ClearFuels Technology Inc.

Hawai'i Energy Policy Forum

Wednesday, October 12, 2005 -- 10:00 a.m. - 2:30 p.m.

Production of Ethanol from Biomass

Enabling Highly Efficient Low Cost Sustainable Energy Production

Why should we develop biomass energy?

- Meet some of our most crucial needs
  - transportation fuels
  - electric power generation,
- Assure that our natural resources are continually being replenished for future use
- Ethanol, biodiesel and other potential biomass-based liquid transportation fuels are the only renewable alternatives to imported oil
- Combustion or gasification of biomass can sustainably generate a large amount of electrical energy.
- Biomass gasification can also be used to make hydrogen and liquid transportation fuels from syngas

Biomass is the World's 4th fuel

- Potential is a function of land and competition for energy use.
  - Land: Food, Urbanization, Fibre, Water, Conservation
  - Energy: Utility and cost as a delivered energy form
- Hawaii and US have land and significant capability
- Both US and Rest of World require energy crops to reach full potential

Biomass Resources for Bioenergy

- Primary = energy/food/forest crops
- Primary residues
  - Agricultural crops – sugarcane ,straw, and stover
  - Forest – tops, branches, stand improvement, thinnings.
- Secondary residues
  - Food processing residues e.g. bagasse, stillage
  - Fiber processing residues e.g. black liquor, sawdust,
  - Animal excreta – dung, chicken litter
- Tertiary residues
  - Urban residues (MSW) landfill avoidance

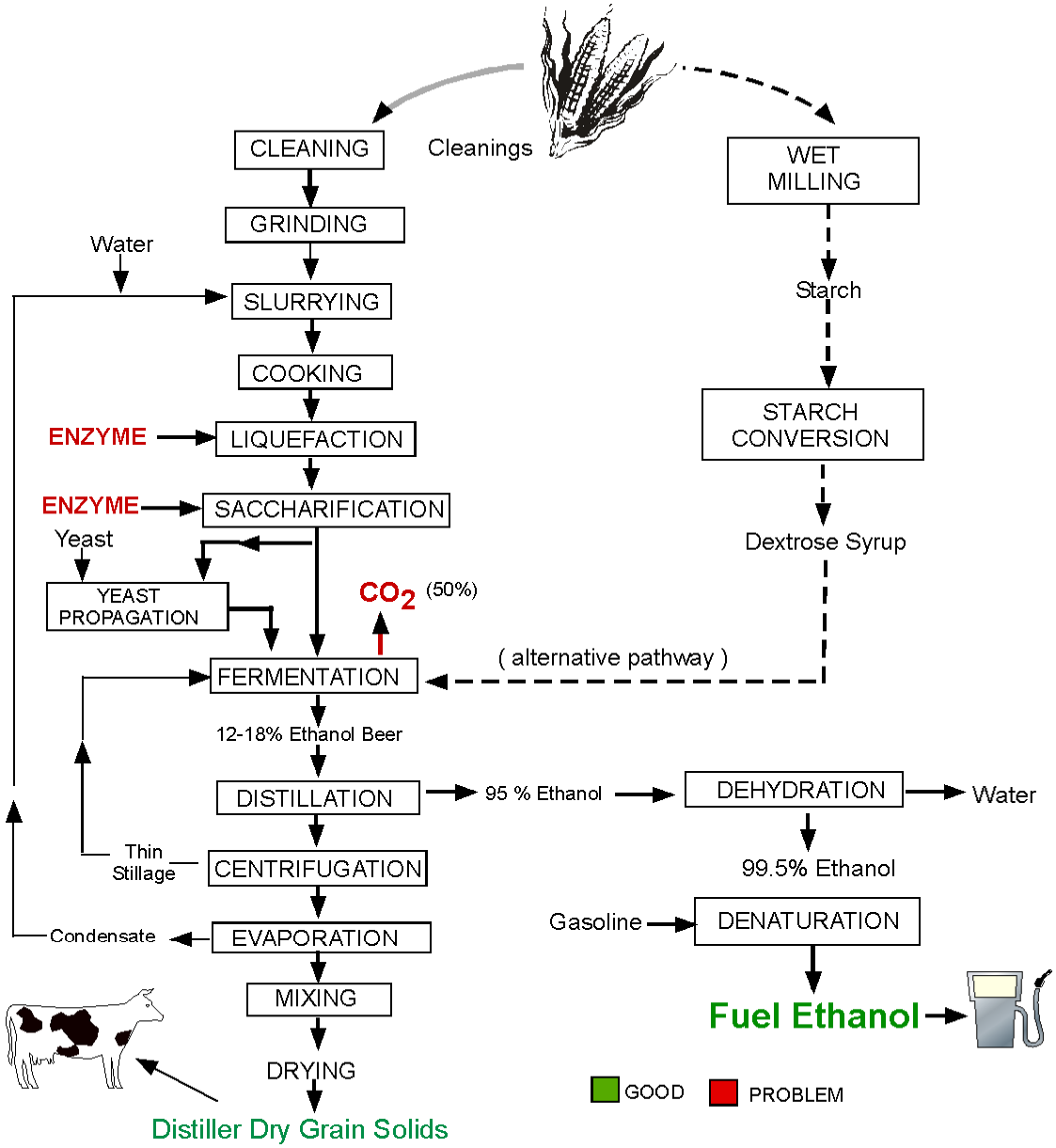
Incentives for Biomass-Fuel Ethanol

- **National Security** >> Less reliance on Middle East Region
- **Economy** >> Reduce oil imports to improve balance of trade
- **Environment** >> Reduce air pollution from gasoline, Global warming
- **Social** >> Support rural agricultural jobs

Corn Ethanol

- 95 % of the ethanol produced in the United states is based on fermentation of corn
- Understanding the corn issue builds an appreciation for biomass ethanol

