FRONTLINE
BIOENERGY, LLC
Renewable Fuels & Products

Biomass Processes & Technologies

Adding Value to Home Grown Resources

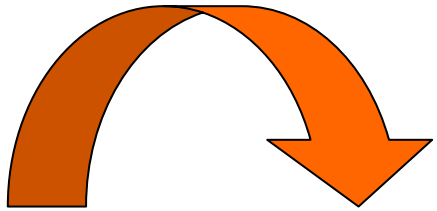
Jerod Smeenk
Frontline BioEnergy, LLC

Home Grown Energy Conference – Morris, MN

February 28, 2006

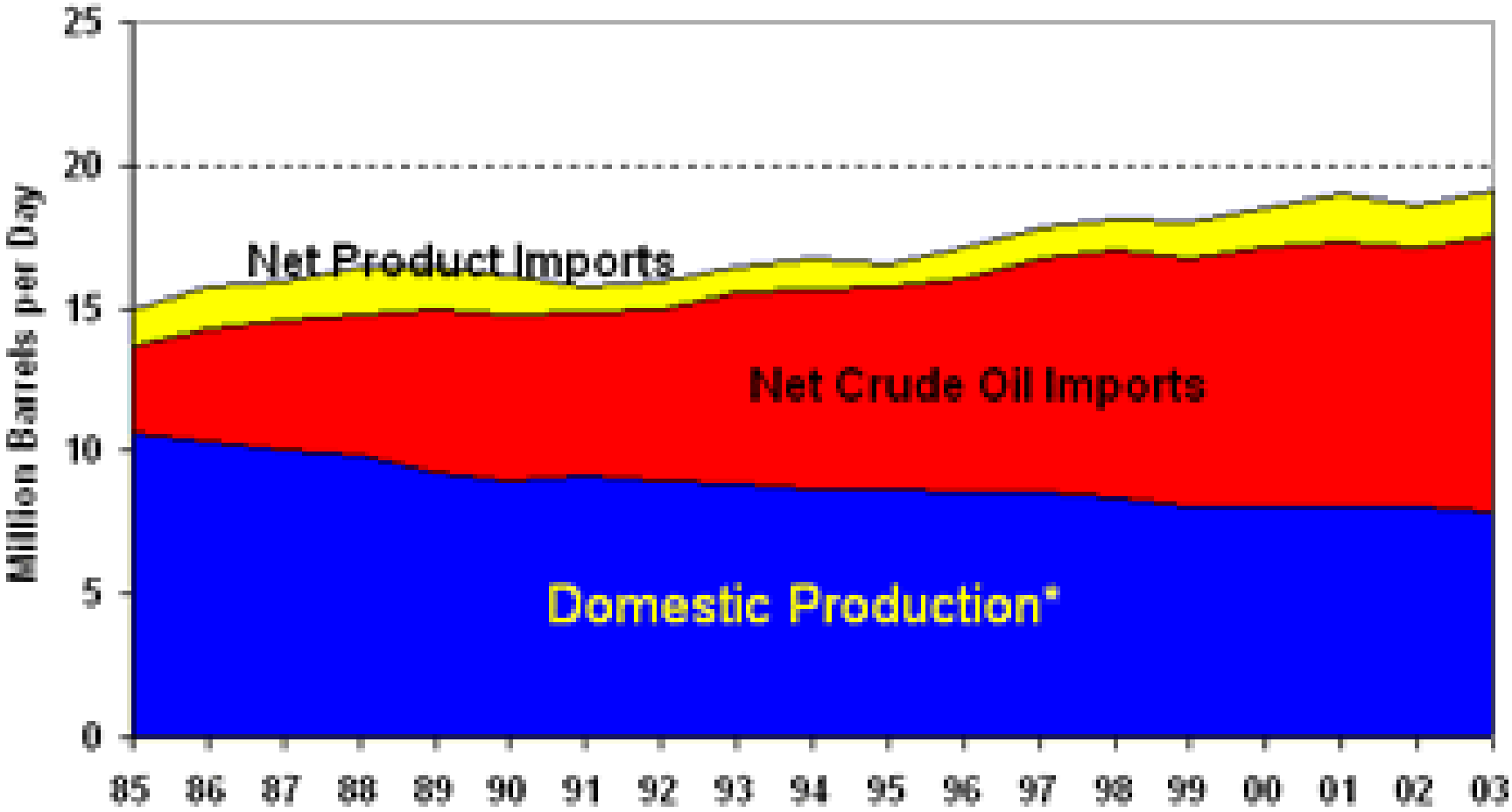
Transition to a “New” Economy

