


Cellulose Conversion in a Dry Grind Facility

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Midwest Consortium for Biobased Products & Bioenergy


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For gifts of enzymes

Genencor (Enzymes)

Distillers Grains and Stillage

Big River Resources, LLC

Interactions and Inputs

Gene Petersen, Chad Schell,

DOE Golden Field Office

Background

- Rapid growth of fiber rich DDGS and distillers' grains (DG) from expanding corn dry milling industry
- Proliferation of DDGS has potential to depress market for this by-product and decrease profitability of dry grind facilities
- Cellulose conversion technology provides a solution
- Processing DDGS & DG into additional fermentable sugars and ethanol will add value, decrease volume, and enrich protein of remaining solids.

Distillers' Dried Grains with Solubles (DDGS)

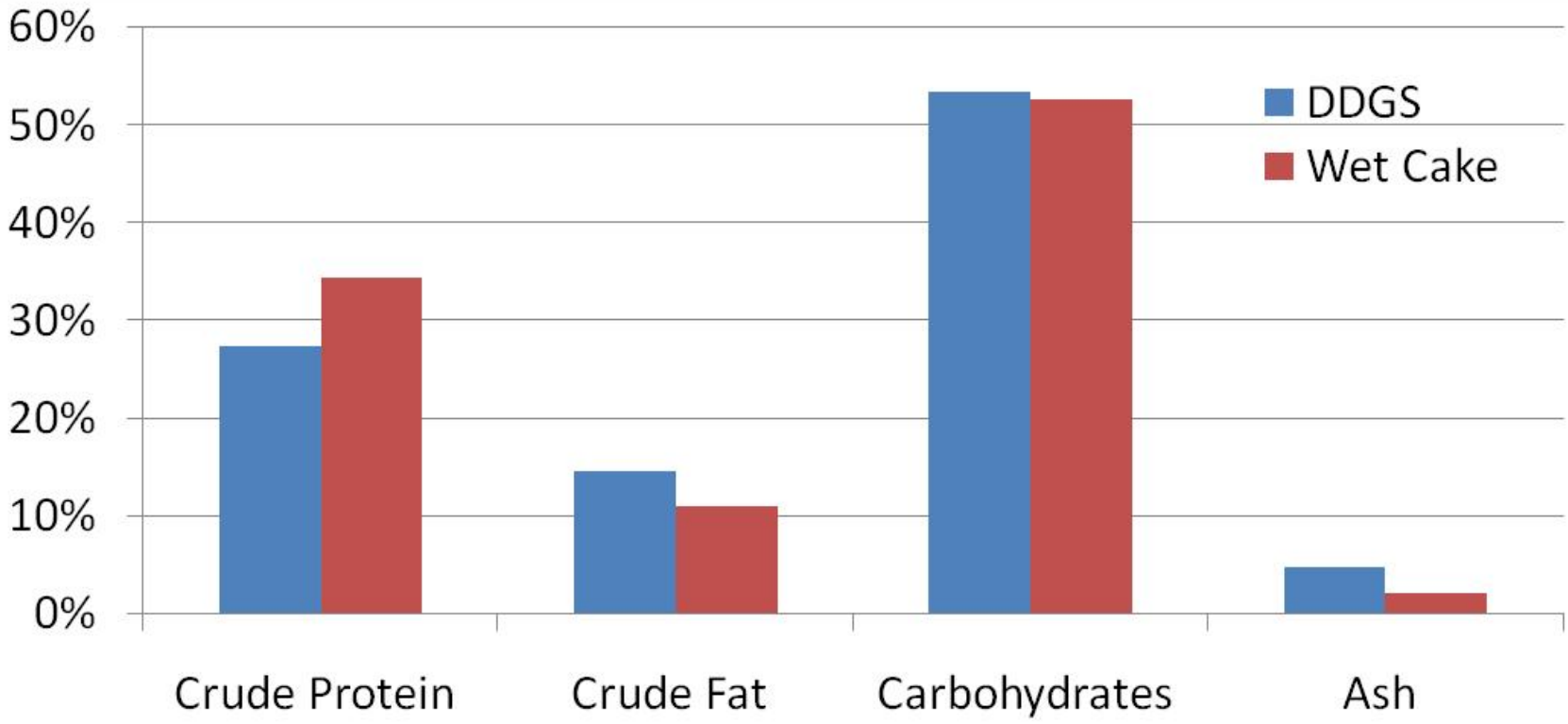
product of the *Dry Grind* Ethanol process

composed of unhydrolyzed, unfermented grain components - seed hull (pericarp), germ, protein, oil

produced by mixing *wet cake* with evaporated *light stillage* and drying the mixture.

