

# BIOMASS FEEDSTOCK ENGINEERING OPPORTUNITIES AND INNOVATIONS

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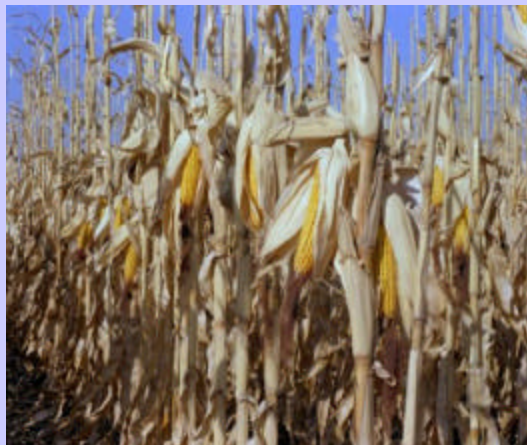
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**OAK RIDGE NATIONAL LABORATORY  
ENERGY EFFICIENCY AND RENEWABLE ENERGY PROGRAM  
U. S. DEPARTMENT OF ENERGY**

# OUTLINE

- **Background – *what is feedstock engineering***
- **The perspective – *encouraging evidence***
- **Sample data – *significance of engineering data***
- **In progress – *efforts here and there***
- **A vision – *seeing a successful enterprise***
- **Acknowledgment – *sponsors and colleagues***

# Biomass to Energy and Products



**Feedstocks**

Trees  
Grasses  
Agricultural Crops  
Agricultural Residues  
Animal Wastes  
Municipal Solid Waste



**Conversion Processes**

Acid/enzymatic hydrolysis  
Fermentation  
Bioconversion  
Chemical Conversion  
Gasification or Pyrolysis  
co-firing



## USES

### Fuels:

Ethanol  
Renewable Diesel

### Power

Electricity  
Heat

### Products

Plastics, resins, foams  
Phenolic resins  
Solvents, cleaning fluids  
Chemical Intermediates  
Adhesives  
Fatty acids  
Carbon black  
Paints, coatings  
Dyes, Pigments, and Ink  
Detergents  
Hydraulic & lubricating fluids

# BIOMASS

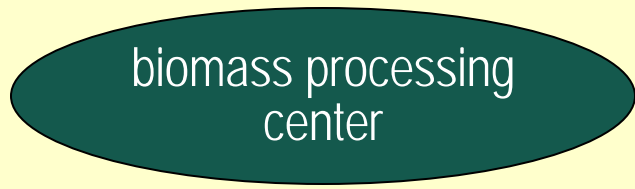
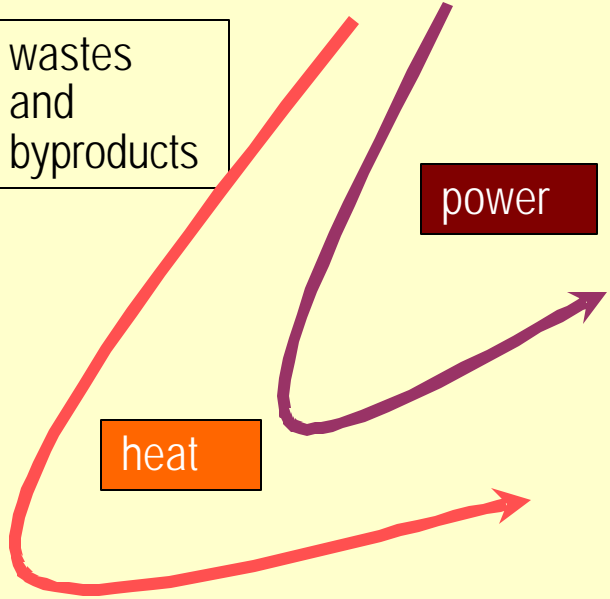
## Biomass to feedstock conversion and logistics A new business model

