



Fuel Ethanol Technology and Markets Beyond the Renewable Fuel Standard

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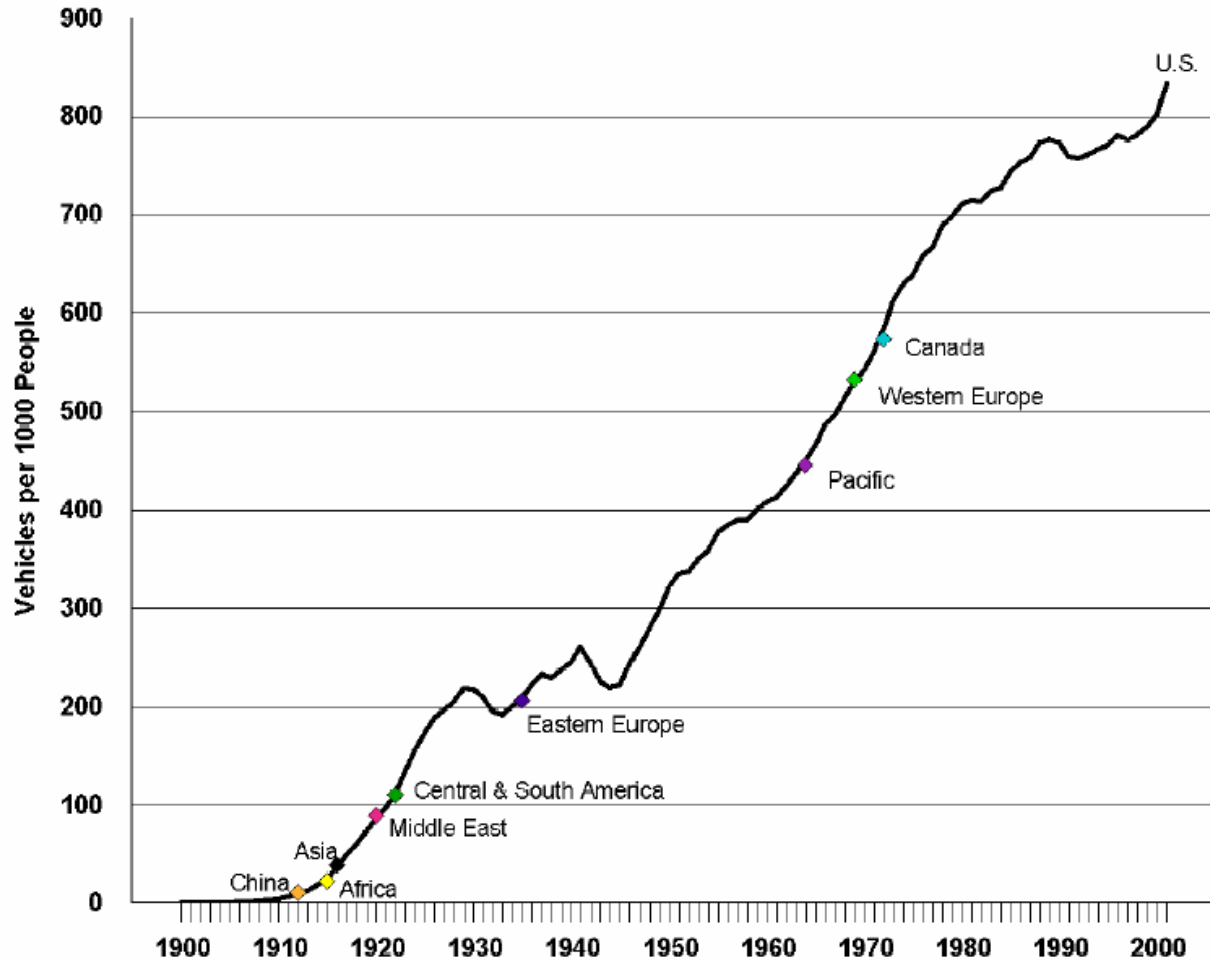
Towards Sustainable Mobility

- Personal mobility one of the most distinctive conquests of the modern society. Is one of the most coveted goals of people worldwide as they gain increased affluence.
- Access to inexpensive and widespread mobility for goods and people essential to the unprecedented economic growth of the XX century
- Transportation almost completely dependent upon oil derived liquid fuels
- Transportation responsible for a large part of global green house gas emission



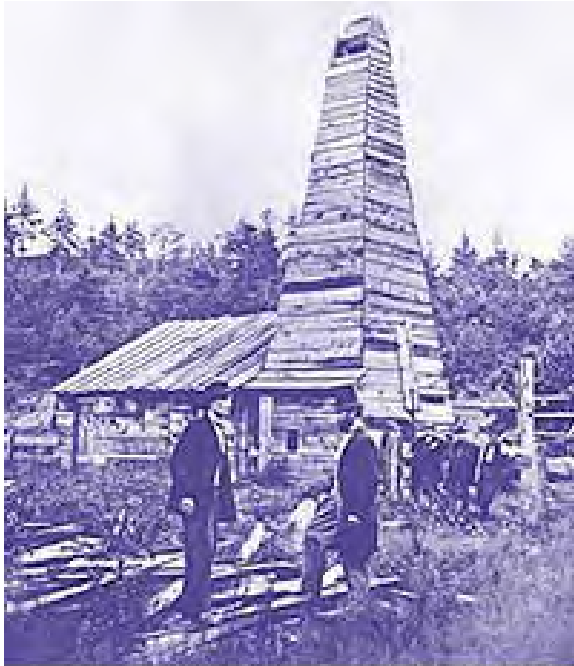
Delivering access to sustainable and affordable mobility is one of the defining challenges of the XXI century

Figure 3.1. Vehicles per Thousand People: U.S. (Over Time) Compared to Other Countries (in 2002)



Source: US DOE Transportation Energy Data Book (<http://cta.ornl.gov/data/index.shtml>)

Some history.....