Geological Economy

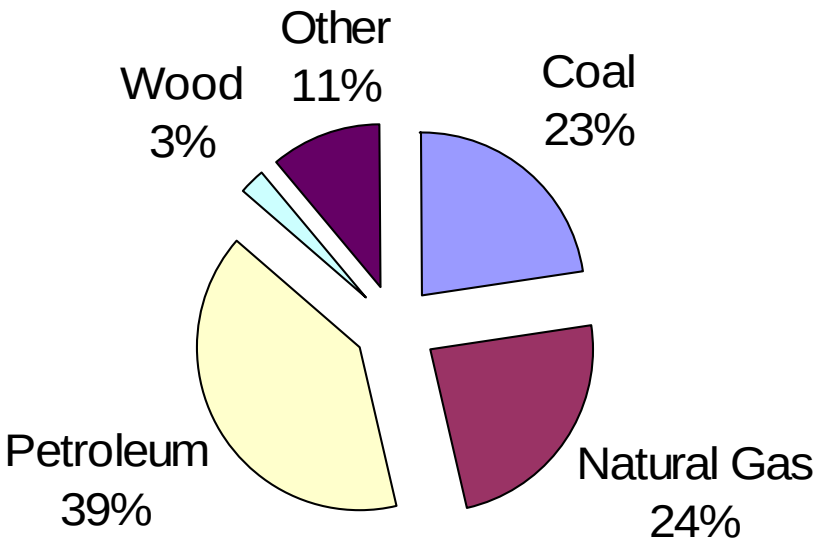


Biological Economy

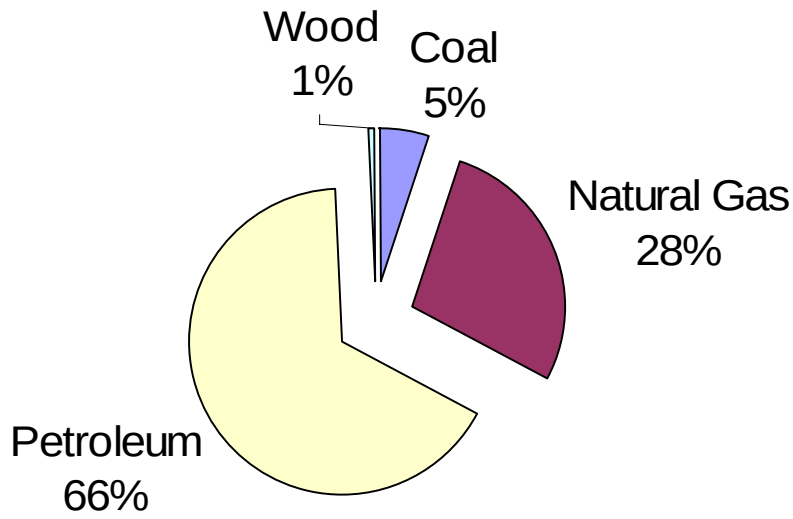
U.S. Oil Production and Imports



Energy Use and Cost in the U.S. - 2001



96.3 Quads



$505.9 billion

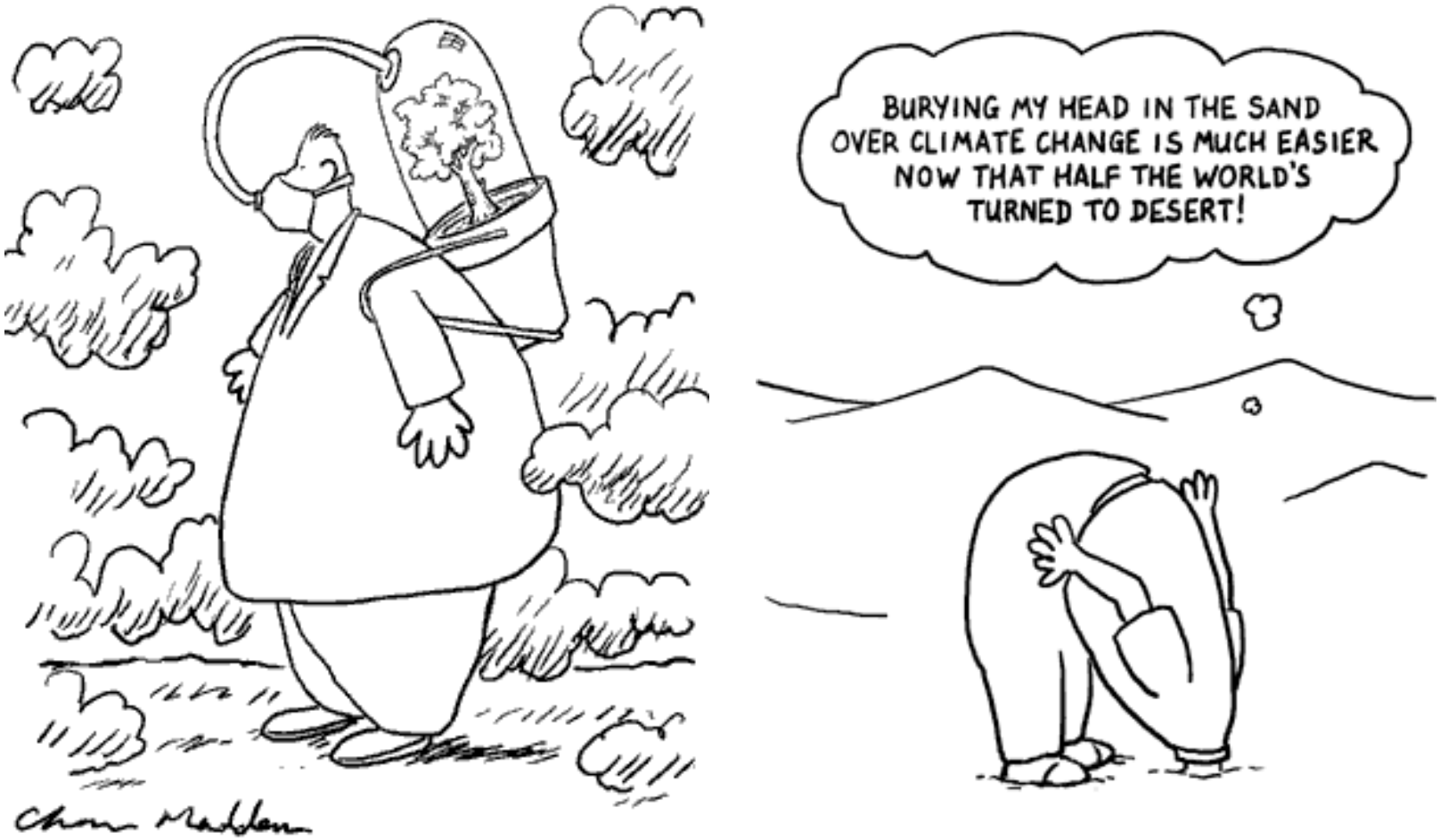
Source: Energy Information Agency (http://www.eia.doe.gov/)

