# Corn Ethanol – Process and Production Economics

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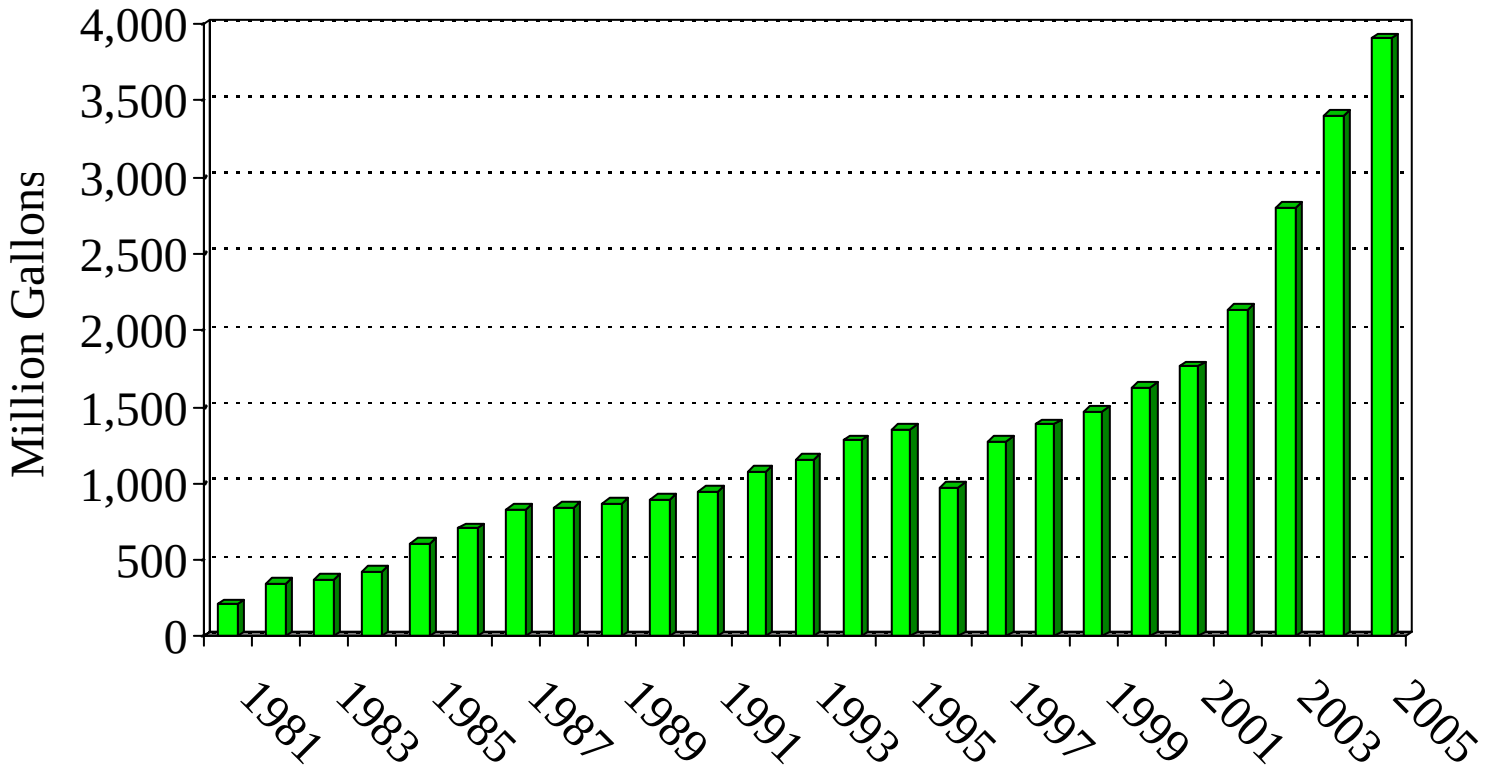
# Ethanol ($CH_3CH_2OH$)

- Ethyl alcohol made primarily by converting starch in agricultural products to sugar and then to alcohol.
- Used as an additive to enhance octane and add oxygen to motor gasoline.
- Most ethanol sold as a 10% blend (E-10)
- E-85 is slow out of the blocks due to infrastructure constraints

