

BIOMASS FEEDSTOCK ENGINEERING OPPORTUNITIES AND INNOVATIONS

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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

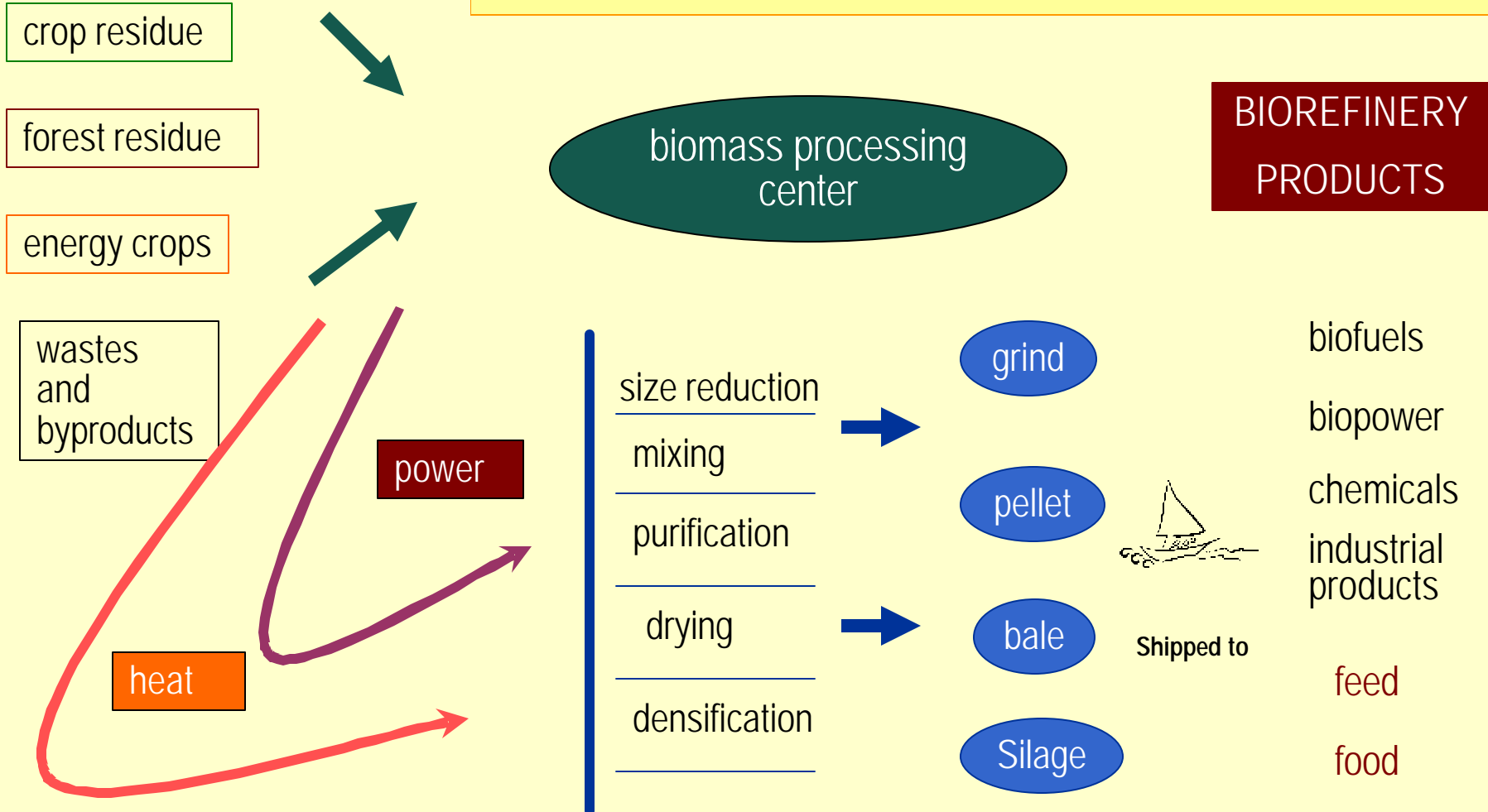
Electricity
Heat

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

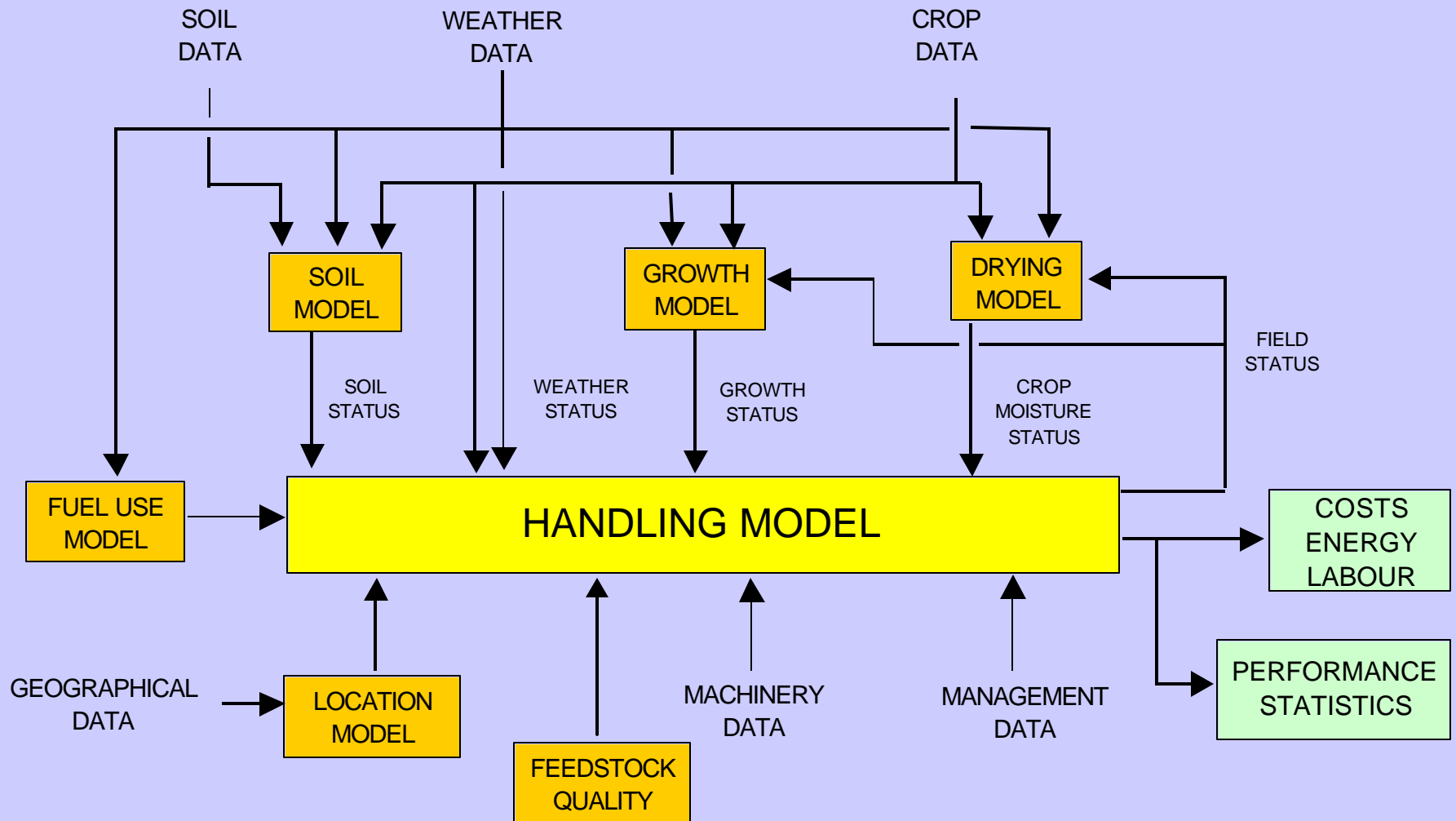


