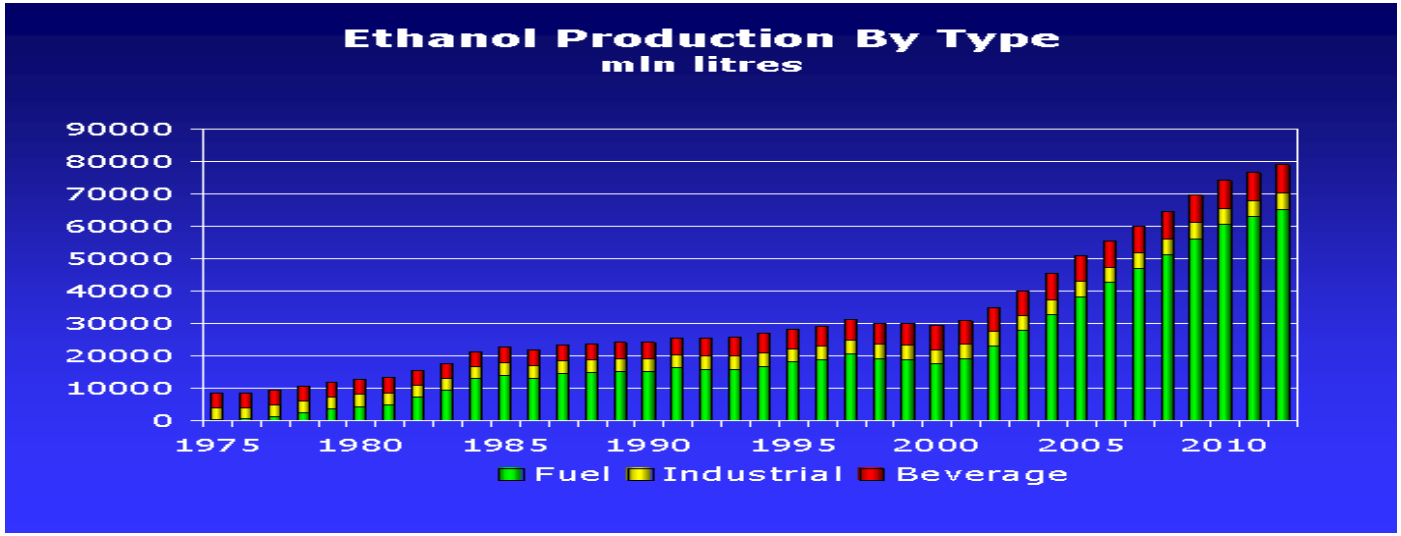
Cellulosic Bioethanol

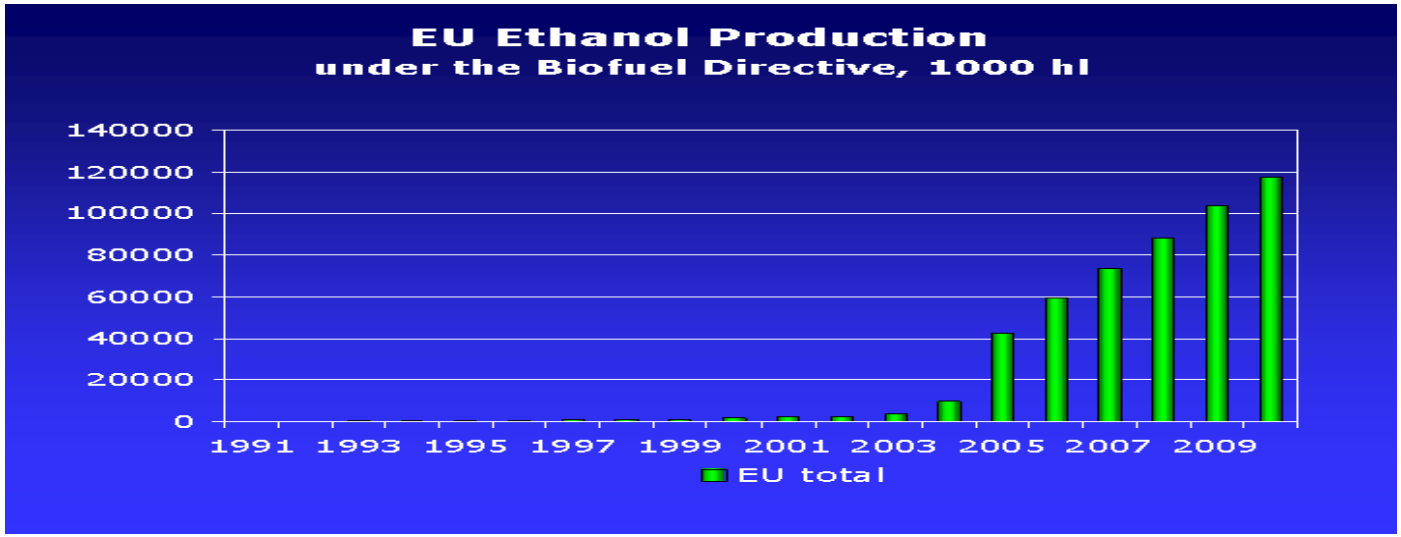
Fundamentals of the New Technology

Bioethanol Industry

Current development

- Exceptional growth demonstrated in the previous years (particularly in the U.S.) will remain strong for the following reasons:
  - Rapidly growing global need for energy
  - Strong push for alternative an renewable sources of energy from governmental and non-governmental organizations
  - High fossil fuel prices and depletion of these resources
  - National energy security primarily in countries with no or limited resources of fossil fuel, including USA, Europe, China and India