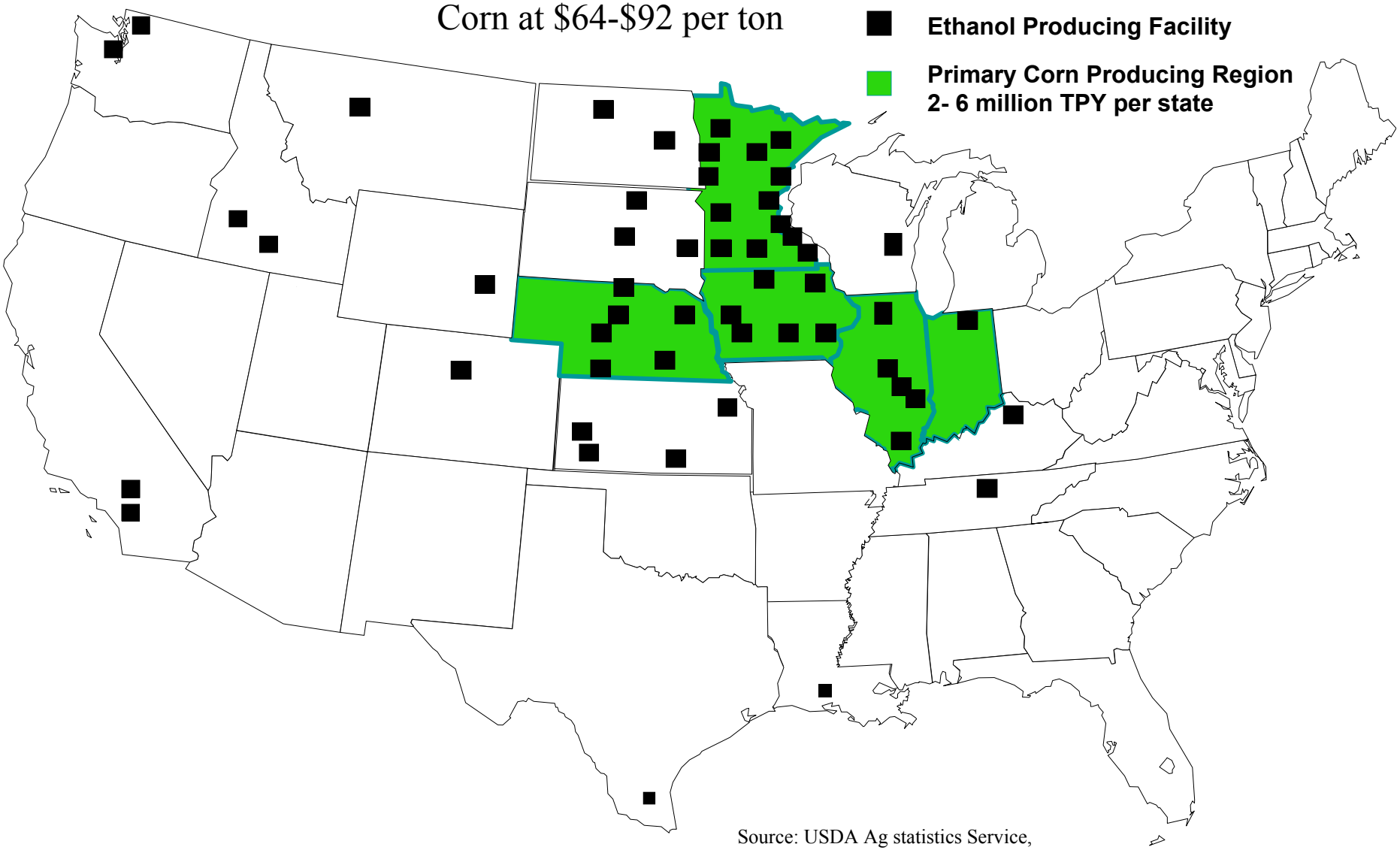
Corn Ethanol



Lower biomass cost and higher conversion ratios reduce feedstock cost per gallon of ethanol

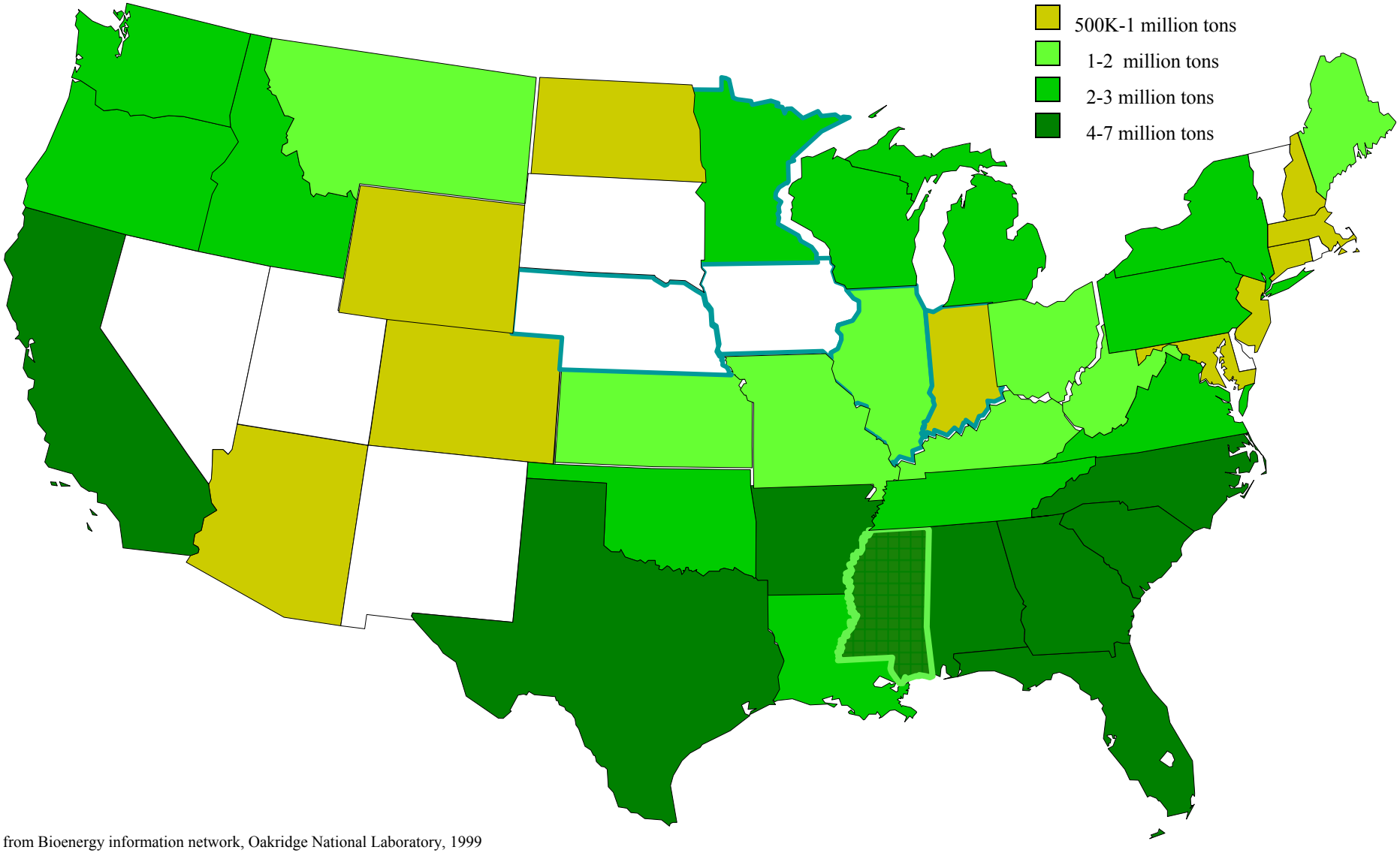
Feedstock	**Price** $/dry ton	**Conversion rate** gal/ton	**Feedstock cost** $/gal ethanol
Corn	$64-$92	100 gal/ton Fermentation	$0.64-$0.92
Waste Biomass (wood, rice hulls, bagasse, etc.)	< $30.00	>200 gal/ton PTI process	**$0.16**

