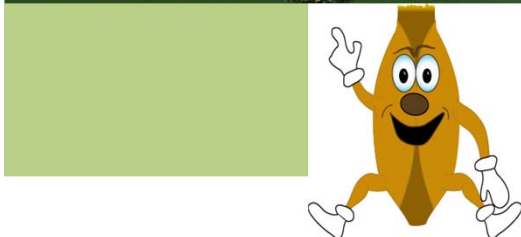




EASTERN REGIONAL RESEARCH CENTER



Winter Barley Ethanol and Other New Advanced Biofuels



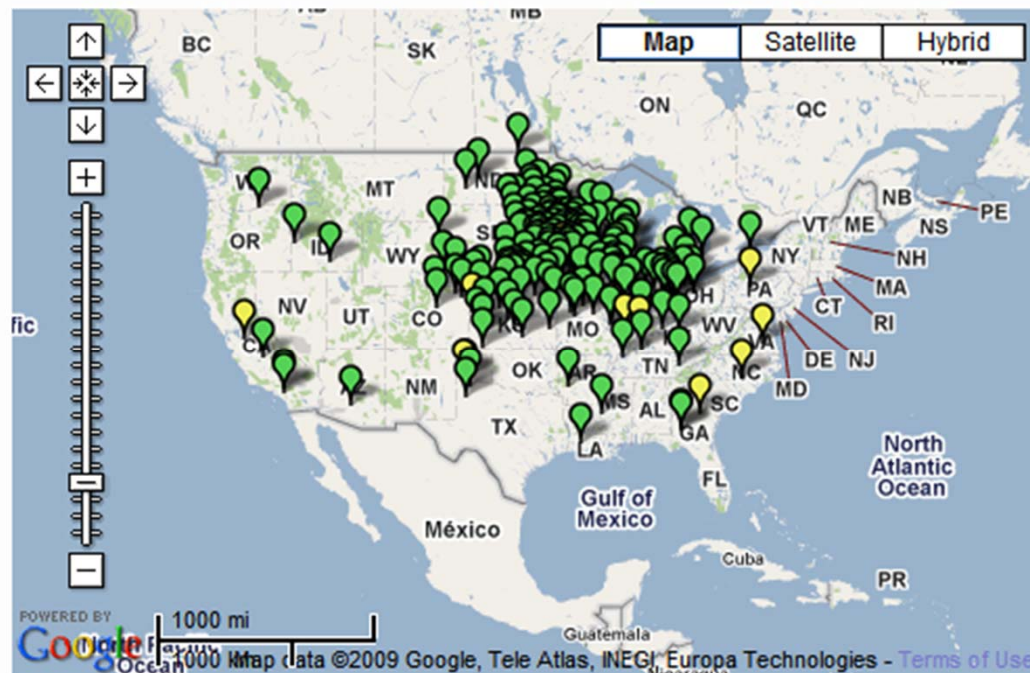
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Number of Ethanol Plants, Locations, and Their Capacities as of 9/30/2010