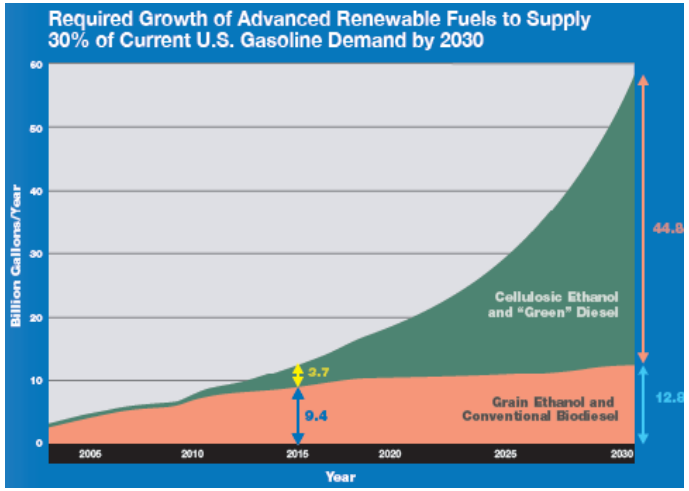


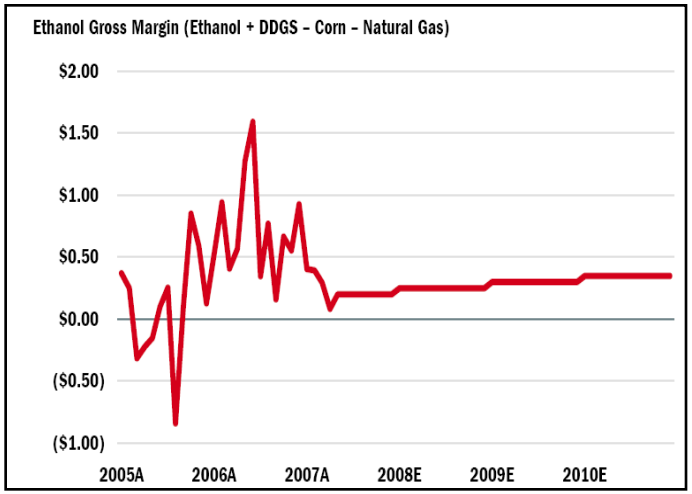


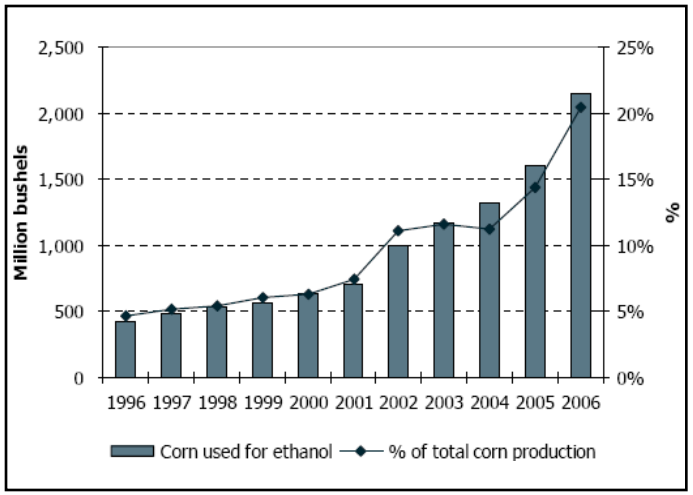
Current Problems of the Industry

Problems faced by the conventional bioethanol industry

- Current traditional bioethanol production is experiencing significant hurdles:
  - Price of underlying commodities (corn, sugar cane, grains) are growing, while ethanol price dropped in the last year
  - Margins are flattering and overcapacity is expected in the nearest future in the U.S.
  - Based on USDA projections by 2015 corn ethanol will be able to supply approximately 9 billion gallons of ethanol, far short of the required demand
  - Continuous debate on whether ethanol is actually producing any extra energy or whether it energy wasting fuel