When feed markets for DDGS are near the ethanol facility drying step may be eliminated. This significantly lowers the energy cost for the facility.

DDGS Composition



Amount produced goes here……

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Overall Goals

Support Platform Goal of Advanced Energy Initiative; Make Cellulose Ethanol Cost Competitive by 2012

1. Address dry mill pathway as a first test bed for cellulose conversion
2. Contribute to multi-year technical plan of Biochemical and Sugar Platform, Dry Grind Pathway
3. Help address targets to establish biomass as a significant source of sustainable fuels for the US.

This project starts with source of cellulose already at plant gate.

Project Goals

1. Create new markets for DDGS

2. Transition cellulose conversion technologies for use in existing corn to ethanol plants

3. Support DOE biochemical and sugar platform

Approach

Description and Organization of Tasks

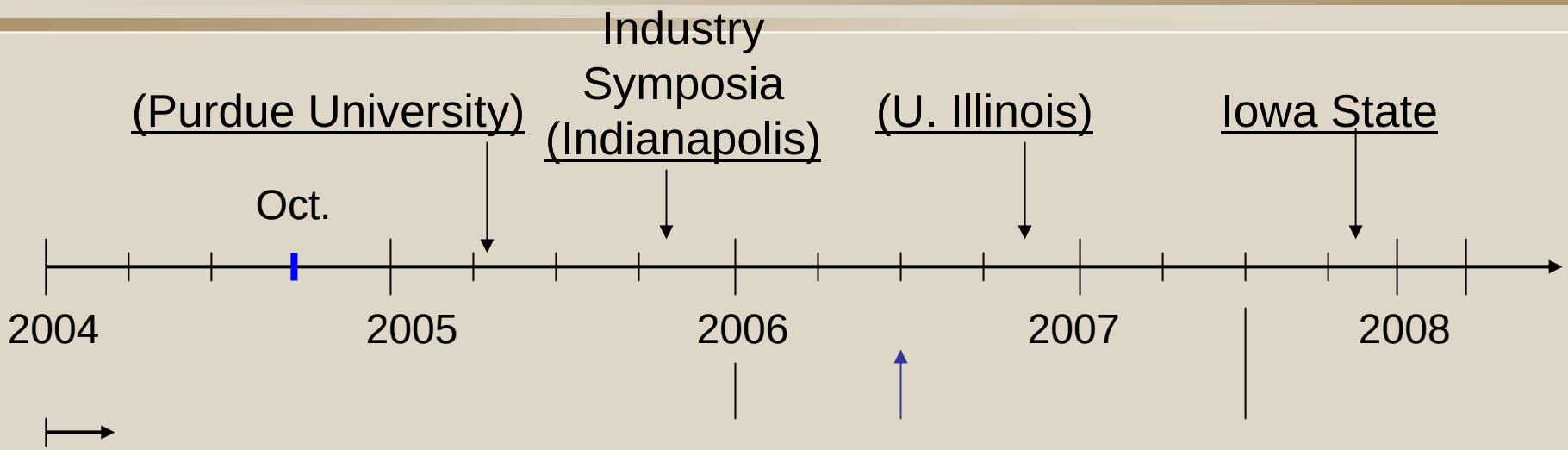
1. Advance pretreatments to enhance digestibility/reactivity of fiber component (cellulose, hemicellulose) of DG (*Purdue, Michigan State, CAFI, USDA NCAUR, Ames Laboratory, Big River*)
2. Characterize enzymes and catalysts for hydrolyzing pretreated DG to fermentable sugars, and removing cellulose, hemicellulose (*USDA NCAUR, Purdue, U. Illinois, Iowa State, Genencor*)
3. Ferment hydrolysates to ethanol and other products (*U. Illinois, USDA NCAUR, Purdue)*
4. Analyze compositions with closure on material balances (*U. Illinois, USDA NCAUR, Purdue, Michigan State)*
5. Assess impact of environmental factors of corn based biorefineries and crop production systems that support them through life cycle analysis (*Michigan State*)
6. Develop economic model for processes, technologies, and markets that incorporate uncertainty in key technological and market parameters (*Purdue*)