crop residue

forest residue

energy crops

wastes and byproducts



# BIOREFINERY PRODUCTS

size reduction

mixing

purification

drying

densification



Shipped to

biofuels

biopower

chemicals

industrial products

feed

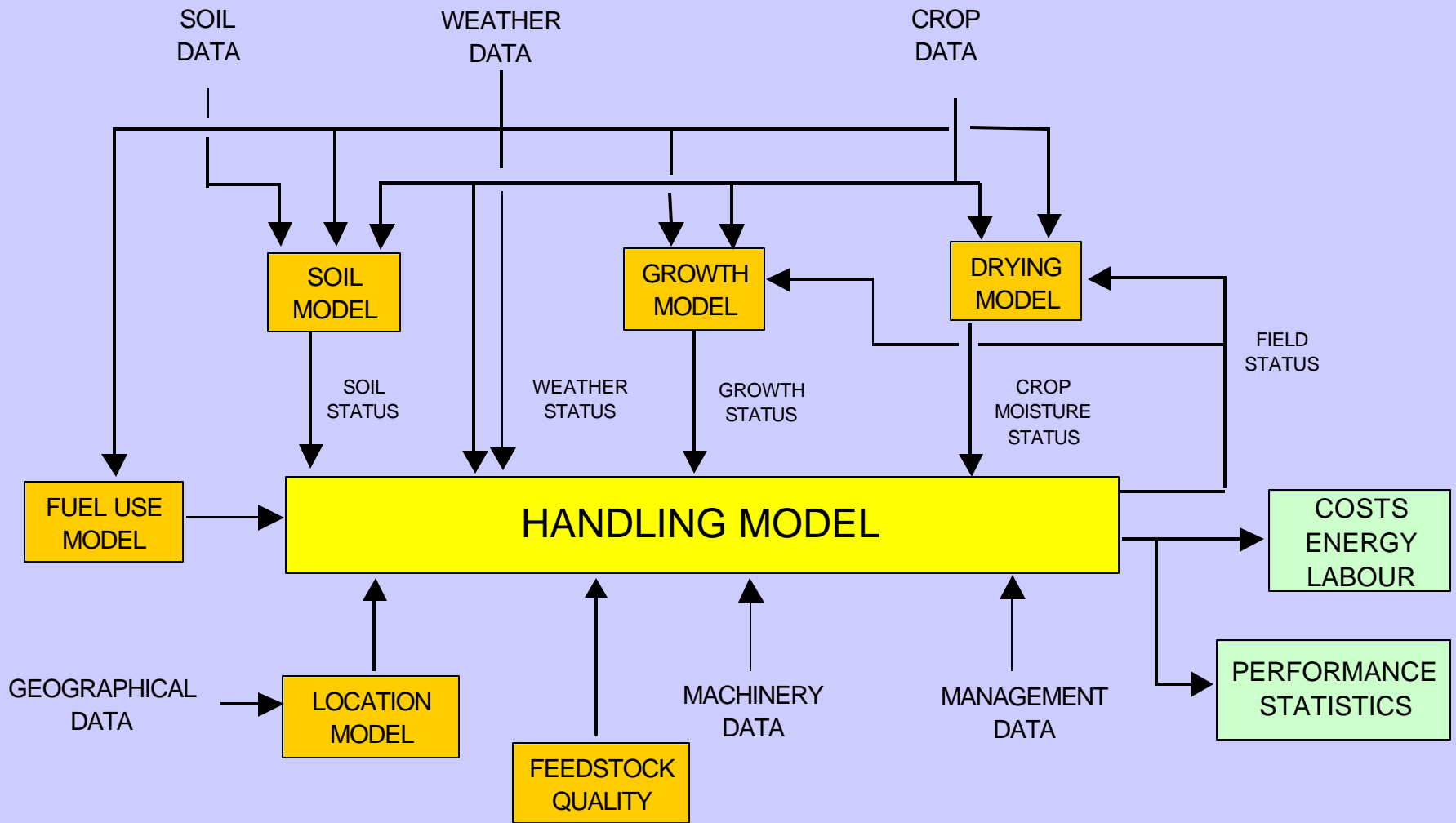
food

# Definitions

- ***Biomass: Organic matter available on a renewable basis.***
- ***Feedstock: Processed biomass delivered to conversion plant.***
- ***Feedstock Engineering: Engineering for **converting** biomass to feedstock and **timely** delivery.***