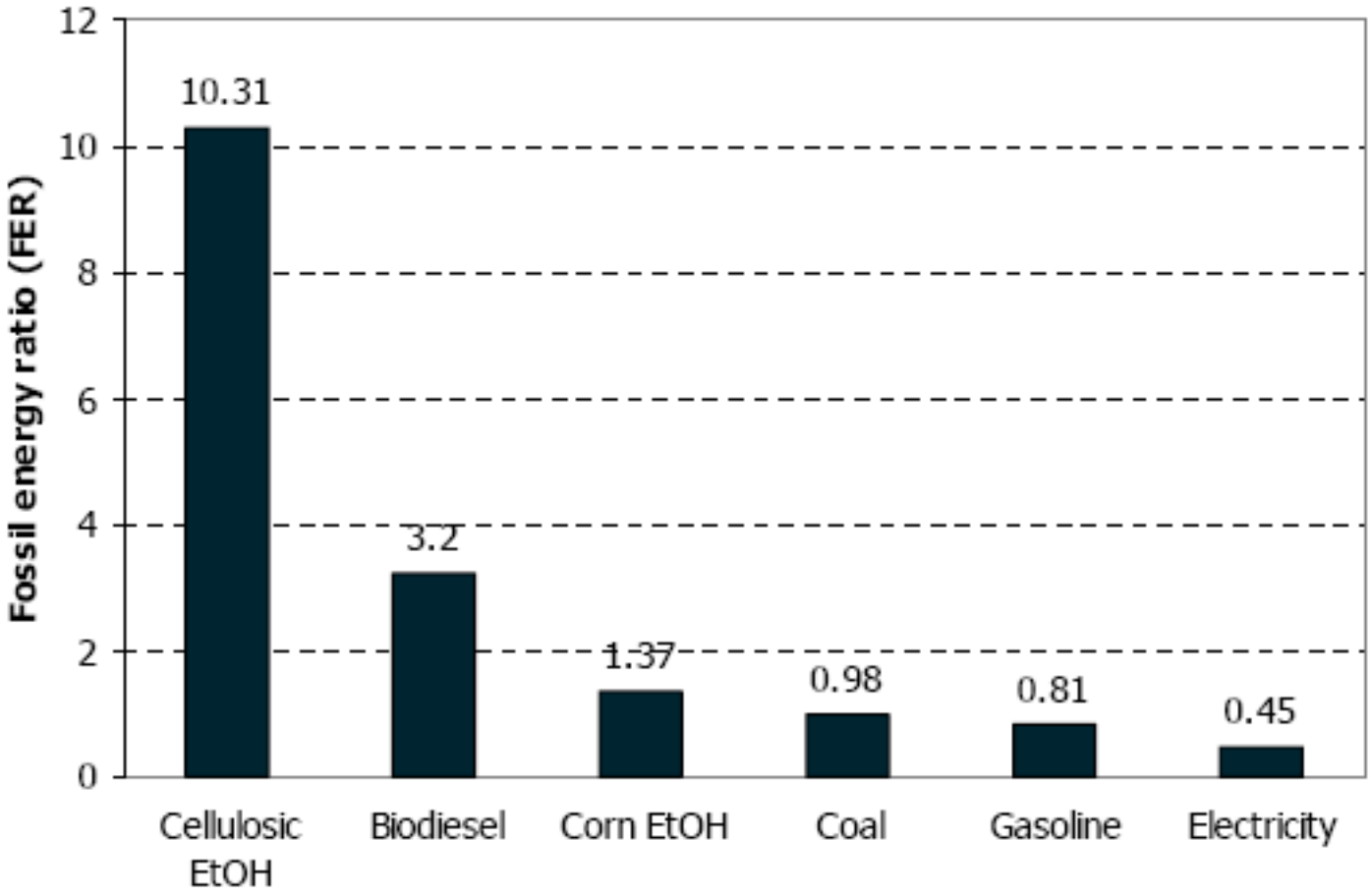


Cellulose Bioethanol – New Generation Fuel

Fundamentals

- Cellulose bioethanol is the most energy efficient: fuel:
  - It generates 10 times more energy than it takes to produce it
  - There is an abundant supply of raw material
  - The costs of the raw materials, which in traditional bioethanol comprise up to 70% of the product costs are significantly lower

FOSSIL ENERGY RATIO (FOR)