Drake Well Museum

- 90 million gallons of farm ethanol produced at the beginning of the 1860's
 - Mostly used as lamp fuel
- Colonel Drake struck oil in Pennsylvania in 1859
- The Union Congress passes a \$2.08/gallon tax on alcohol to help with the civil war effort in 1862
- Kerosene from the fledging oil industry is taxed at only \$0.1/gallon
- A young accountant named John Rockefeller buys a small refinery and calls it "The Standard Oil Company"...
- Ethanol is a recommended fuel for the first Ford Model T
- Ethanol is declared the fuel of the future by Charles Kettering (GM first Research Director)
- The Ethyl corporation develops high octane gasoline in 1924 and fuel ethanol disappears.
- Fuel Ethanol is proposed again as a domestic fuel with the OPEC oil embargo of 1974 and subsequent energy crises
- Fuel Ethanol expands its market reach with local phasing out of MTBE and increased demand for oxygenated fuel in the late 1990's



2005 Energy Bill. Key relevant points.

- Renewable Fuels Standard (RFS)
 - Nationwide blending target mandate
- No MTBE Liability Protection
- Volumetric Ethanol Excise Tax Credit (VEETC)
 - 51 cts/gal Refiner/Blender Credit
 - Adds 2.5 cts gal to Federal Highway Fund
 - Program runs through 2010
- Small Producer Tax Credits expanded to production up to 60 Mgal/yr
- For years 2012 and beyond
 - At a minimum: Renewable fuels must continue to represent at least the same percentage of total gasoline consumed as existed in 2012
 - Targets: set by EPA and DOE after reviewing years 2006-2012
 - Cellulosic biomass must constitute at least 250 million gallons of the renewable total



RFS Target

Year	bgal/yr ethanol	mbbl/yr ethanol	mbbl/yr * gas equiv	% of ** gas demand
2006	4	95.24	63.81	1.91%
2007	4.7	111.90	74.98	2.25%
2008	5.4	128.57	86.14	2.58%
2009	6.1	145.24	97.31	2.92%
2010	6.8	161.90	108.48	3.25%
2011	7.4	176.19	118.05	3.54%
2012	7.5	178.57	119.64	3.59%

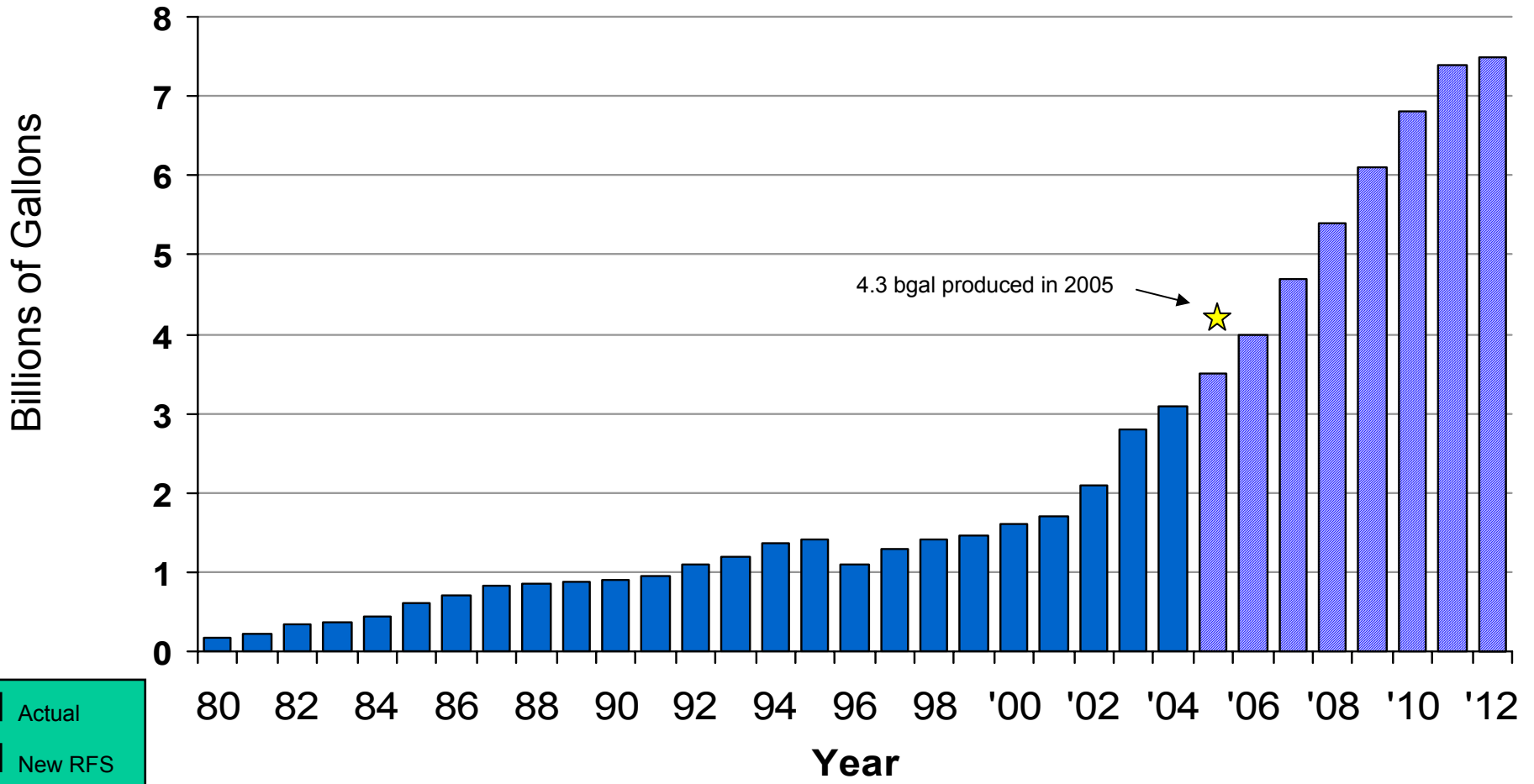
* Accounts for lower energy content of ethanol