Motivation for Returning to a Bioeconomy

- Environmental quality
  - Local and regional (smog, acid rain, waste disposal)
  - Global climate change
- Excess agricultural production
  - Especially in U.S., but many countries are becoming self sufficient in food production
- National security
  - Reduced reliance on foreign cartels
- Rural development
  - Rural economies are not thriving in many parts of the world

Courtesy USDA NRCS

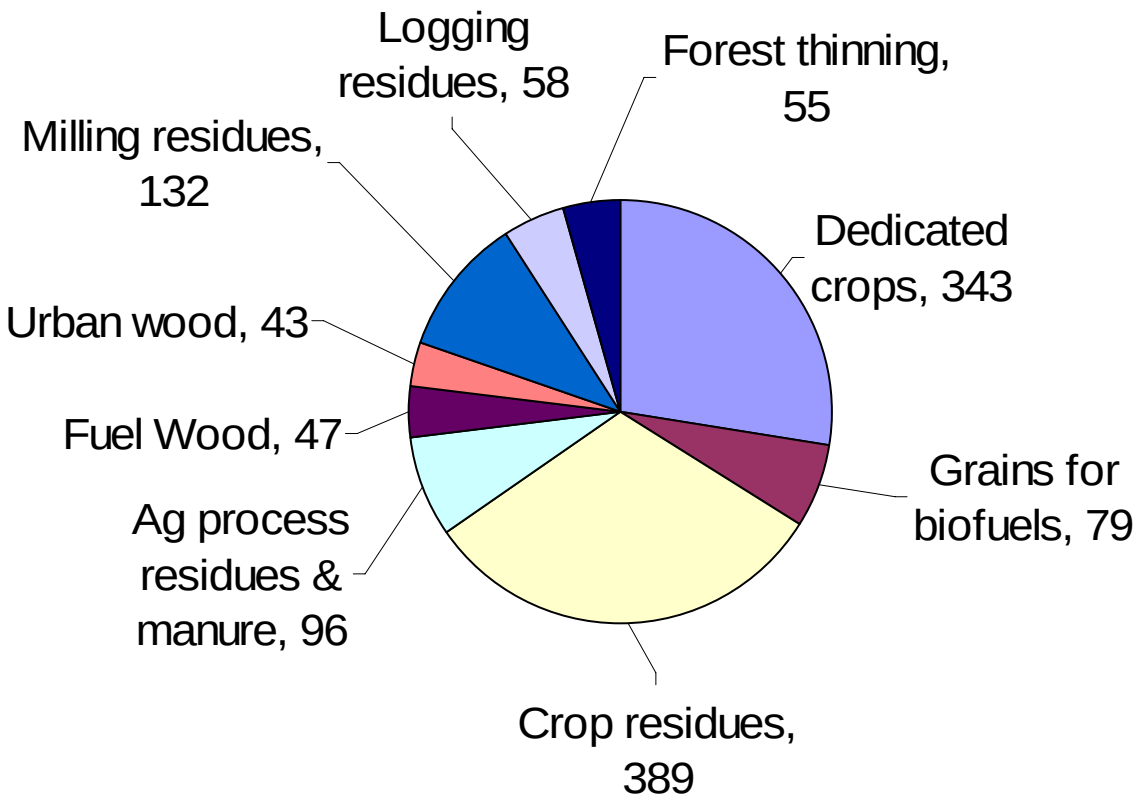
Motivation for Returning to a Bioeconomy