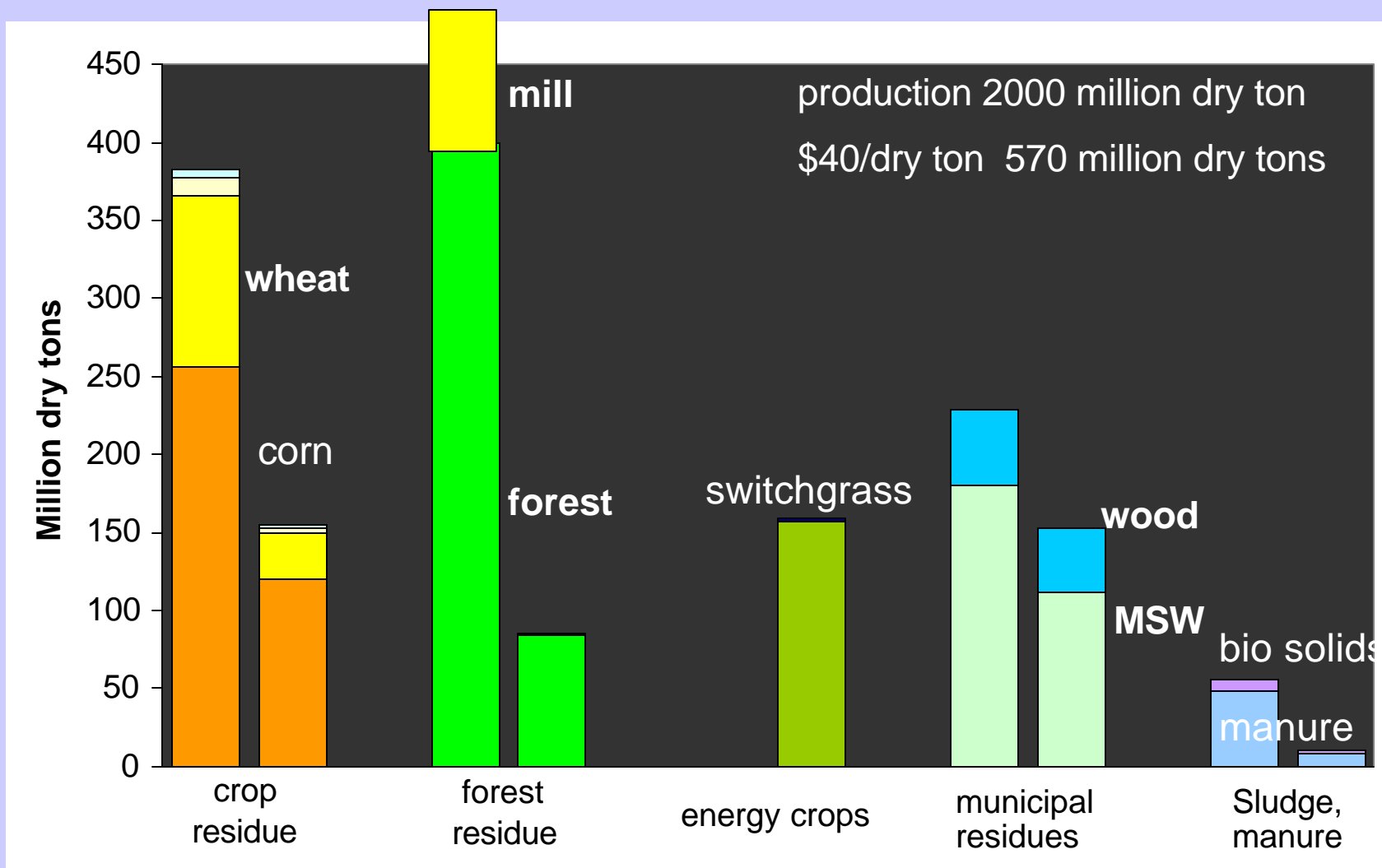


# Developing the entire collection and delivery system



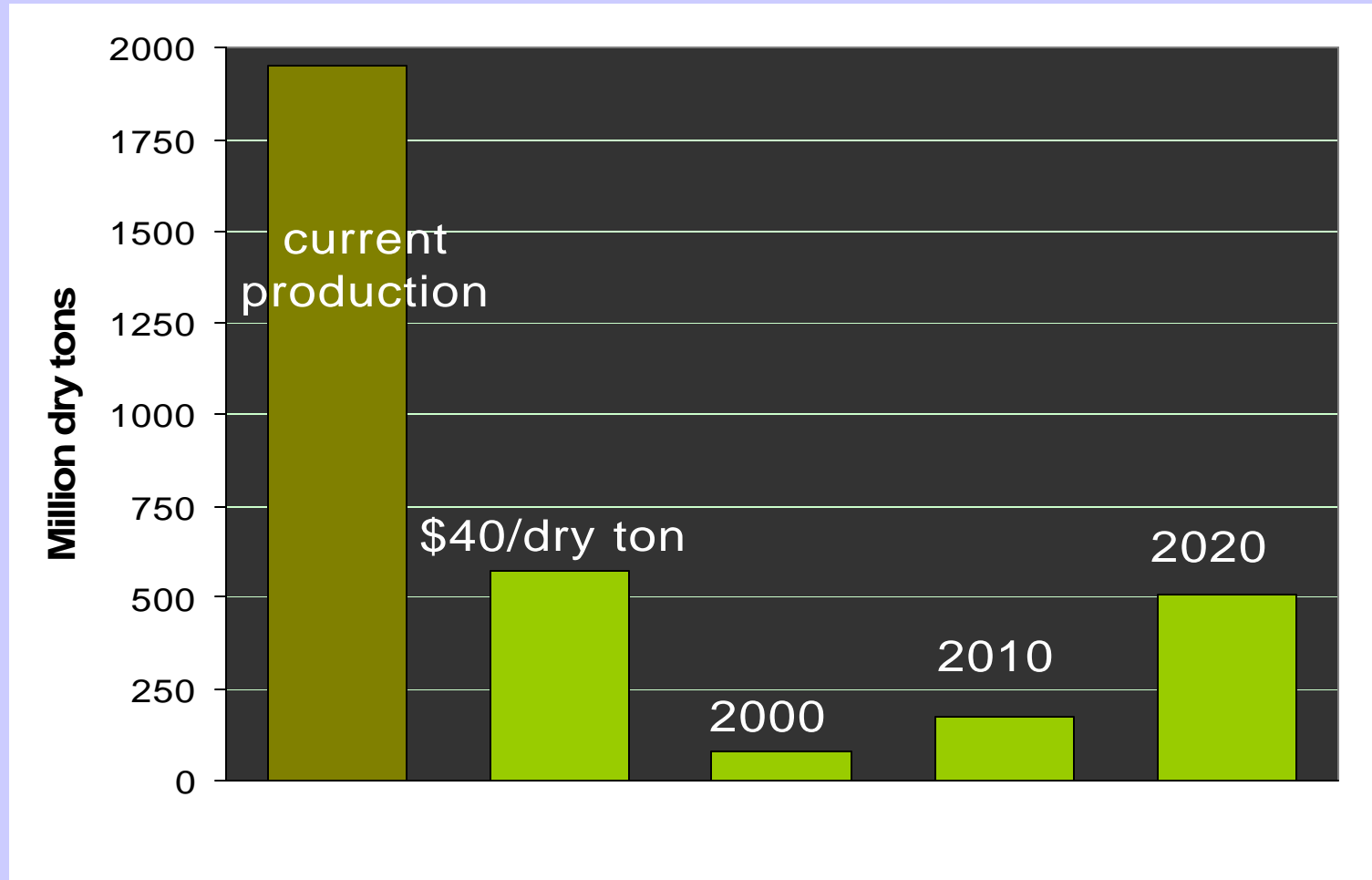
# THE PERSPECTIVE

# Quantities of current annual production versus potentially available biomass at \$0- 40 per dry ton farmgate





# Supply and projected demand on biomass



## Demand on new equipment and storage (billion dollars)

	2010	2020
<i>Field equipment</i>	3.7	14.3
<i>Power (tractor)</i>	5.8	22.3
<i>Storage</i>	3.2	10.6
<i>total</i>	12.7	47.2

Filed equipment: mower, rake, shredder, baler, transporter, lifter

Power: tractors 80-250 hp

Storage: steel bins, warehouses, shed, pad

Yet to be estimated: transport equipemnt, grinders and densifiers, dryers, controls.

# Industry response

Darrin Drollinger, Vice President Research and Safety  
Association of Equipment Manufacturer (AEM) –