95% Ethanol Production is in Corn-Growing Regions



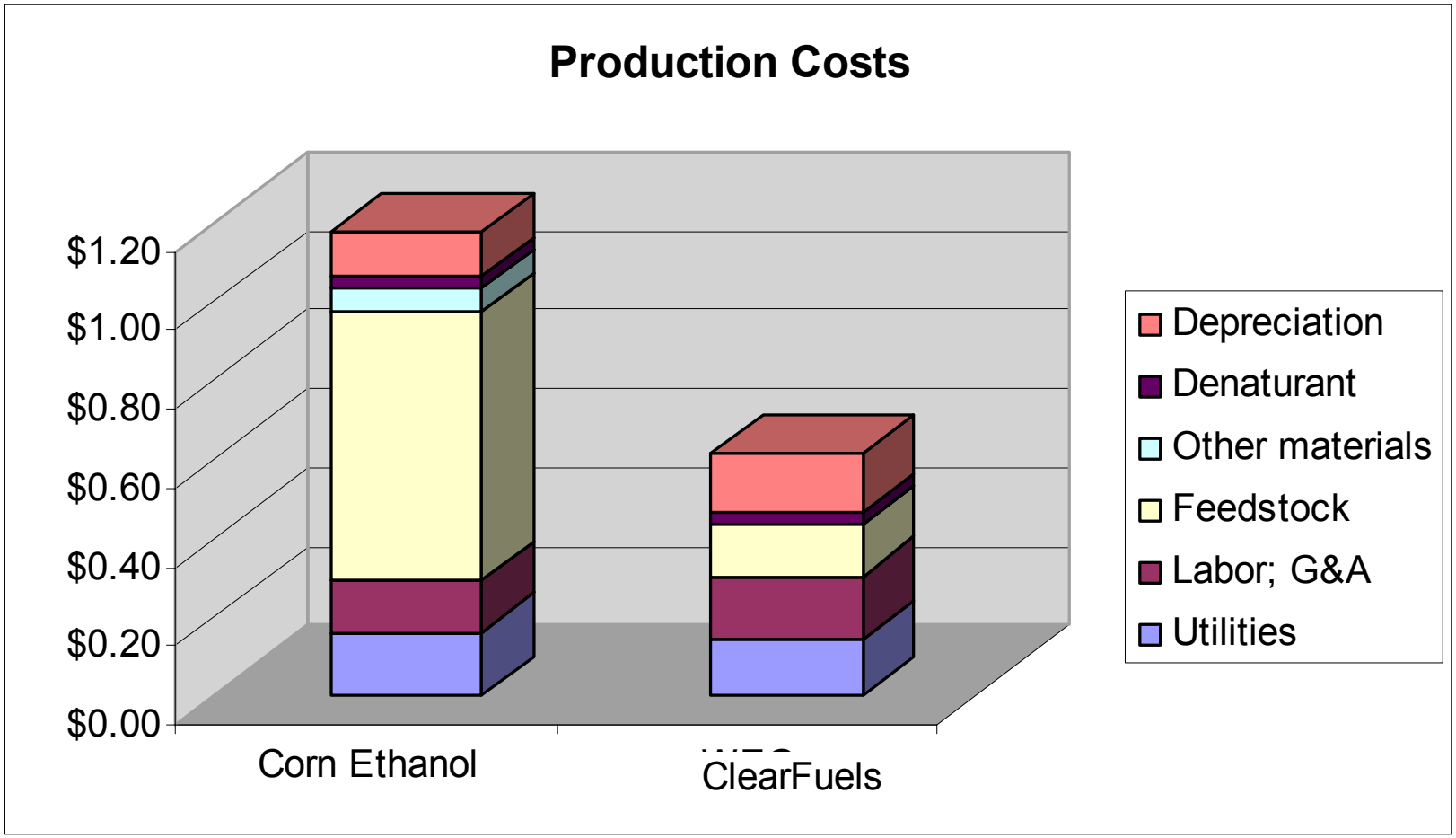
Source: USDA Ag statistics Service,

Tons of waste biomass; 40 states; >$30 per ton



Data from Bioenergy information network, Oakridge National Laboratory, 1999

Advantage: Reduced Ethanol Costs



SOURCE: WEG (ClearFuels) GRANT APPLICATION-Analysis from document research
SUBMITTED TO: **OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY**
SOLICITATION NUMBER**: 1435-01-02-RP-86382**