** Based on US gasoline consumption of 140 billion gal/yr



Historical and 2005 7.5byn RFS as passed 7/27/05

The industry is ahead of the targets



Source: Renewable Fuel Association



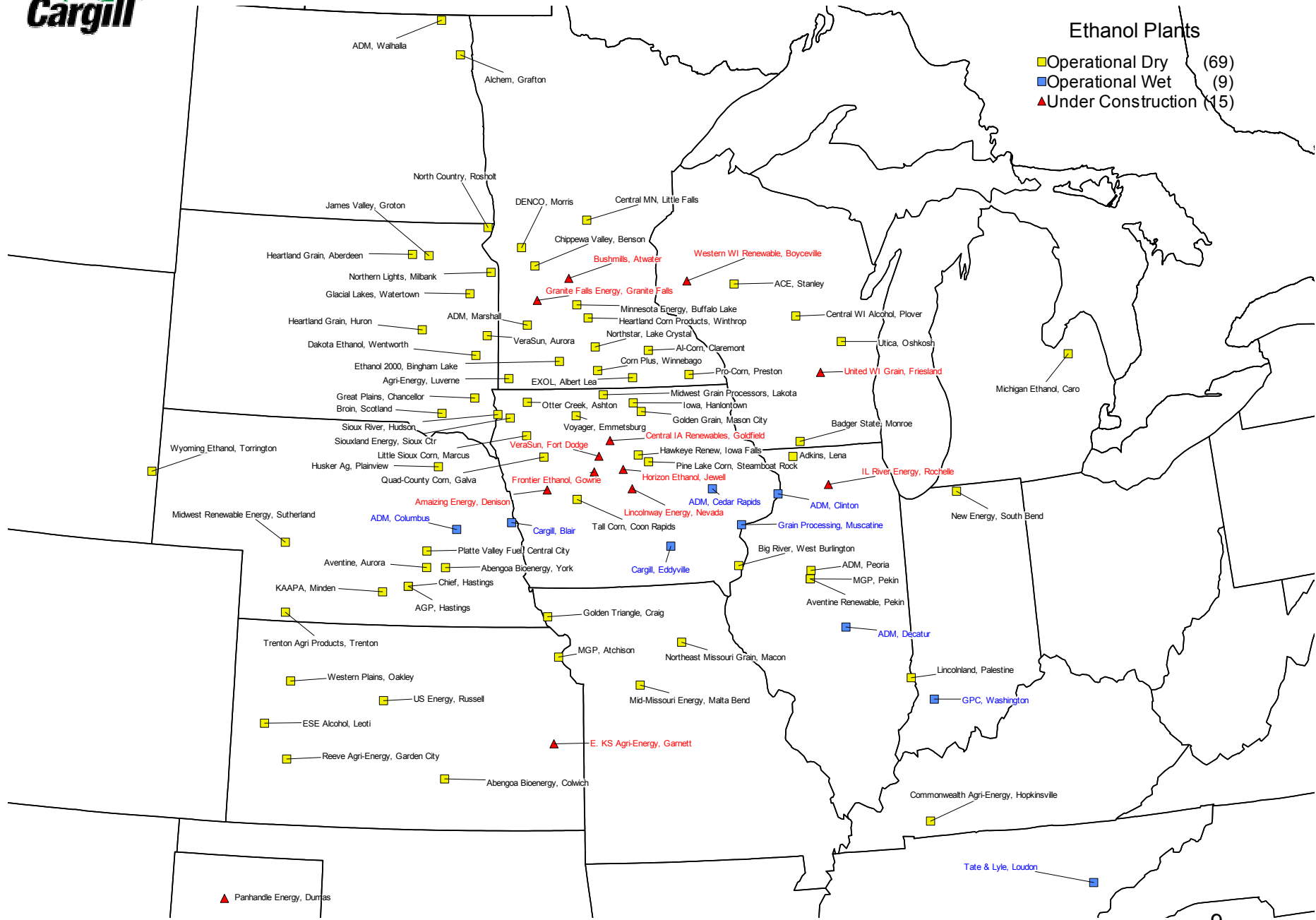
U.S. Ethanol Growth

- Nationwide 93 plants today - 4.3 billion gallons (102 mil. bbls)
- >15 under construction
- > 70 plants in the corn belt
- 40-50 announced or being publicly considered, possibly more being evaluated
- 7.5 billion gal. achievable by 2009 (179 mil. bbls)



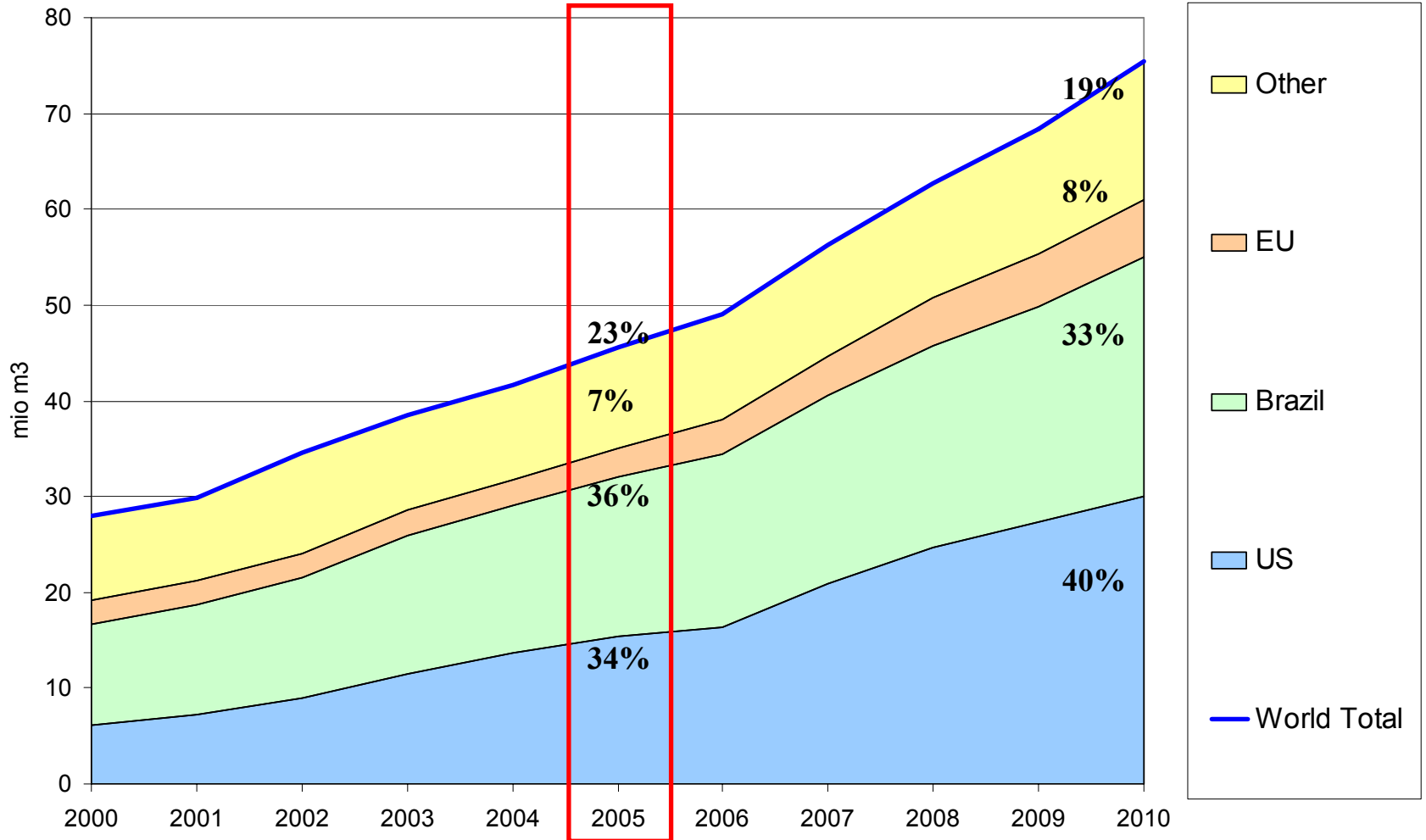
Ethanol Plants

- Operational Dry (69)
- Operational Wet (9)
- ▲ Under Construction (15)