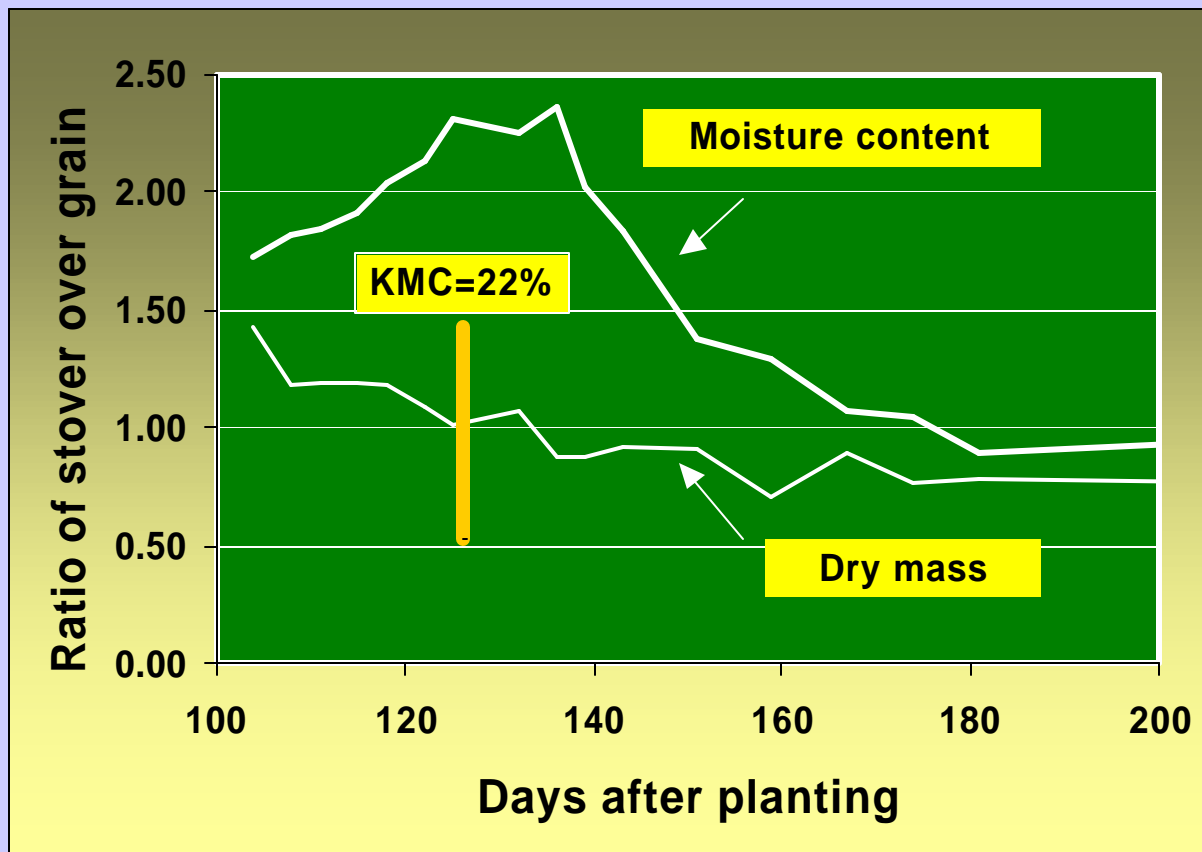
***“The biomass industry holds great promise and as you have estimated in the proposal, there may be a tremendous demand for new and re-designed equipment.***

***The three objectives as outlined seem both meaningful and well defined. A suggestion to item one would be to expand it to also examine equipment needs for crop or feedstock planting.”***

