
Accelerating Production of Advanced Biofuels with Industrial Biotech Breakthroughs



BIOMASS 2008
Conference



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Can Biotechnology Save Ethanol? Wrong question

United Press International. 

Energy - Analysis

Analysis: Can biotechnology save ethanol?
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By RICHARD M. SAWYER
UPI Senior Writer

Even ethanol's most ardent proponents are beginning to wonder if the industry's days are numbered.

Traditional corn ethanol has reached a dead end in the popular press lately due to concerns over energy costs and concern of more bio-fuels fueling climate change.

Non-experts often agree with these assertions, but smart investors don't agree that biotech ethanol is not viable. In fact, new biotech options could revolutionize ethanol.

Debtors' experts say this potential could reduce ethanol's price tag to \$1.50 per gallon, as well as a host of other benefits. But some big oil companies think ethanol is never more than a long shot.

As a result, some experts have expressed doubt over whether the biofuels industry will be able to meet the new Renewable Fuel Standard, which requires that 20 billion of the 35 billion gallons required by 2008 come from "renewable sources," or non-fossil fuel oil.

U.S. EPA: Our critics think the agency under Bush administration did nothing to help the industry.

"With the situation as it is right now, we don't think that renewable portions of ethanol produced after 2002 will be sufficient to meet the new RFS targets," Dan Weiss said in a Senate Energy Committee hearing.

Non-experts' responses diverge. "The pushers may be overstating all kinds of benefits, they say, and lead to unnecessary restrictions on a range of green."

The biofuels industry is making living organisms—usually yeast plants—to produce ethanol better. In the next 20 years, biotech ethanol targets to revolutionize the agriculture industry, as biotech yeast varieties with higher yields, increased drought resistance and other positive qualities emerge on the marketplace.

The long-term change will occur in the ethanol industry, as biotechnology drives a larger role in fuel production, says Mark Elson, spokesman for Cargill, a biotechnology company that focuses on biofuels development.

The RFS2 aims for biotechnology gas stations throughout the United States to have 20 percent of their fuel come from ethanol. Cargill and U.S. Biofuels International, "biotech ethanol" already says, are leaders in the industry and adding to their resources.

Non-experts are working on developing a wide variety of products to address different aspects of the process, from field to fuel station.

Can biotechnology breakthroughs help us meet the Renewable Fuel Standard on schedule and in a sustainable manner while helping us produce more food for the world? Answer: YES

Why We Can't Afford for Biofuels to Fail: Rising Global Energy Demand



Biotechnology Breakthroughs Improving Biofuels

■ AGRICULTURAL BIOTECHNOLOGY

- Improving crop yields per unit of land
 - Increasing ethanol production efficiency
 - Increasing hardiness and survival of crops
 - Developing new dedicated energy crops

Biotechnology Breakthroughs Improving Biofuels

■ INDUSTRIAL BIOTECHNOLOGY

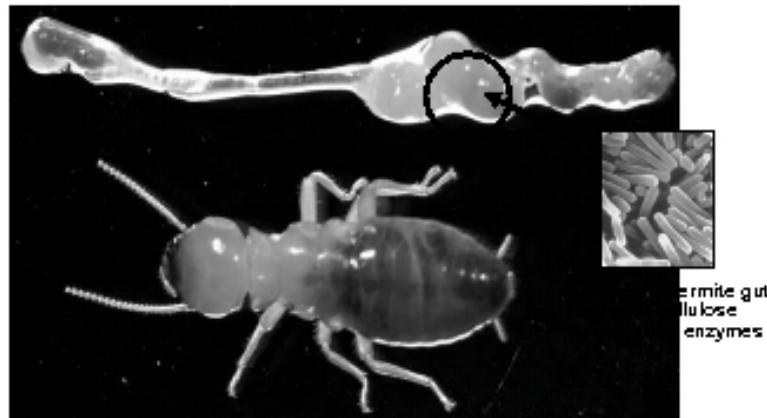
- Improving conventional ethanol production
- Enabling commercial scale cellulosic ethanol
- Developing bio-butanol
- Researching and developing renewable hydrocarbons