Scope of Work: Major Tasks

Major Tasks

1. Obtain internally consistent compositions of DG, DDGS
2. Pretreat, hydrolyze, ferment, characterize hydrolysates
3. Develop overall process flow diagram, obtain closure on material balances
4. Carry out economic modeling and life cycle analysis
5. Transition research results to industrial application and for policy analysis

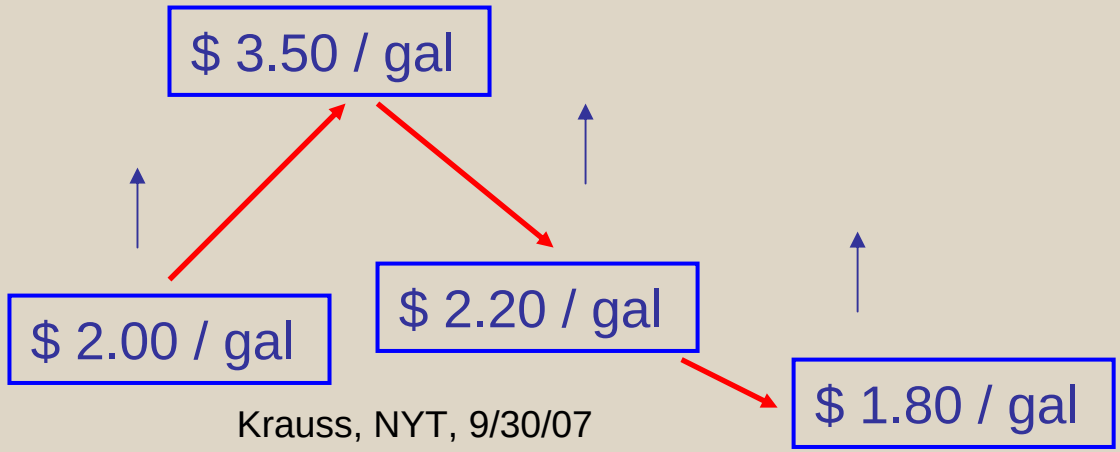
Timeline



Tasks

Fundamentals

i. Work Plan
ii. Enzyme Hydrolysis
iii. Robust Catalysts
iv. Lignin Utilization
v. Biomass Process Integration
vi. Fundamental Studies
vii. Alternate Conversion Paths
viii. Feedstock
ix. Economic Analysis

