Responsible Packaging within the Context of a Biorefinery

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USDA
Albany, California
USA

Partnerships: Industrial Cooperators

Chevron

CLOROX

Mantrose-Haeuser Co., Inc.

Cargill™

Sunkist

YULEX.

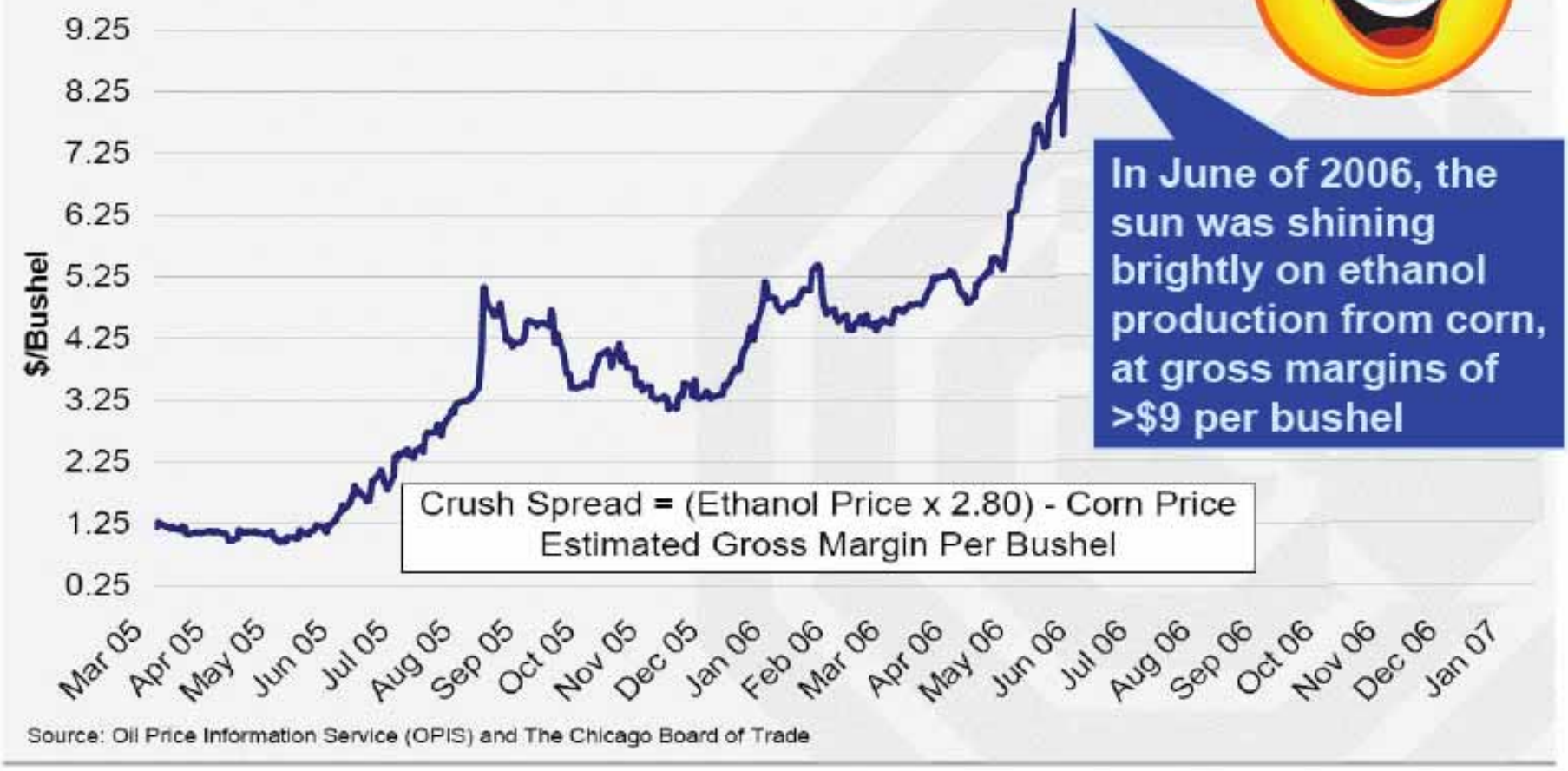
PENFORD
FOOD INGREDIENTS CO.

Ethanol

CBOT Ethanol Crush Spread

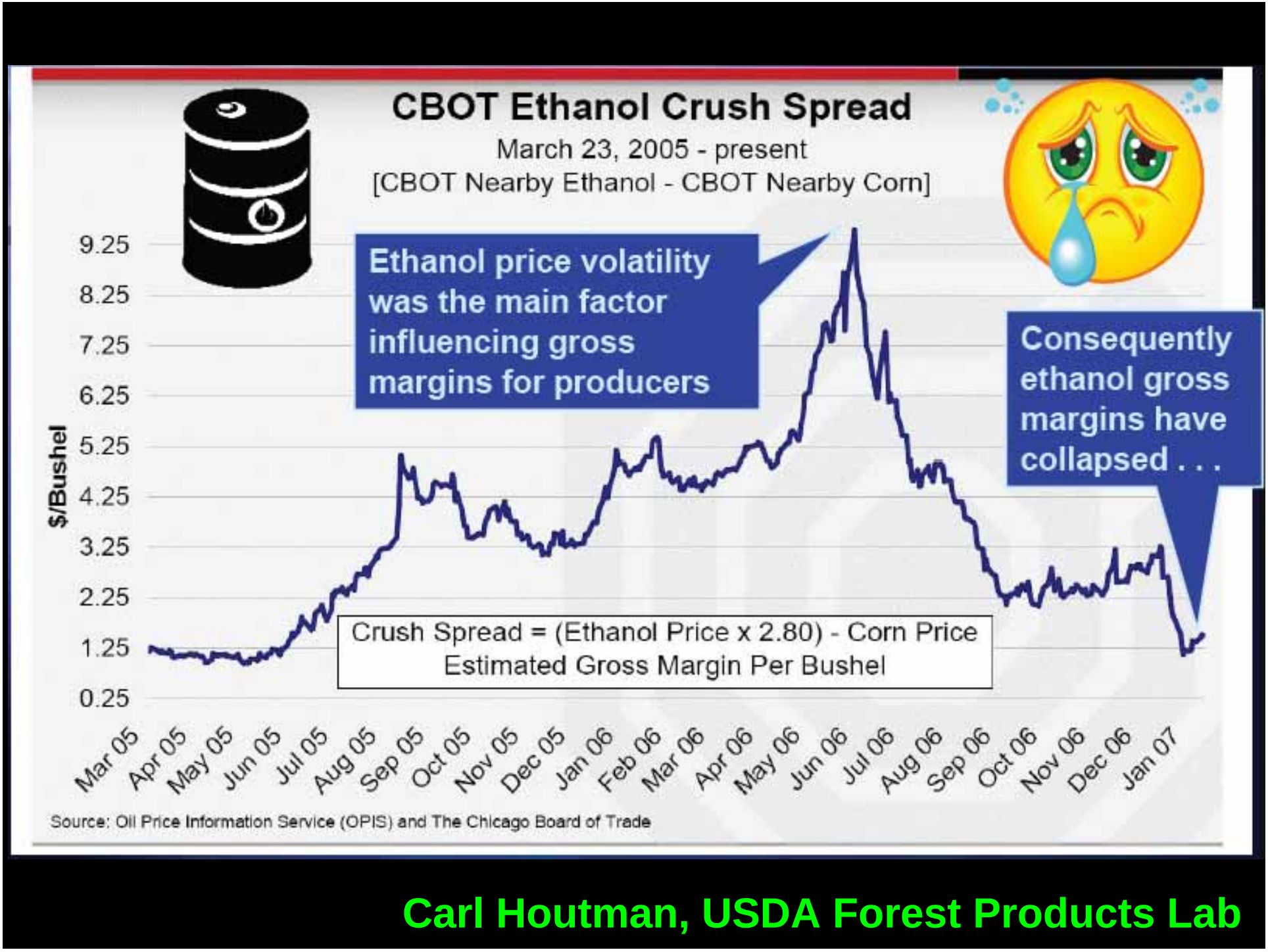
March 23, 2005 - present

[CBOT Nearby Ethanol - CBOT Nearby Corn]