Biorenewable Resources

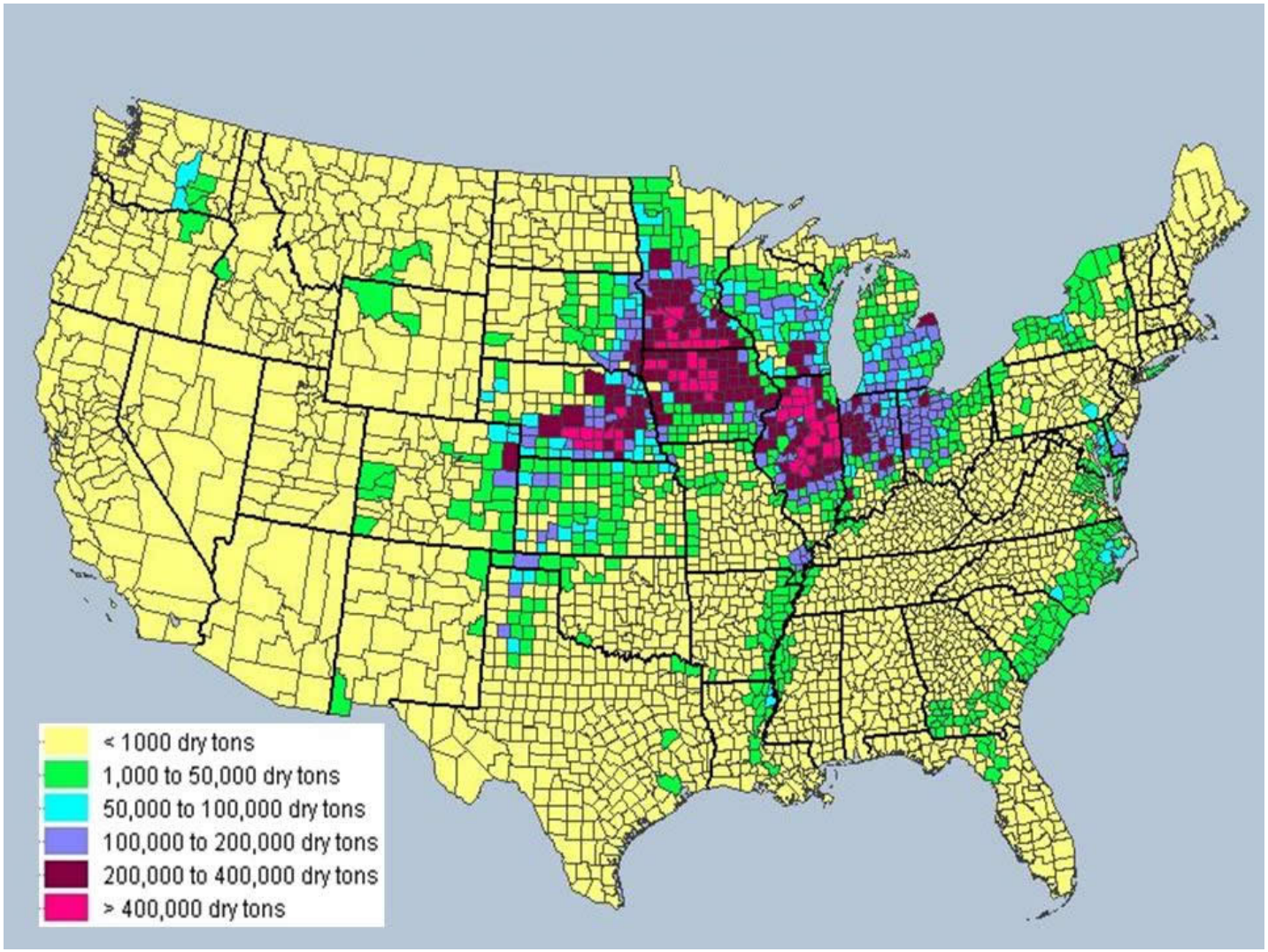
- Organic materials of recent biological origin (commonly known as biomass)

USDA/DOE Biomass Supply Analysis: 1.3 billion tons



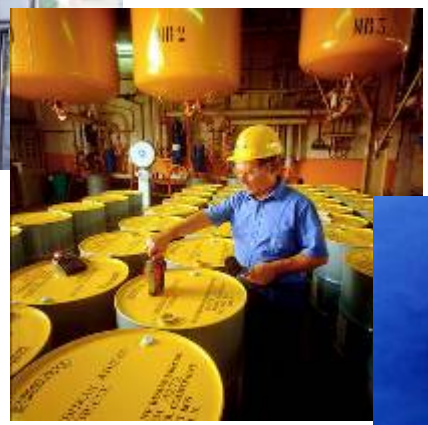
This biomass supply could be used to fulfill one-third of U.S. demand for transportation fuel.