BIOREFINERY LOCATIONS



Currently Operational
Under Construction

Source: RFA

**204 Plants with 13.8
Billion Gallons Capacity**

**Plants under
Construction will Provide
another
0.8 Billion Gallons**

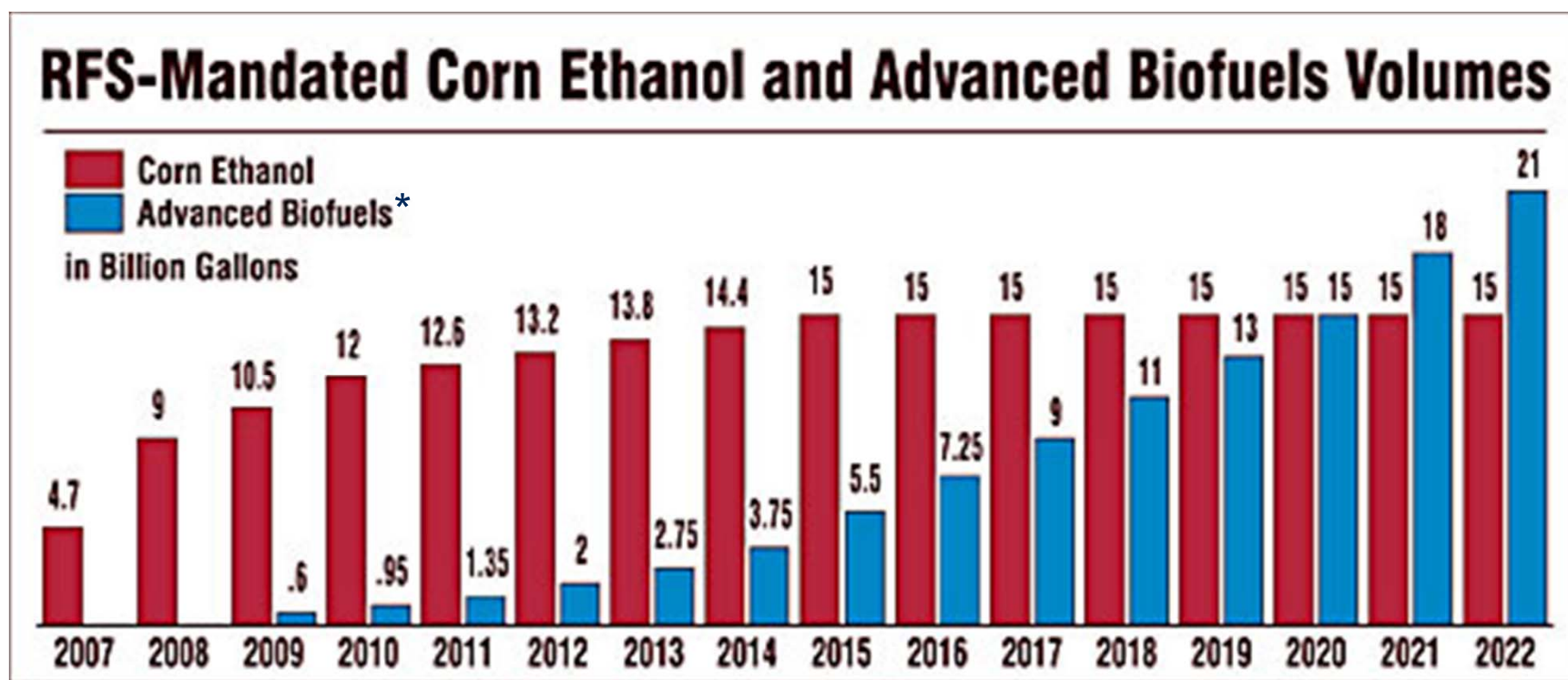
**Total Capacity When
Completed = 14.6 Bil. Gal.**

**14.6 Billion Gallons meets
about 10% of our total
transportation fuel needs!**

**Corn is Still the #1
Feedstock**



The 2007 Energy Independence and Security Act Requires Aggressive Increase in Advanced Biofuels!



Based on Energy Independence and Security Act of 2007

* *Advanced biofuels* is renewable fuel other than ethanol derived from corn starch that is derived from renewable biomass, and achieves a 50 percent greenhouse gas (GHG) emissions reduction (compared to gasoline).

How will we meet these goals?

→ **Cellulosic Ethanol**

- **Outstanding Potential**
- **Uses Non Food Feedstocks**
- **Still Major Research Challenges to Solve**
- **Still 5-10 years away from commercial viability?**