# U.S. Ethanol Production




*Source: US Energy Information Administration; Renewable Fuels Association*

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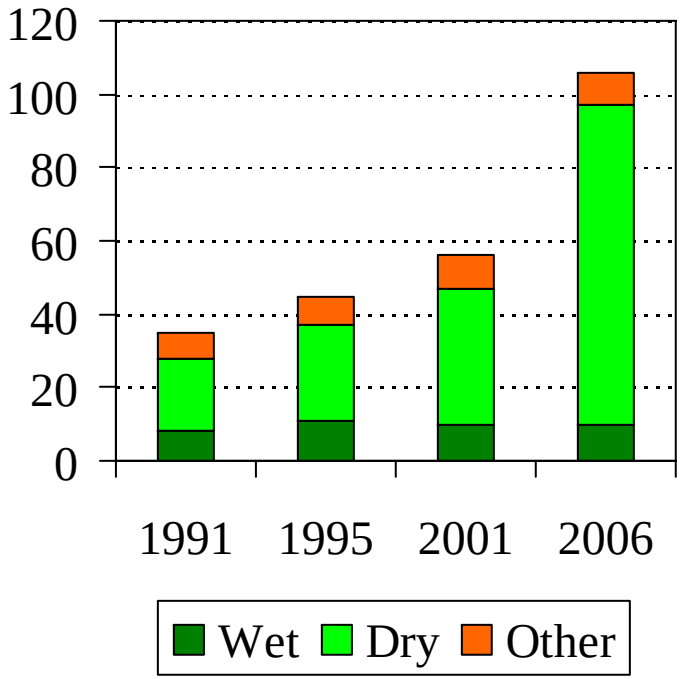
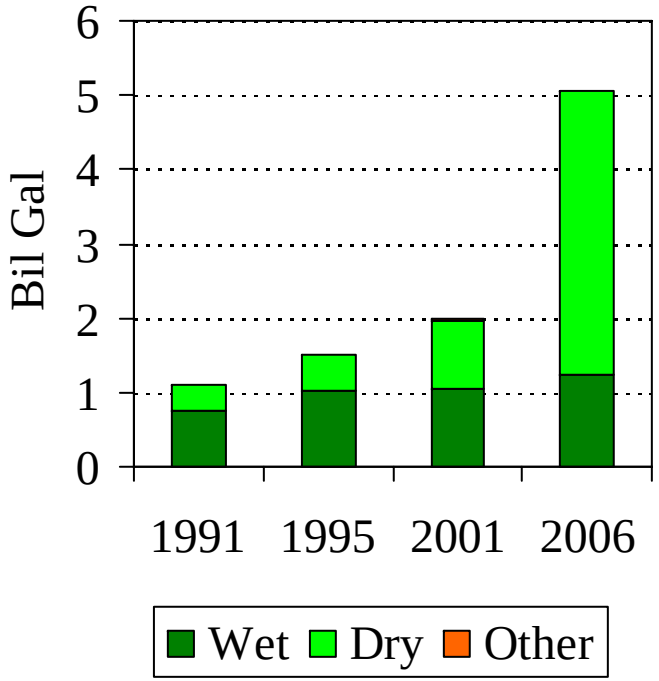
# Most ethanol today is made from the corn dry milling process