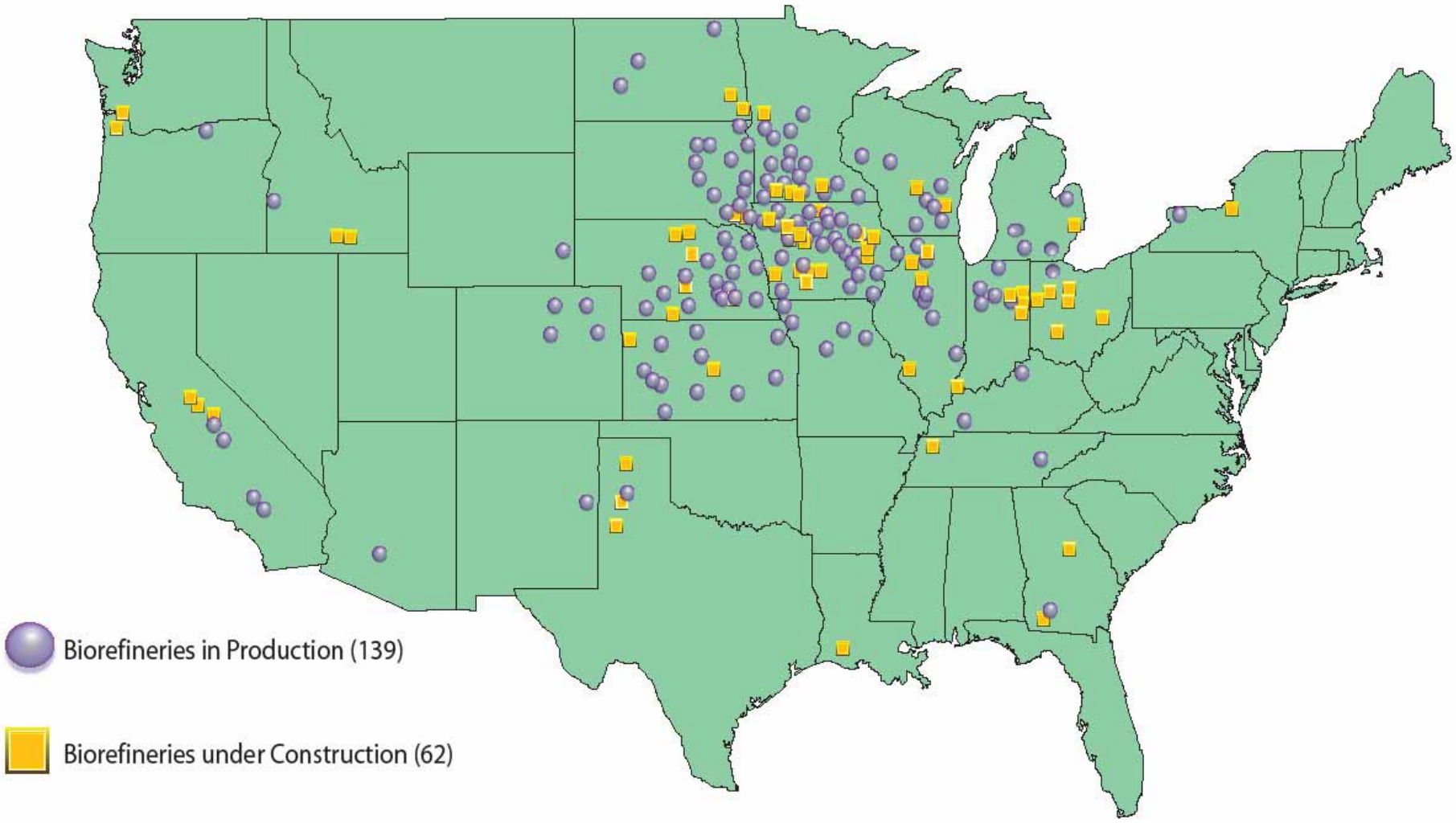


Source: Oil Price Information Service (OPIS) and The Chicago Board of Trade

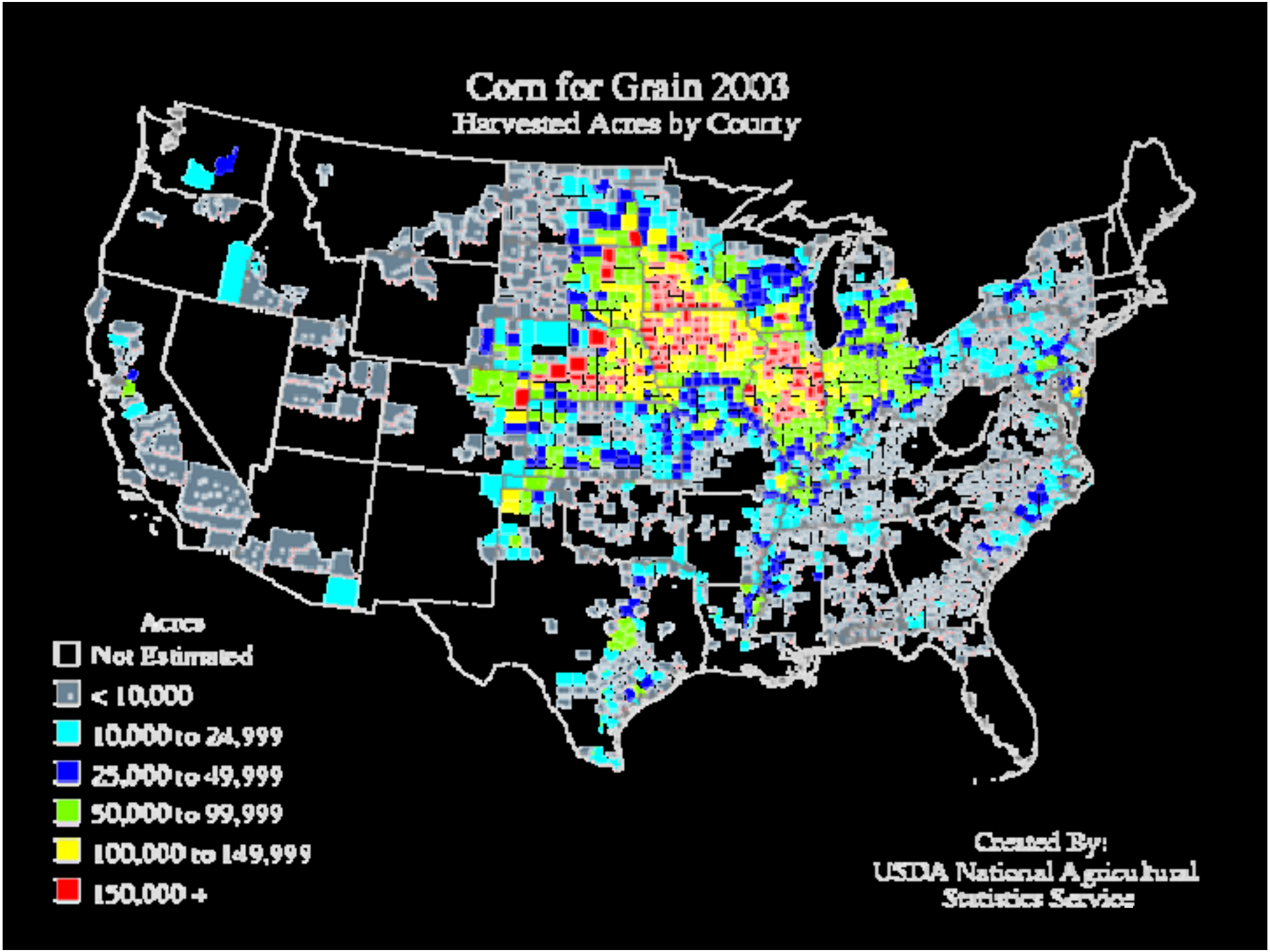
Carl Houtman, USDA Forest Products Lab



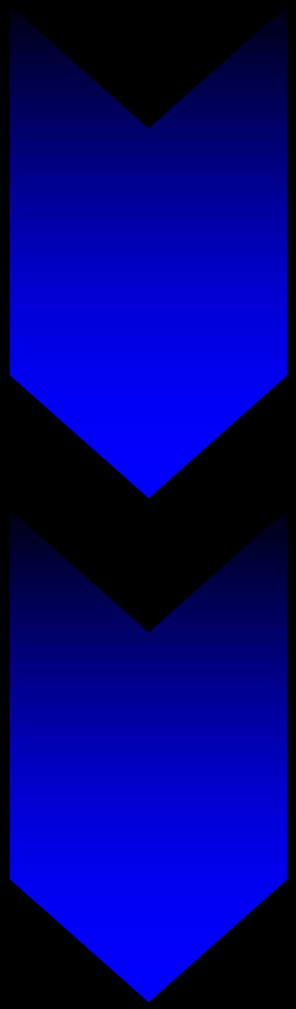
Carl Houtman, USDA Forest Products Lab



Source: Renewable Fuels Association
01.24.08


Corn for Grain 2003
Harvested Acres by County
Acres
Not Estimated
< 10,000
10,000 to 24,999
25,000 to 49,999
50,000 to 99,999
100,000 to 149,999
150,000 +
Created By:
USDA National Agricultural
Statistics Service

Corn-to-Ethanol: U.S trends



- Ethanol production is at 5-6 billion gals/yr
- ~2% of transportation fuel
- Ethanol uses ~20% of US corn
- Most ethanol is not produced near refineries
- It is not widely produced in the most populated states.