BIOMASS ETHANOL

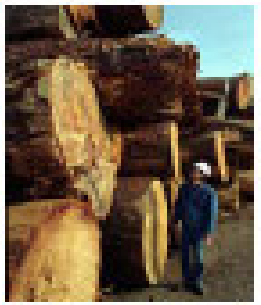
BIOMASS ENERGY PRODUCTS

Lignocellulosic Biomass

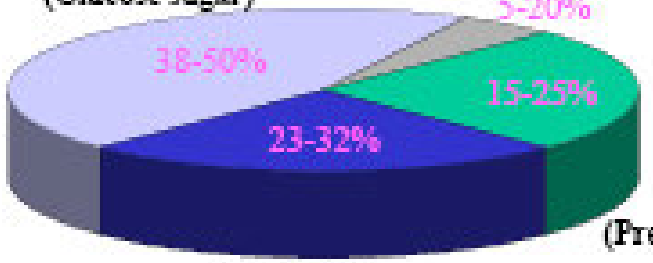
Corn Stover

Bagasse

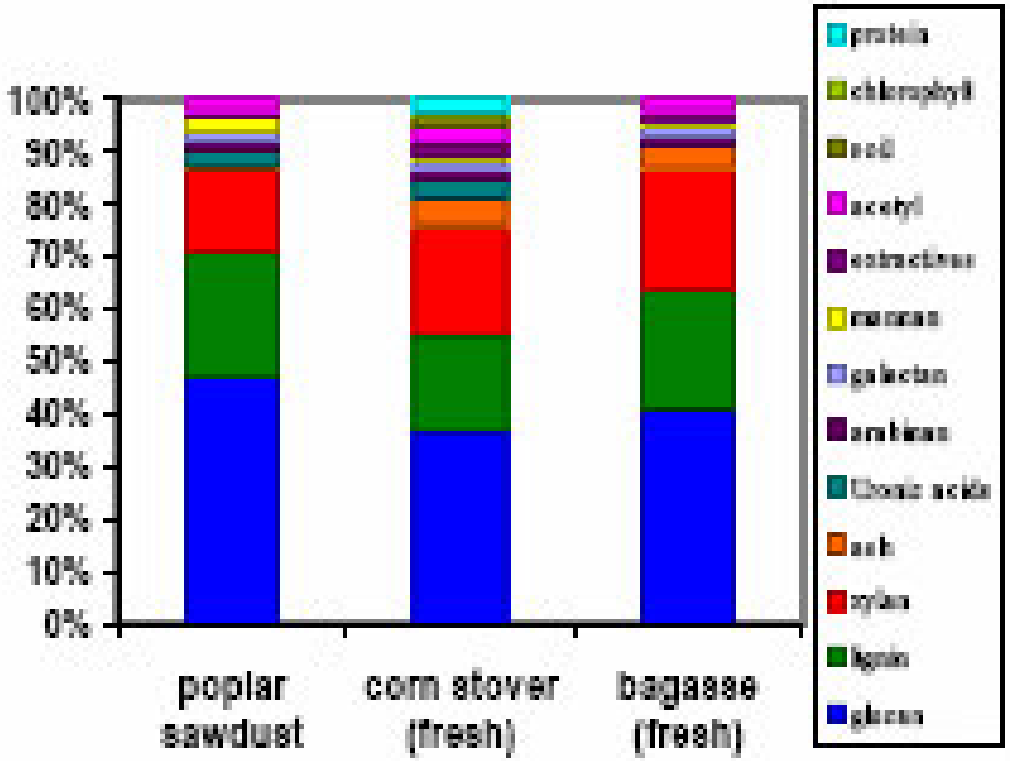
Hardwood



Softwood

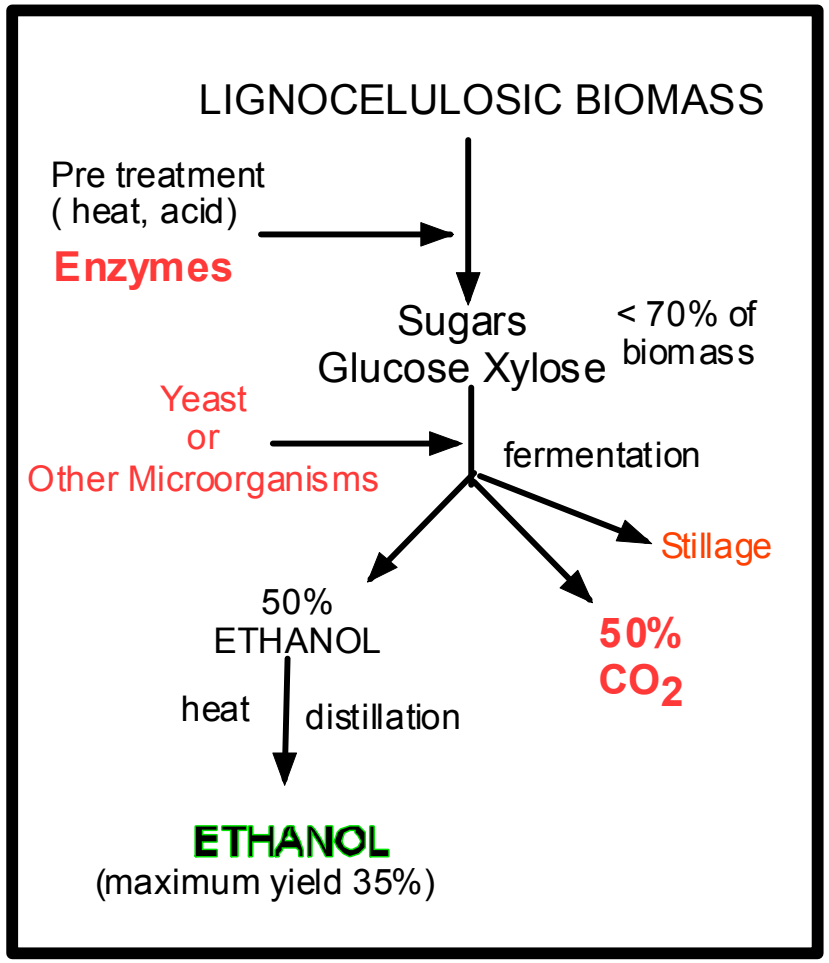


Stover and Bagasse—Many Similarities

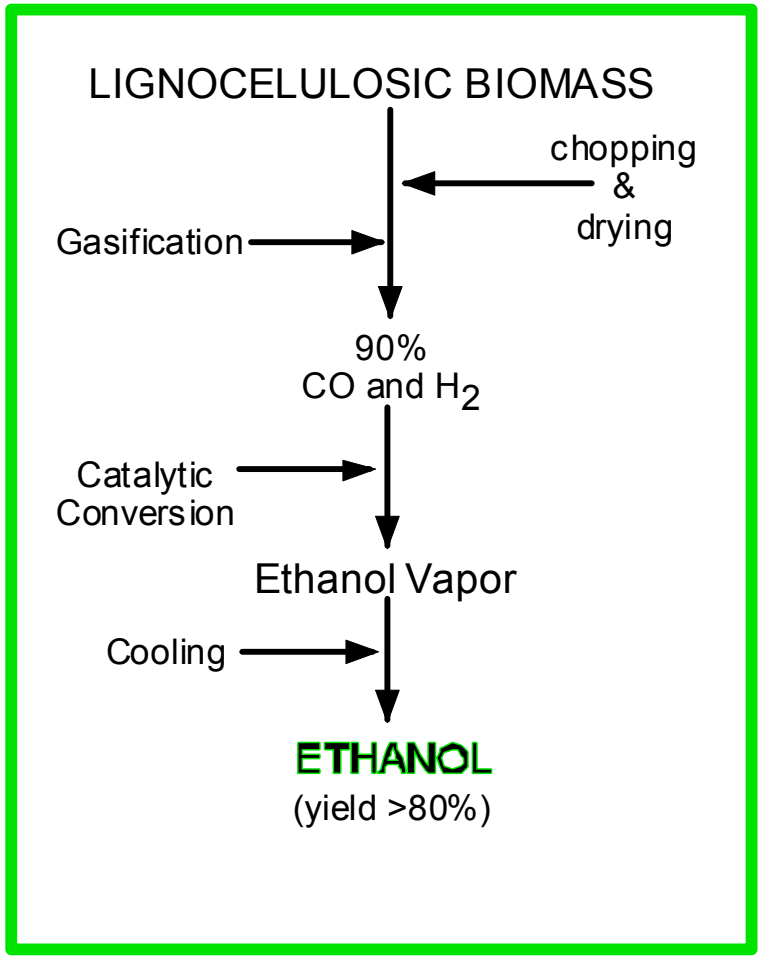


BIOMASS ETHANOL TECHNOLOGIES

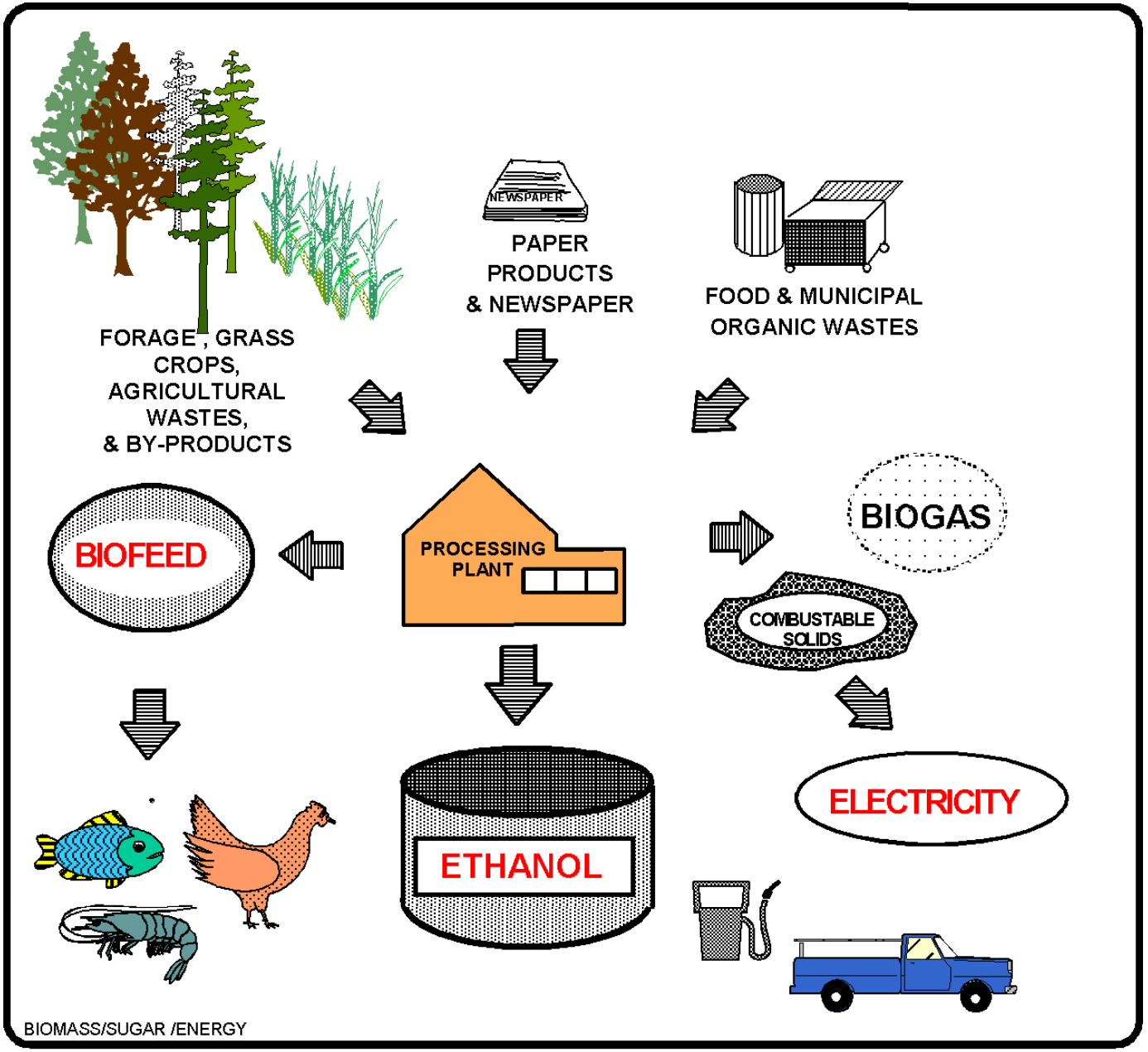
SACCHARIFICATION - FERMENTATION TECHNOLOGY



GASIFICATION - CATALYTIC CONVERSION TECHNOLOGY

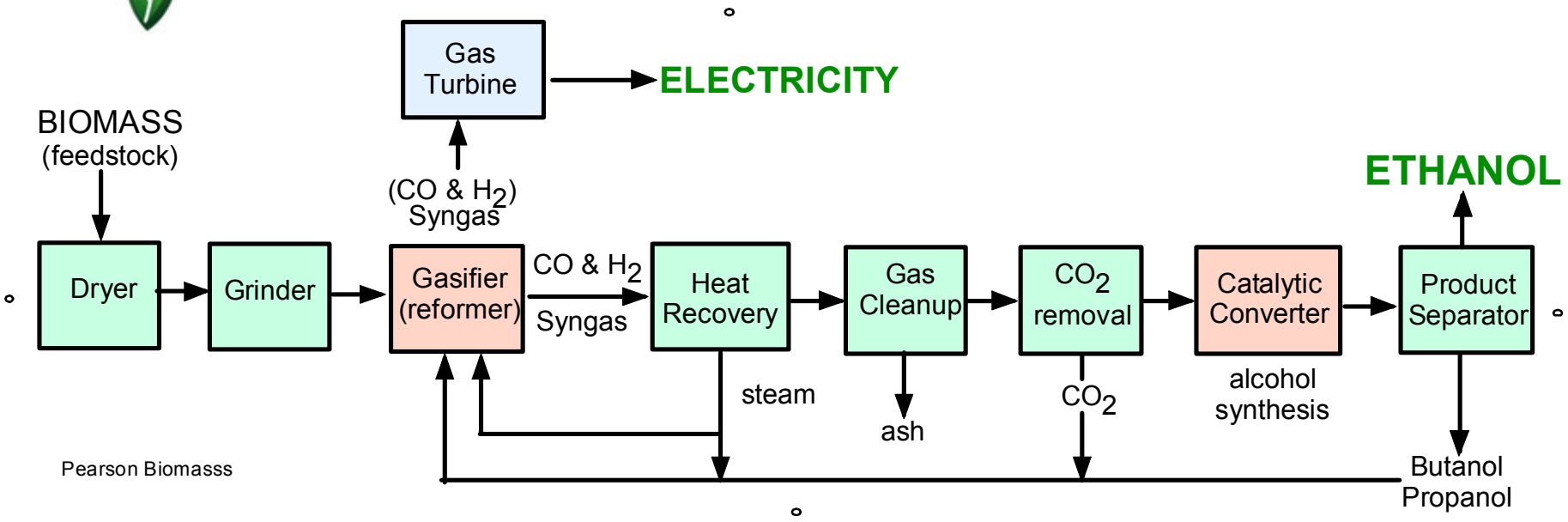


BIOMASS OPTIONS



shleser august 1996

ClearFuels Technology Inc.



- (1) a proprietary reformer, that "gasifies" biomass and other carbon based substances including wastes, in an oxygen starved environment to produce a targeted synthesis gas or "syngas" (primarily carbon monoxide and hydrogen.)
- (2) The syngas is reacted with a proprietary catalyst in a Fischer-Tropsch synthesis loop to produce ethanol with a conversion of greater than 90% with recycle.
- The balance of the system consists of standard chemical plant components.

5 ton per day pilot plant

Syngas from Bagasse

(January, 2005)