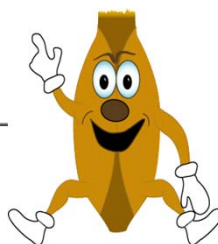
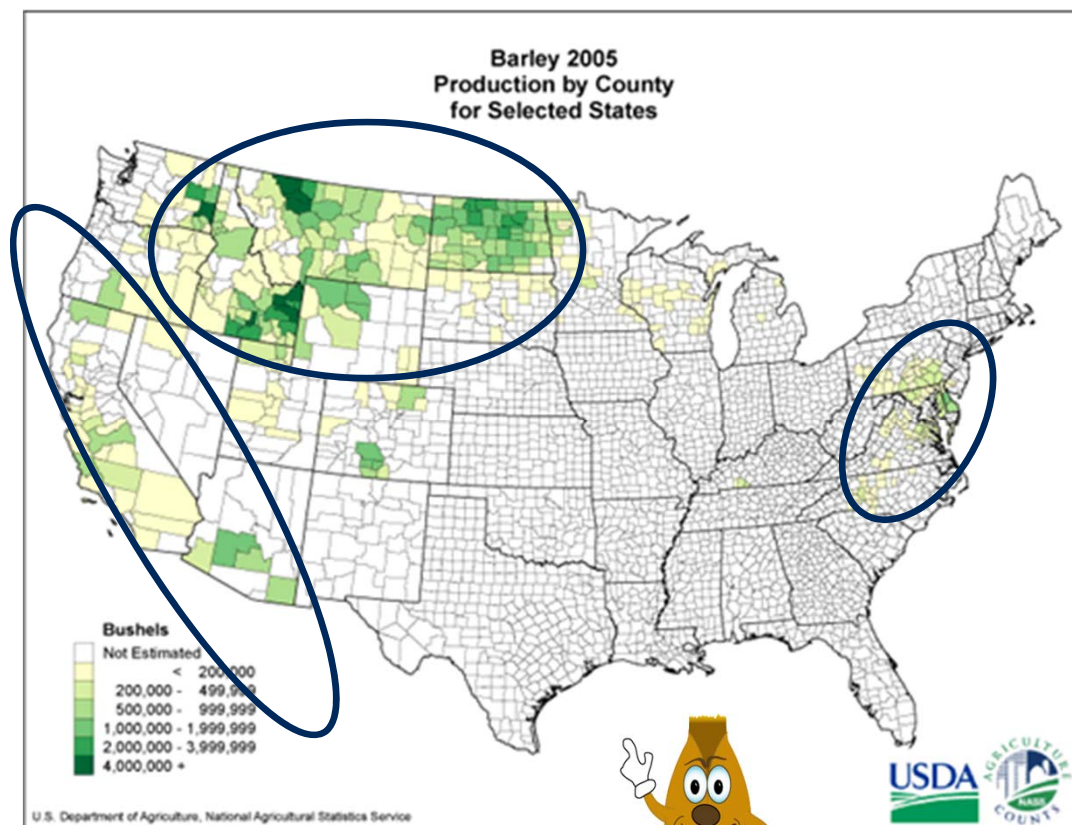
→ **Pyrolysis and Gasification-Based Bio-Fuels**

- **Outstanding Potential**
- **Uses Non Food Feedstocks**
- **Still Major Research Challenges to Solve**
- **Still 5 years away from commercial viability?**

Is There a Simpler Way?

- Wouldn't it be great if there were another feedstock we could use right now to make Advanced Biofuels?
- One that we could convert to “low-carbon” fuel ethanol and valuable food and feed products
 - One that wouldn't compete with food crop production
 - One that wouldn't harm the environment

There is Such a Crop and it is Winter Barley!



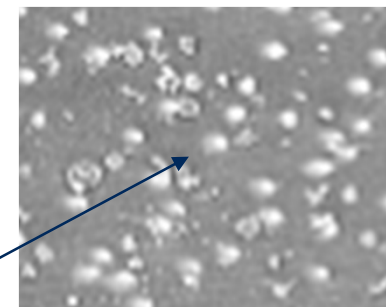
These “barley belts” can provide feedstock for ethanol plants outside the corn belt where transportation fuels and economic development are needed!

Why Winter Barley For Fuel Ethanol ?

- Provides feedstock for ethanol plants outside the Corn Belt
- Farmers on the East Coast and other areas with mild winters can grow barley as a winter crop, allowing double cropping with soy followed by corn the next year! (3 crops in 2 years – More grain on same acreage)
- Winter barley is grown on “fallow ground” and doesn’t compete with food production thus there are no Indirect Land Use Change effects.
- Winter barley acts as a cover crop, preventing soil and nutrient losses to the environment- this is critical for sustainability of soil and water. Especially important for the Delaware and Chesapeake Bays.
- Higher protein and digestible amino acids than corn, especially lysine means that barley DDGS should sell at a premium relative to other grain DDGS.