Definitions

- ***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.***

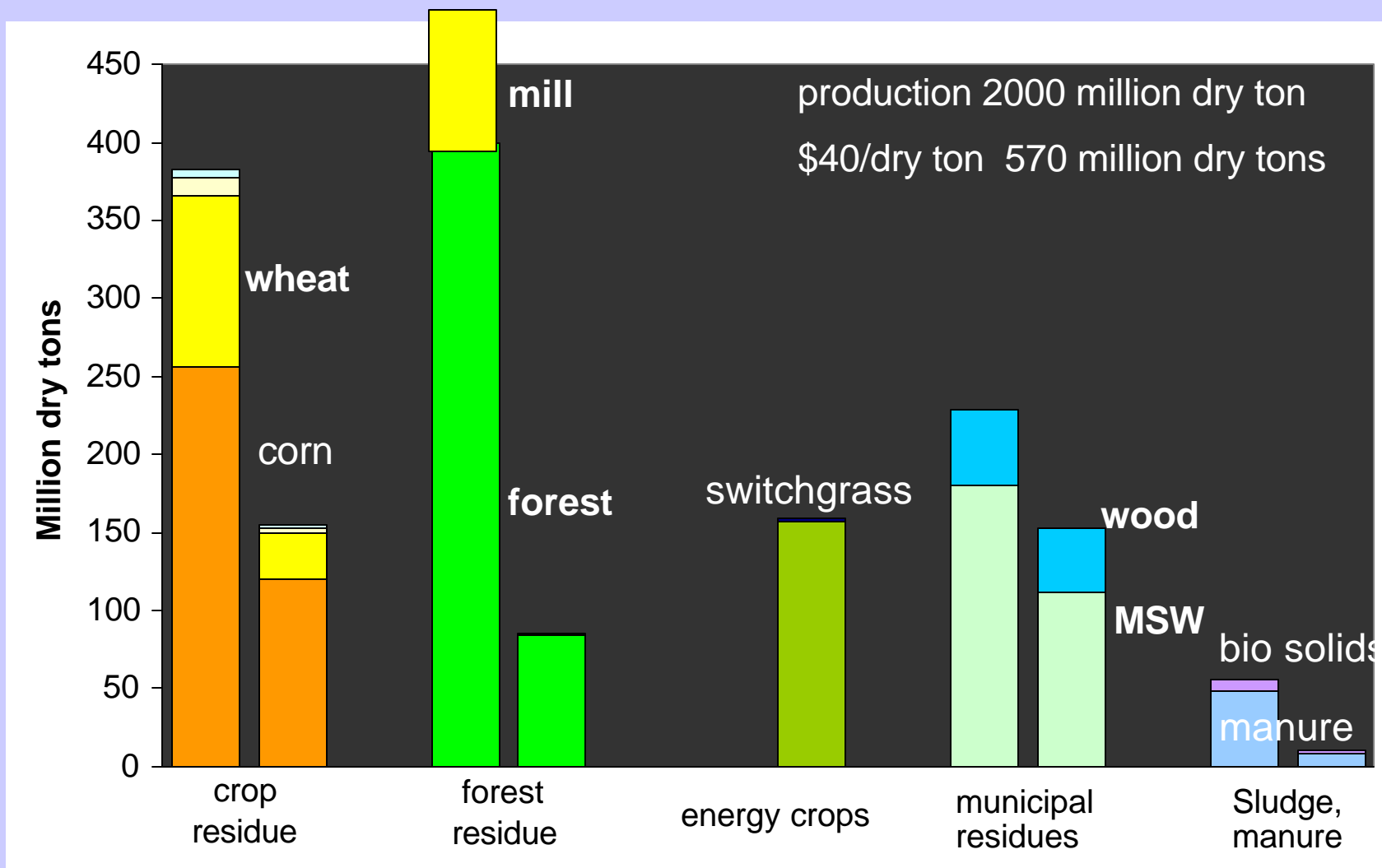


Developing the entire collection and delivery system

