



Breakout Session 2E: Cellulosic Derived Sugars

July 11, 2012

Neil Rossmeissl

DOE

Moderator



Biographical Info



Cellulosic Derived Sugars: Realizing the Opportunities and Challenges

July 11, 2012

Cynthia Tyler
CNJV

“If you can make low-cost sugar, you can make anything.”
Phycal CEO Kevin Berner

Renewable Fuels & Fuel Intermediates



Diesel, Jet fuel, Gasoline, Butanol

Renewable Chemicals/Materials



Surfactants, lubricants, polymers (plastics), synthetic rubber, emollients (moisturizers), detergents, carbon fibers, binding agents, dispersants, phenols

Nutrition



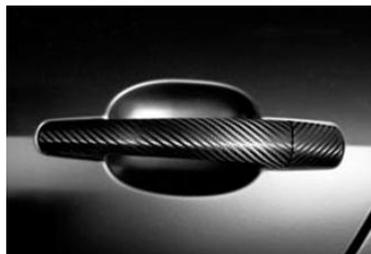
Amino acids, industrial yeasts, enzymes, flavor enhancers

Pelletized Energy Source



Lignin as an energy source for Viridia plants and other industrial manufacturing plants

Carbon Fibers



Lignin-based complex carbon fibers to incorporate into composite materials for a large number of industries.

Flame Retardants



Flame retardants for use in plastic compounds, replacing petroleum-based compounds in common manufacturing technologies.



Source: www.virdia.com/markets

greentechmedia:

Cellulosic Sugar Could Be Next Sweet Investment

A Piper Jaffray analysts says the industry has space for companies devoted to just breaking down biomass into sugar to sell to biofuels companies.



UCILIA WANG: OCTOBER 22, 2008

BiofuelsDigest

Viridia ups the ante in the Race for the New Sugars

Jim Lane | March 6, 2012

9 Low-cost cellulosic sugar maker

announces \$100 million in financing; name change from HCL

CleanTech, support from Mississippi. The race for leadership in low-cost sugars heats up.



NOVEMBER 21, 2011

C&EN

CHEMICAL & ENGINEERING NEWS



THE SUGAR MAKERS

Start-up firms target cheap sugars to make possible **COST-EFFECTIVE BIOFUELS** and biochemicals

MARC S. REISCH, C&EN NORTHEAST NEWS BUREAU

Plastics Technology

FERMENTABLE SUGARS FROM BIOMASS ARE CLOSER TO COMMERCIAL REALITY

From: Plastics Technology

Issue: April 2012

The brave new world of bioplastics relies in large part on fermentable sugars from plants (see Close Up on Biopolymers in this issue). Industry wants to get away from obtaining those sugars from food crops such as corn and to use instead waste plant matter and other inedible cellulosic materials, referred to collectively as "biomass." Although there is currently no industrial-scale production of fermentable sugars from biomass, a number of firms are working toward that goal.

BiofuelsDigest

BlueFire and the race for low-cost sugars

Jim Lane | February 17, 2012

5 BlueFire Renewables' low-cost sugars

subsidiary, SucreSource, announces a major project in Korea backed by oil refiner GS Caltex.



Who else is gaining traction in the race to provide low-cost sugars? A generation of magic bugs — who turn sugars into renewable fuels, chemicals, flavors, fragrances and more — await them.