Major Challenges with Barley for Ethanol Production in 2001

Phytoliths



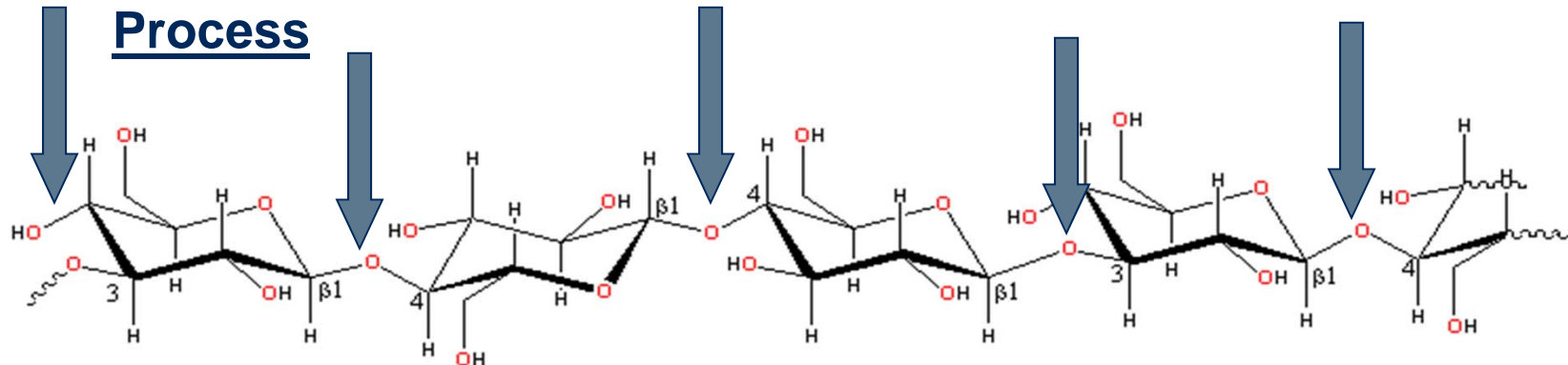
- **Abrasive nature of hull – destructive to grain handling and grinding equipment**
- **Low starch content (~50-55%) compared to corn's (~70%) – results in low ethanol yields plus too much fiber**
- **High viscosity of mash due to beta-glucans – makes ethanol production difficult and expensive and limits the feed use of the ethanol co-products, DDGS to primarily ruminant animals**

ERRC/ARS Created A Barley Research Program to Solve These Technical Issues

- Working with breeders at Virginia Tech to develop better hull-less and hulled barley with high starch content for fuel ethanol production. (Griffey, C. et al. Journal of Cereal Science. 51: 41–49. 2010.)
- Developing dry fractionation and other processes to separate barley grain into fermentable and non-fermentable fractions and coproducts. (Flores, R.A., et al., Cereal Chem. 82(6):727-733. 2005.)
- Working with Genencor, A Danisco Division to develop new enzymes to reduce viscosity, increase ethanol yield, and develop energy saving fuel ethanol processes

We Discovered How to Completely Hydrolyze β -Glucans and Simultaneously Increase Ethanol Yields