***(August 7, 2002)***

# CHARACTERISTICS (experimental data)

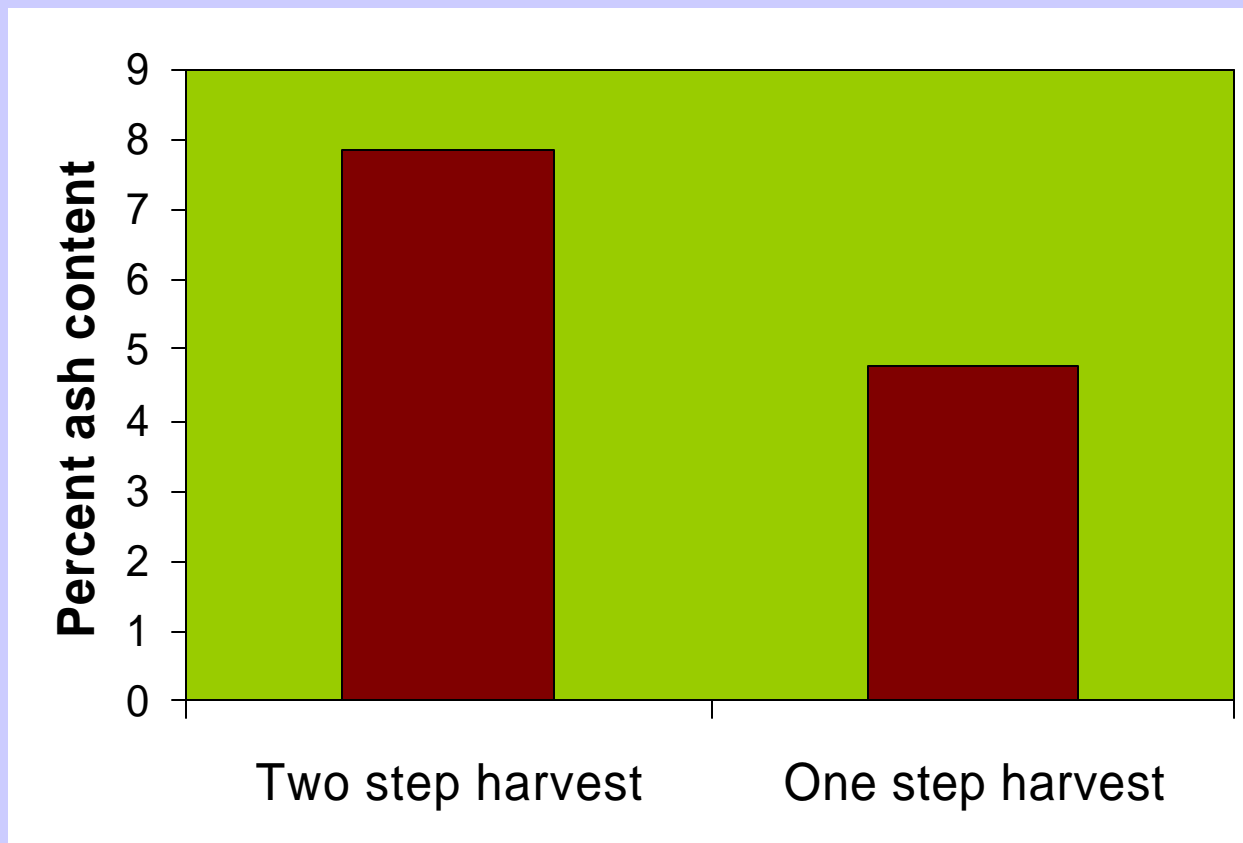
# Ratio of stover over grain for moisture content and for dry mass