Industrial Sugar Providers



Industrial Sugar Providers

COMPANY	FEEDSTOCK	TECHNOLOGY	BUSINESS STRATEGY
BlueFire (SucreSource LLC)	Energy Crops, Agricultural & Wood Wastes, Construction & Demolition Debris, MSW	Concentrated Sulfuric Acid Hydrolysis	Direct Sales, Technology Package
Viridia (formerly HCl CleanTech)	Agricultural Waste, Woody Biomass	Concentrated Hydrochloric Acid Hydrolysis	Direct Sales, Seeking Sugar Convertors to Locate Near Future Mississippi Plant
Weyland (Norway)	Agricultural Waste, Woody Biomass	Concentrated Acid Hydrolysis	Technology Package, License Technology
American Process Inc. (AVAPCO)	Energy Crops, Agricultural Waste, Woody Biomass	Enzymatic Hydrolysis	Initially Direct Sales then License Technology
Blue Sugars (formerly KL Energy)	Agricultural Waste, Woody Biomass	Enzymatic Hydrolysis	License Technology
Chemtex (Beta Renewables; Italy)	Energy Crops, Agricultural Waste	Enzymatic Hydrolysis	License Technology
Comet Biorefining	Energy Crops, Agricultural Waste, Woody Biomass	Enzymatic Hydrolysis	License Technology or Co-location
EdeniQ / Logos Technologies	Energy Crops, Agricultural Waste, Woody Biomass	Enzymatic Hydrolysis	Corn EtOH to Cellulosic Bolt-on Technology
Fiberight	MSW & Industrial Waste	Enzymatic Hydrolysis	Retrofit Corn EtOH Plants to Cellulosic; Co-location with MSW & Industrial Waste
RSA (Old Town Fuel & Fiber)	Woody Biomass	Pulping Process / Hydrolysis	Direct Sales
Sweetwater Energy / BioGasol	Agricultural Waste, Woody Biomass	Hydrolysis by Decentralized Processors Produce Separate C5 & C6 Sugar Streams	Own and License Processors to Biomass Producers, Sell Sugars to Biorefineries
Proterro	CO ₂ + H ₂ O + Nutrients	Cyanobacteria Grown in Photo-Bioreactors Produce Sucrose	Co-location at Fermentation Facilities
Renmatix	Energy Crops, Agricultural & Wood Waste, Woody Biomass	Supercritical Water	License Technology, Co-location



Challenges & Opportunities

POLITICS

FINANCE



biofuels international

Insight: "Green Fleet" sails, meets stiff headwinds in Congress

May 2012

 **biofuels** finance

As growth in new advanced biofuels technology marches on to a breakthrough for worldwide commercialisation, currently led by Ineos Bio in the US, Enerkem in Canada, and Beta Renewables in Italy, project finance options for 'first of a kind' technologies remain scarce

The project finance market – is it open for biofuels?