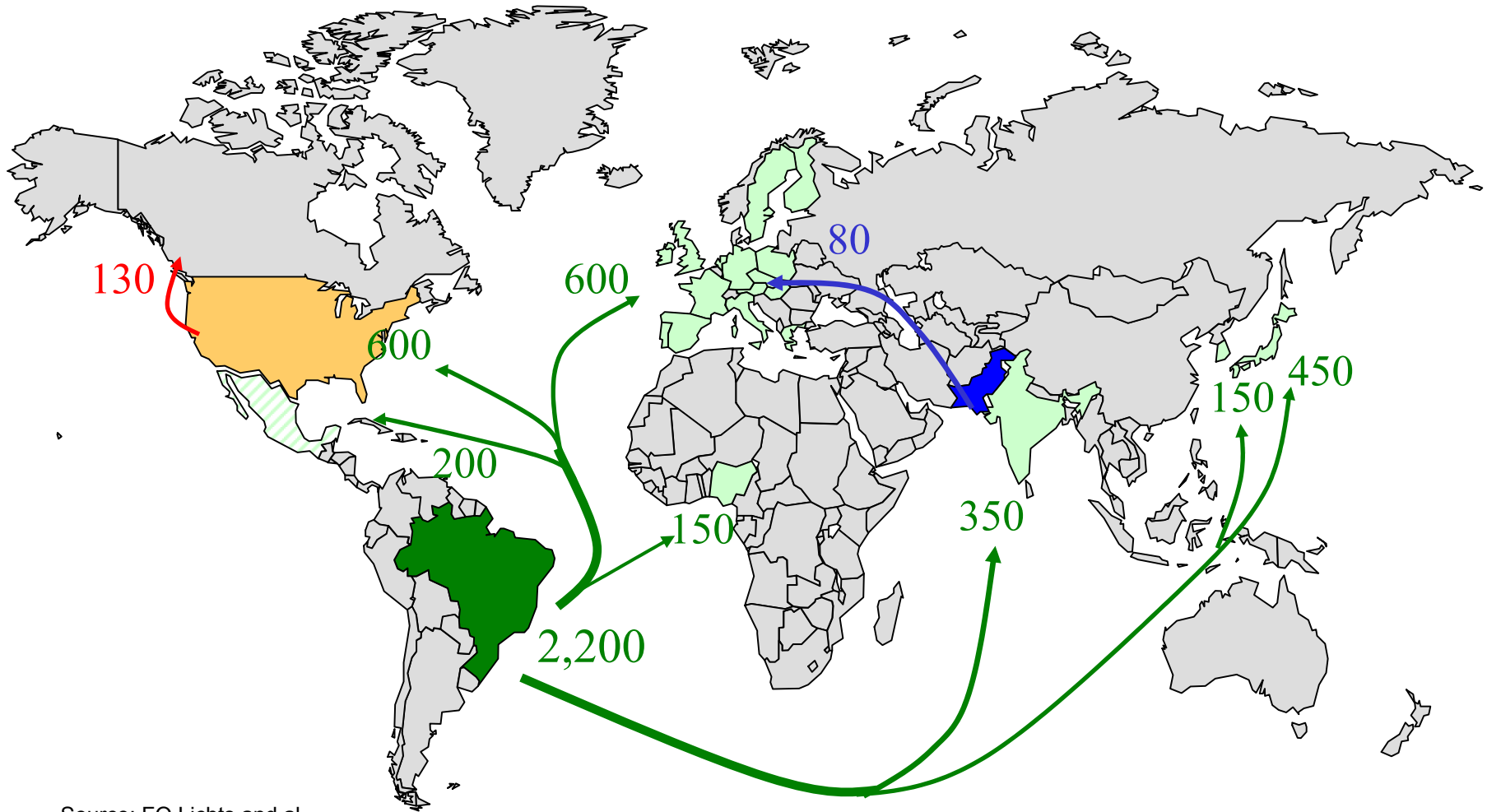


World-wide ethanol growth



Source FO Lichts and al.

Fuel Ethanol 205 Trade Flows in Million Liters. A Fledging Super Commodity



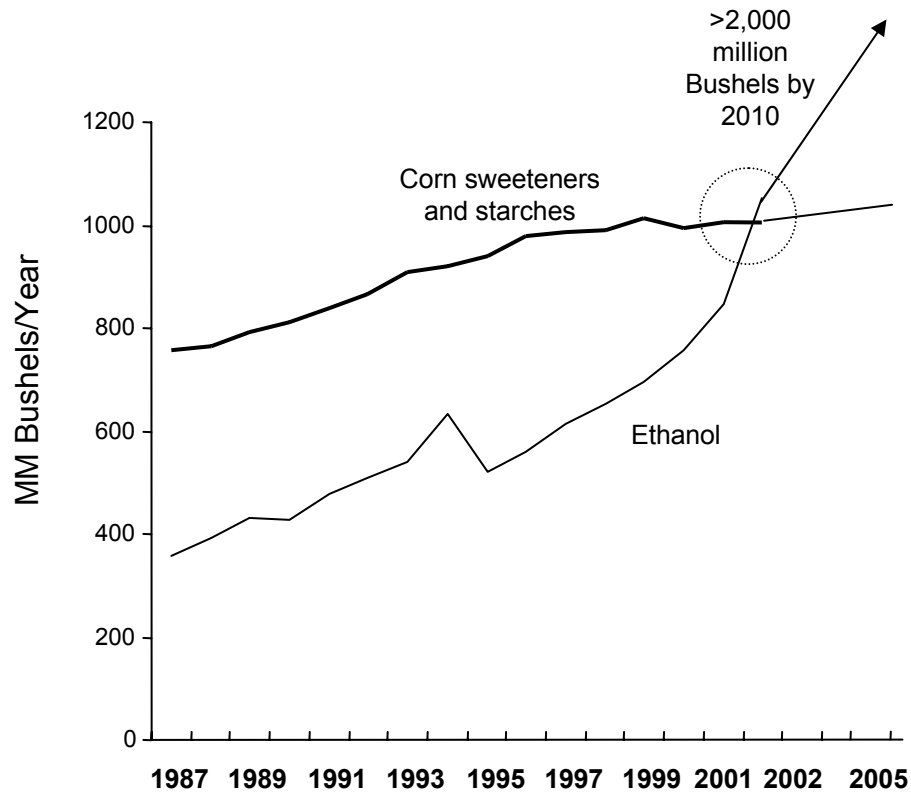
Source: FO Lichts and al.



