the energy of innovation™

Future Opportunities and Challenges for Ethanol Production and Technology

Presented by

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Introduction

- Today's ethanol industry
  - Grain based
- Tomorrow's ethanol industry
  - Grain based advancements
    - Globally starch long and protein short
    - Food and fuel
  - Cellulose technology and processing options
    - Sugar platform/Thermal platform

Fifty years ago, the U.S. fed the world

Tomorrow, we can help do that again

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ICM History

Privately held company founded in 1995 in Colwich, KS.

Employs more than 750 people with focus on sustaining the agricultural industry through innovation by engineering, building, and supporting the global biofuels industry.

Two research and development facilities:

Lab-scale research center in Colwich, KS

Lab- and pilot-scale facilities in St. Joseph, MO

ICM Experience

- 60 grain-based plants operating in North America and more than 25 under construction.
- Largest technology provider in the world for corn-based ethanol.

See an interactive version of our project portfolio at icminc.com.

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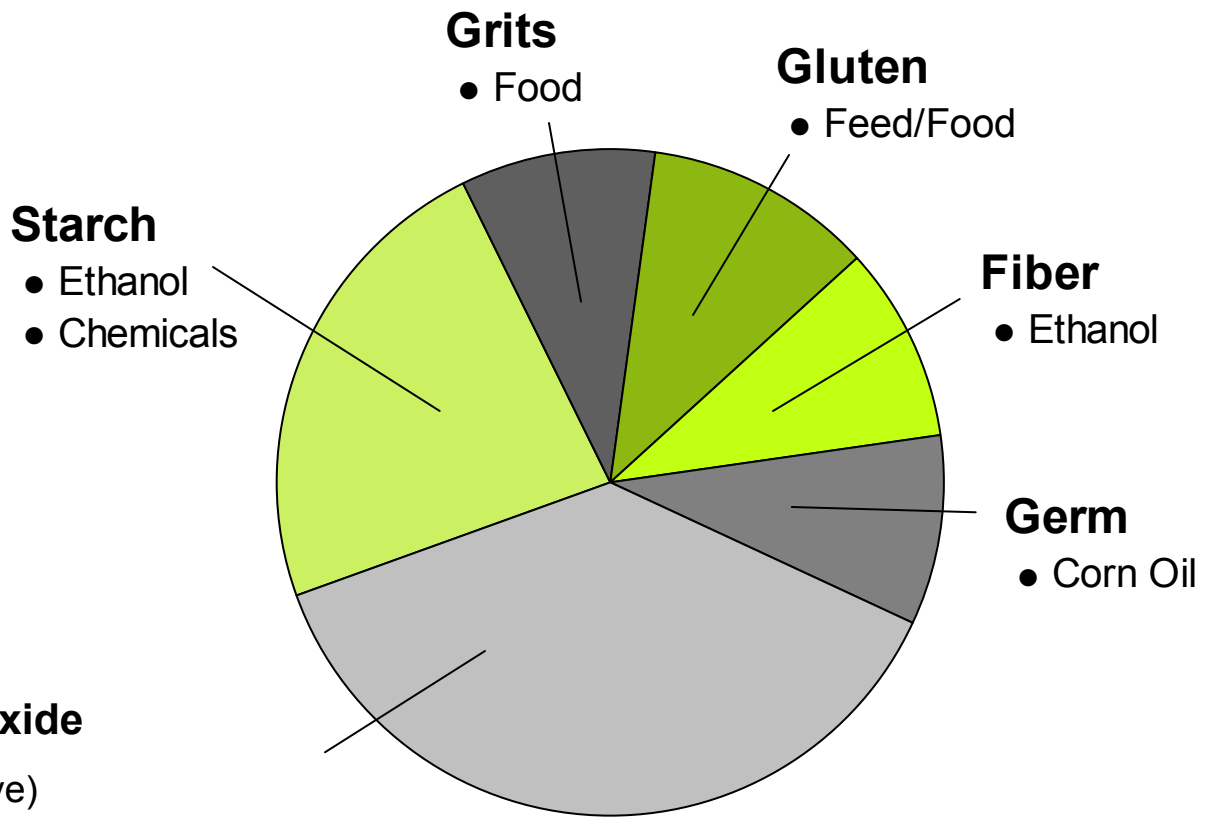
Grain Based Fermentation