Corn Ethanol

H_2O

CO_2

$

~~Starch~~ Fermentable sugars

High Performance Microbial Fermentation

The Biomass-Based Biorefinery

H_2O

CO_2

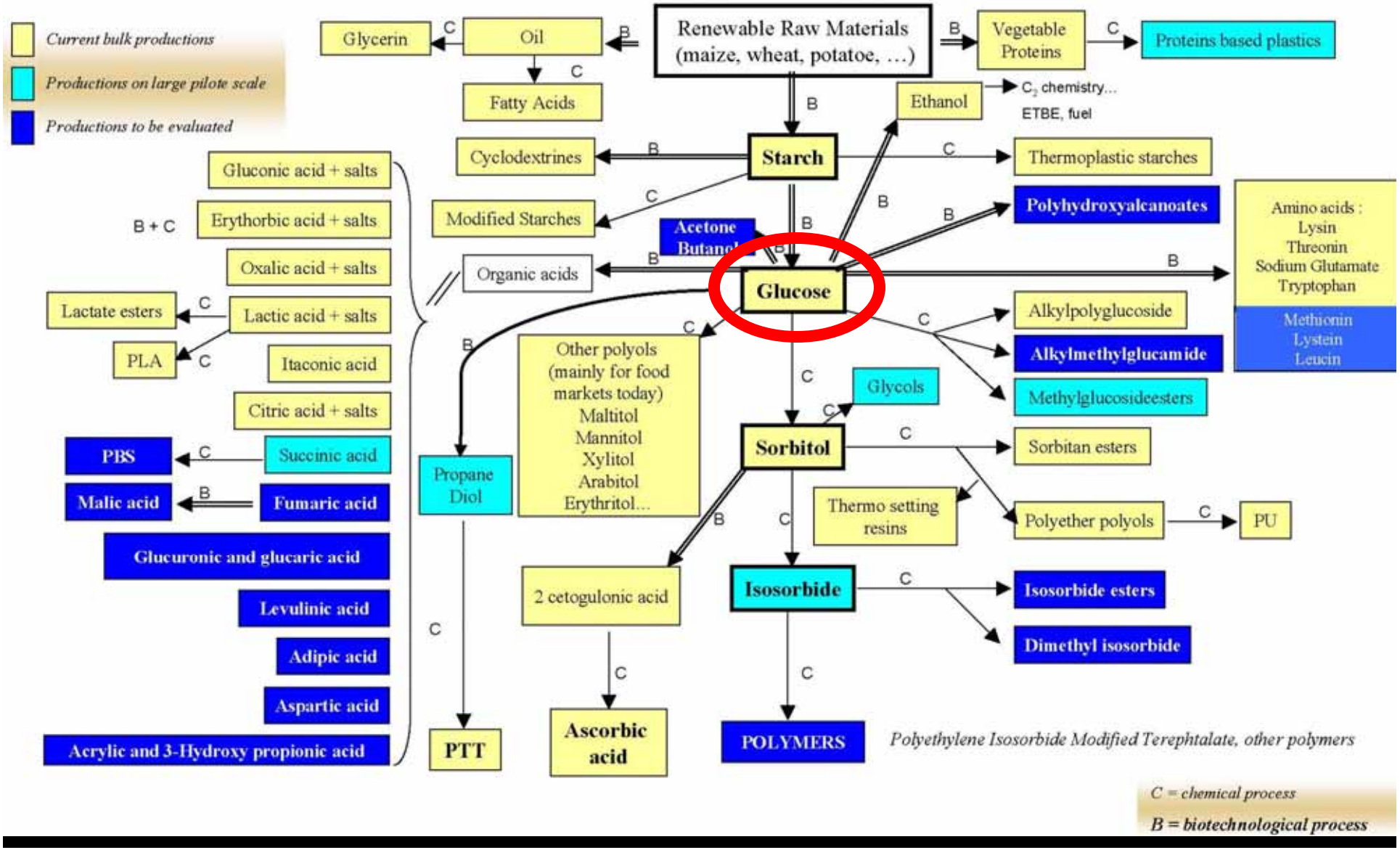
Starch = Fermentable sugars

High Performance Microbial Fermentation

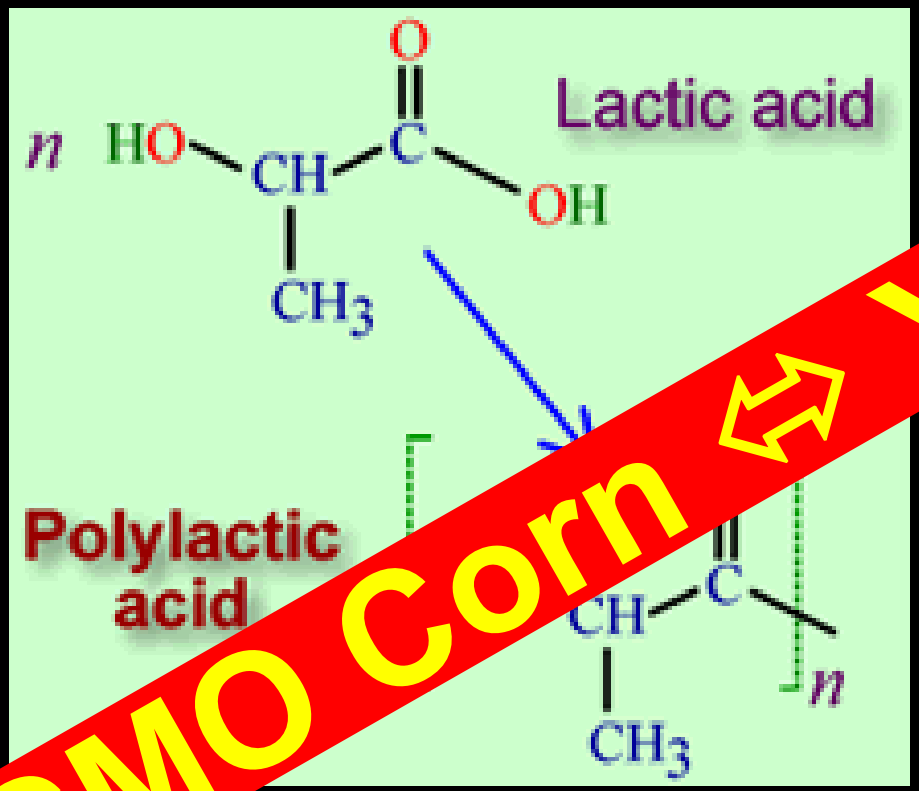
ETHANOL

NONFOOD APPLICATIONS

The Biorefinery ⇔ Sugar is key!

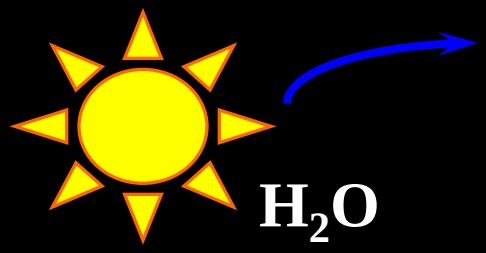


Poly(lactic acid) ⇔ PLA: Cargill



GMO Corn ⇔ Yes or No?