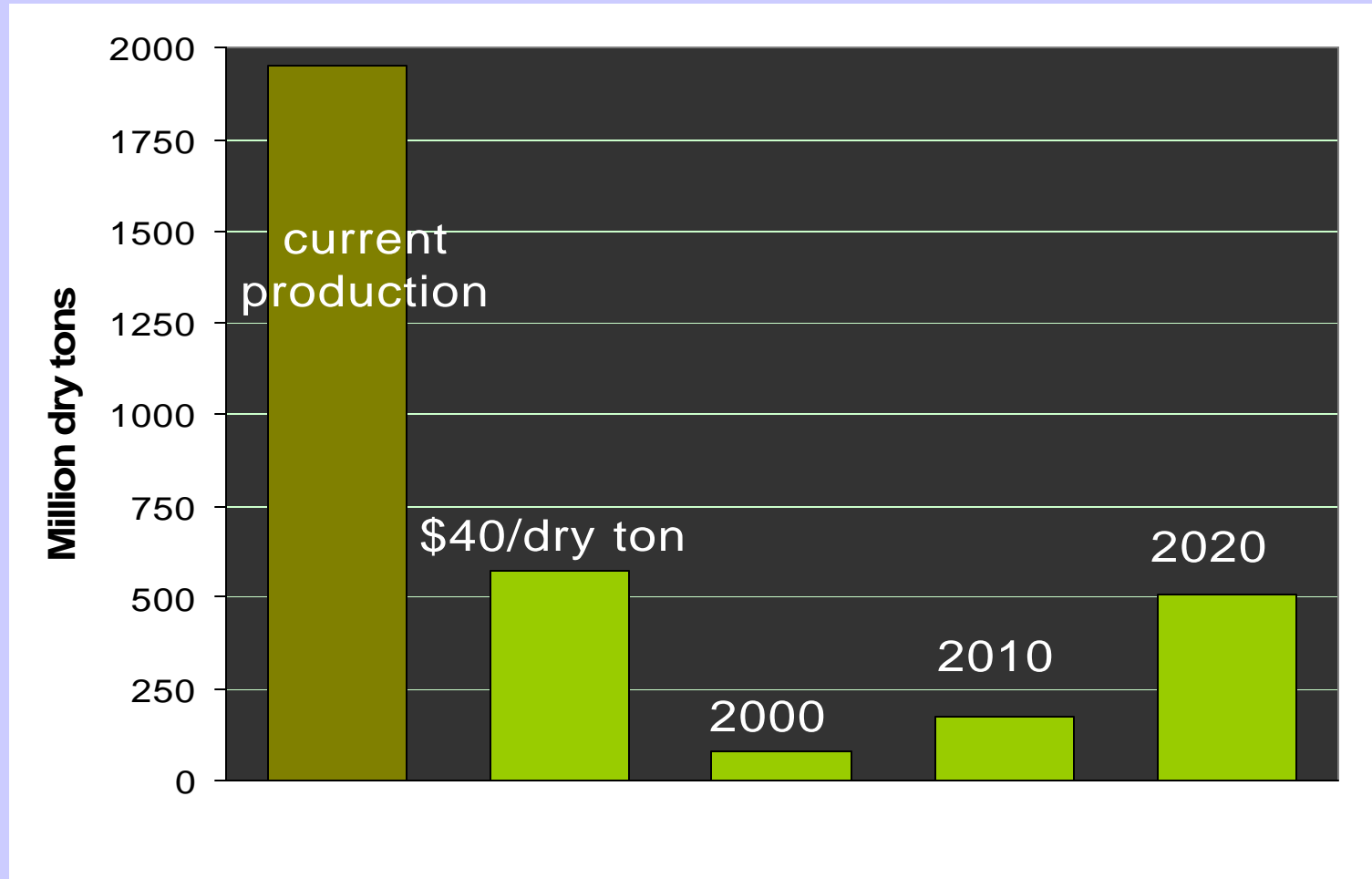


THE PERSPECTIVE

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) –

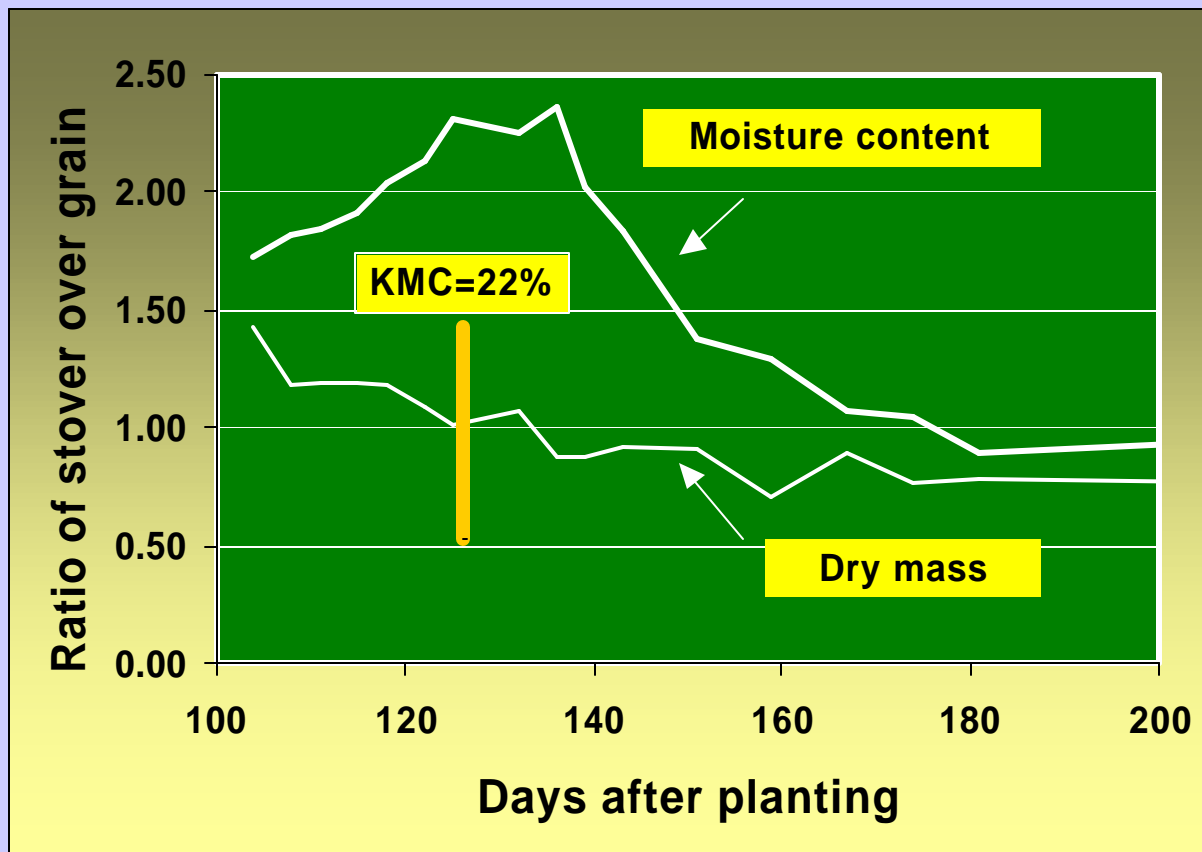
“The biomass industry holds great promise and as you have estimated in the proposal, there may be a tremendous demand for new and re-designed equipment.