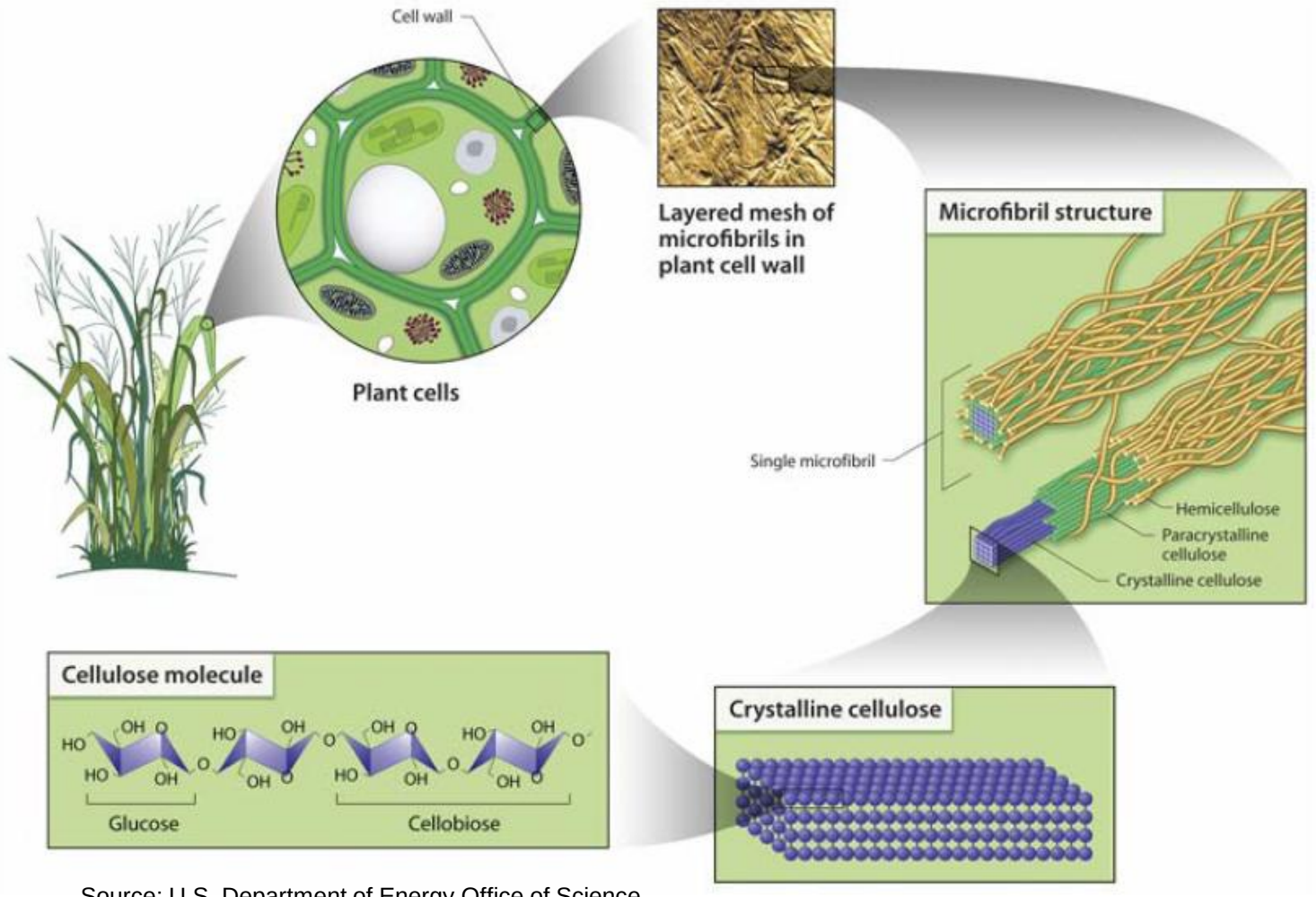


Source: *Genuity Alternative Energy Report*

Cellulose Bioethanol – New Generation Fuel

Fundamentals

- Cellulose ethanol refers to the production of ethanol from the fermentation of sugars derived from cellulose and or hemi cellulose portion of plant matter
- The type of material that is used by a facility will have an impact on the amount of ethanol produced, but generally plants have approximately 20% lignin, 40% cellulose, and 25% hemi cellulose
- Cellulose can be hydrolyzed into hexose sugars (sugars with 6 carbon atoms that are easily fermented to alcohol). Hemicellulose can be hydrolyzed and creates pentose sugars (sugars with 5 carbon atoms). Most pentose sugars are not digestible with standard wort fermentation , and require specialized bacterium/wort fermentation to ferment.



Source: U.S. Department of Energy Office of Science

Cellulose Bioethanol – New Generation Fuel

Fundamentals

- There is no "Standard" facility type that provides a consistent process methodology of converting input cellulose matter to output ethanol
- The key phase, where most of the companies hold a significant amount of proprietary Intellectual Property is so called "pre-treatment", which attempts to split the cellular structure of the matter into its base components of cellulose, hemi cellulose and lignin as efficiently, cheaply, and cleanly as possible
- Summary of the major existing technologies of the "pre-treatment" is provided in the right column
- Further the hydrolysis stage converts the celluloses into sugars that can be digested by wort fermentation into alcohol.

Thermochemical

Technology	Pros	Cons
Gasification – Catalytic	Lower capital cost, feedstock flexibility, high yield per ton of feed	Tar production, requires gas cleanup, catalyst poisoning, catalyst disposal, production of mixture of low alcohols (i.e., impure product)
Gasification – Bioreactor	Lower capital cost, feedstock flexibility, high yield per ton of feed	Tar production, requires gas cleanup - bioreactor poisoning with real feedstocks
Fractionization - Mechanical	Recovery of pure components	Moderate capital cost, high energy cost
Fractionization – Solvents	Recovery of pure components	Moderate capital cost, high energy cost