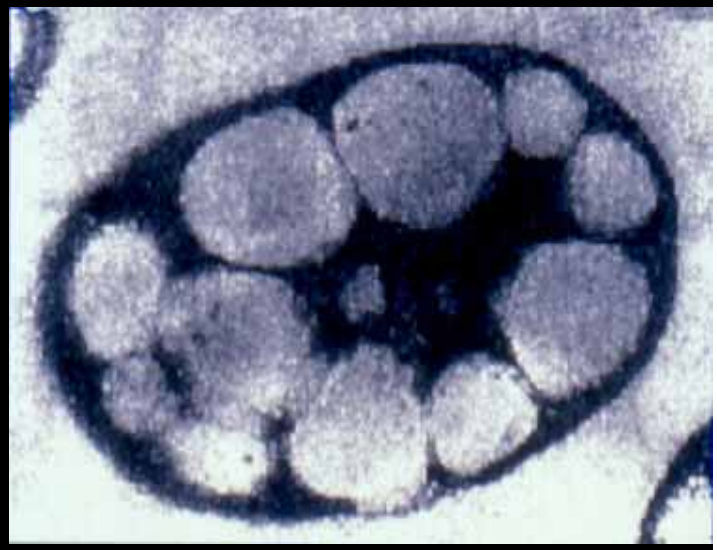
Microbial Polyhydroxyalkanoate (PHA):



Sugars, oils

High Performance Microbial Fermentation

PHAs



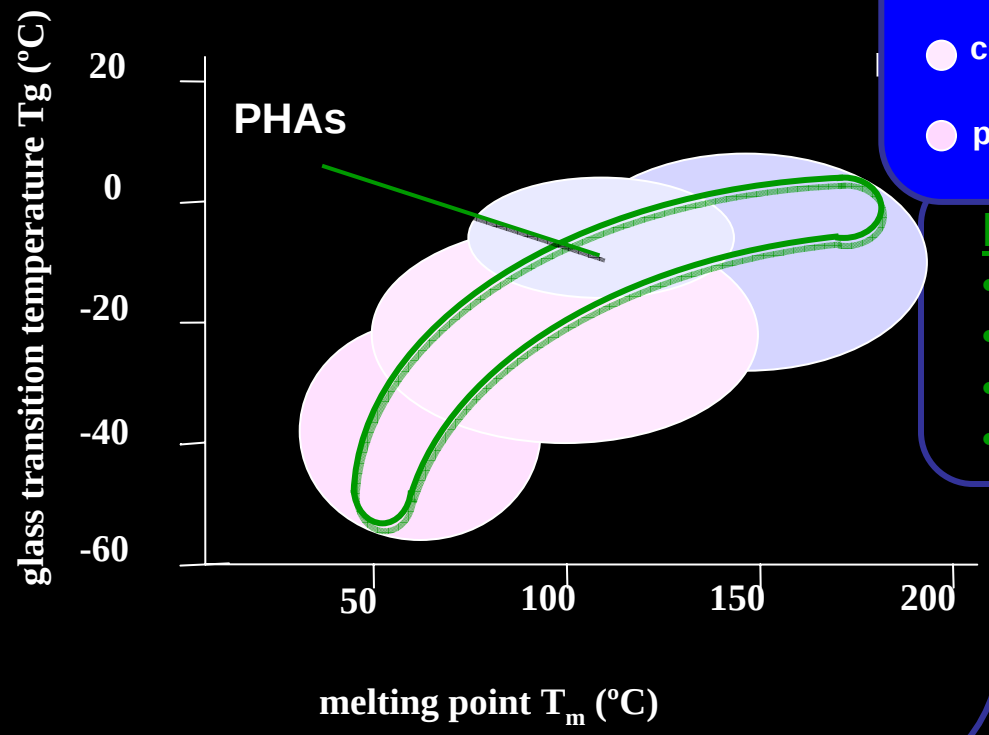
- ✓ **Fully developed by ICI, Zeneca, & Monsanto**
- ✓ **Of recent interest to Metabolix, P & G (NODAX), and Brazilian Producers**

PHA costs (?!?)

- ➥**Slow bacterial growth**
- ➥**Difficult microbial separation**

PHAs: BioPolyester Property Space

THERMAL PROPERTIES



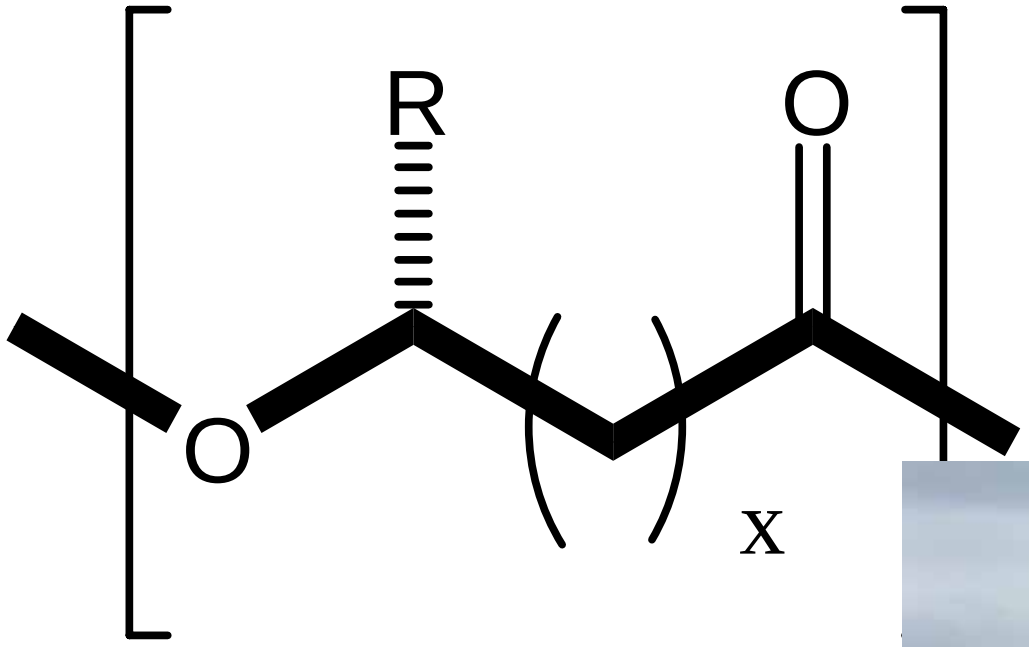
- thermoplastics
- hot melt adhesives
- coatings
- pressure sensitive adhesives

PROPERTIES

- Hydrolytically stable
- Biodegradable
- Form excellent films
- Very good UV stability

Source -- Metabolix

PHAs: Polymer Diversity



Waste oils ⇔ i.e.
Alaskan Fish Waste ⇔
Cheap carbon source
for PHA production

April 23, 2007

Metabolix and ADM bioplastic fantastic -- plant will have an initial annual capacity of 50,000 tons per year

June 21, 2007

Braskem Has the First Certified Green Polyethylene in the World

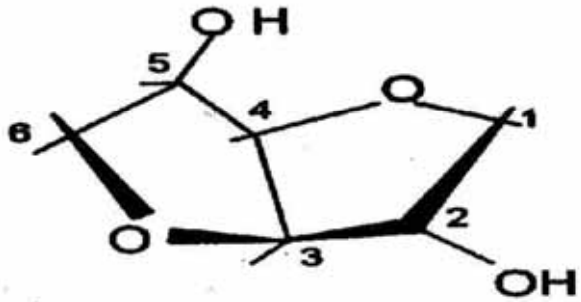
Company is evaluating a project for commercial production of this plastic in 2009

July 19, 2007

Dow and Crystalsev to make polyethylene from sugar cane in Brazil

ROQUETTE ISOSORBIDE

« Molecular Structure »



« Characteristics »