THE AMOUNT OF CORN USED TO PRODUCE ETHANOL IS INCREASING

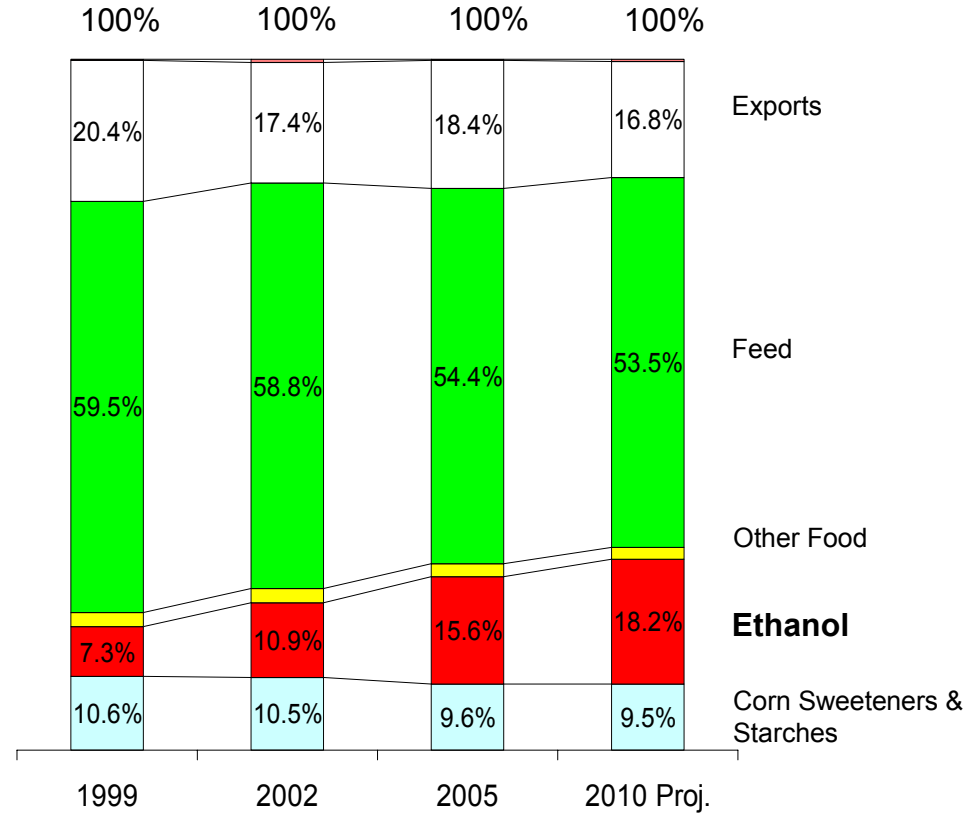
current statistics and projections may actually underestimate the impact of ethanol

Corn Use for Ethanol



Source of data: USDA – Economic Research Service

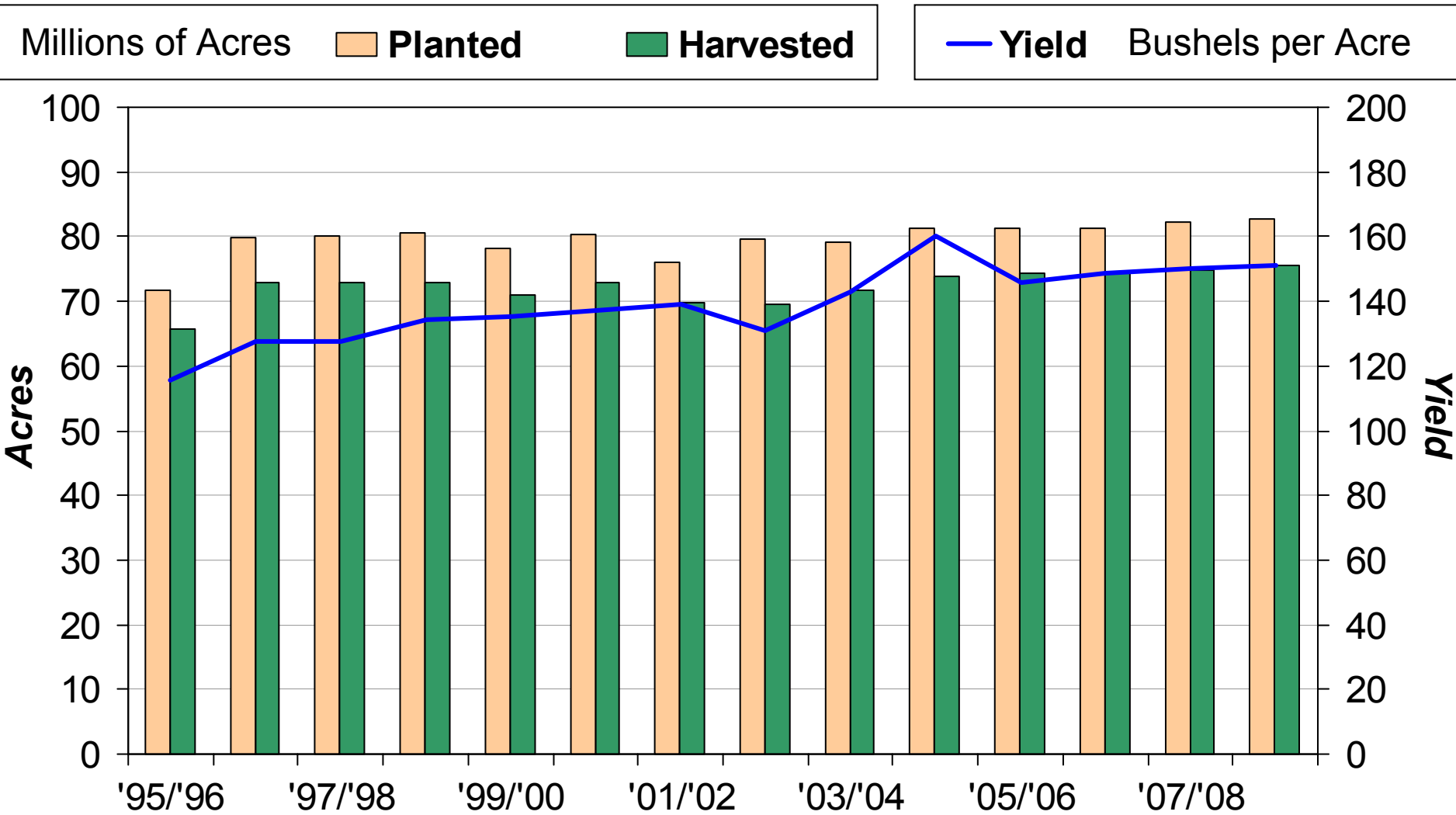
Corn Disappearance



Source of data: (August, 2005) USDA – Economic Research Service
 2010 Projection assumes 5.2 billion gal EtOH/yr & total corn production @ 11 billion bushels/yr, 1% Feed & Sweeteners growth. 2% Food Growth.