By **David Alexander**

WASHINGTON | Mon Jul 2, 2012 3:12pm EDT

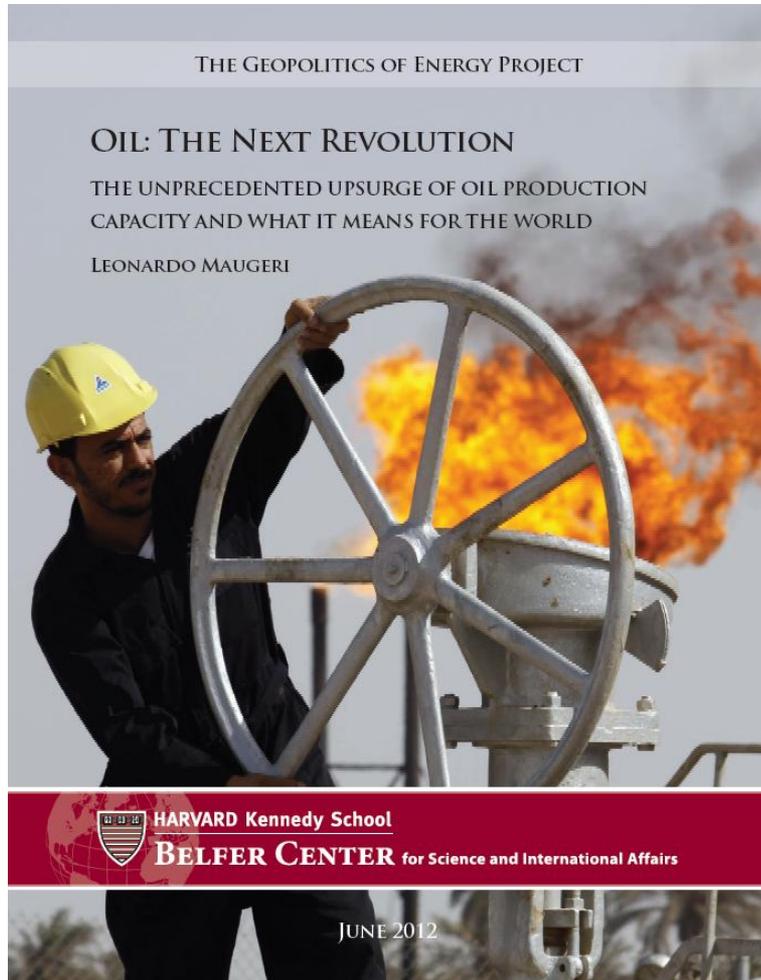
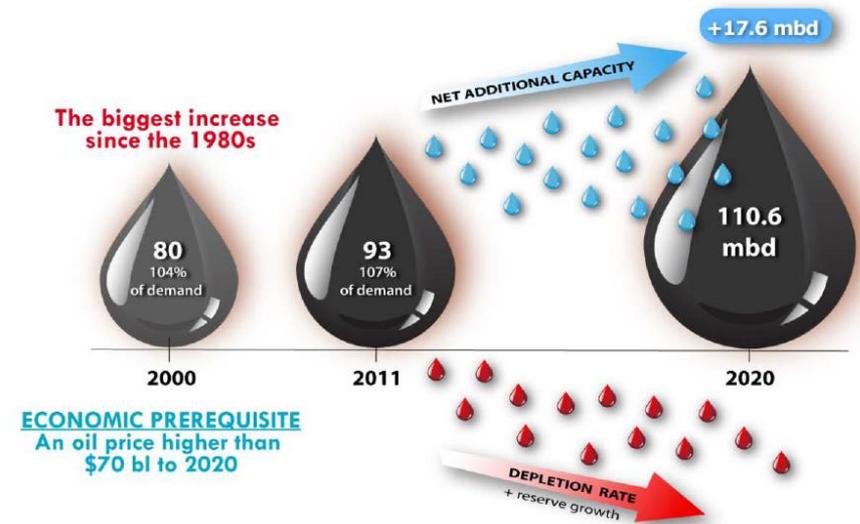


Figure 1: World oil production capacity to 2020
(Crude oil and NGLs, excluding biofuels)