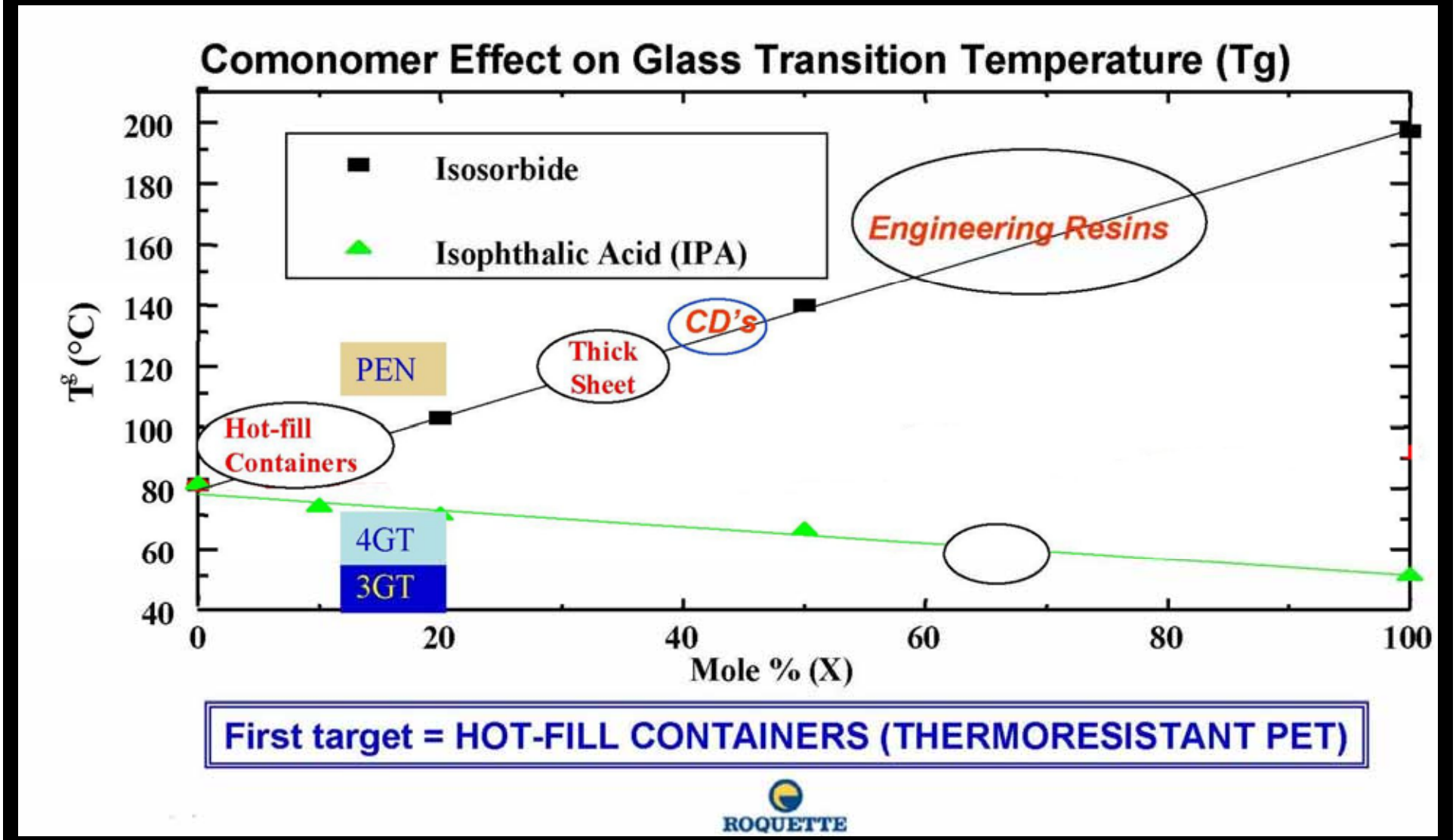
The main chemical and physical properties of crystalline isosorbide are listed below..

CAS No	652-67-5
Molecular formula	$C_6H_{10}O_4$ (Mw=146.14)
Appearance	White crystalline powder, very hygroscopic
Melting point	61-64°C
Boiling point	160°C (10 mm Hg)
Flash point	> 150°C
Solubility	Soluble in water, alcohols, dioxane, ketones Almost insoluble in hydrocarbons, esters, ethers
Isosorbide content	Min. 99 %
Isomannide content	Max. 0.5 %
Water content	Max. 1 %

Isosorbide is non-toxic. In addition, the molecule is very heat stable : decomposition only occurs at about 270°C.

ROQUETTE

Isosorbide – PET Copolymer



Starch Packaging Plates and Bowls

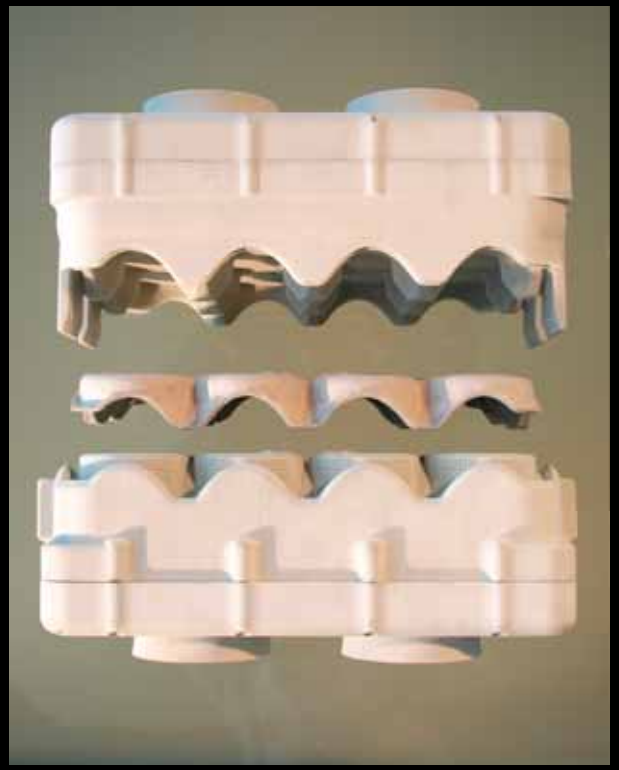
EarthShell PACKAGING

Greg Glenn

Smart & Final

Straw Biomass Utilization:

Straw-based packaging



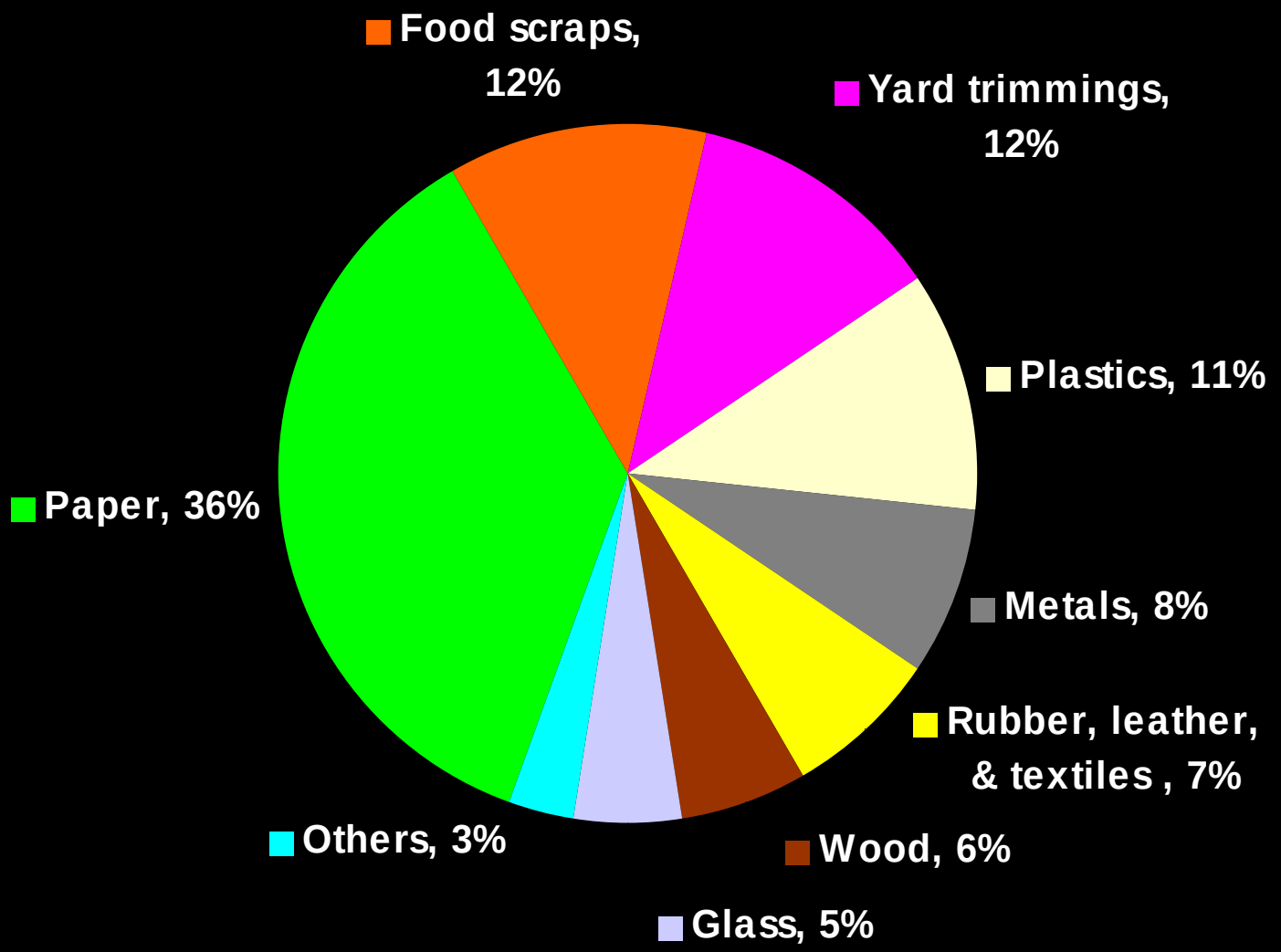
Orts, Glenn – USDA-ARS, Albany

Straw for cellulose-to-ethanol

ISSUES:

- **Straw varies with seasons**
- **Aging ⇔ harvest time is once per year**
- **Moisture and storage are challenging**
- **Transportation ⇔ Low density**
- **Supply is not near highest demand.**

Composition of MSW



425 million tons per year of unsorted MSW produced in U.S. alone (BioCycle, 2006).