THE US CORN CROP CONTINUES TO GROW



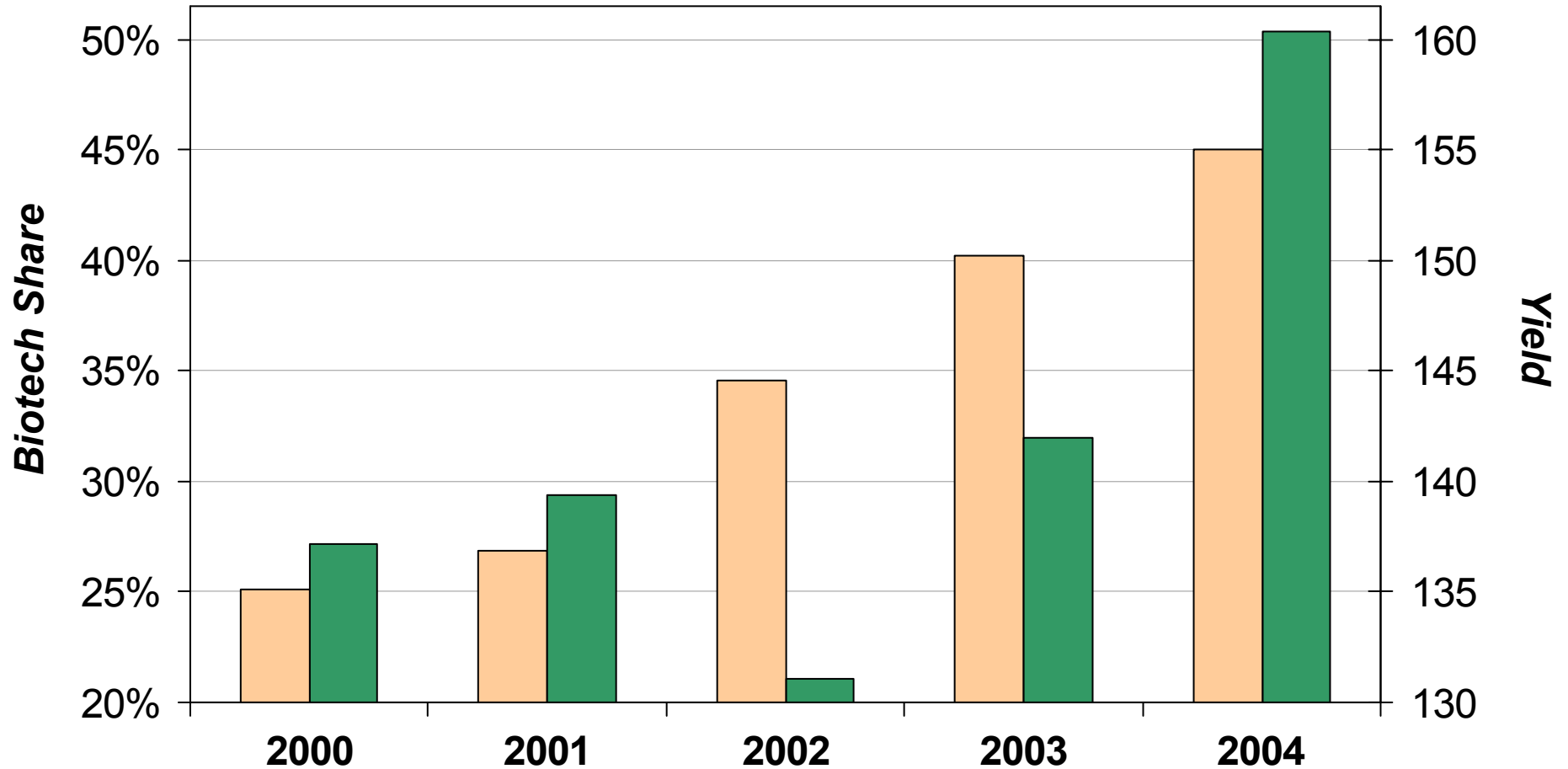
Source: USDA Agricultural Baseline Projections to 2014, February 2005
Economic Research Service, USDA



CORN YIELDS ARE IMPROVING THROUGH AN INCREASE IN THE BIOTECH SHARE OF CROP WITHOUT A PROPORTIONAL INCREASE ON FERTILIZER USAGE

Biotech Share

Average Corn Yield Bushels per Acre



Source: National Corn Growers Association (12-28-04)



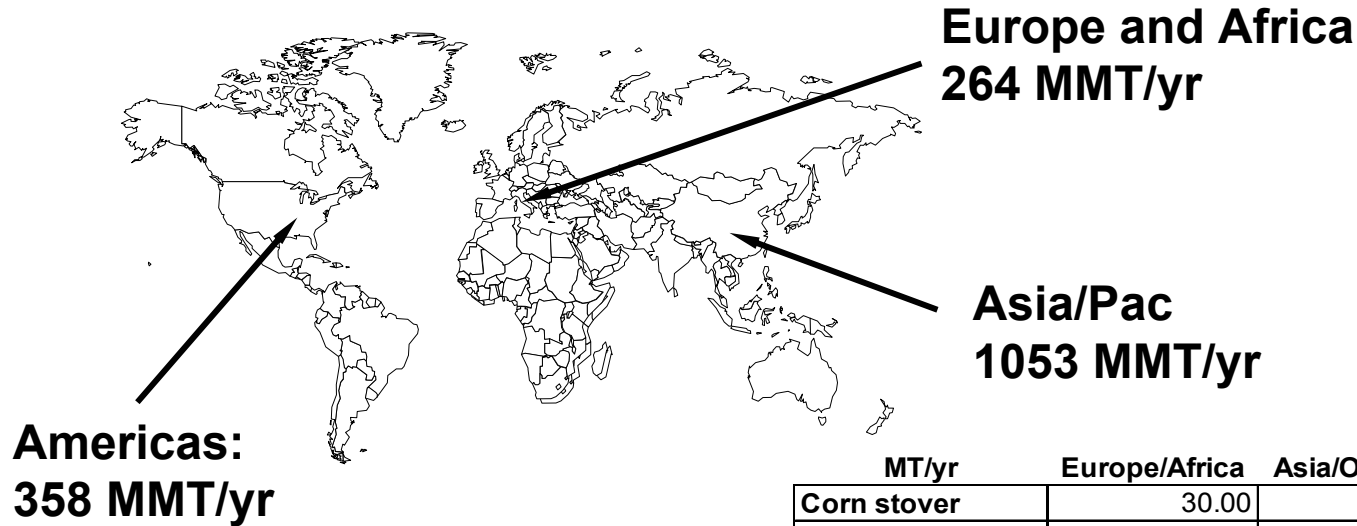
Beyond 2012?

- 20% or more of the US corn to ethanol
- What blending level?
- Nationwide blending level of 10% would require ~ 5 billion bushel or 50% of the corn grown in the US today. It is conceivable.
- Above that?
 - Food vs. Fuel tensions?
 - Impact on agricultural land availability and environment?
 - Commodity prices and rural economies?
- How to foster the transition to lignocellulosics?

Corn is king, but feedstock diversification remains a key objective.