Plants by Process




Capacity by Process




*Source: BBI International; RFA*

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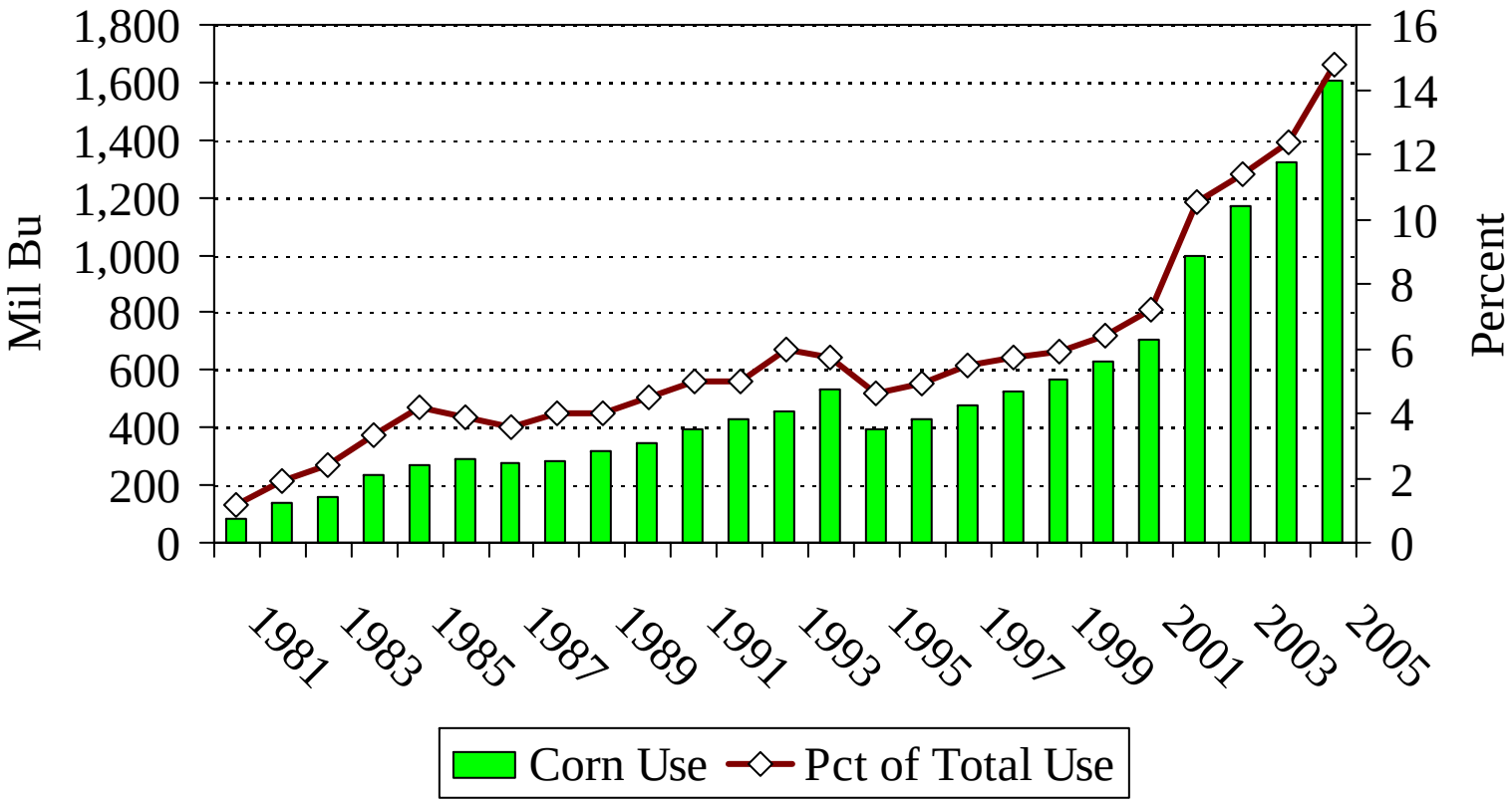
# Feedstock and energy costs are the key to ethanol profitability

- Feedstocks typically account for almost two-thirds of operating costs.
- Co-product credits (distiller's grains and $CO_2$) are crucial to controlling feedstock costs.
- Energy costs are a close second in importance.
  - Using co-generated power from waste-coal or landfill gas as a boiler fuel can cut production costs.

# Corn Used for Ethanol Production




*Source: USDA/ERS*

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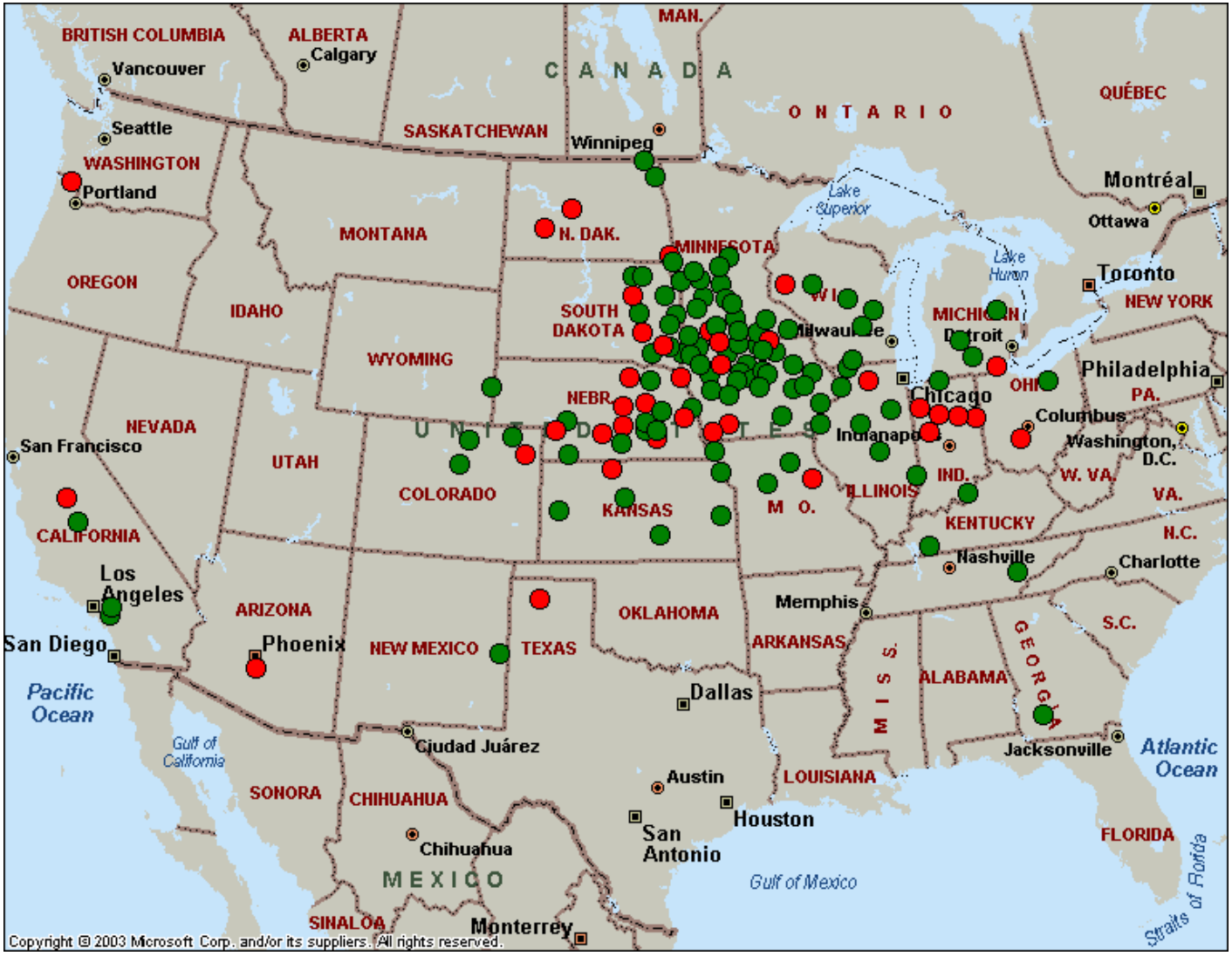
# Today's ethanol industry is Midwest based