Hydrolysis

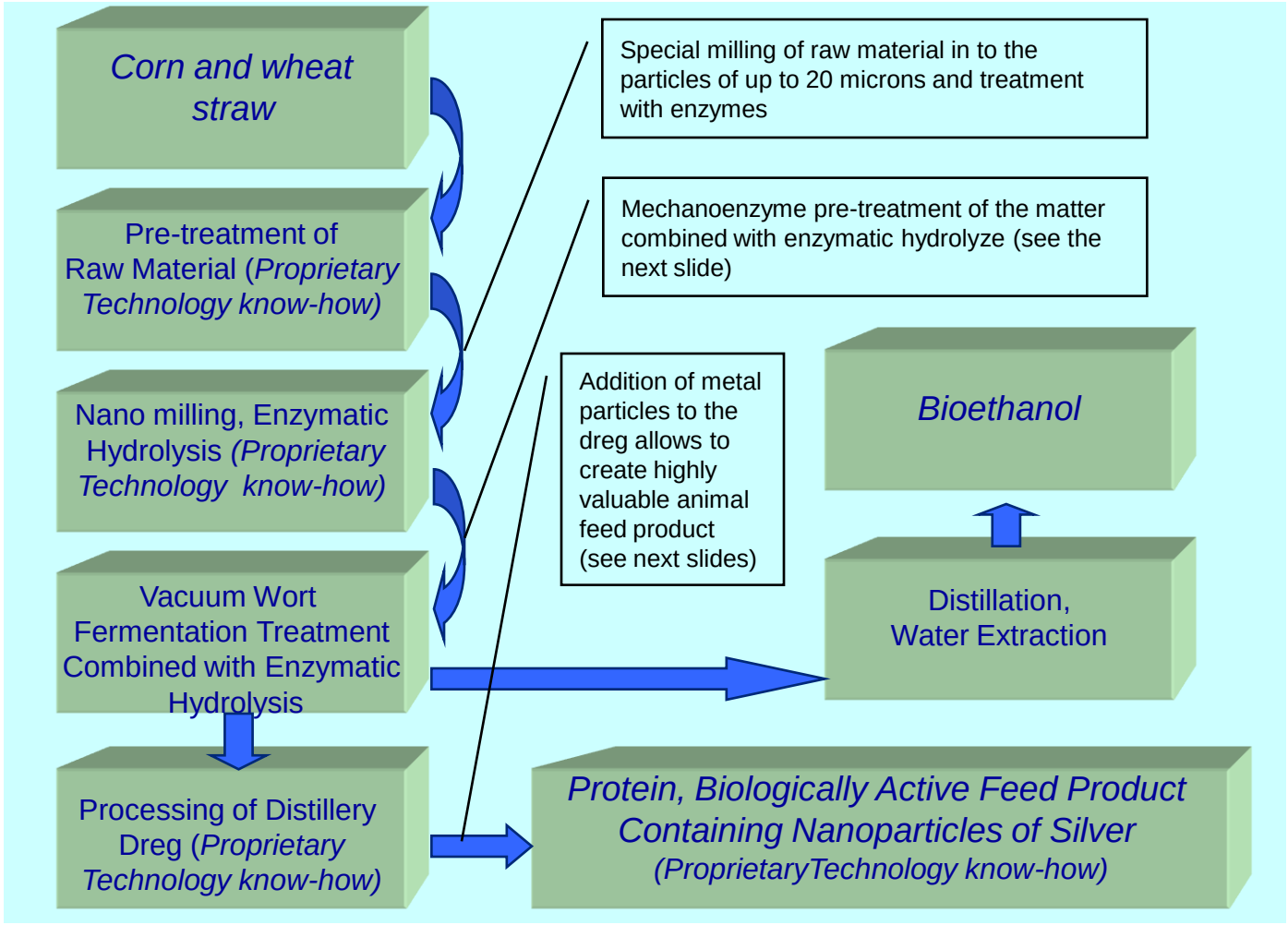
Technology	Pros	Cons
Dilute Acid Hydrolysis	Low capital cost, low acid consumption, public domain technology	Lower conversion efficiency, co-factor/toxin production
Strong Acid Hydrolysis	Medium-high capital cost, low acid consumption	Low conversion efficiency, co-factor production
Concentrated Acid Hydrolysis	98% recycling of acid, high conversion efficiency, near zero liquid discharge	Moderately-high capital cost
Enzymatic Hydrolysis	Enzyme cost reduced recently	NOT Suitable for MSW and Green wastes
Hybrid – Dilute Acid/Enzymatic Hydrolysis	Enzyme cost reduced recently	Co-factor production