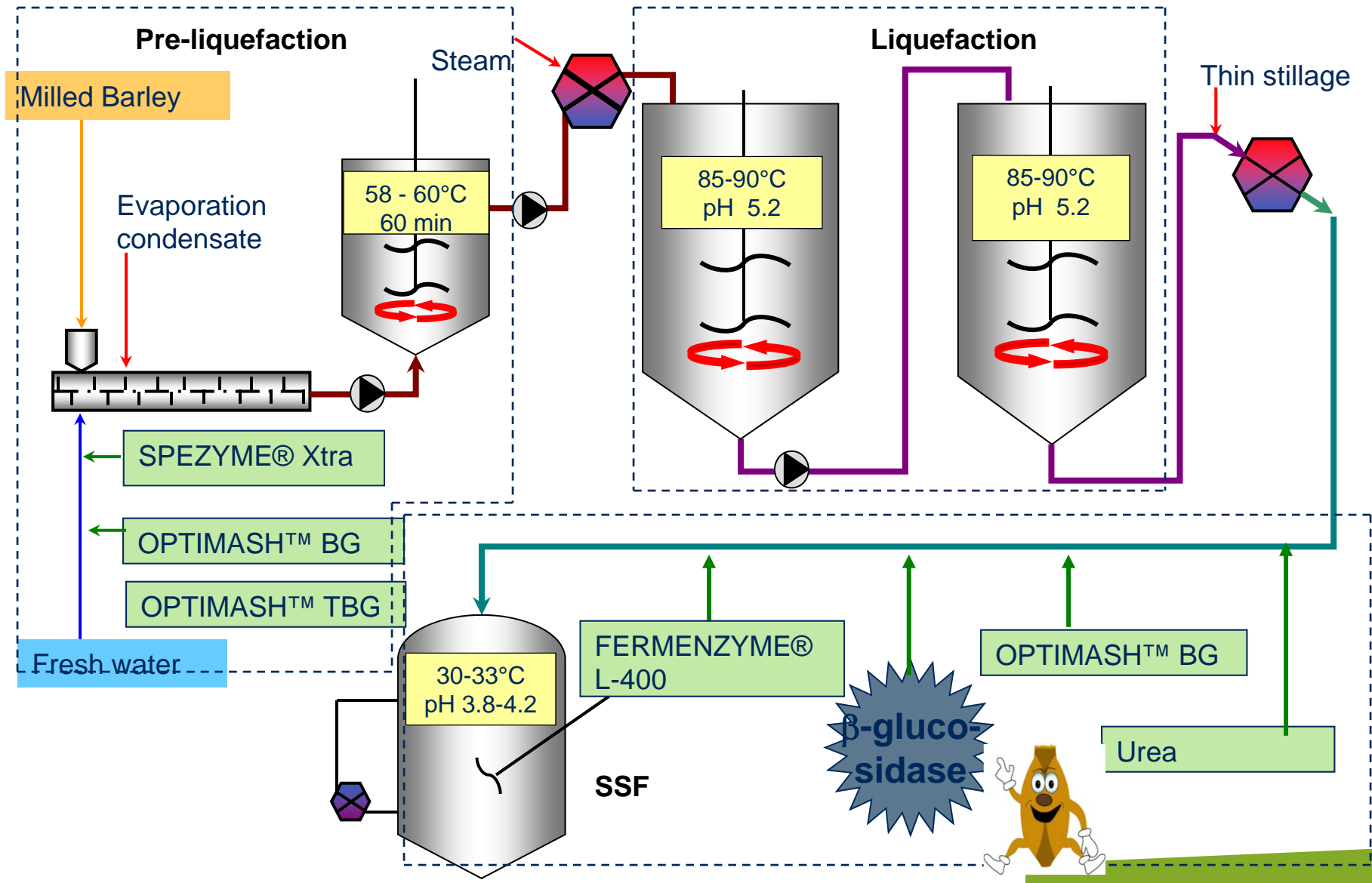
- Our studies showed that complete conversion of β -glucan to glucose can be achieved when we also add another key enzyme, β -Glucosidase
- What are the benefits of this?
 - Additional Viscosity Reduction
 - **Additional Glucose Produced is Fermented to Ethanol, Increasing Yields**
- **This is What Provides the “Edge” to the Barley EDGE Process**



Barley EDGE* Process

*Enhanced Dry Grind Enzymatic

Nghiem, N.P et al. Biotechnology for Biofuels. 3:8. 2010.