Current availability of ag residues.

Approximate Global availability of crop residues: 1.7 BMT/yr

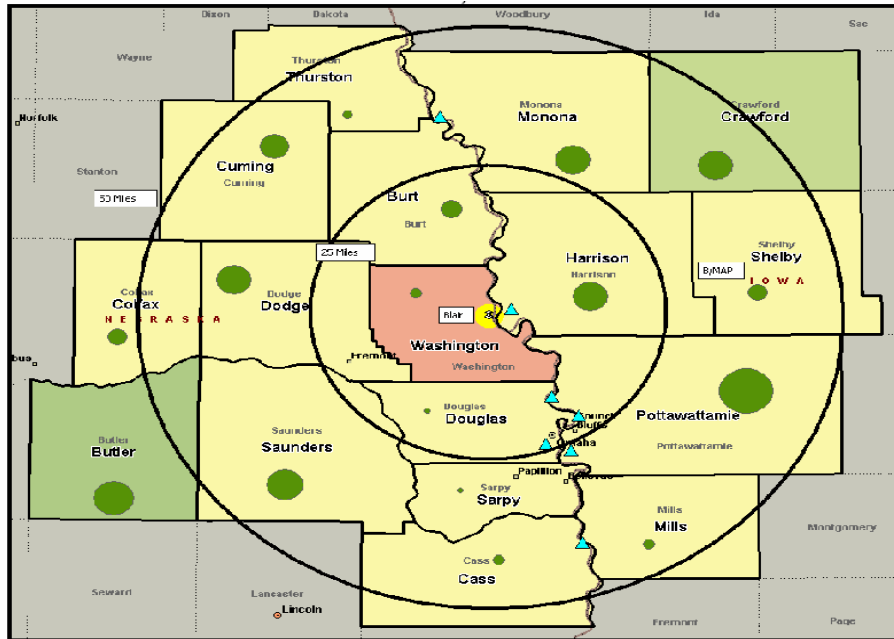


MT/yr	Europe/Africa	Asia/Oceania	Americas	Totals
Corn stover	30.00	34.00	141.00	205.00
Barley straw	40.00	4.00	10.00	54.00
Oat straw	7.00	1.00	3.00	11.00
Rice straw	25.00	670.00	37.00	732.00
Wheat straw	140.00	154.00	63.00	357.00
Sorghum straw	0.00	0.00	10.00	10.00
Bagasse	12.00	81.00	88.00	181.00
Oil Palm residues	10.00	109.00	6.00	125.00
Totals	264.00	1053.00	358.00	1675.00

Source: Bruce Dale et. al.

Close to home: stover challenges

Stover Collection Area within 50 miles of Blair, NE



Open questions:

- Collection
- Storage
- Transportation
- Impact on soil erosion and carbon level.