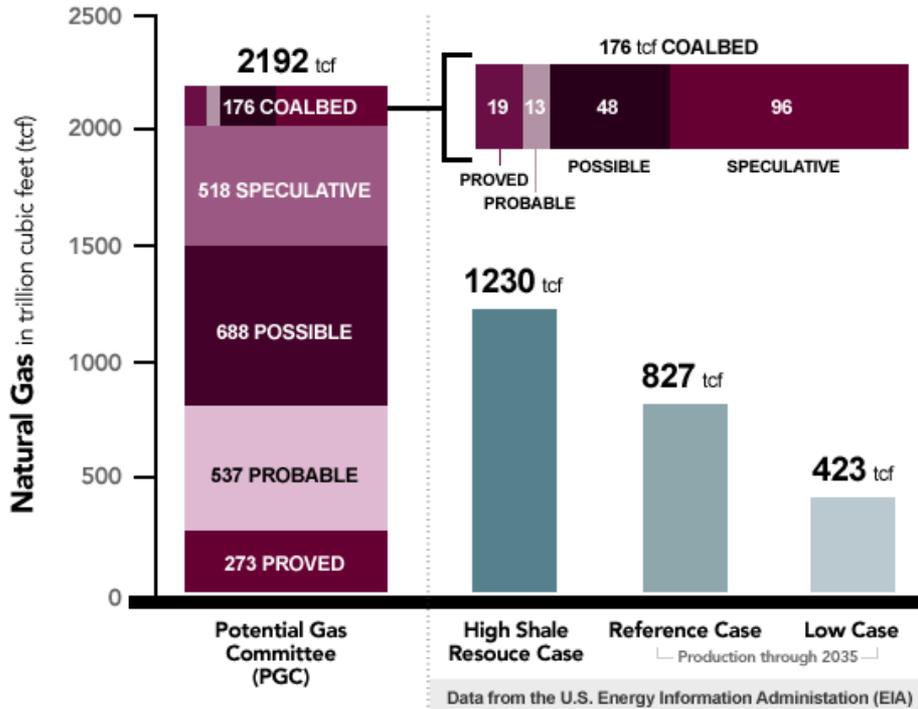


Maugeri, Leonardo. "Oil: The Next Revolution." Discussion Paper 2012-10, Belfer Center for Science and International Affairs, Harvard Kennedy School, June 2012.

Challenge: 100 Year Supply of Natural Gas?

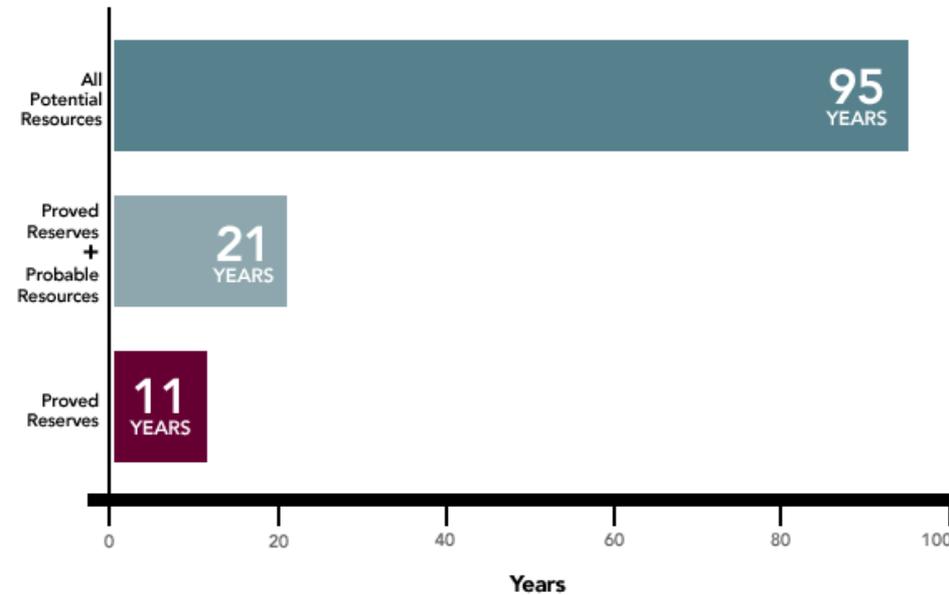
HOW MUCH GAS ARE WE SITTING ON?

Future Natural Gas Supply Estimates



HOW LONG WILL IT LAST?

Based on the Potential Gas Committee Estimates and 2010 Consumption Rate (of 24 tcf / year)



Natural Gas: Threat or Opportunity for Cellulosic Sugars?

Natural gas uses besides chemical feedstocks:

- Compressed natural gas (CNG) vehicles
- Conversion or replacement of coal-fired power plants with natural gas
- Possible Sasol natural gas to diesel plant in Louisiana
- Celanese TCX™ process to produce ethanol from natural gas





 **NREL** National Renewable Energy Laboratory
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Innovation for Our Energy Future

Determination of Sugars, Byproducts, and Degradation Products in Liquid Fraction Process Samples
Laboratory Analytical Procedure (LAP)
Issue Date: 12/08/2006
A. Sluiter, B. Hames, R. Ruiz, C. Scarlata, J. Sluiter, and D. Templeton

Technical Report
NREL/TP-510-42623
January 2008



NREL is operated by Midwest Research Institute • Battelle Contract No. DE-AC36-99-GO10337