USDA Study: Biomass Distribution



Biobased Products

Fuels



Chemicals

Fibers

Power

Biorefineries turn biomass into multiple products

Plant Science
- Genomics
- Enzymes
- Metabolism
- Composition

Production
- Trees
- Grasses
- Agricultural Crops
- Agricultural Residues
- Animal Wastes
- Municipal Solid Waste

Processing
- Acid/Enzymatic hydrolysis
- Fermentation
- Bioconversion
- Chemical Conversion
- Gasification
- Combustion
- Co-firing

End-Uses

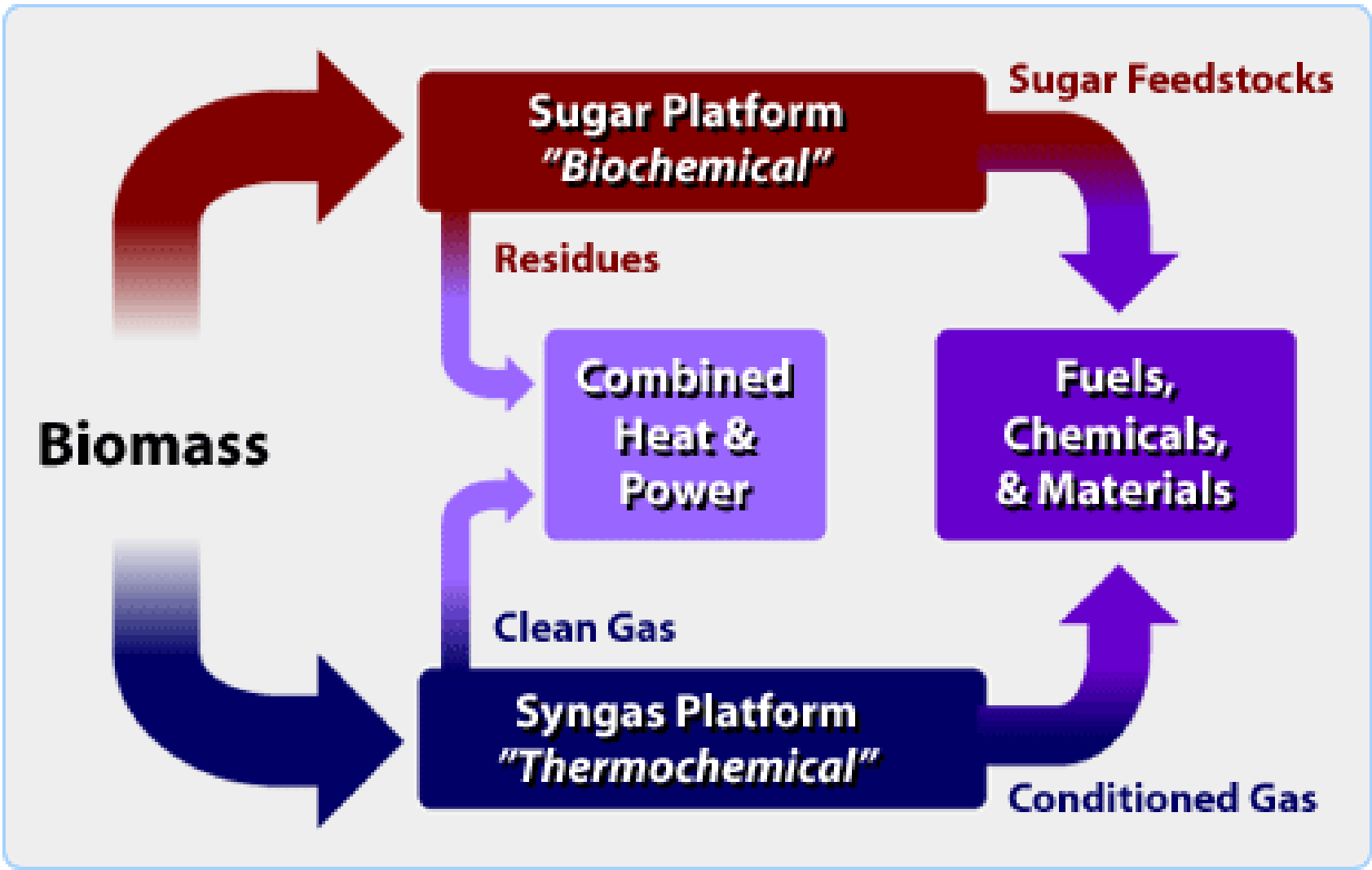
Transportation Fuels

Chemicals
- Plastics
- Functional Monomers
- Solvents
- Chemical Intermediates
- Phenolics
- Adhesives
- Hydraulic Fluids
- Paints
- Dyes, Pigments, and Ink
- Detergents
- Paper
- Fiber boards
- Solvents
- Adhesives
- Plastic filler
- Abrasives