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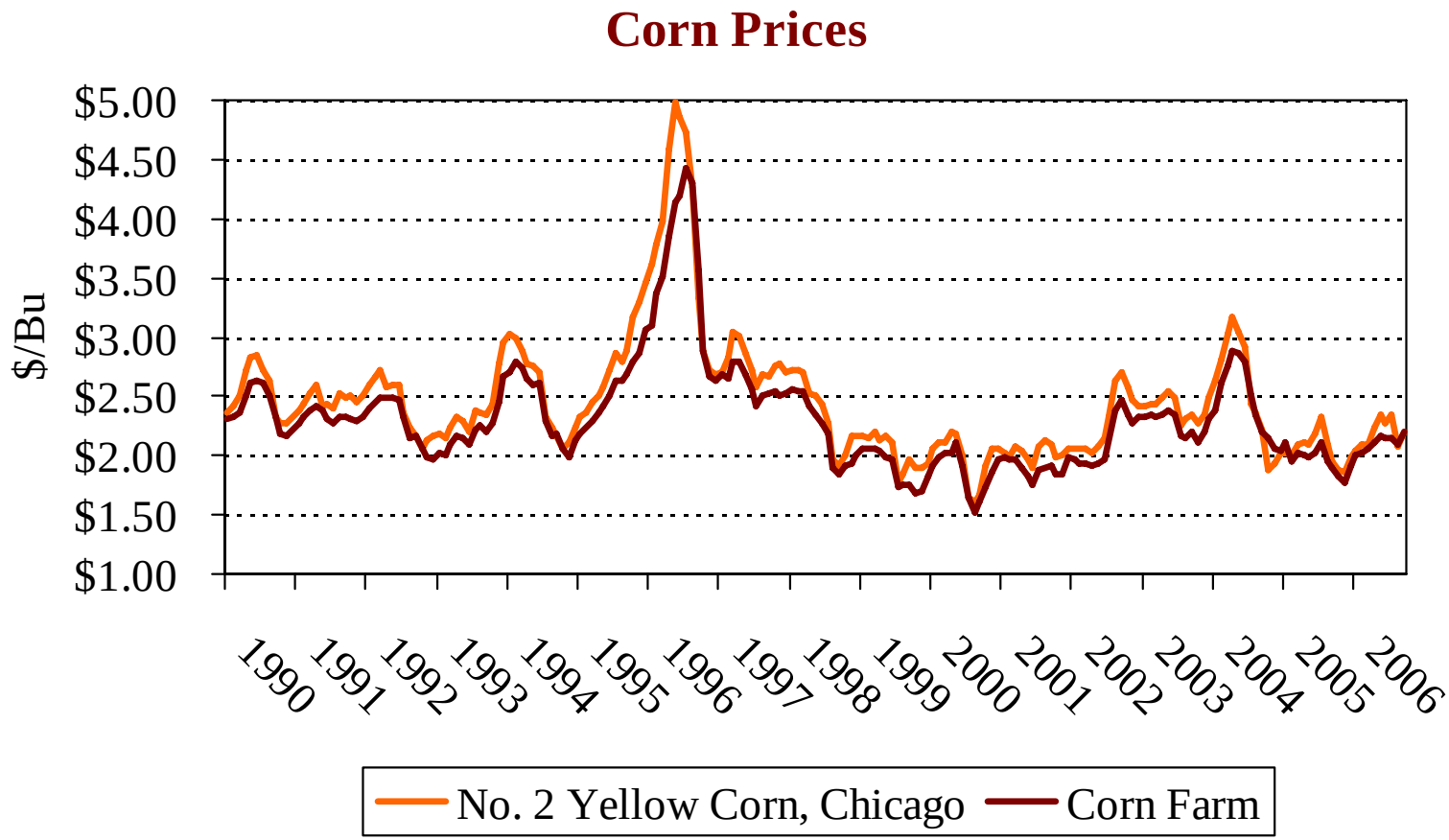
# Feed stocks account for about 60% of production costs