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

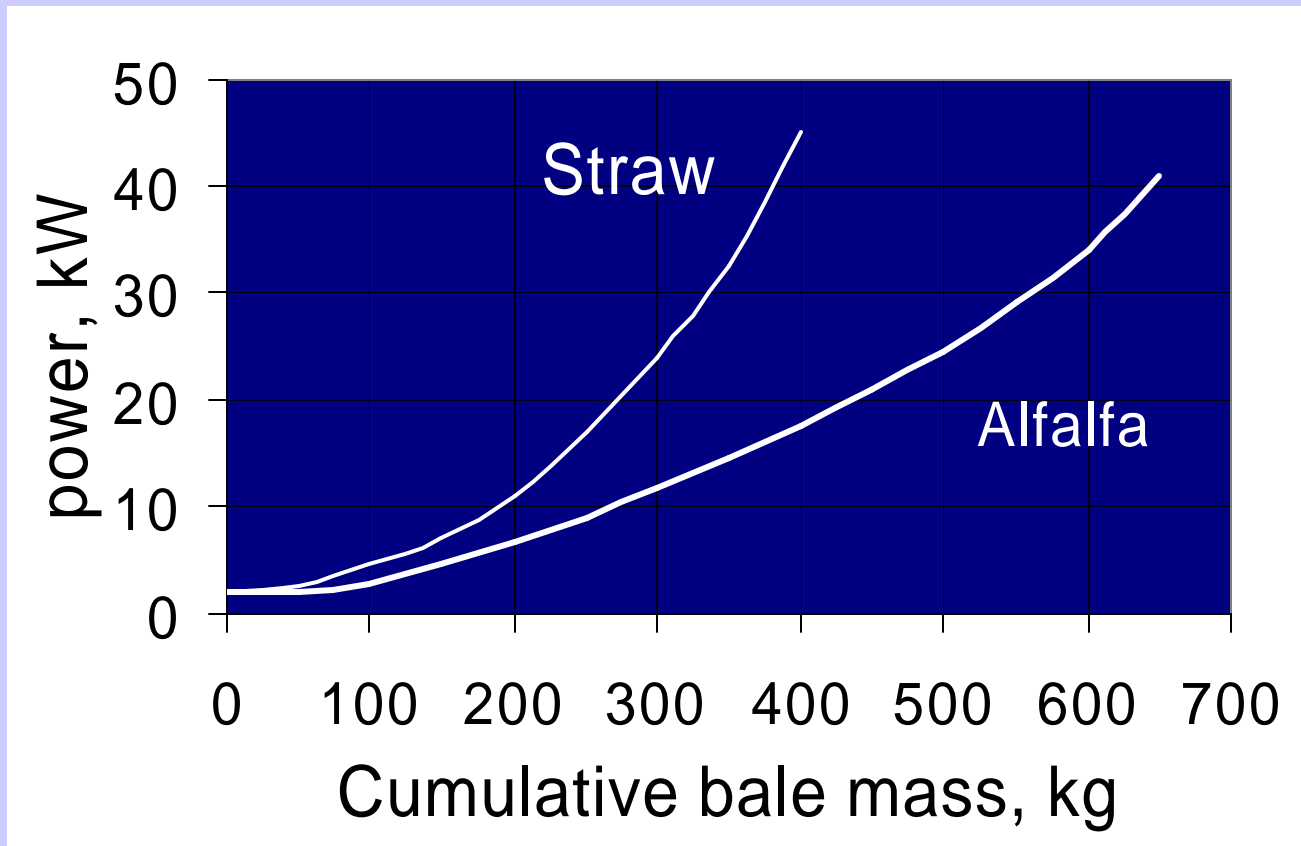
Limited data from Iowa

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 ³	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

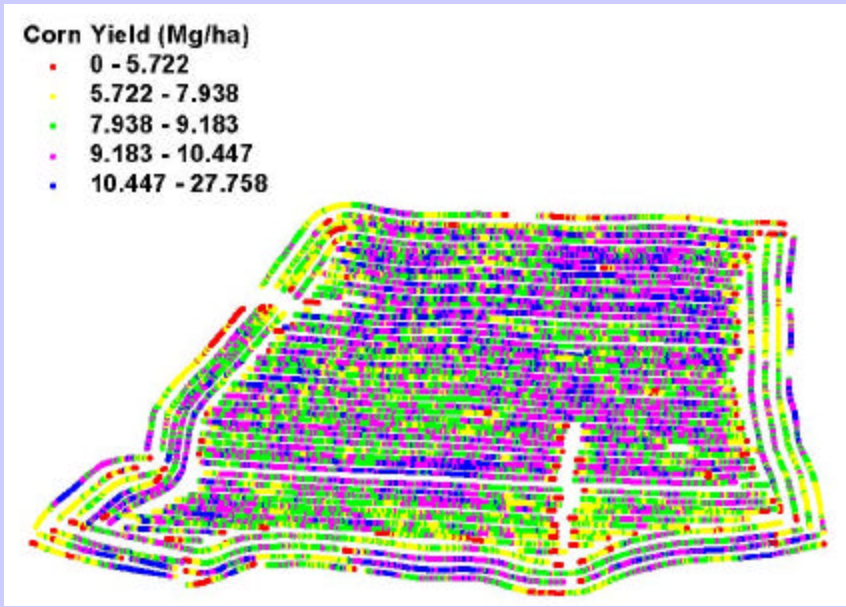
Power requirement of a round baler for wheat straw bales and alfalfa bales