Biomass Pretreatment:

A pressurized hot water treatment allows straw, co-mingled with MSW, to be hydrolyzed relatively easily.

Conveyor loading MSW to autoclave

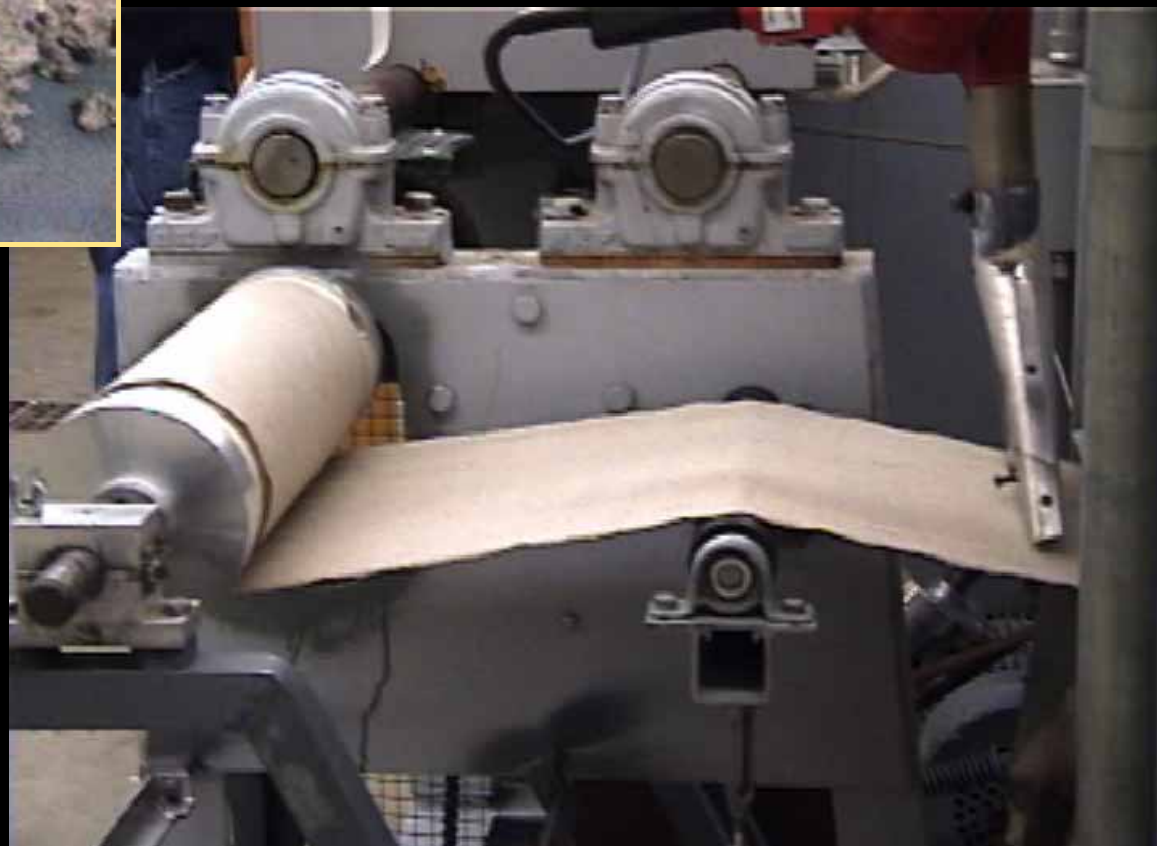
MSW inside the autoclave prior to steam treatment