- Maize based (corn kernel)
  - ~95% of US industry ferments corn kernels
  - Other starch based
    - **Grain sorghum (milo)**
    - **Small grains (wheat, barley, rye, triticale)**
- "Typical" new dry grind plant today
  - Ethanol: 2.8 gal/bushel corn
    - 96 gallons per dry ton
  - DDGS: 18 lbs/bushel corn
  - CO2 capture where economics allow
  - > 98%+ up time
  - Emissions below 100 tpy
    - **(NOx, VOC, PM, CO, SOx)**
  - Higher focus on DDG quality
- Fuel ethanol produced exclusively by fermentation
  - Plant consumption per gallon ethanol
    - **< 32,000 BTU**
    - **< 0.75 kW electrical input**
    - **< 3 to 4 gallons water**
      - **Majority of water needed for cooling**

Grain Advancements - LifeLine Foods, Energy & R&D Facility

- Goal—Demonstrate new technology for grain-fed plants
- Pilot plant investigates both forms of ethanol production from cellulose
  - Sugar platform – converting corn fiber to ethanol
  - Thermal platform – converting corn fiber to ethanol

Dry Fractionation and Grain Processing Optimization



Carbon Dioxide

- Food (positive)
- Sequestration (more positive)

Tomorrow, Cellulosic Ethanol?

- What is cellulosic ethanol?
  - Ethanol derived from non-starch or sugar biomass
    - Ag residues - corn stover, wheat straw, sorghum stubble
    - Dedicated energy crops – switchgrass, miscanthus, big bluestem, sweet sorghum, forage sorghum, softwood trees
    - Wood waste, solid municipal waste What is cellulosic ethanol
  - Typically structural components of biomass
    - Cellulose
      - C6 polymer
    - Hemicellulose
      - C5 and C6 polymer
      - Different based on source (corn, wheat, grass, trees, etc.)
    - Lignin
      - Complicated, not able to ferment
      - Monomers similar to oil in nature

Biomass Sources

Sugarcane

Wheat Barley

Corn Starch

Corn Fiber

NEAR TERM

Switchgrass

woods

Stover

Wood Chips

Paper

ABUNDANT
& AVAILABLE

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Purchase, Collection and Transportation

- Biomass purchase
  - No good infrastructure exists
  - Market not very well developed compared to grain
- Collection
  - Harvest window different for grain vs biomass
    - Corn kernels harvest window wider than stover
  - Quality of grain easy to control
    - Drying facilities, uniform crop, good agronomic practices
    - Stover and residue crops
      - Entrained dirt, moisture and biological contaminants
- Transportation
  - Biomass 1/5 density of grain
  - Biomass does not convey well
    - Grain flows like water
    - Well developed systems for moving and storing

Volume for Conversion

Amounts of feedstocks to produce 10 mL ethanol

<u>Moisture Content</u>

Corn 15%

Fiber 46%

DDG 64%

Stover 5%

NCERC, 2006

Sugar Platform

- How is cellulosic ethanol produced?
- Two fundamentally different routes, sugar or thermal
  - Sugar platform
    - 1) Chemical and enzymatic hydrolysis (pre treatment)
    - 2) Fermentation similar to current grain-based ethanol
    - 3) Distillation and dehydration of ethanol
    - 4) Generate thermal and electrical demand from lignin
    - ***Positive – uses similar technology to today's plants***
    - ***Negative – process very specific to feedstock***
    - ***Needs lots of water, wastewater issues, GMO ethanologens***

Thermal Platform

- Thermal platform
  - 1) Synthesis gas produced through high heat (1000-3000˚F)
    - Often high pressure 150 to 1500 psi (300 to 600 psi)
  - 2) Catalytic conversion to ethanol
  - 3) Dehydration of ethanol
  - 4) Co-generation of heat and electricity from biomass
  - ***Positive – "universally" applicable***
  - ***Low water needs***
  - ***Negative – similar to oil refinery in complexity***
  - ***Ash will need disposal***
  - ***Generally does not scale down very well***

Cellulosic Potential

- What are the challenges
  - Production costs are high
    - Capital is 3 to 6 times starch plant
    - Operational costs significantly higher
  - Technology is not proven
  - No commercial plants today
- What is the potential?
  - Theoretical is up to 140-150 gallons/ton
  - Practical limit is closer to 100 gallons/ton
  - First plants will be around 50-70 gallons/ton
    - Grain based today is ~96 gallons/ton
  - ~ 60 billion gallons ethanol in US from biomass