Microbes and Fungi Found in Nature--Used to Make New Biotech Enzymes



Source: NOVOZYMES

One source of new cellulase enzymes



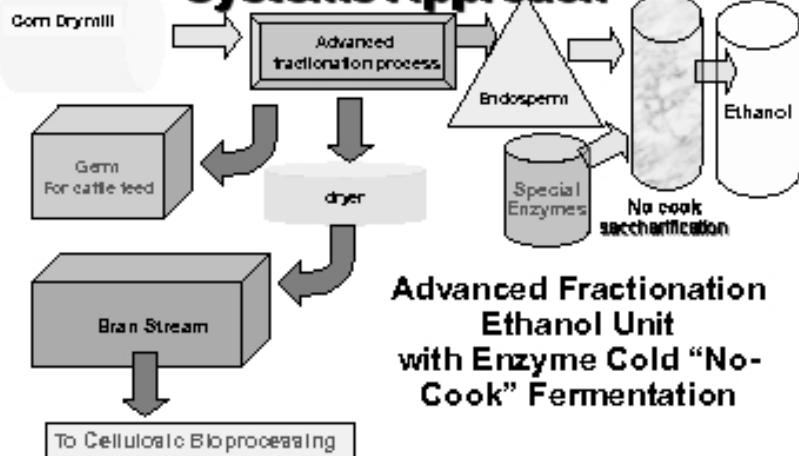
The Pacific Damp wood Termite
Zootermopsis angusticollis

Courtesy of Jared Leadbetter, CalTech, Pasadena, CA

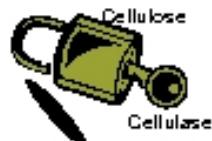
Conventional Ethanol Improvements

- More efficient grain fractionation increases efficiency and creates a new cellulosic feedstock stream
- New biotech enzymes for "no cook" saccharification—increase efficiency and reduce energy inputs and CO₂ outputs
- Increases ethanol yield by 6% per bushel of corn

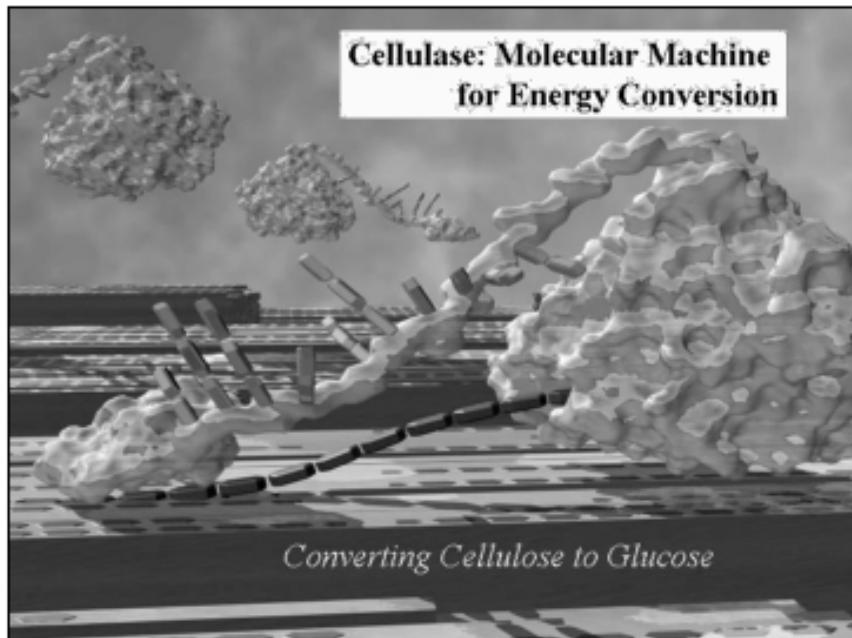
POET Advanced Fractionation Systems Approach



Enabling Cellulosic Ethanol



- Cellulase enzymes are the key to cellulosic ethanol
- These enzymes are produced by genetically enhanced microbes or GEMs and they convert the tightly bonded sugars in cellulosic plant matter into individual 5 carbon and 6 carbon sugars.
- These sugars (glucose and xylose) are then available for fermentation to ethanol or other products by other microorganisms.