MSW in the autoclave after steam treatment

Clean fiber from MSW after centrifugal cleaners

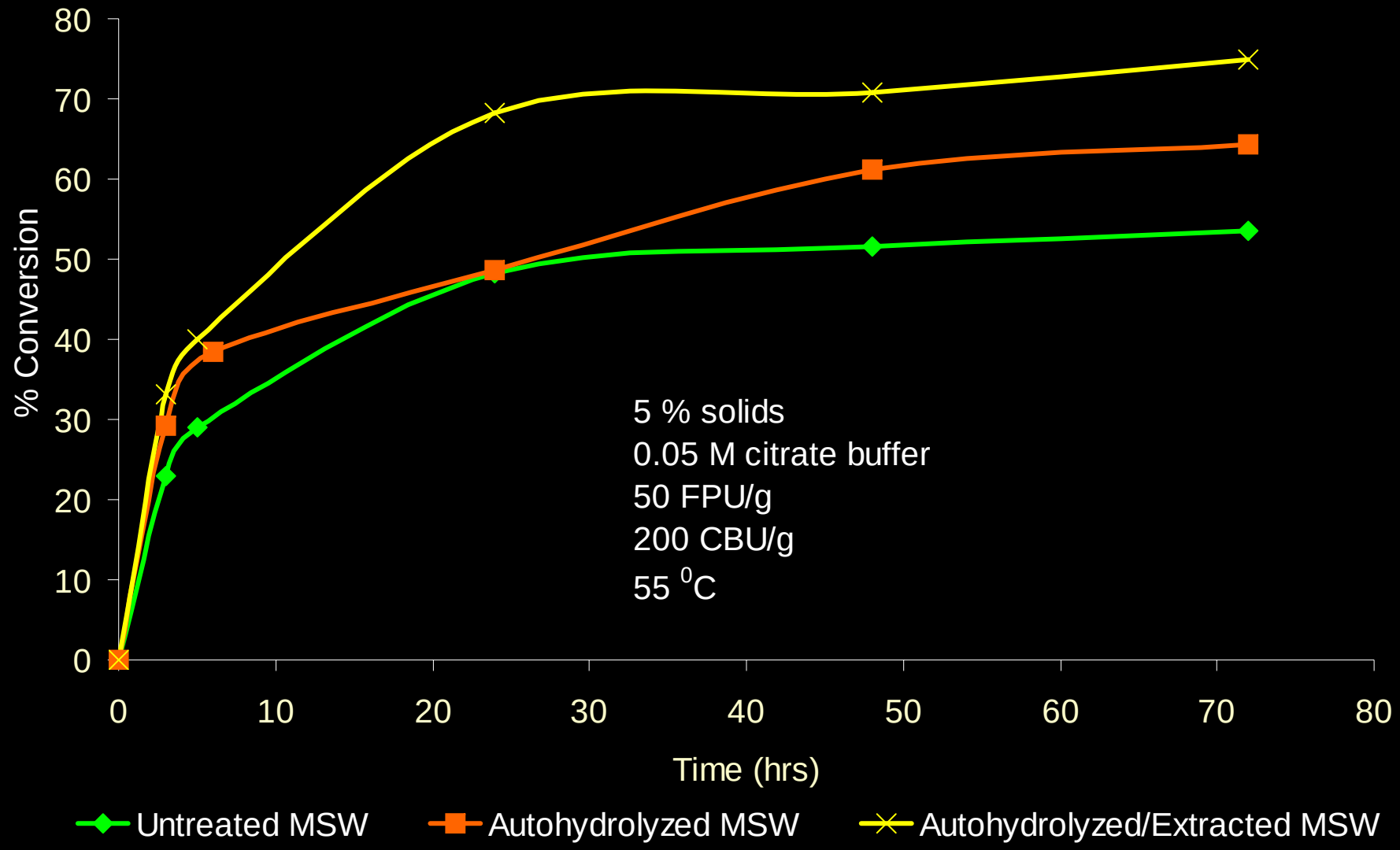
Cellulose-to-Ethanol Biorefinery ⇔ CR^3

Processed paper from recovered fiber

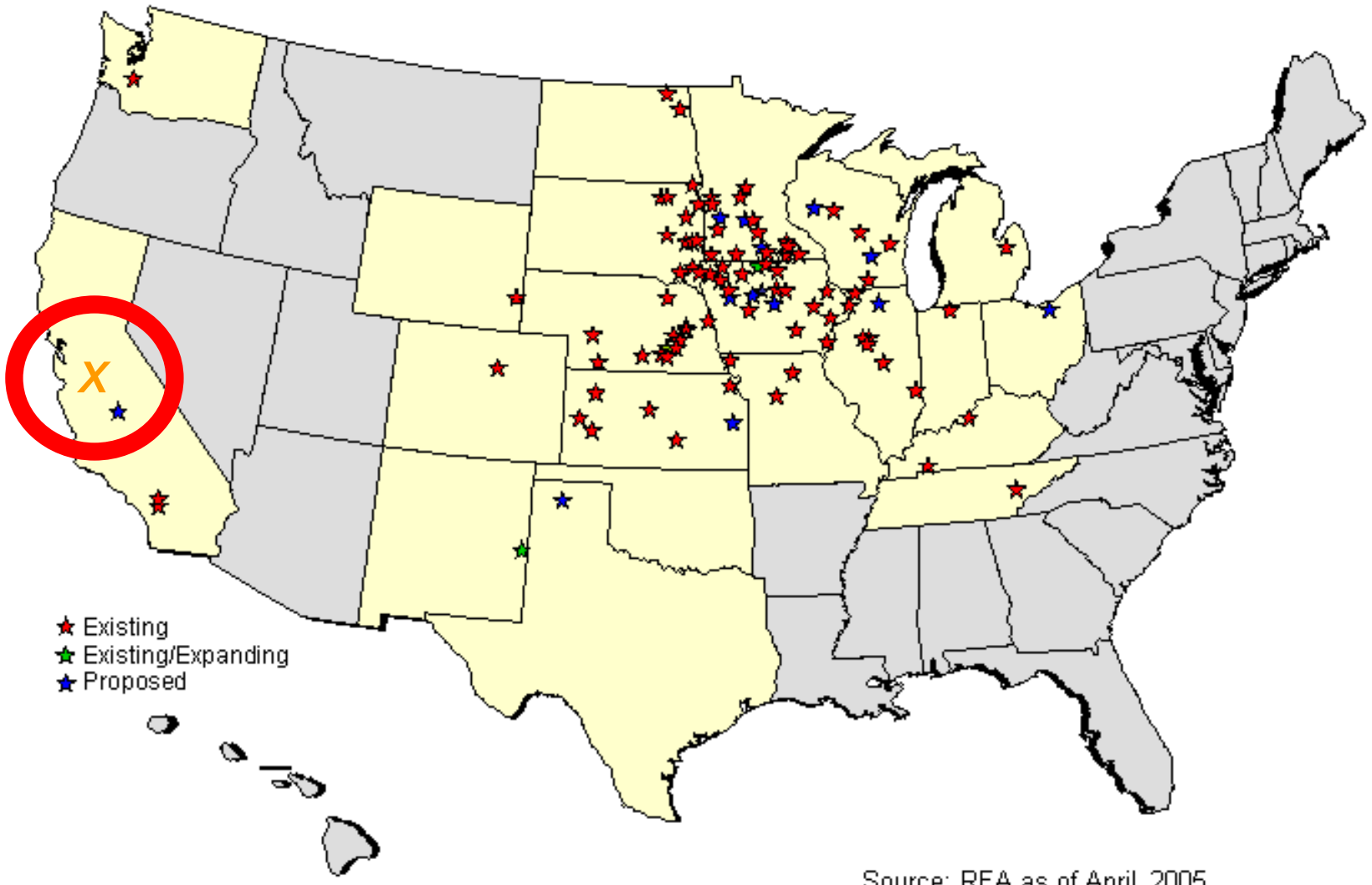


Biomass ⇔ MSW and ag-waste processing plant in Salinas

Enzymatic hydrolysis of MSW

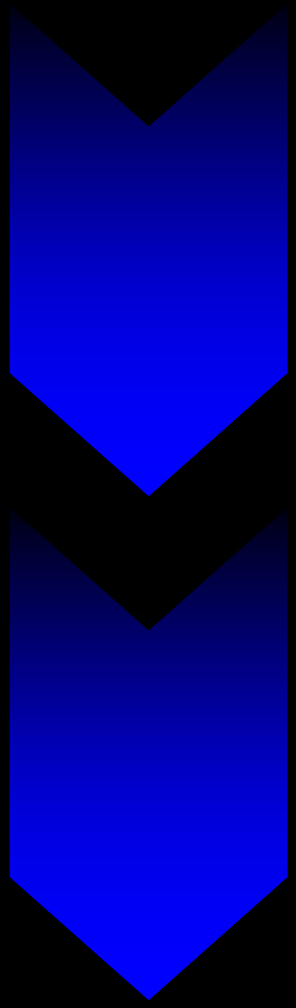


U.S. ETHANOL MANUFACTURING LOCATIONS



Source: RFA as of April, 2005

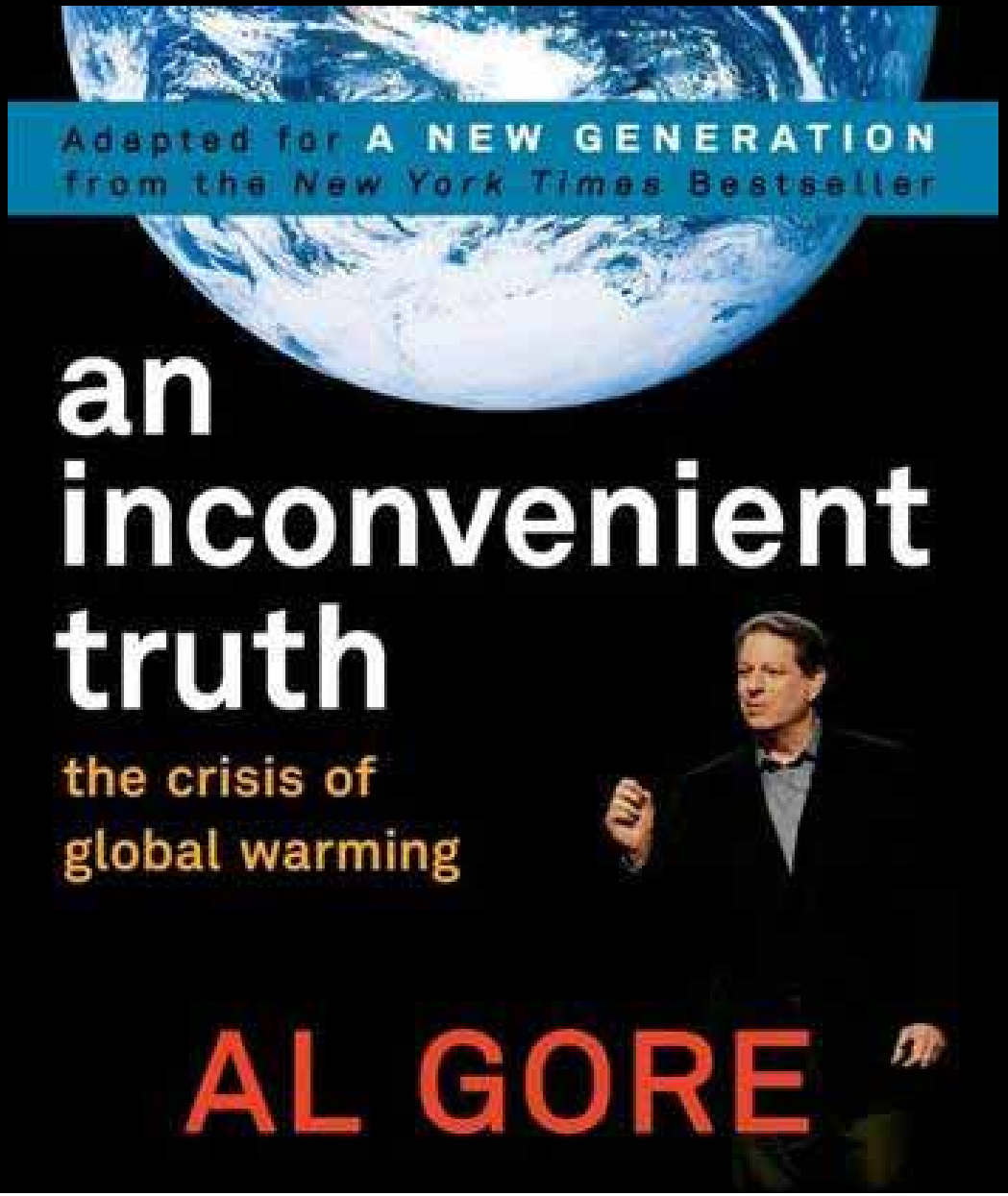
MSW as a Platform for Biomass-to-Ethanol Biorefinery