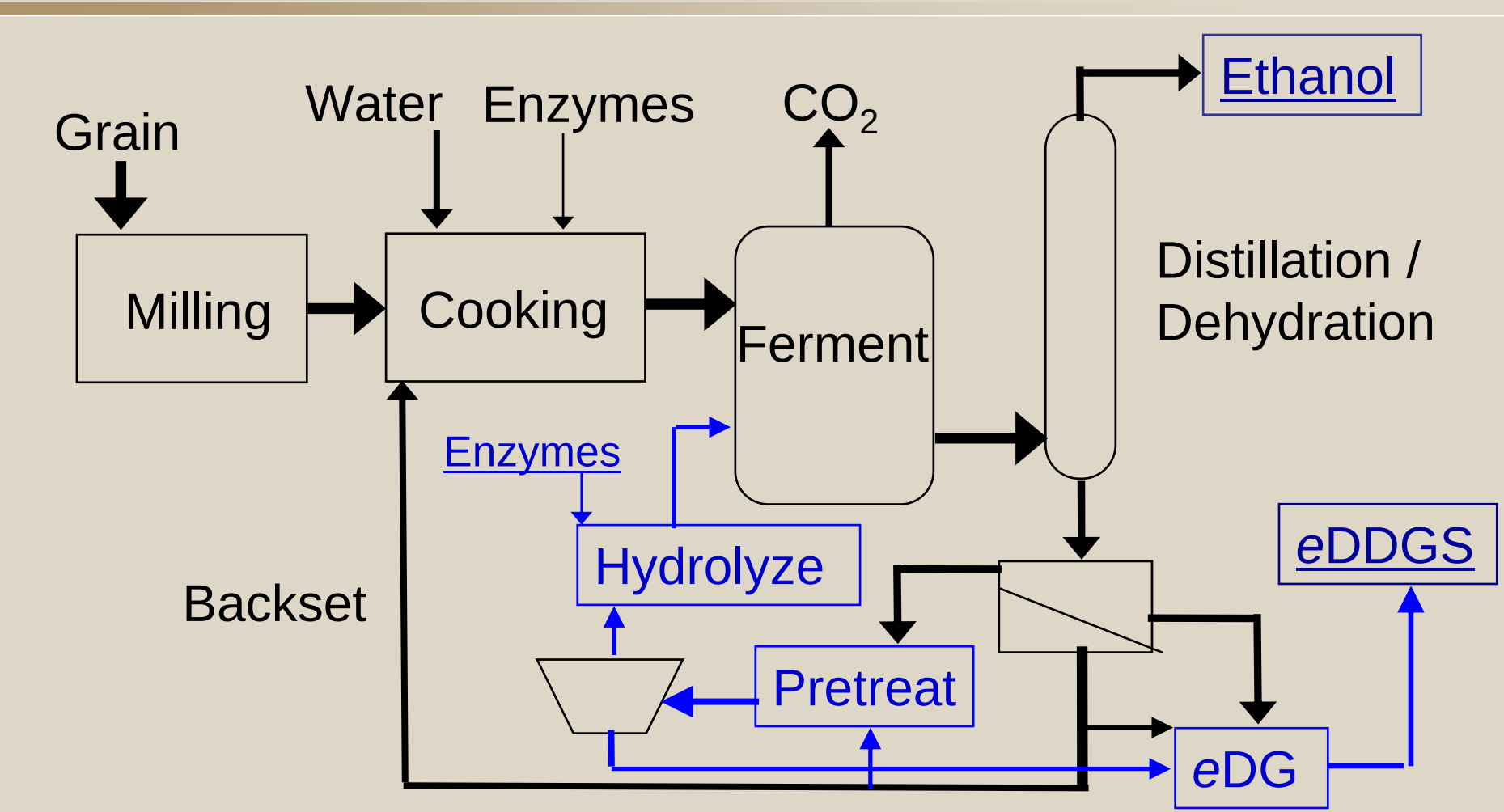


Krauss, NYT, 9/30/07

Presentations today will address:

1. **Pretreatment** of the distillers' grains to reduce time/ enzyme required for complete hydrolysis of cellulose
2. **Hydrolysis** of the resulting streams at > 90% yield
3. **Fermentation** of xylose and glucose in hydrolysates to alcohols (ethanol and butanol)
4. **Analysis of composition** for various streams to generate preliminary material balances
5. **Life cycle analyses** to assess environmental impacts of new processes to allow for more rapid implementation of technology;
6. **Economic model to assess** impact of process improvements from this research on market potential.

Dry Grind Process with Cellulose Conversion



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Future Directions

Research

- High loading effects
  - Physical properties (characterization)
  - Enzyme effectiveness at constant *enzyme / glucan* ratio (inhibition; mass transfer, diffusion)
  - Fermentation (SSF vs fractionated sugar approach)
  - Mathematical models for these effects
- Enzymes and enzyme formulations
  - Hemicellulose hydrolysis
  - Use as bioprocessing aids
- Feedstock (DDGS, DG) Variability
- Fermentation of glucose and xylose to ethanol
- Integrative process models for mass balances
- Extension of Economic models

Engagement

- Integrative, peer reviewed publications
- Industry test beds

Loading Effect Constant Enzyme / Glucan Ratio

Conversion at 5% Loading (50 g / L) DDGS = 90 %
Conversion at 30% Loading (300 g / L) DDGS = 70 %

Enzyme / Glucan Constant at 15 FPU / g glucan

Inhibition? Possible - local pockets of sugars – diffusion effects

Mass Transfer? Maybe (surface area effect)

Mixing and reactor design need to be considered