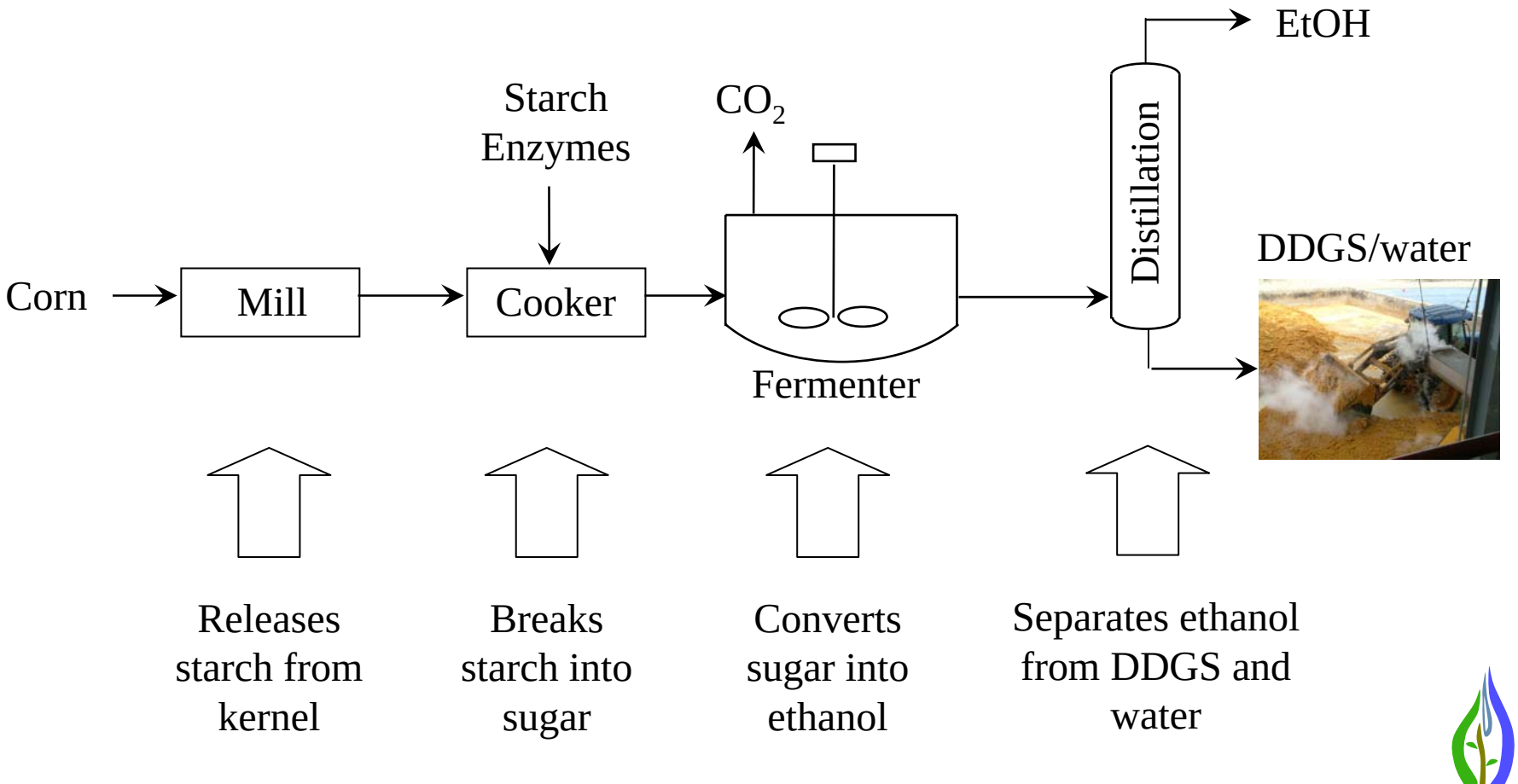
Fibers

Electric Power

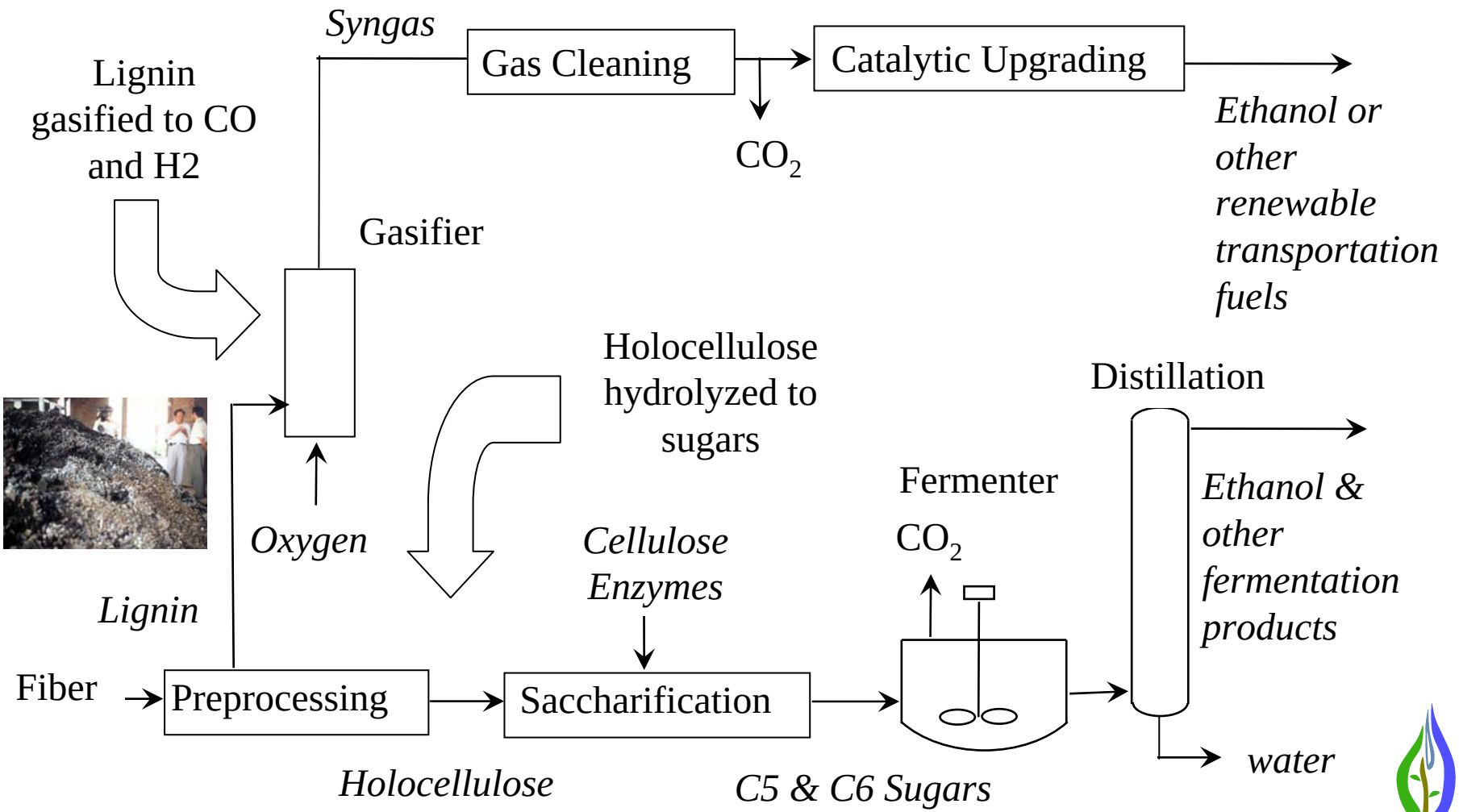