Fermentation of Cellulosic Sugars



- Xylose (a 5 carbon sugar) is not readily fermentable by common industrial yeasts
- NREL and others developing new organisms that can efficiently ferment 5 carbon sugars to ethanol or convert them to other fuels
- Organisms also being developed to co-ferment 5 and 6 carbon sugars in one step

logen's Pilot Plant in Canada



Wheat Straw Feedstock



logen Planned Commercial Scale Unit 2008-2009

- Will use wheat straw as cellulosic feedstock
- Plants to be located in Idaho & Canada
- Scale of 50 to 100 million gallons/yr

Abengoa Bioenergy Facility in Spain

Currently under construction to be completed in mid-2008



Salamanca cellulosic biomass-to-ethanol plant
wheat straw feedstock

Abengoa Bioenergy Salamanca, Spain

- Will produce 5 million liters per year
(1.3 million gallons per year)
- Wheat straw feedstock
- Construction complete by mid-2008
- Biotech process not thermochemical

**Abengoa Bioenergy
Planned Facility in Kansas
2007-2008**

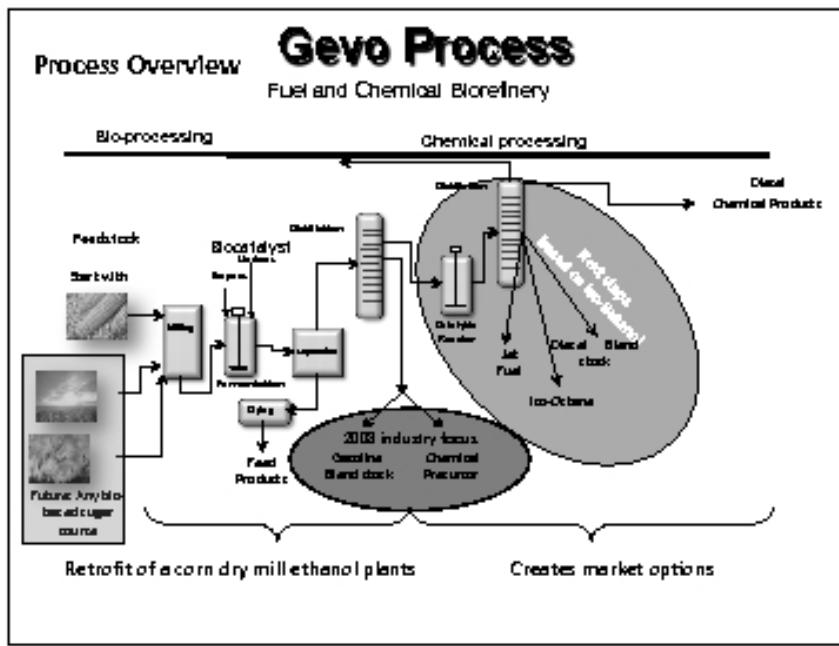
- 100 million gallon capacity
- 90 million gallons from corn starch
- 10 million gallons from wheat straw
- Will have energy island that utilizes corn stover for boiler fuel

**Beyond Ethanol—3rd Generation Biofuels
Longer Chain Alcohols and
Hydrocarbons**

- Involves using microbes and synthetic biology to build new microorganisms that can produce higher value compounds for use as transportation fuels

Examples

- Amyris—modular design of metabolic pathways
- LS9—combining genomics, proteomics and synthetic biology
- Gevo—butanol and other molecules



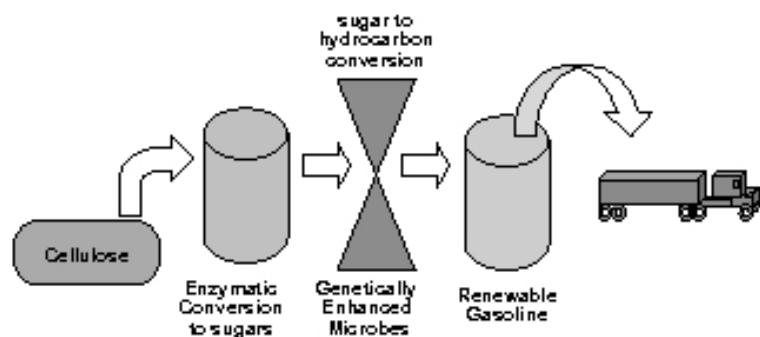
Renewable Gasoline

- Involves using microbes and rapid enzymatic pathway construction techniques to build new microorganisms that can produce higher value compounds (hydrocarbons) for use as transportation fuels