*Source: USDA/ERS Feed Grain database*

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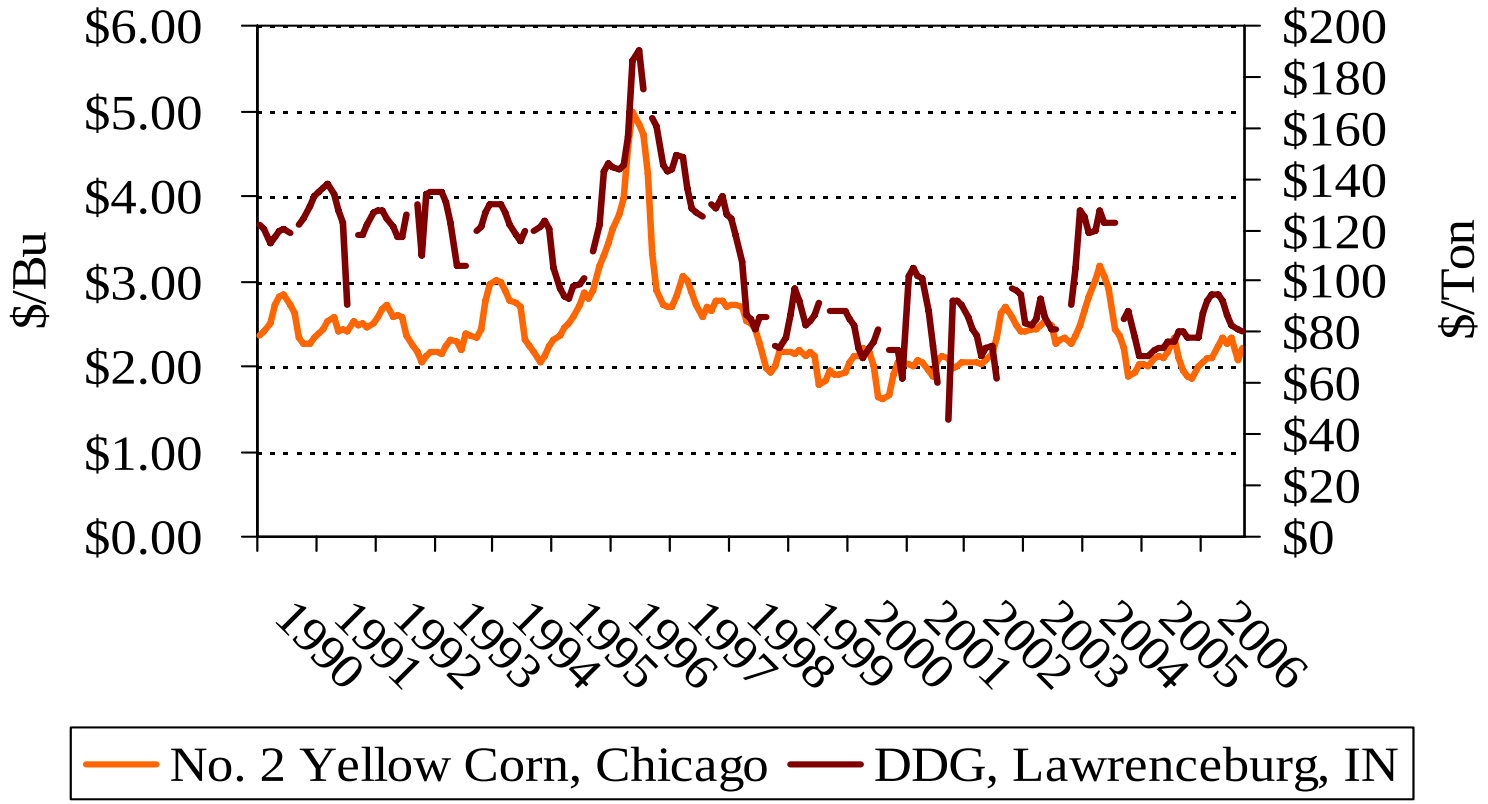
# Co-product (DDG) prices closely follow corn prices