Moisture control is a key technology

Source: Pordesimo et al. 2002

# Biomass contamination with soil



Pordesimo et al. , 2002

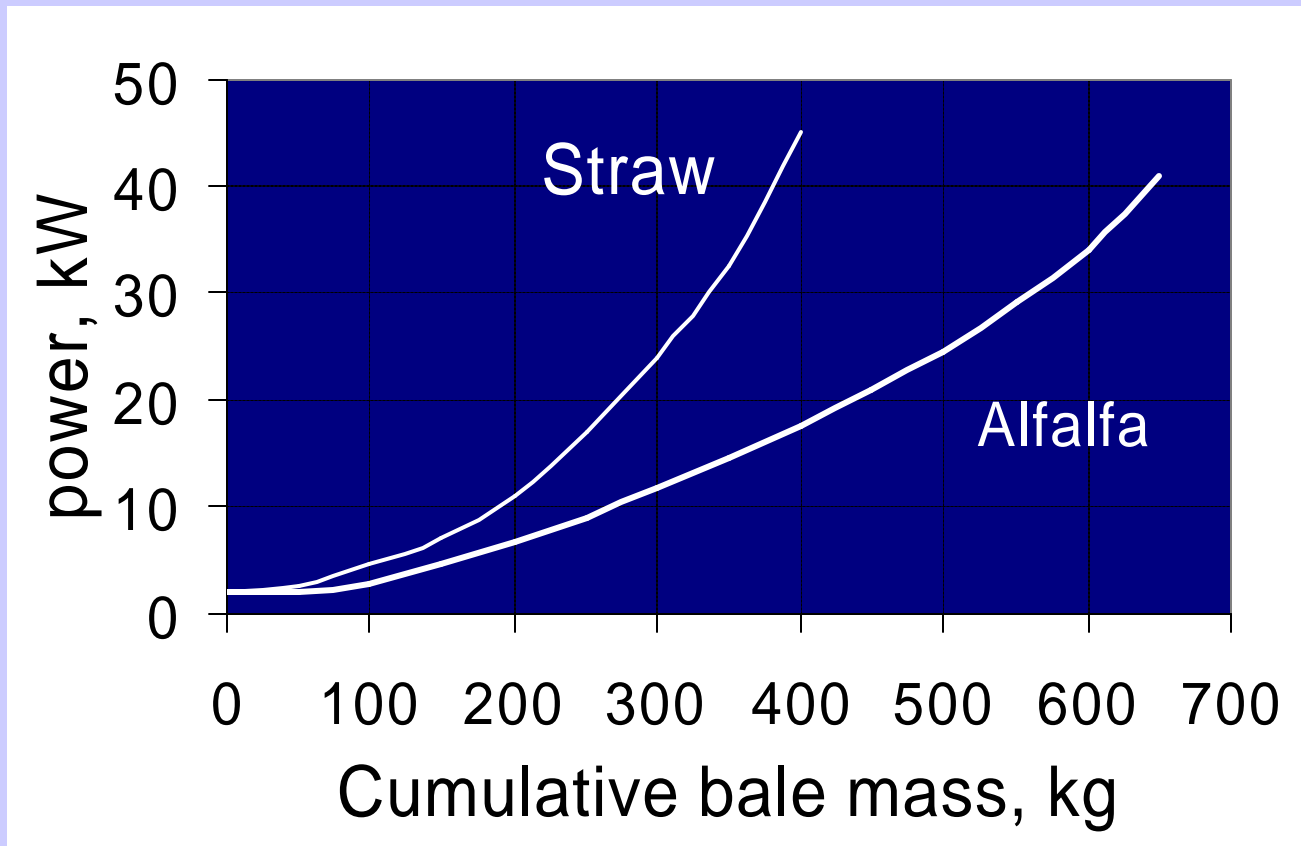
Limited data from Iowa

# Sensitivity analysis on the cost of stover collection

	Worst	Base	Best
Yield, ton/ac	1.1	1.5	2.5
\$/ton	31.10	26.90	22.20
Density, lb/ft <sup>3</sup>	7	9	10
\$/ton	30.90	26.90	25.50
Operating hours	50%	100%	150%
\$/ton	29.80	26.90	25.80
Combinations*, \$/ton	41.00	26.90	21.00