Component	(Mol %)
H_2	51.04%
CO	25.32%
CH_4	5.55%
CO_2	18.09%
TOTAL	100.00%

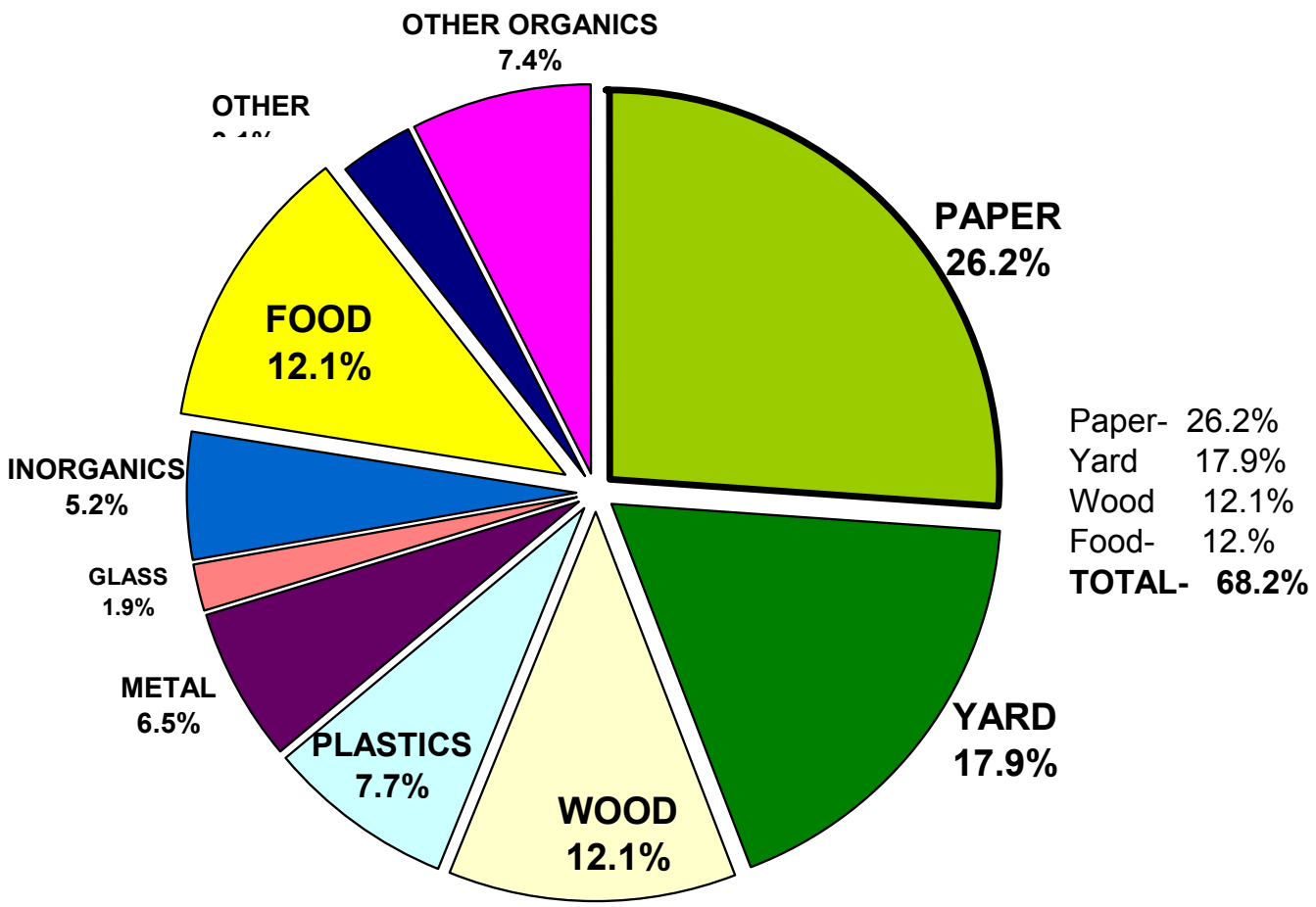
Biomass Ethanol Technologies

TECHNOLOGY	Uses Total Biomass	Requires Acid	Requires Enzymes	Uses Ferment-ation	Produces 50% CO_2	Ethanol gal /dry ton
Dilute Acid Hydrolysis	N	Y	N	Y	Y	40 - 60
Conc. Acid Hydrolysis	N	Y	N	Y	Y	65 - 75
Sacch.& Fermentation	N	Y	Y	Y	Y	50 - 90
Corn	N	N	Y	Y	Y	110 -120
Gasification & Microbial Conversion	Y	N	N	N	N	90 -110
Gasification & Catalytic Conversion	Y	N	N	N	N	>180

Waste & Opportunity

“Waste is our most sustainable resource”

HAWAII MSW


OTHER ORGANICS
7.4%
OTHER
PAPER
26.2%
FOOD
12.1%
INORGANICS
5.2%
GLASS
1.9%
METAL
6.5%
PLASTICS
7.7%
WOOD
12.1%
YARD
17.9%
Paper- 26.2%
Yard 17.9%
Wood 12.1%
Food- 12.%
TOTAL- 68.2%

BIG ISLAND CELLULOSIC WASTE TO ETHANOL
(gasification technology)

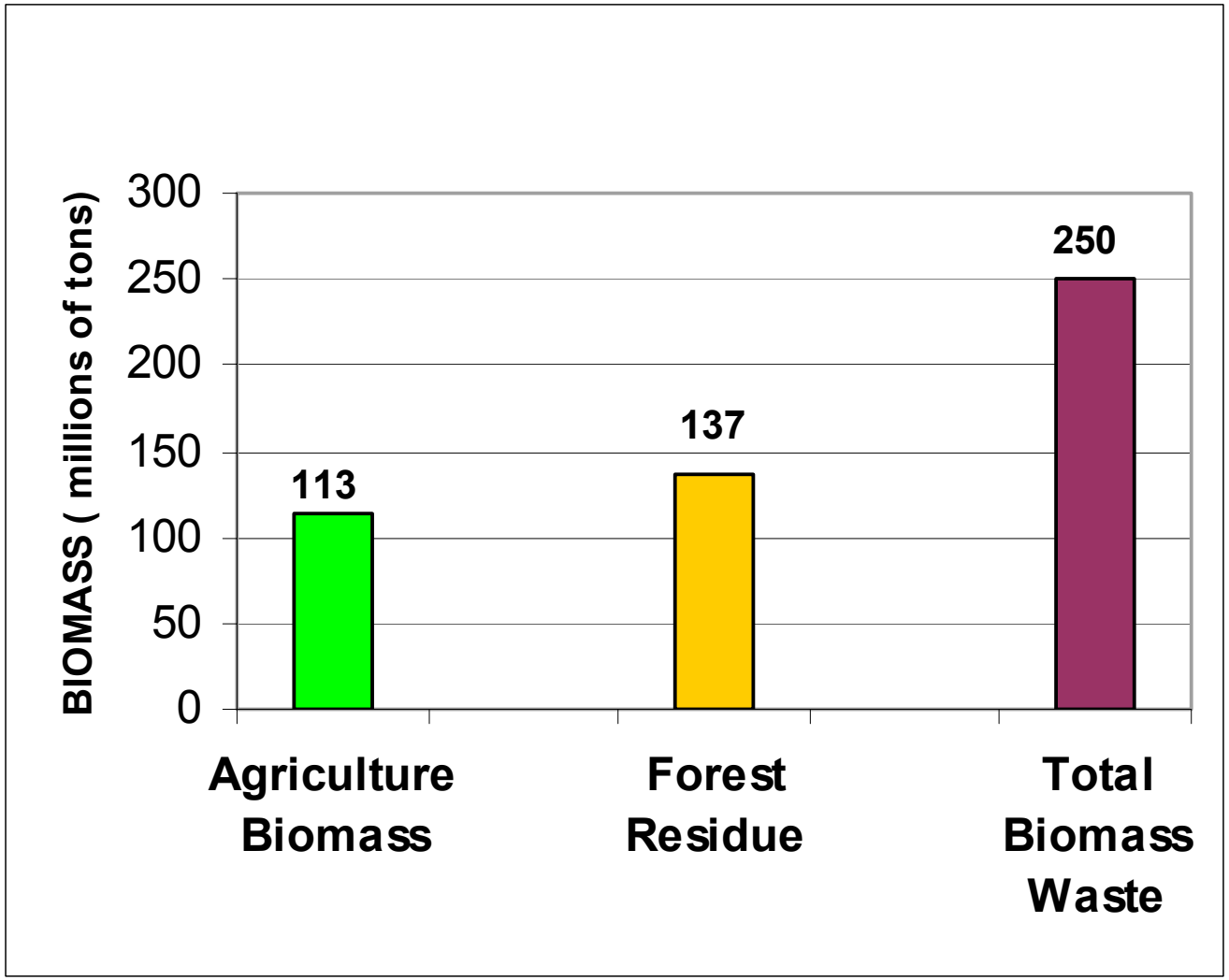
West Hawaii Landfill (tons/ day)	**350**	tons/ year	**126,000**			
East Hawaii Landfill (tons/day)	**220**	tons/ year	**79,200**			
Operation days/ year	**360**					
Ethanol gallons / ton	**180**					
WASTE COMPONENT	**Percent of total**	**West Hawaii (tpy)**	**West Hawaii Ethanol (gal/yr)**		**East Hawaii (tpy)**	**East Hawai Ethanol (gal/yr)**
Paper Waste						
Newspaper	3.70%	4,662			2,930	
Cardboard	6.70%	8,442			5,306	
High Grade	1.60%	2,016			1,267	
Low Grade	9.00%	11,340			7,128	
Compostable	3.90%	4,914			3,089	
Other Paper	1.40%	1,764			1,109	
TOTAL	**26.30%**	33,138	**5,964,840**		**20,830**	**3,749,328**
Yard Waste	**17.90%**	**22,554**	**4,059,720**		**14,177**	**2,551,824**
Wood Waste						
Untreated Lumber	1.80%	2,268			1,426	
Untreated Plywood	0.90%	1,134			713	
Pallets/Crates	4.80%	6,048			3,802	
*Treated Wood	3.90%	4,914			3,089	
Stumps	0.70%	882			554	
TOTAL	**12.10%**	**15,246**	**2,744,280**		**9,583**	**1,724,976**
ETHANOL (gal / year)			**12,768,840**			**8,026,128**
BIG ISL ETHANOL -TOTAL		**20,794,968**				