Source: Genuity Alternative Energy Report

New Technology Process

Fundamentals

- New technology achieved a breakthrough technological capability of making cellulosic ethanol production economically viable and price competitive with the corn ethanol production
- The company has developed and implemented a proprietary, highly cost effective **mechanoenzyme** pre-treatment process of grain straws or corn husks, which allows to distil bioethanol from agriculture residues and unused parts of corn crop at a very high rates
- Mechanical fermentation and cellulose conversion produce a higher sugar yield and also minimizes the time of the fermentation process from dozens of hours to literally just a few minutes.



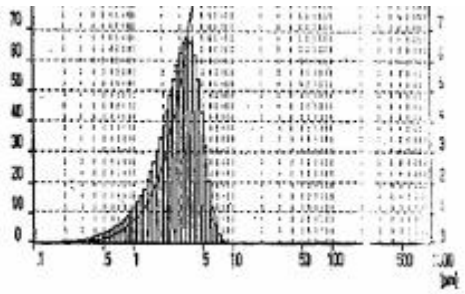
New Technology Process

Fundamentals

- The mechanoenzyme process combines milling the biomass to nano-particle size (average 20 microns) with the introduction of enzymes at the milling stage. The large cellulose and hemicellulose molecules are broken down into the C5 and C6 sugars (Xylose and Glucose) by a combination of mechanical fracturing and enzymatic conversion, making the process many times faster than existing methods
- Other technology – steam explosion pre-treatment – creates particles of significantly larger size (1 mm), requires more time to convert cellulose into sugar and uses acid in the process

Raw Corn Stover

Mechanoenzyme Pre-treatment



Steam Exploision Pre-Treatment

Steam Exploded Corn Stover

NewTechnology Process – General Data

Comparison with other cellulosic bioethanol production technology

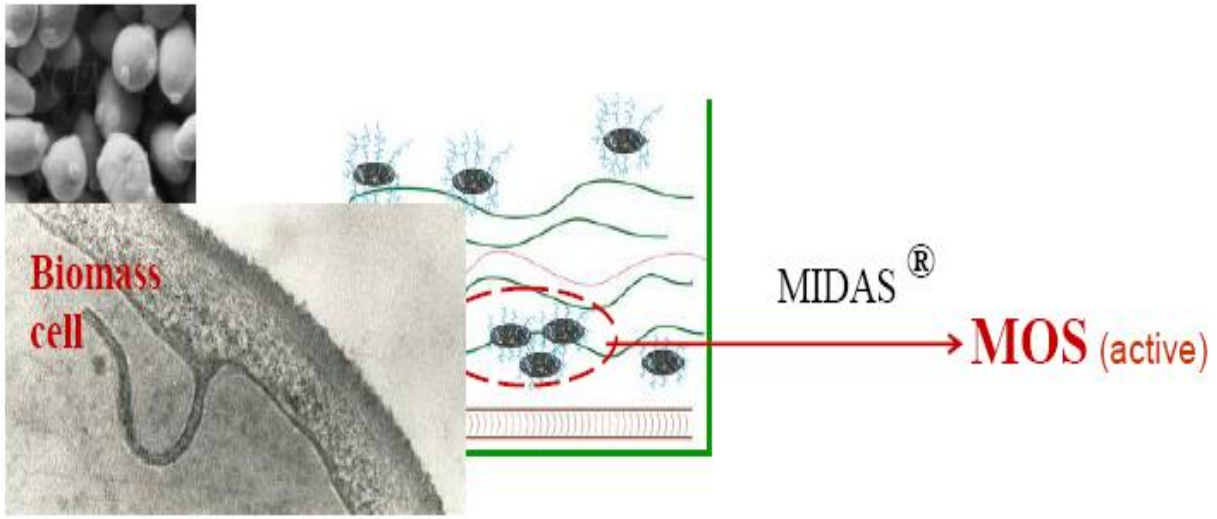
- The new technology results significantly exceed any existing cellulose bioethanol production technologies not only in the amount of the final product produced, but also in terms of cost and energy effectiveness
- results were fully confirmed during the laboratory testing