Biorefinery Concept



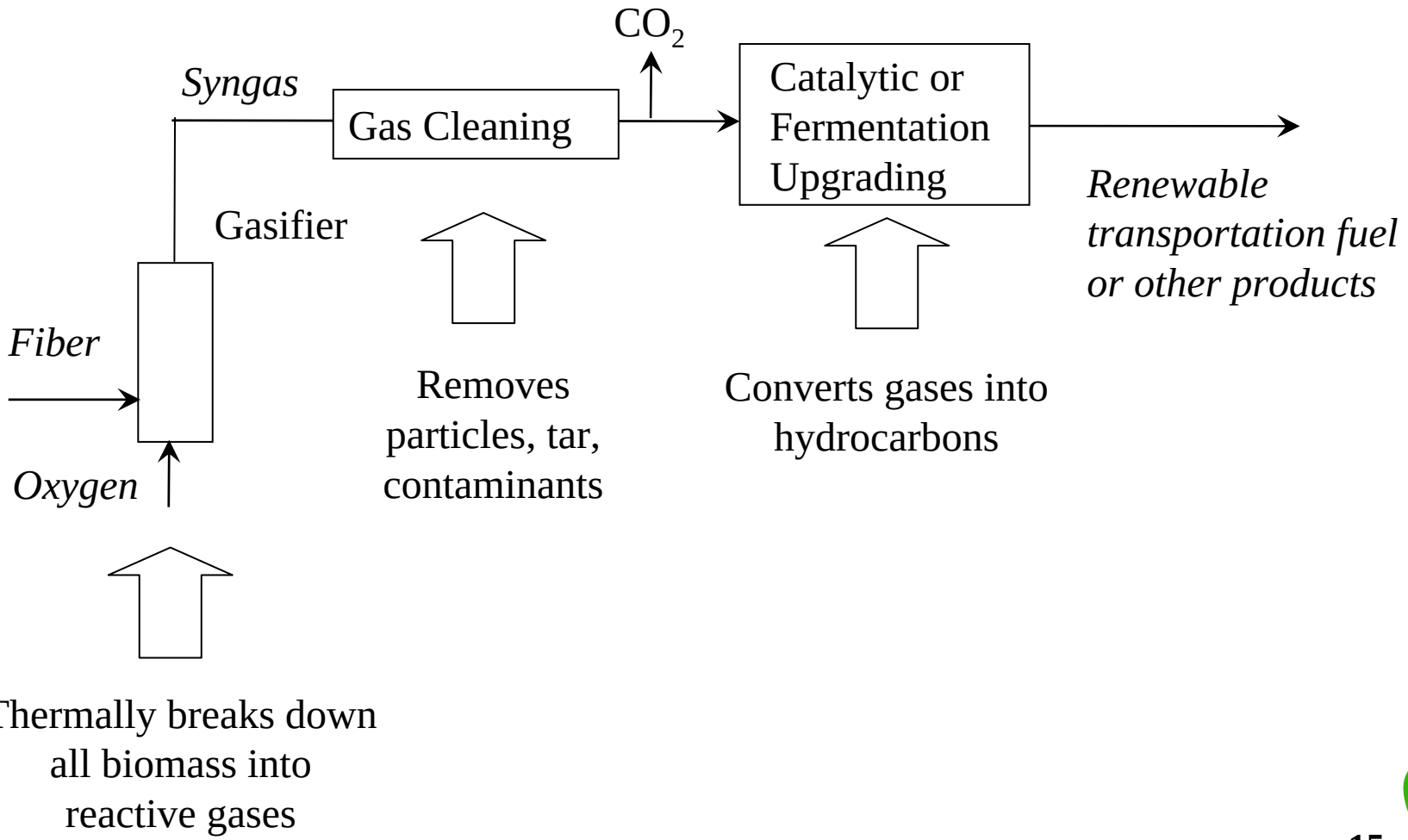
Current Technology: Grain-to-Ethanol Production