C&C Honolulu

Ethanol from Cellulose Waste

Nov-04		
Oahu Population	900,000	
Oahu annual Waste (tons)	1,600,000	
Ethanol gallons / ton	180	
WASTE COMPONENT	**Percent of total**	**Annual Amount (tons)**
Paper	26.20%	419,200
Yard Waste	17.90%	286,400
Wood	12.00%	192,000
TOTAL	**56.10%**	**897,600**
Annual gallons ethanol	**161,568,000**	

US Forest and Agriculture Unused Waste Biomass **



** Does not include MSW

Ethanol from US Agriculture and Forest Waste*

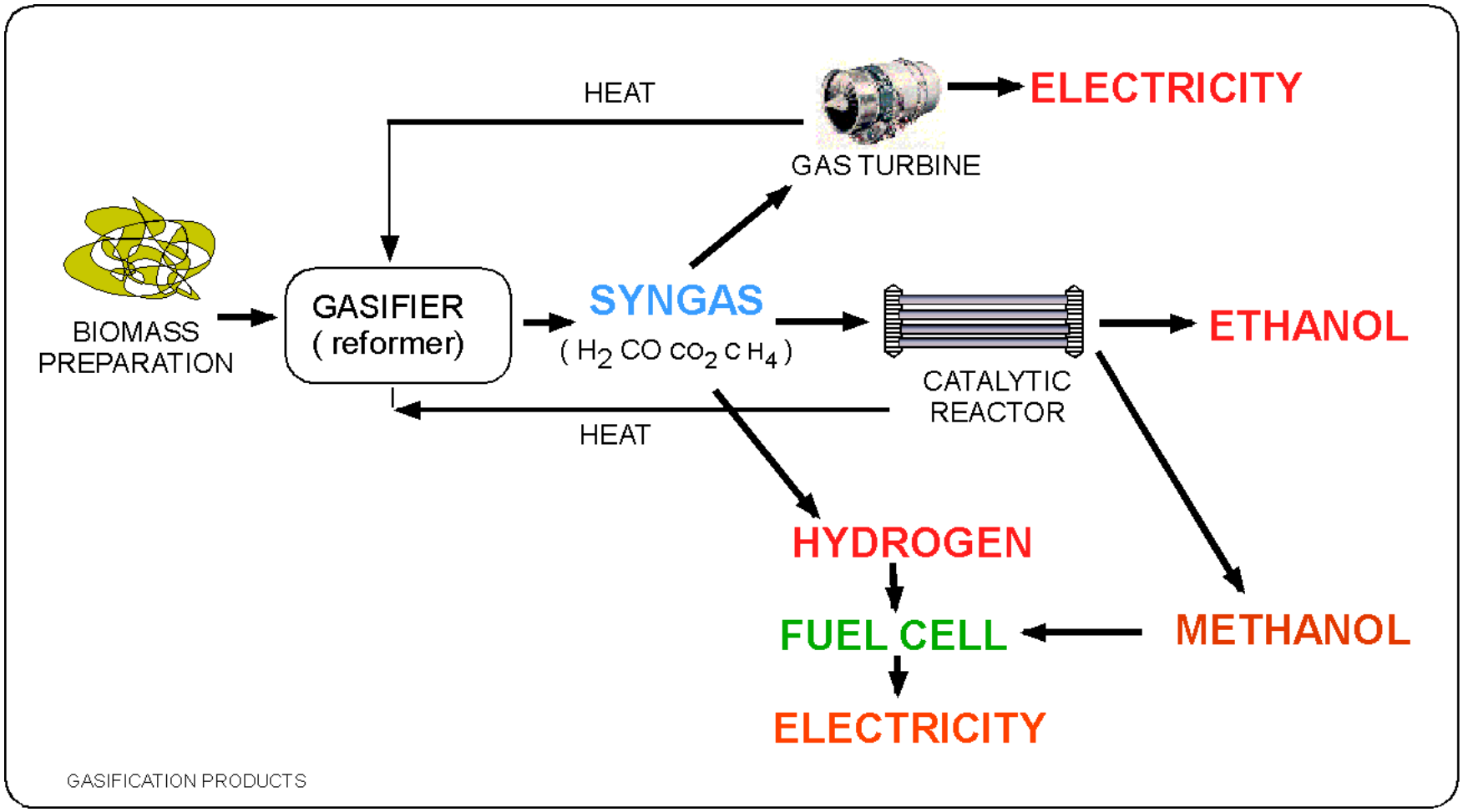
	catalytic conversion	**saccharifaction-fermentation**
US Gasoline Annual Consumption (gallons)	140,000,000,000	140,000,000,000
US Gasoline Produced from Imported Oil (galons)	93,540,010,000	93,540,010,000
Agriculture biomass available (tons)	113,000,000	113,000,000
Forest residue available (tons)	137,000,000	137,000,000
Total waste biomass projected (tons)	250,000,000	250,000,000
Technology Specific Ethanol / dry ton (gallons)	180	90
Ethanol potential from waste biomass (gallons)	**45,000,000,000**	**22,500,000,000**
Percent of total gasoline **supply** from ethanol (gallons)	**32%**	**16%**
Percent of total gasoline **imports** from ethanol (gallons)	**48%**	**24%**