*Source: USDA/ERS Feed Grain database*

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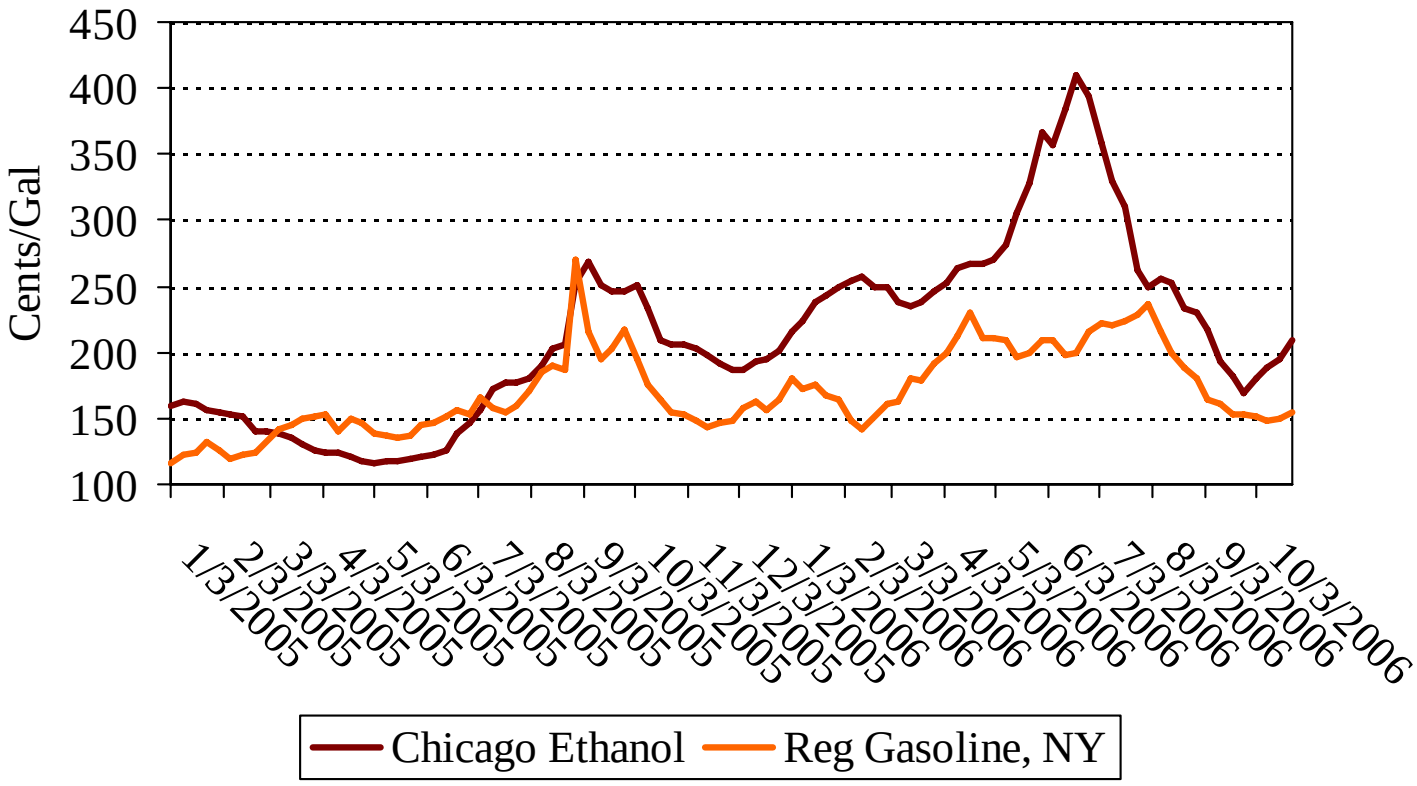
# Ethanol prices closely track gasoline prices




*Source: OPIS; EIA*

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# Technology and Capital Cost

- Conventional grain fermentation ethanol production technology is well understood.
- Current technology for cellulosic ethanol is another matter.
  - Current technology for cellulosic ethanol is the acid hydrolysis process. Capital costs are almost 4X that of dry mill ethanol.
  - Enzyme technology holds promise for improved economics, but is not yet commercialized.