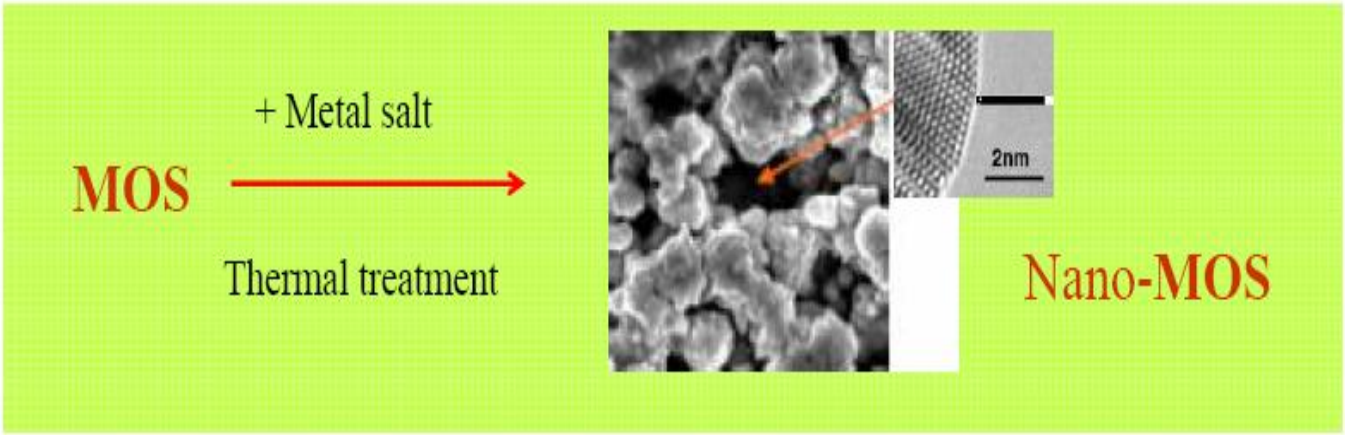
Comparative products output (kg) from 1 ton of wheat straw		
Modern pilot plant (Volume) (based on the data from SunOpta, USA; BC International, USA; Iogen, Canada)		**Proprietary Technology Process (Volume)**
Bioethanol	250 liters (195 kg)	360 liters (282 kg)
CO2 Gas	195	300
Microbe mass	100	100
Residues: lignin and untransformed sugars	510	318

New Technology – Distillery Drag Treatment

Nano-MOS

- has designed a new treatment of the distillery drag treatment using Mannano Oligosaccharide (MOS) – one of the components of distillery drag (ecologically safe substance that could replace antibiotics in farming).
- By including nano-metal particles, we are able to create a new product for animal feeding with enhanced characteristics. It is more cost efficient and possesses higher healing qualities in comparison with the world standard feed ingredient Bio-Mos®.





Project Summary

Current state and future steps

The discovery of a fundamentally new principle of cellulosic bioethanol production that is based on a number of know-hows developed by the company. Preliminary theoretical analysis of the technology was fully confirmed by the laboratory experiments.

Company achieved the following results during laboratory tests:

• 90% from the theoretically possible conversion of cellulose derived from wheat straw and corn husk into sugar, giving 360 litres of bioethanol and 330 litres from one 1 ton of material correspondingly
• Significantly lower energy costs associated with the production process resulting in the lower prime costs in comparision with other cellulosic bioethanol producers
• Cellulose hydroliz time was significantly reduced
• Simulateneous process of hydroliz and yeats treatment has been tested and produced exceptional results
• New technology of distillery drag treatment by nano-metal particles has been successfully tested

Current stage:
• world-wide patent protection process launched (using PCT system)
• continuation of programme to further develop the technology - currently conducting experiments using rice straw and palm oil production residuals as raw material for cellulosic bioethanol production