- MSW ⇔ 425 million tons/year in U.S.
  ~ equates to 12% of our fuel
- 35 - 45% paper and paperboard products
- Will reduce landfill volume by >80%
- In MSW, paper is already fractionated
- Can produce other co-products
  - ⇔ Pulp
  - ⇔ “Fermentable sugars”

“Athletic Biorefinery”

Cap & Trade: Carbon Credits



Cap & Trade: Carbon Credits

Biobased Products ⇔ CARBON CREDITS

ASTM D6852

Based on "age of the carbon"

- **ratios of isotopes shows whether the carbon is "new" (renewable) ro "old" (fossil fuel).**

Summary

Food/feed should be for food/feed

The cost of “fermentable sugars” is the key!

Bioproducts add value to the whole biorefinery operation

Flexible biorefineries will expand our scope ⇔ MSW ??

CARBON CREDITS?

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Dominic Wong
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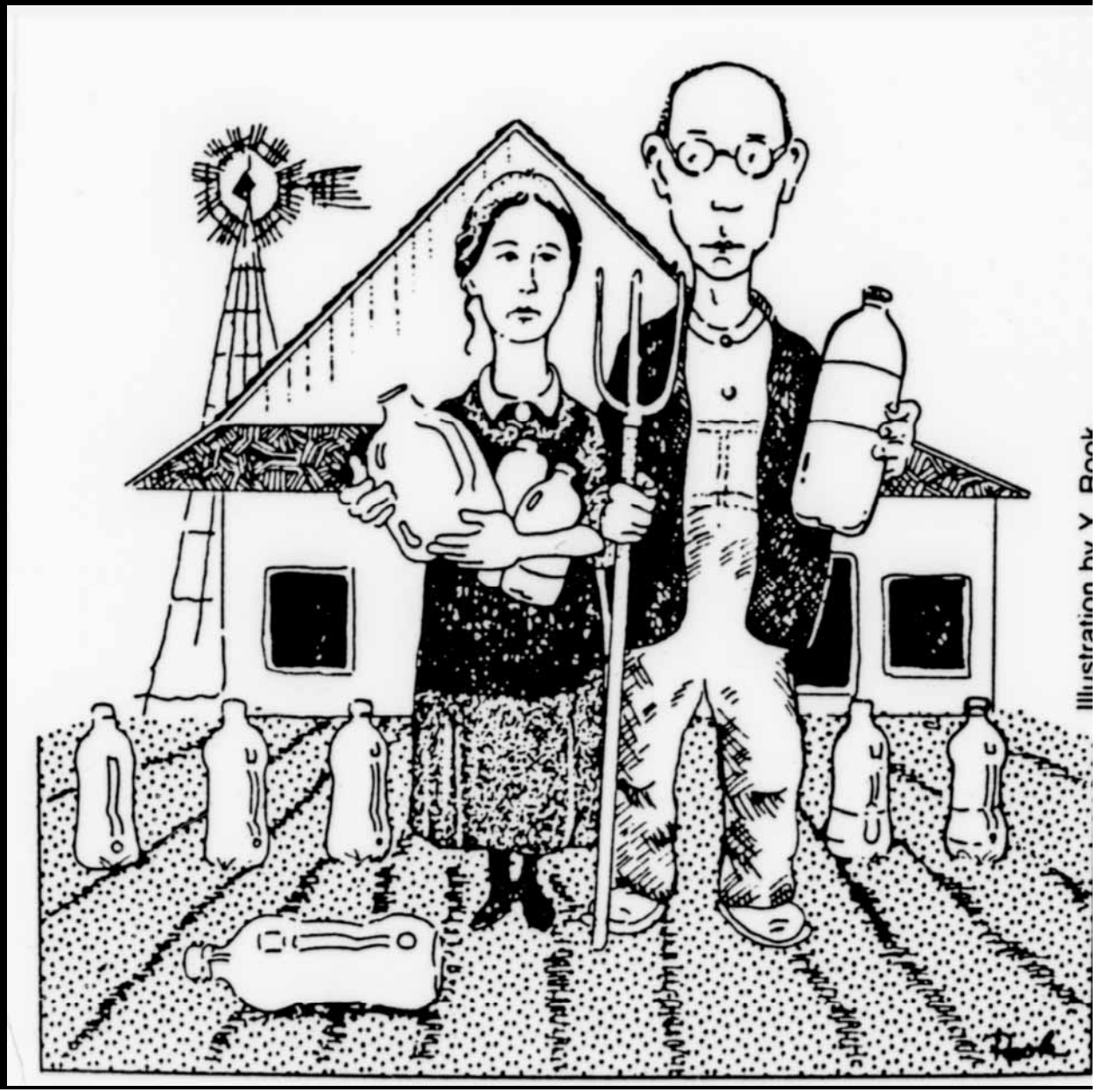
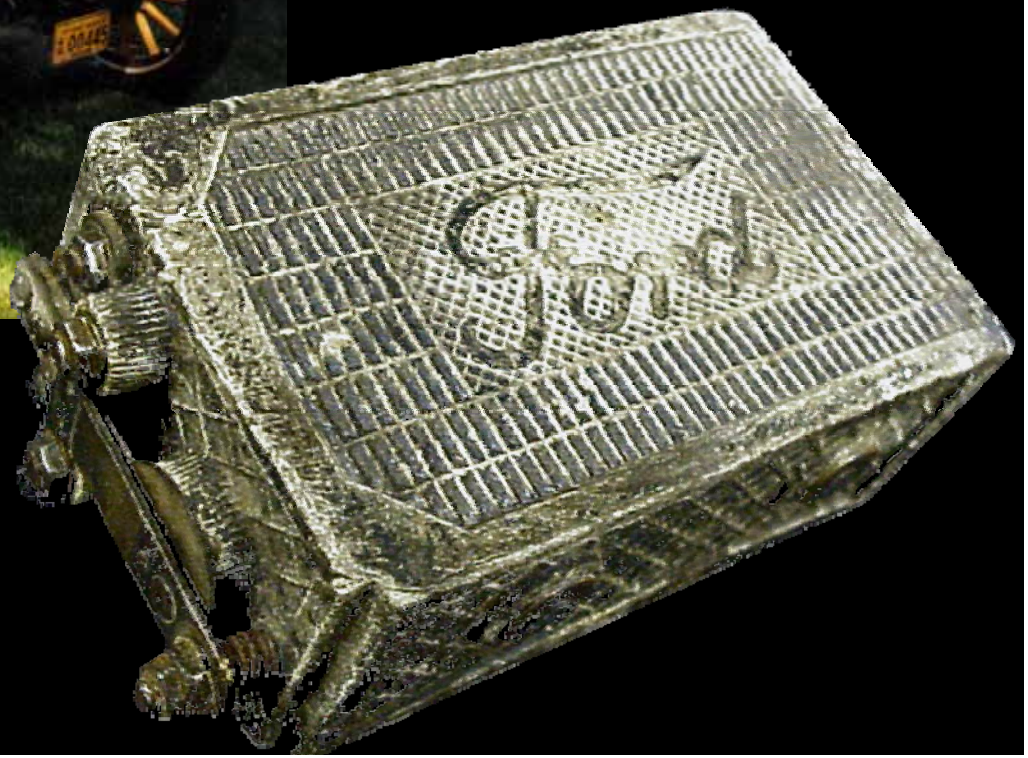



Where do
we go
from here?

Back to the future



Energy Return – Based on Petroleum Equivalents

Eg. = 1 BTU

Corn Ethanol 1.3:1 up to 2:1

Energy Return – Based on Petroleum Equivalents