- Quality of sugar will depend on the production process
- Each organism has specific requirements for inhibitors (e.g. lignin, organic acids, furans), type of sugar, and concentration
- Produce the highest quality sugar possible or tailor sugars to individual organisms?
- Chemical conversions of clean sugars will also require sugar standards
- NREL developed various standard biomass analytical procedures
http://www.nrel.gov/biomass/analytical_procedures.html



Butamax™
Advanced
Biofuels LLC

A joint venture between BP and DuPont



Plastics, Fibers, Rubber and Other Polymers



PMMA



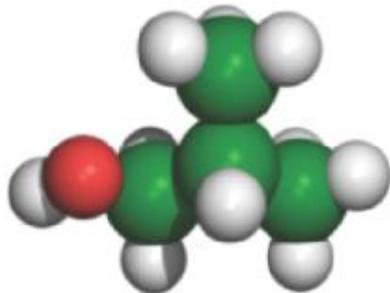
POLYESTERS/
XYLENE/STYRENE



POLY-
PROPYLENES



RUBBER, LUBRICANTS
& ADDITIVES



Isobutanol

Hydrocarbon Fuels



GASOLINE



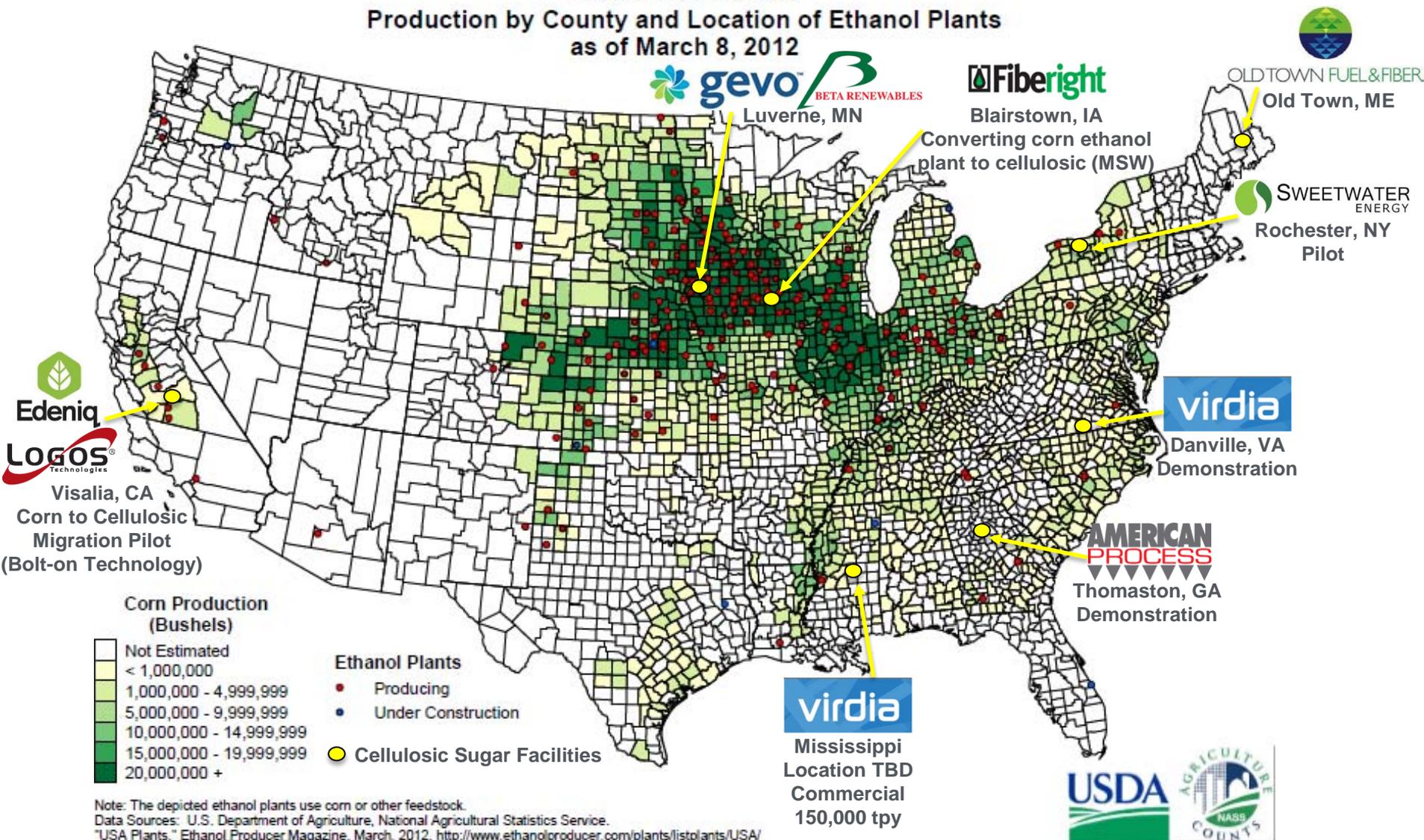
DIESEL



JET

Ethanol Plant & Cellulosic Sugar Facilities Map