# Bioenergy Crop-based Processes

| Raw Material | Pre-treatment | Current Yield (gal/ton) | Potential Yield (gal/ton) | Production Cost ($/gal) | Capital Cost ($/gal) |
|---|---|---|---|---|---|
| Com'l Crops | Mechanical | 106 | 106 | $1.12 | $1.10 |
| Biomass | Gasification | | | Unknown | $2.40 |
| Biomass | Acid Hydrolysis | 52 | | $1.80 | $4.70 |
| Biomass | Base Hydrolysis | | 120 | $0.75 | $2.40 |

Source: Paul W. Gallagher. "Energy Production with Biomass: What Are the Prospects?" *Choices. 1st Quarter 2006 21(1)*

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# What does it take to produce a gallon of ethanol?

| Input | Quantity | Units |
|---|---|---|
| Corn | 0.364 | Bu |
| Enzymes | 0.037 | Lb |
| Yeast | 0.005 | Lb |
| Chemicals | 1.121 | Lb |
| Denaturant | 0.030 | Gal |
| Electricity | 0.750 | Kw |
| Natural Gas | 0.014 | Mcf |
| Steam | 20.0 | Lb |
| Water | 4.700 | Gal |

# What does it cost to make a gallon of ethanol today?

| | |
|---|---|
| **Corn, Cent Ill Cash ($/bu)** | **$3.26** |
| **DDG ($/ton)** | **$89.14** |
| **CO2 ($/lb)** | **$2.50** |
| | **($/Gal)** |
| **Feedstock Costs** | **$1.185** |
| **Byproduct credits (DDGS)** | **$0.276** |
| **Carbon Dioxide** | **$0.007** |
| **Net Feedstock Costs** | **$0.903** |
| **Cash Operating Expenses** | |
| **Electricity** | **$0.048** |
| **Fuels** | **$0.276** |
| **Enzymes, Yeast, Chemicals** | **$0.056** |
| **Water & sewer** | **$0.007** |
| **Denaturant** | **$0.044** |
| **Maintenance** | **$0.053** |
| **Labor** | **$0.055** |
| **Admin & Other Costs** | **$0.045** |
| **Subtotal** | **$0.585** |
| **Total Costs** | **$1.488** |

*Source: LECG. LLC. Corn and ethanol prices on 10/31/06; August 2006 natural gas prices*

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# Even at today's rising corn prices, ethanol is profitable!

| | ($/Gallon) |
|---|---|
| Revenue from ethanol sales | $2.07 |
| Net Operating Cost | $1.49 |
| EBITDA | $0.58 |
| Depreciation | $0.18 |
| Interest cost (60% debt, 10 years @ 8%) | $0.05 |
| Net Income | $0.36 |
| ROI ($1.75/gallon capital cost) | 33.3% |

# Ethanol Profitability Matrix (EBITDA)

Corn Price →

Ethanol Price ↓

| | $2.00 | $2.50 | $3.00 | $3.50 | $4.00 | $4.50 | $5.00 |
|---|---|---|---|---|---|---|---|
| $1.50 | $0.47 | $0.29 | $0.11 | ($0.07) | ($0.26) | ($0.44) | ($0.62) |
| $1.75 | $0.72 | $0.54 | $0.36 | $0.18 | ($0.01) | ($0.19) | ($0.37) |
| $2.00 | $0.97 | $0.79 | $0.61 | $0.43 | $0.24 | $0.06 | ($0.12) |
| $2.25 | $1.22 | $1.04 | $0.86 | $0.68 | $0.49 | $0.31 | $0.13 |
| $2.50 | $1.47 | $1.29 | $1.11 | $0.93 | $0.74 | $0.56 | $0.38 |
| $2.75 | $1.72 | $1.54 | $1.36 | $1.18 | $0.99 | $0.81 | $0.63 |
| $3.00 | $1.97 | $1.79 | $1.61 | $1.43 | $1.24 | $1.06 | $0.88 |