Equipment for biomass must be powerful and robust

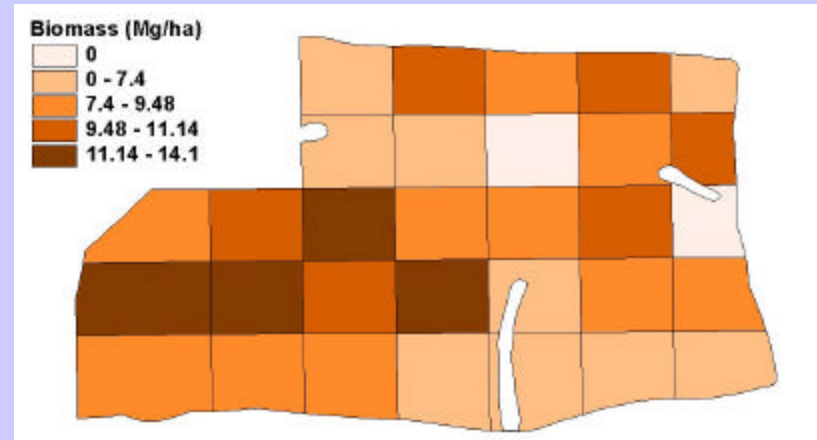
IN PROGRESS

Precision Biomass Collection and Conversion to Feedstock Systems



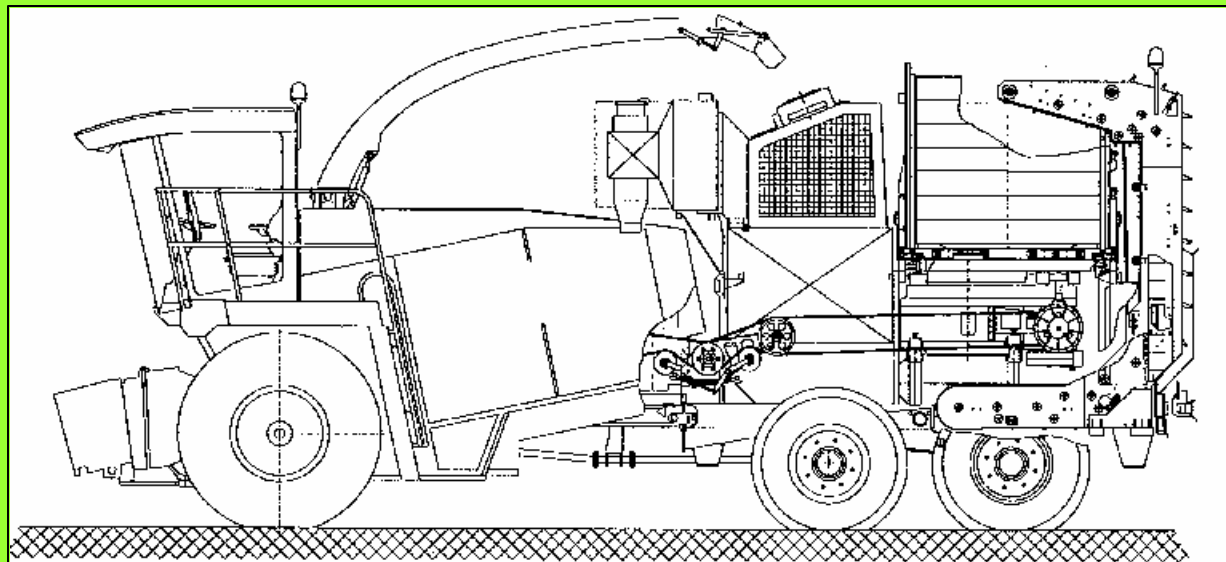
Yield Map – 36 acres

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/ft³
- 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

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Mr. Darrel Drollinger, AEM

John Deere Company/Timberjack