Corn for Grain 2011
Production by County and Location of Ethanol Plants
as of March 8, 2012



Sweetwater Energy Decentralized Processing



Harvest



Biomass
(Ag and wood residues)

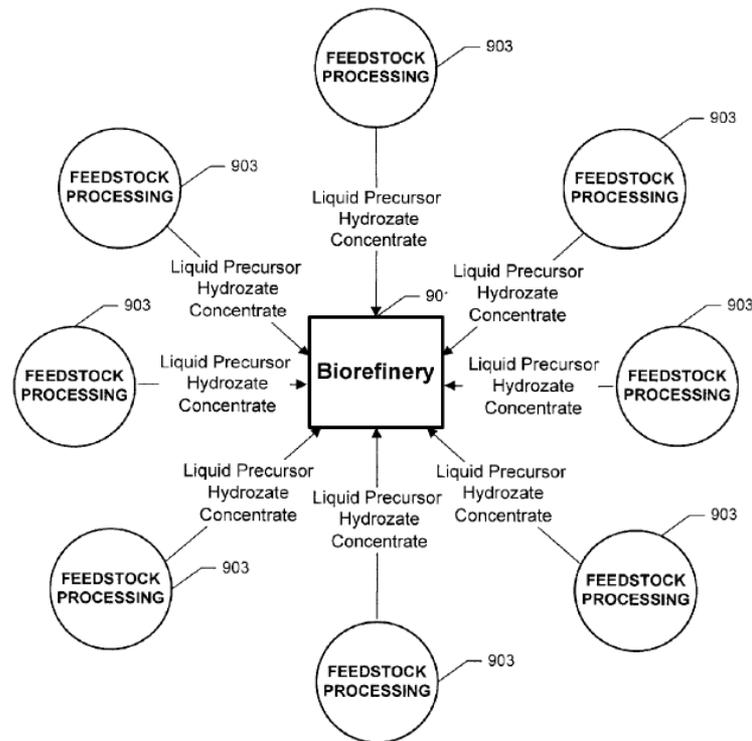


SweetMachine_{SM} Processor



Concentrated sugar solution

“Near the farm” = significantly reduced logistics costs



US Patent Application
Pub. No. 2010/0144001 A1

Market Pull: Commercial Aviation Alternative Fuels Initiative

The Commercial Aviation Alternative Fuels Initiative (CAAFI) seeks to enhance energy security and environmental sustainability for aviation through alternative jet fuels.



Market Pull: GE Aviation's Ohio or Midwest-regional Renewable Jet Fuel



GE Aviation



5 million Gallons beginning in 2015

Plant PET Technology Collaborative (PTC)



INSERT BIOMASS 2012 LOGO