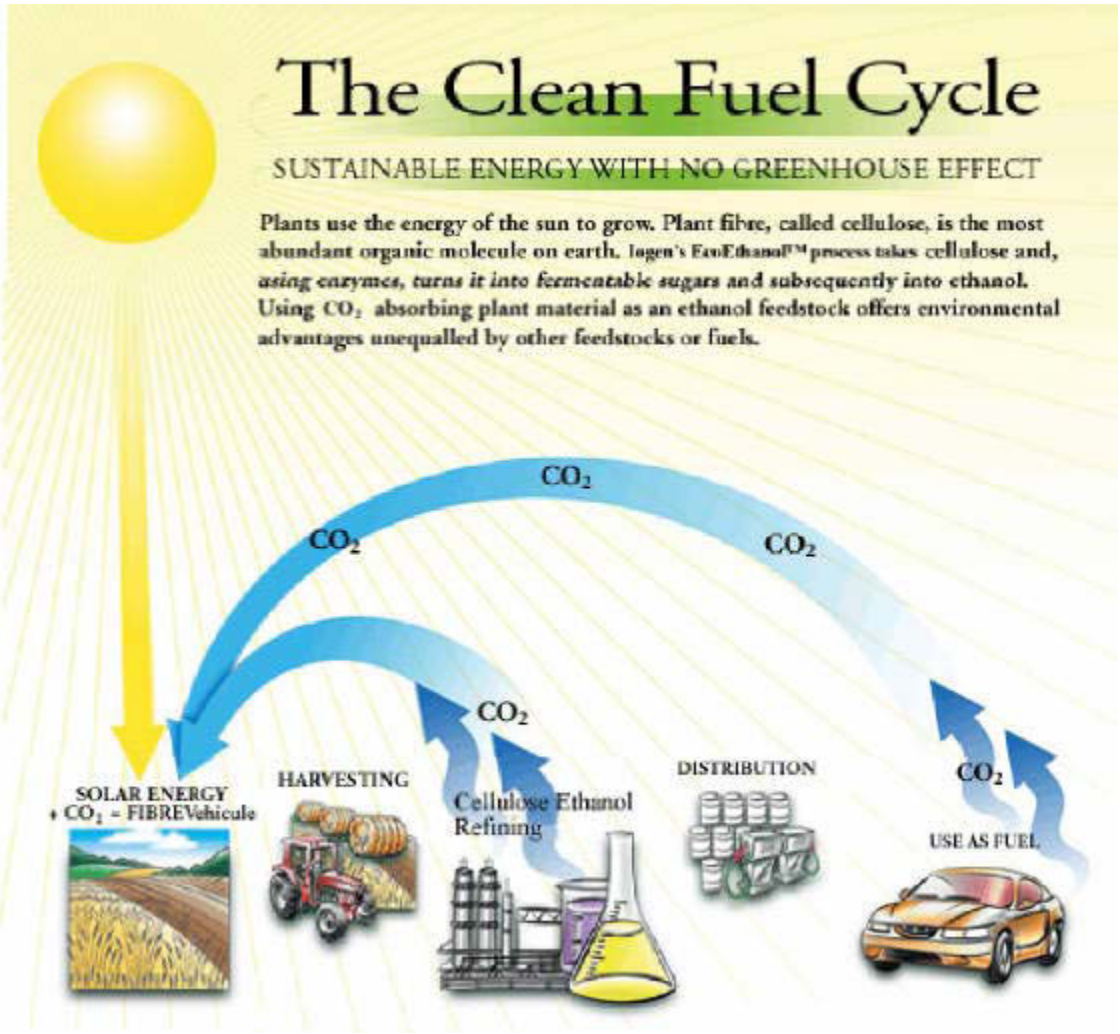
* Does not include any MSW

HYDROGEN FROM BIOMASS

(reformation technology)

Clear Fuels Products



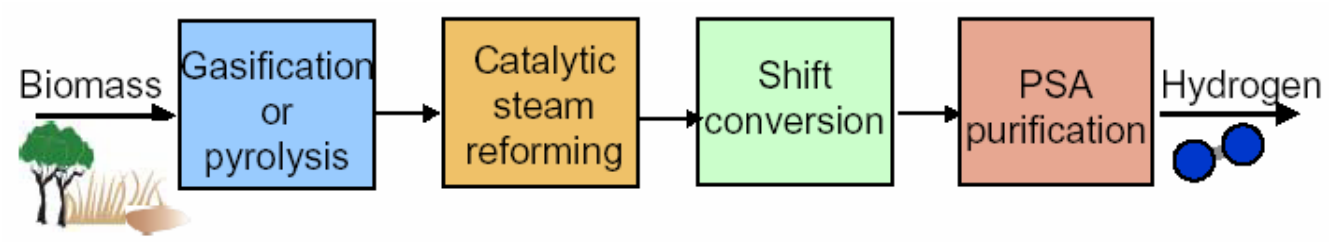

The Clean Fuel Cycle
SUSTAINABLE ENERGY WITH NO GREENHOUSE EFFECT
Plants use the energy of the sun to grow. Plant fibre, called cellulose, is the most abundant organic molecule on earth. Iogen's EcoEthanol™ process takes cellulose and, using enzymes, turns it into fermentable sugars and subsequently into ethanol. Using CO_2 absorbing plant material as an ethanol feedstock offers environmental advantages unequalled by other feedstocks or fuels.
CO_2
CO_2
CO_2
CO_2
CO_2
SOLAR ENERGY
+ CO_2 = FIBREVehicule
HARVESTING
Cellulose Ethanol
Refining
DISTRIBUTION
USE AS FUEL

SUMMARY BIOMASS ETHANOL

- **Current status of the technology/application/usage/cost**
  - Many technologies emerging
  - Technologies will improve
  - Production costs range from $0.80 / to $2.00 / gallon
- **Expectations for the next decade –** (the promise as well as challenges)
  - Yields will increase
  - Production costs will decrease
  - The market will expand
  - Assuring access to land and feedstock supplies will be a problem
- **Recommendations for furthering/expediting development of the resource,**
  - Increase awareness of Governor and legislature on potential
  - **?**
- **Proposals that might be submitted to the upcoming Legislature.**
  - **?**

WASTING WASTE IS WASTEFUL !

BIOMASS HYDROGEN PRODUCTION



Reforming

$$C_xH_y + H_2O \longrightarrow CO + H_2 + CO_2 \quad {}^{C_xH_y}_{CH_4}$$

$$C_xH_yO_Z + H_2O \longrightarrow CO + H_2 + CO_2 \quad {}^{C_xH_yO_z}_{CH_4}$$

Shift conversion

$$CO + H_2O \longrightarrow CO_2 + H_2 \quad {}^{CO\ C_xH_y}_{CH_4\ C_xH_yO_z}$$

Purification (PSA)

$$CO_2 + H_2 \longrightarrow \begin{cases} H_2 & >99.99\%\ \text{purity} \\ CO_2 & {}^{CO\ C_xH_y}_{CH_4} \end{cases}$$