic biomass combustion
- Biomass gasification is “first half” of thermochemical process
- Grain fractioning produces homogenous cellulose streams
- Cobs as part of corn harvesting – ideal cellulosic feedstock
- Fermentation, Distillation, Dehydration, Evaporation, other process systems similar in sugar platform cellulose technology and conventional plants
Biofuel by EISA 2007 Definition

- Current Production
- Conventional Biofuel
- Advanced and Cellulose

BioFuels in billions of gallons per year

Year: 2000 to 2022
The Energy Independence and Security Act of 2007
Incremental Steps from now to 36 billion gallons

• Existing producers first to implement new technologies to reduce GHG, improve efficiency

• New technologies are necessary for cellulose and advanced biofuels to achieve GHG and efficiency targets, too.

• Corn to ethanol “cap” at 15 bbgy in EISA 2007 will impede overall bill objectives, unless “Conventional” plants have incentives, and measured by same standards as other fuel technologies

• Indirect land use – has to be fair and accurate (most industry assumptions use no new land, no decrease in exports)

• GHG Ag inputs and ethanol production impacts continue to decrease
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Paul Kamp
Business Development
pkamp@deltatcorp.com
773-360-7710