Average Stover Production (1995-2000): 5,400,000 t/yr

Available today with tillage: 1,800,000 t/yr

Available with no tillage: 3,600,000 t/yr

Cost under current harvesting practices: >\$50 t/yr

Cost under foreseeable harvesting practices: \$30 t/yr

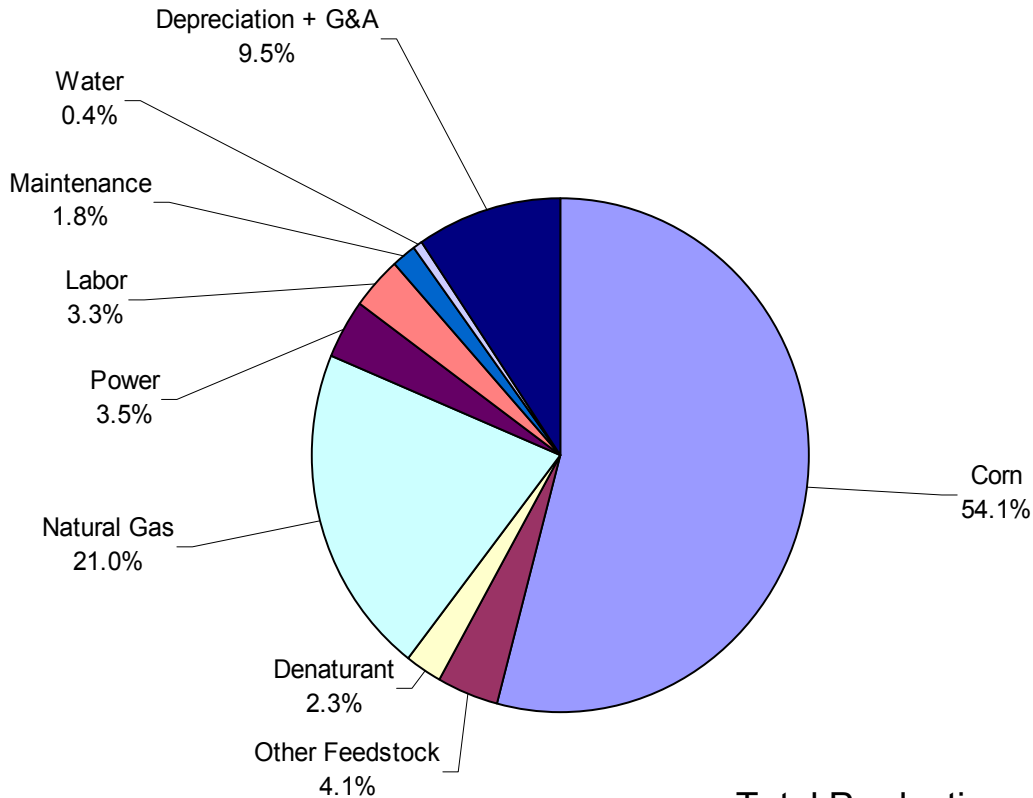


The gateway to the future





US Dry Grind Ethanol - Economics



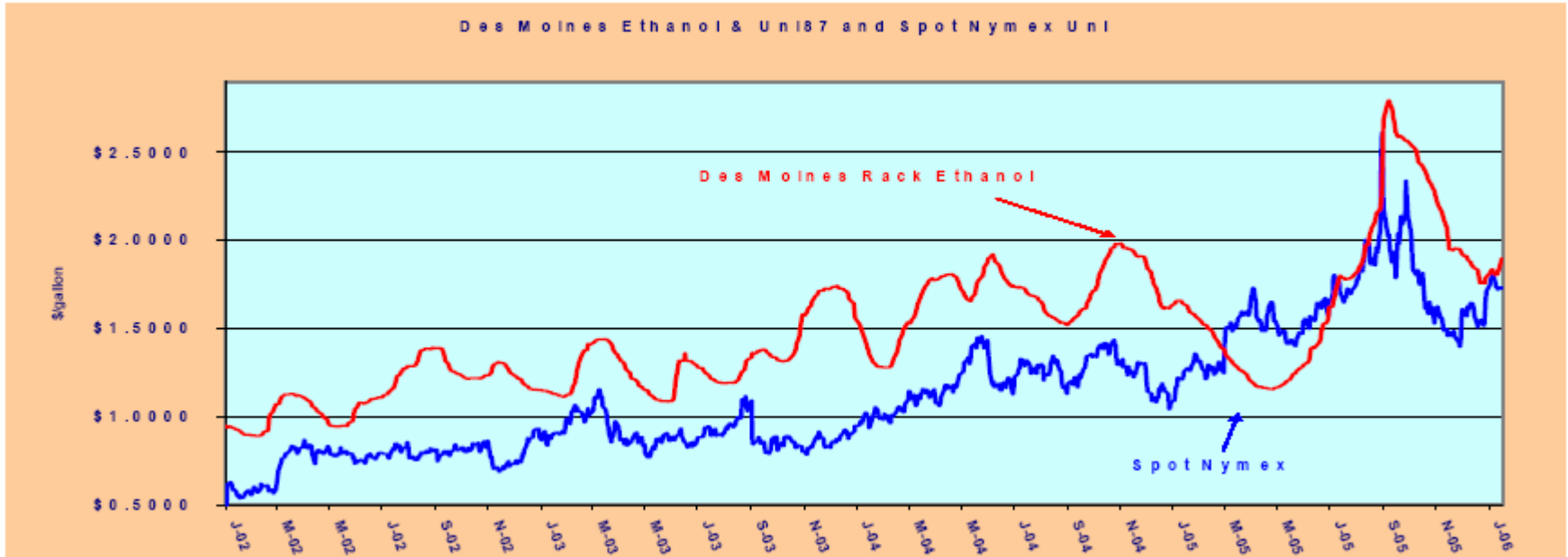
Corn \$2.20/bu
NG \$10/MMBTU
100 Mgal/yr plant
DDGS \$80/ST

Green Field Capex
\$1.06/gal capacity

Total Production cost \$1.15-1.35 gal
Accounting for \$0.25-\$0.35 gallon of DDGS credits

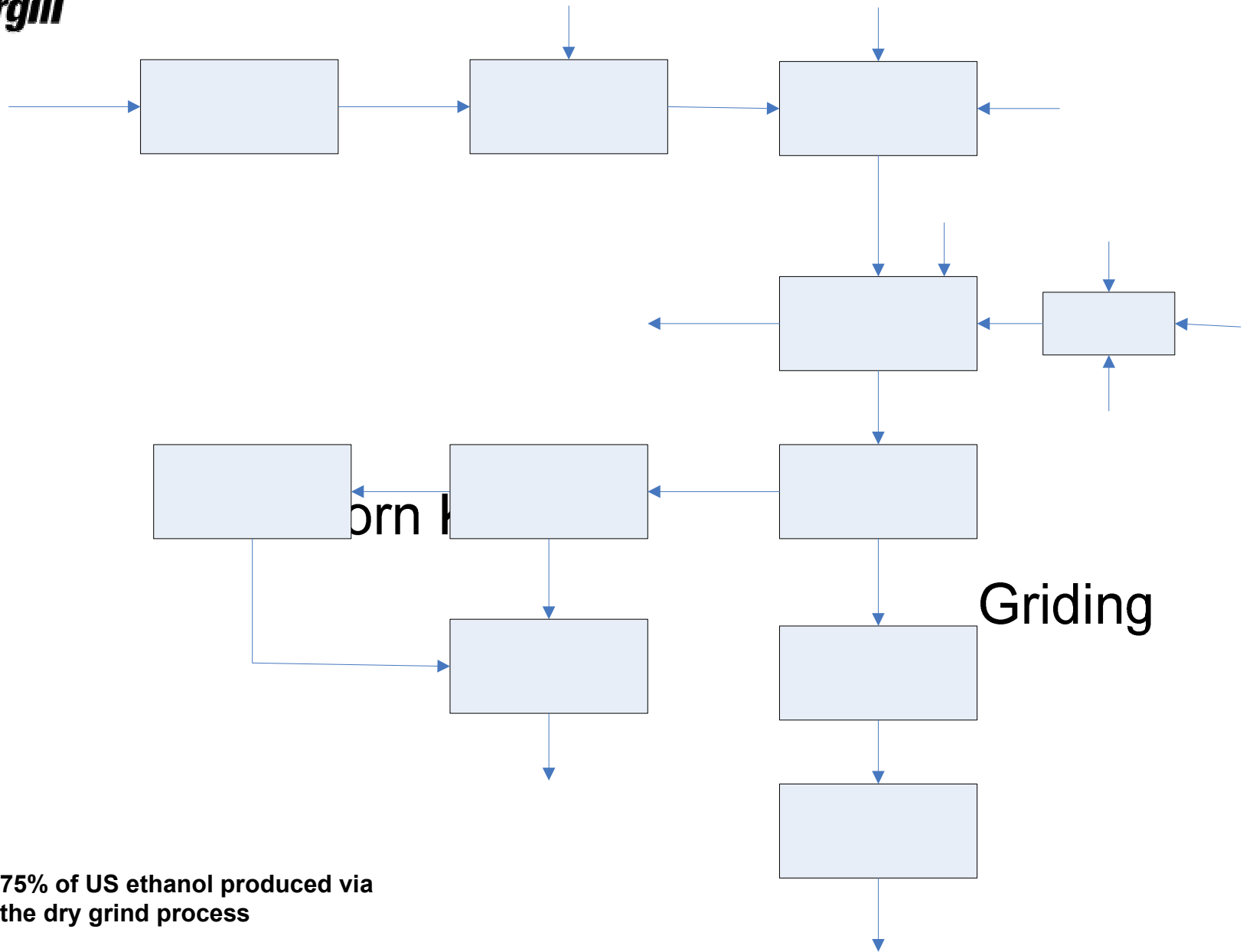


Industry is profitable and good margins are being invested in R&D



Source: BioAge

Many improvements being developed in today's corn ethanol industry prelude to future lignocellulosics bio-refineries.



75% of US ethanol produced via the dry grind process

Developments to watch

(in no particular order)

- Improved front end (fractionation) for germ and fiber recovery
- Corn oil recovery for food or biodiesel
- Energy efficiency improvement
- Conversion to renewable fuels
 - Biomass fuel
 - DDG gasification
- Improved enzymatic treatment
 - Higher starch recovery
 - Low temperature saccharification
- Improved fermentation
 - Very high gravity fermentation
 - Extractive fermentation
 - Highly tolerant yeast strains
- Advanced separation techniques
 - Pervaporation
- High protein DDGS
- Integration towards multiple feedstock including including lignocellulosics
- Integration with thermo-chemical processing
- Water intensity reduction.



Luverne, Minnesota. April 2005
Photo Courtesy of Minnesota Public Radio