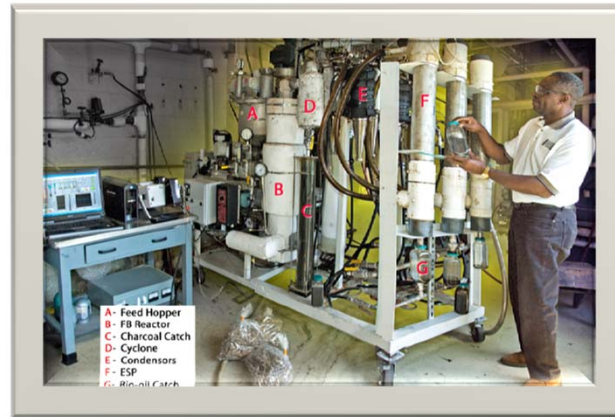


Thermochemically Derived CoProducts

→ Conversion of Barley Hulls, Straw, and DDGS by Pyrolysis can yield valuable Bio-Oil and Bio-Char



Hulls,
Straw,
DDGS



Green Gasoline
and Diesel

Bio-Oil and
Bio-Char

Improves soil fertility
and sequesters carbon

Boateng, A.A., K.B. Hicks, R.A. Flores and A. Gutsol. *Pyrolysis of hull-enriched byproducts from scarification of barley (Hordeum vulgare L.)*. J. Analy. & Appl. Pyrolysis, 78: 95-103 (2007).

Mullen, C.A., A.A. Boateng, N.M. Goldberg, K.B. Hicks, and R. Moreau. *Analysis and Comparison of bio-oil produced by fast pyrolysis from three barley biomass/byproduct streams*. Energy & Fuels 24:699–706 (2010).

Osage Bio Energy is Turning a Vision into a Reality by Building the First Winter Barley Ethanol Plant in Hopewell Virginia!



Maximizing Bio Processing to Create Food and Fuel

Company
Careers
Newsroom
Contact Us



Producers

Elevators

Partners

Feed Suppliers



Let's Work Together

Are you a producer currently growing barley?

We want to hear from you!

- Take our ["Farmer Survey"](#)

About Osage Bio Energy

- OBE is a Virginia-based company that will use regional grain to produce biofuels and related products.
- OBE is building its first regional bioprocessing facility in Hopewell, VA -- it will go online in Spring 2010.



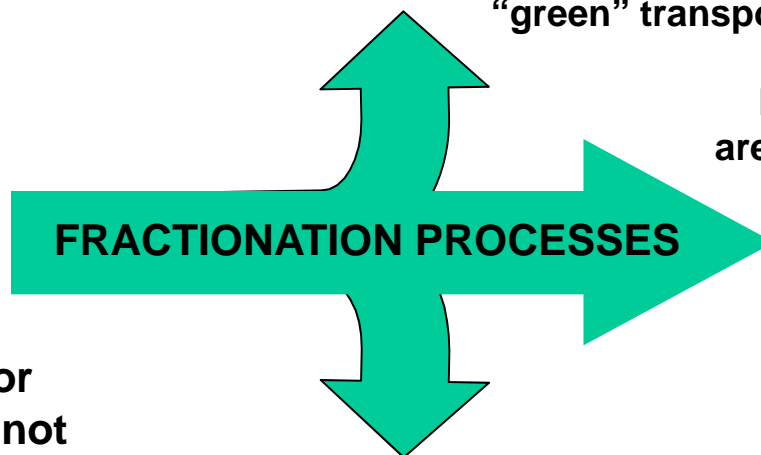
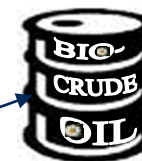
The Winter Barley BioRefinery Vision and Action



Growing winter barley for ethanol feedstock does not compete with food production and it actually improves soil and water quality!

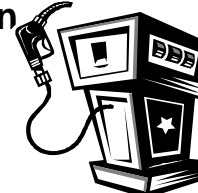
ethanol
Fuel For Clean Air

High fiber (hulls) and straw from barley can be used to make cellulosic ethanol and pyrolysis oil for producing “green” transportation fuels.



High starch fractions are used for fermentation and Fuel Ethanol Production plus Premium DDGS

ethanol
Fuel For Clean Air



Low starch fractions (high-protein, high-Tocol, high- β -glucan) for health-promoting, obesity-fighting, foods and nutraceuticals



Contact: kevin.hicks@ars.usda.gov





First US Winter Barley Ethanol Facility