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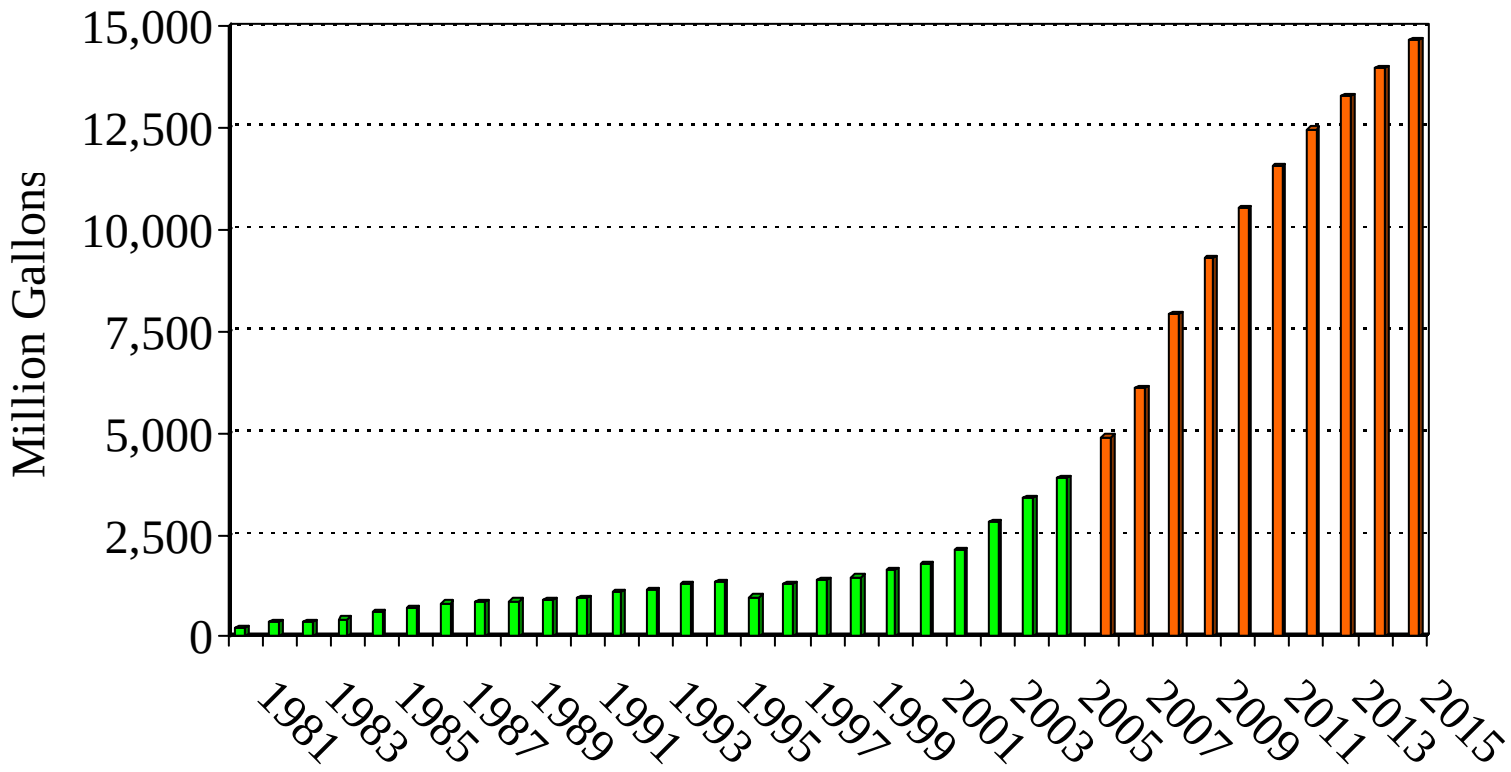
# How is the industry likely to grow?




*Source: LECG LLC October 2006*

# Projected Sources of Ethanol

| | ETOH Production (MGY) | Corn (MGY) | Other Feedstocks (MGY) | Cellulose (MGY) |
|---|---|---|---|---|
| 2005 | 3,904 | 3,592 | 312 | 0 |
| 2006 | 4,905 | 4,659 | 245 | 0 |
| 2007 | 6,115 | 5,809 | 306 | 0 |
| 2008 | 7,920 | 7,524 | 371 | 25 |
| 2009 | 9,279 | 8,723 | 507 | 50 |
| 2010 | 10,521 | 9,785 | 637 | 100 |
| 2011 | 11,533 | 10,611 | 773 | 150 |
| 2012 | 12,453 | 11,208 | 1,045 | 200 |
| 2013 | 13,258 | 11,667 | 1,341 | 250 |
| 2014 | 13,948 | 11,996 | 1,453 | 500 |
| 2015 | 14,638 | 12,296 | 1,342 | 1,000 |

# Why is ethanol desirable?

- Ethanol is renewable and has a significant positive net energy balance.
- Ethanol provides important environmental benefits.
- Increased demand for grain improves farm revenues and reduces the cost of government programs.
- Ethanol reduce America's dependence on imported oil, expands the economy, creates jobs, and puts money into the pockets of American consumers.

**Thank you,**

**Questions?**