Examples

- Amyris--modular design of metabolic pathways
- LS9--combing genomics, proteomics and synthetic biology

Renewable Gasoline



ACHIEVING SUSTAINABLE PRODUCTION
of Agricultural Biomass for
Biorefinery Feedstock

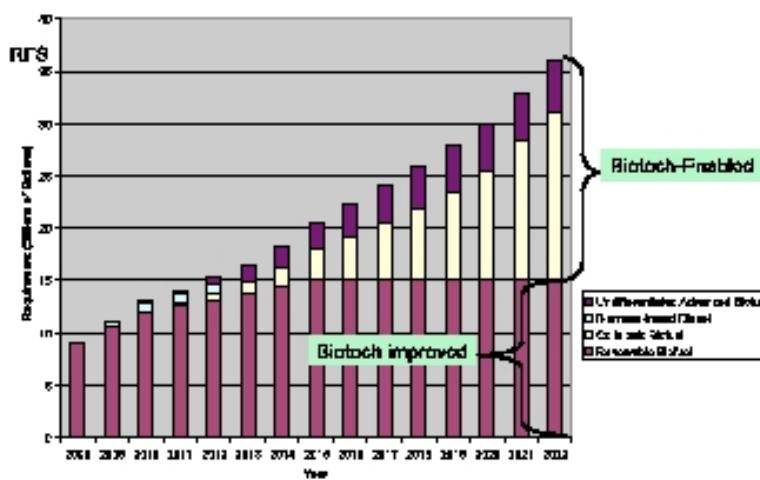
INDUSTRIAL AND ENVIRONMENTAL SECTION - 100% RENEWABLE ENERGY GROUP

Bio
REFINERY

Achieving Sustainable Production of Agricultural Biomass for Biorefinery feedstock

- Some findings:
- Corn stover and cereal straw are most likely cellulosic feedstock in the near term due to high per acre yields
- Corn farmers could supply over 200 million dry tons annually within three to five years
- Collection of 30% of current annual stover production would yield 5 billion gallons of ethanol
- No-till may be required on some farms to preserve soil fertility and allow for sustainable harvesting