Lignocellulosic Biorefinery



Thermochemical Biorefinery



Thermochemical Conversion

- ‘Thermochemical’ – high temperature conversion of biomass into other, useful products
- Conversion pathways
  - Direct Combustion
  - Thermal Gasification
  - Fast Pyrolysis

Comparison of Thermal Conversion Pathways

- Combustion
  - Fuel + Oxygen (usually from air) → Hot Exhaust + Ash
- Gasification
  - Fuel + Limited Oxygen (from air) → "Producer Gas" + Heat + Char + Tar
  - Fuel + Steam + Oxygen (enriched O_2) → "SynGas" + Heat + Char + Tar
- Pyrolysis
  - Fuel + Heat → Fuel Gas + Char + Tar

↓

"Pyrolysis" Bio-oil

Combustion Applications

Pellet and corn stoves

Wood fired boiler generating 12,000 lb/hr process steam

Ottumwa Generating Station – 750 MWe coal fired power plant that co-fires 17.5 MWe switchgrass

McNeil Generating Station – 50 MWe wood fired power plant

Pyrolysis Applications

Pyrolysis oil

- Ensyn
  - Numerous commercial installations
  - Fueled with wood
  - Produce organic resins, food flavoring, and fuel
- Dynamotive
  - Single commercial installation
  - Fueled with wood
  - Fire pyrolysis oil into a combustion turbine to generate electricity

Gasification Applications

BFC Gas & Electric in Cedar Rapids, IA

Primenergy Facility in Rossano, Italy

- Ethanol industry for natural gas displacement
- Central Minnesota Ethanol
  - Primenergy gasifier to fire the thermal oxidizer
  - Fueled with wood
  - High pressure steam with co-generation
- Chippewa Valley Ethanol
  - Frontline gasifier to fire boilers and dryers
  - Fueled with DDGS and stover

Points to consider for thermochemical conversion

- What is the desired end product?
  - heat?
  - electricity?
  - fuel?
  - chemicals?
- What are the characteristics of the fuel?
  - moisture?
  - ash composition?
  - size?
  - availability?
- What are the motivating factors?
  - cost of alternatives?
  - renewable?
  - Rural development?
  - tax advantages?
  - sustainable?

Advantages of each conversion process

- Combustion
  - Ease of operation
  - Tolerant of high moisture fuels
  - Less fuel preparation
  - Less expensive
- Gasification
  - Use of multiple fuel gas conversion technologies
  - Several end products
  - Process difficult fuels with ash separation
  - Potentially lower emissions
- Pyrolysis
  - Higher energy content in gas
  - Liquid end product
  - Extraction/production of chemicals

"All I'm saying is now is the time to develop the technology to deflect an asteroid."

"Change won't occur until the alternative is less painful than status quo."

- author unknown

Contact Information

Jerod Smeenk
Frontline BioEnergy, LLC
2521 Elwood Drive, Suite 125
Ames, IA 50010
(515) 292-1200 x103
jsmeenk@frontlinebioenergy.com