Densification is a key technology

# Power requirement of a round baler for wheat straw bales and alfalfa bales

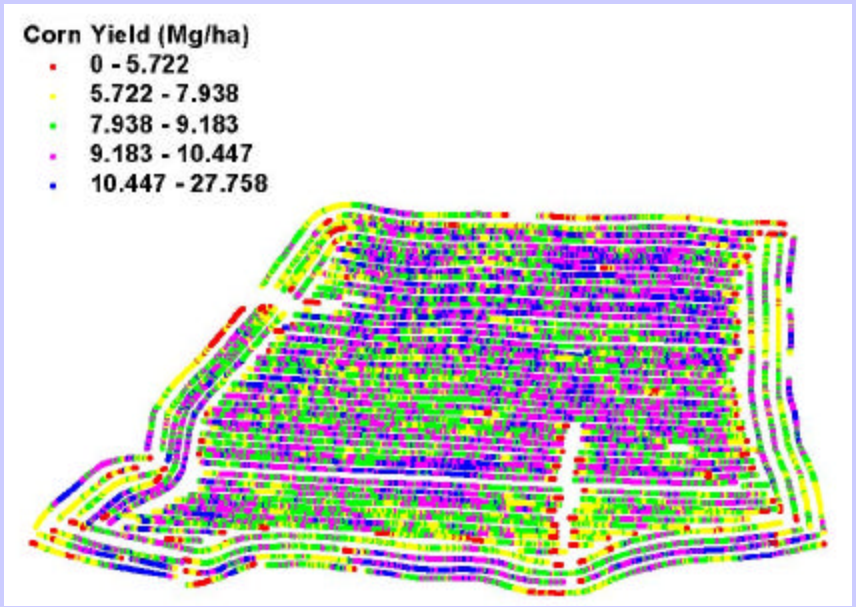


Equipment for biomass must be powerful and robust



**IN PROGRESS**

# Precision Biomass Collection and Conversion to Feedstock Systems



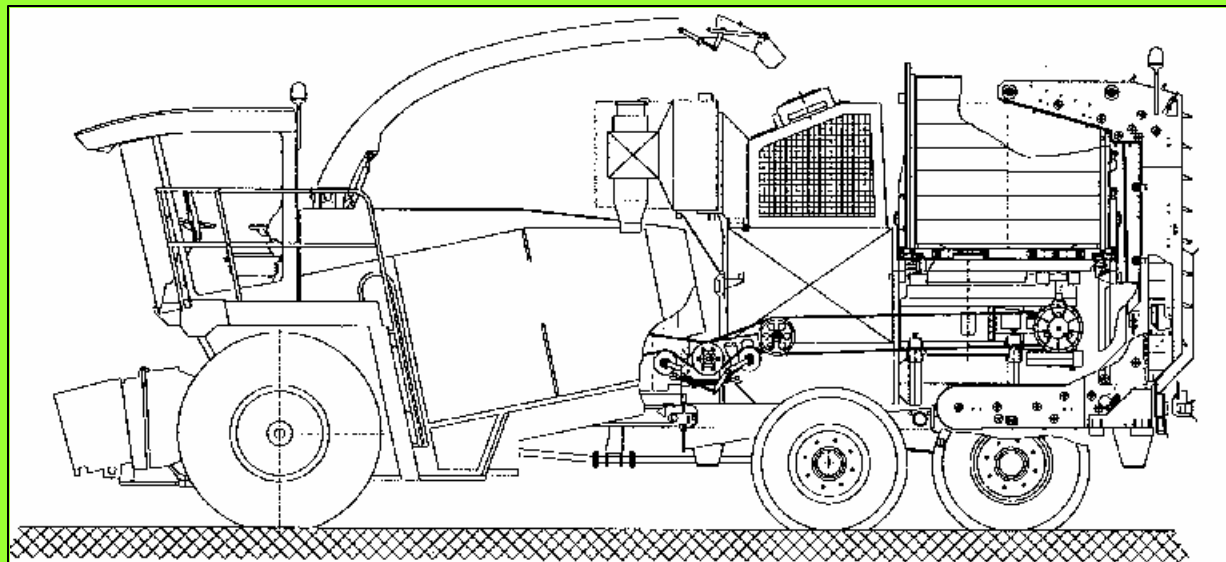
**Yield Map – 36 acres**

## Grid Data of Stover Distribution Stover to grain mass ratio 1:1



Source: University of Kentucky, 2002

# Pelleting technology – Mobile



## Situation analysis

- Mobile densifier (for grass) was developed and abandoned (1960-1970, John Deere and Lundell)
- Self propelled Biotruck is developed and tested in Europe (number not known) ,

- Biotruck specifications:
- Based on Claas Jaguar forage harvester platform
- Collects, grinds, dries, makes pellets: 10mm long, 60 mm wide, 12 mm thick
- Bulk density: 20-30 lb/ft<sup>3</sup>
- Power required 450 hp
- Output 3-5 ton/hr
- Manufacturer: **Haimler company, Germany**
- None in the U.S.

# One step harvest – Iowa State University, 2001

- **John Deere 9750 STS Combine**
  - 8-Row Corn Head
  - 6-Row Bean Head
- Used with “Stover Caddy”
  - Collects All Material From Rear of Combine
  - Uses Forage Blower to Convey Into Wagon



# Densifying forest thinnings and residues



## R & D opportunities

- Adaptation to harvesting systems in the U.S.
- Tree species
- Time study and economics
- Energy conversion

## Situation analysis

- Gathering and densifying forest slush - bundling
- Dimension 2 ft diameter, 10 ft long, 400 kg each
- Each bundle produces 1 MWh
- 20-30 bundles per hour
- Transported with standard log trucks and handling equipment.
- Bundles are crushed with log chippers
- 7.7 \$/MWh (37 \$/dry ton) - 80 km travel (Finish data)
- 10 Machines are tested in Europe, none in the U.S.
- Manufacturer: Timberjack (John Deere)

# Loading, transporting, stacking in one operation



*"Our method for stacking hay in the past had been using 2-3 semi trucks, 2 loaders (1 in the field & one in the stack yard), & 2-3 men. Now with the HAYING MANTIS we have one machine & one operator, doing more than all 3 of us could do in one day."*

Ken Heersink 4x4x8 Some Custom quoted about the HAYING MANTIS hay transport hay equipment.

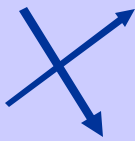
# VISION

# Biorefinery integrated with biomass-to-feedstock engineering

Biomass to feedstock

Feedstock to energy & products

residues  
dedicated  
crops  
wastes  
by-products



grind  
pellets  
bales  
silage  
haylage  
liquids

specifications  
demand schedule

low cost, consistent  
Just in time delivery

chemicals  
biopower  
biofuels  
industrial  
chemicals and  
products  
food  
feed



# ACKNOWLEDGMENT

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