Renewable Fuels Standard Requirements

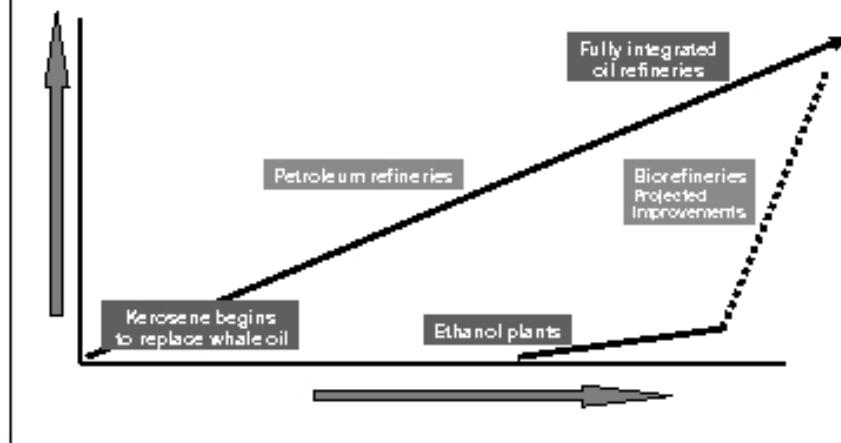


History of Oil Refineries Instructive for Biorefinery Development

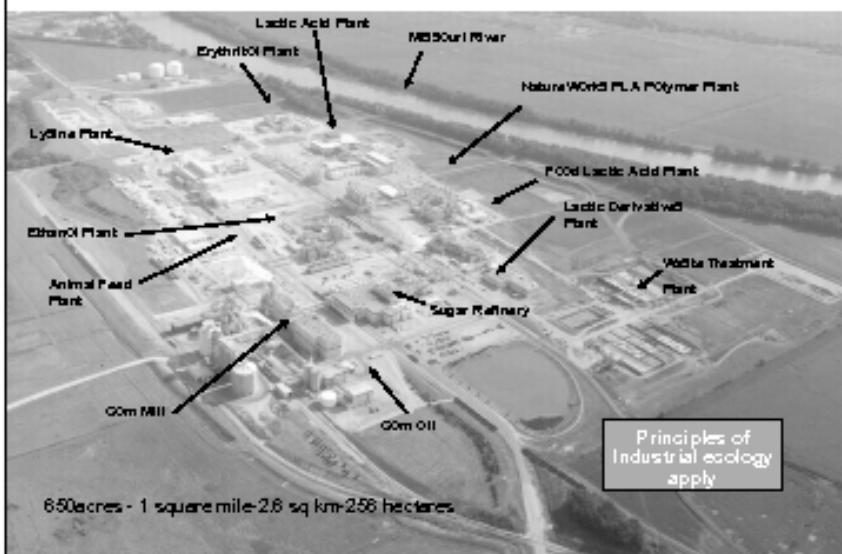
1853—Lukasiewicz was the first to distill kerosene from seep oil

- 1. 1858—Principal refined product from petroleum was kerosene which quickly replaced whale oil in the United States. (disruptive technology)**
- 2. 1868—“horseless carriages” needed fuel. Distillation refining did not produce enough of it—only about 20 percent gasoline from a unit amount of crude oil.**
- 3. 1913—Thermal cracking then doubled the efficiency of refining, to produce 40 percent gasoline per unit of oil. The refiners could then keep pace with automobile demand.**
- 4. 1930's—Catalytic cracking added to refining efficiency**
- 5. Today—coking, steam cracking, alkylation, catalytic reforming, hydrocracking are used to maximize refinery outputs**
- 6. Modern oil refinery was over 125 years in development**

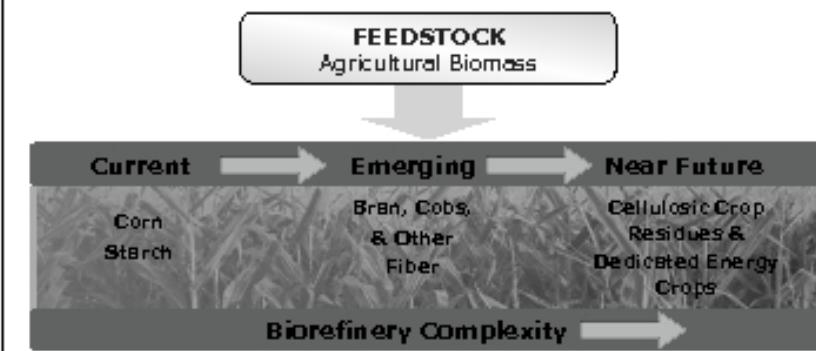
We Are Just at the Beginning of the Biorefinery Journey



Example of a Biorefinery—Blair, NE (Cargill Site)



Biorefineries and Feedstocks Will Evolve Over Time



Biotech Innovation is Accelerating Evolution in Biofuels Development

- Improving starch to ethanol processes
- Enabling cellulosic ethanol processes
- Enabling new fuels—like butanol to be produced from carbohydrate feedstocks
- Enabling radical new technology to produce renewable hydrocarbons from ag feedstocks through the application of synthetic genomics
- Producing crop yield improvements
- Developing new dedicated energy crops

Biotechnology Addresses Biofuels Concerns

• Energy Balance

- 1970s – Ethanol at best net energy neutral
- Today – Corn ethanol produces 1.4 units energy for every unit fossil input
- No cook technology will improve
- Tomorrow – Cellulosic > 5:1 return on fossil investment

• Food & Fuel

- Biotech varieties have helped increase yields 30% since 1996
- McKinsey & Co estimate that at this rate the first 15 billion gallons RFS would require no additional corn acres

• Sustainability

- The only actual field study of cellulosic ethanol from switchgrass (PNAS, Jan08) found 93% reduction in GHG vs. gasoline
- Biomass utilization enhances GHG profile

• RFS

- Biotech is rapidly improving conventional ethanol production
- Cellulosic and other second generation biofuels are moving to market much faster than predicted
- Third generation biofuels coming soon

New Blog



<http://biofuelsandclimate.wordpress.com/>



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Do it Smart

Thank you