Renewable Energy Needs

- Need liquid fuels (ethanol) from grain and cellulose for sustained energy independence
- When will we see commercial cellulosic ethanol?
  - 8-10 years before significant impact in agriculture
  - Will see small demonstration plants sooner
  - Success of demonstration plants will foster commercial facilities
  - Various goals by federal government and national interests

    R.F.S. 25 x 25, 30 x 30, 20 in 10
- What is really happening to slow progress?
  - $1 Billion a day leaves U.S. for fuel imports
  - Ethanol's customer is also its competitor
  - Ethanol as fuel currently is discounted to gasoline when tax incentive is included

Renewable Energy Needs

- What did the Energy Bill address?
  - New and expanded Renewable Fuel Standard based on gallons and carbon reduction
  - Authorizes significant funding ($500 million annually) for advanced biofuels with 80% lifecycle GHG reduction
  - Authorizes grants for installation of refueling infrastructure for E85

What is yet to be addressed?

- No biofuels tax provisions or extensions were part of the Energy Bill – the secondary tariff on imports currently expires 1/1/09 and the blender's credit expires 12/31/10
- Some biofuels tax provisions may be included in the Farm Bill
- EPA implementation of the GHG and carbon reduction rules will have a tremendous impact on current and future technology

Ethanol - a part of the bridge to our energy future

- Continuous improvement in the grain-to-ethanol industry (food and fuel)
- Commercializing cellulose ethanol
- Engine optimization favoring renewable fuels at higher blends
- Blender pumps that allow consumers to choose blend
- Continued development of a flexible fueling and terminal infrastructure
- Hybrid vehicles
- Implementing other sources of renewable energy – wind, solar
- Nonpartisan federal based program for advancing bioenergy

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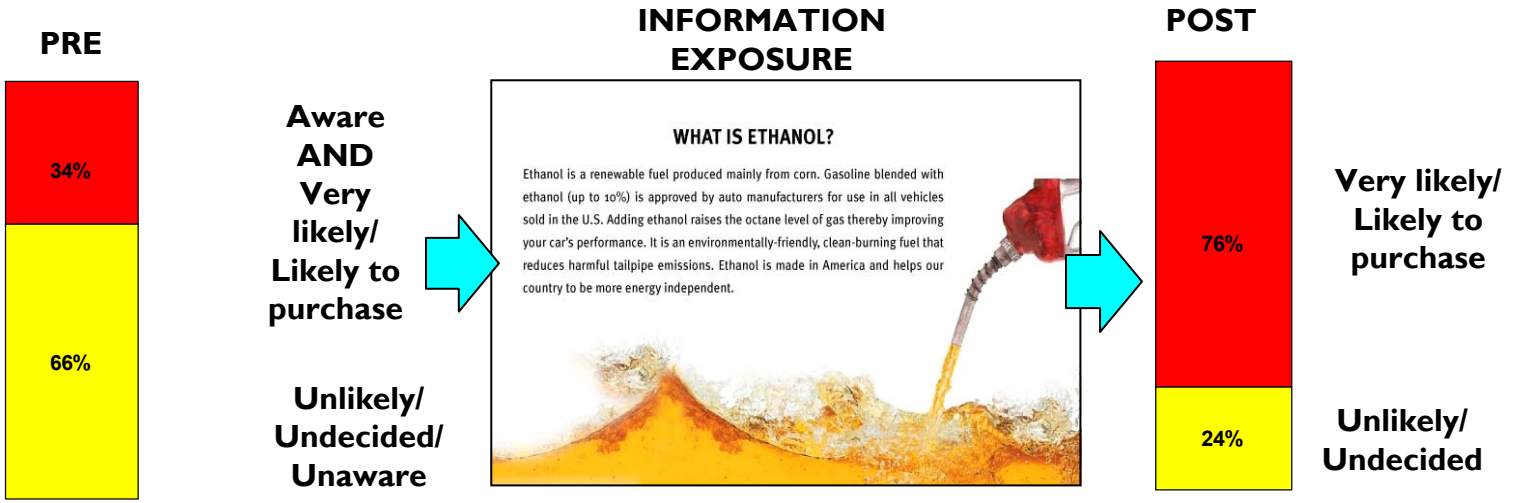
EPIC - Creating Consumer Demand



Research showed 1 in 3 consumers consider themselves aware of ethanol and likely to purchase. After exposure to the benefits, 3 in 4 would choose ethanol.

So what does the future hold?

"We are all faced with a series of great opportunities brilliantly disguised as impossible situations."

- Charles R. Swindoll

For More Information

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Helpful websites:

ICM: icminc.com
Ethanol: drivingethanol.org