Global Economic Impacts of Ethanol Industry Growth

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Ames, Iowa, U.S.A.
Some perspectives

• Iowa – the epicenter of biofuels growth

• The U.S. – rapid expansion & huge agricultural changes

• Brazil – also expanding very rapidly

• Global impacts
Figure 1. USDA Feb. '07 & Previous 10-Yr. Projections of Corn for Ethanol, Plus Existing & Under Construction Capacity + Likely Construction to 2010

- 1/30/07 cap. + potential constr'n.
- USDA 2004
- USDA 2003

Mil. Bu. of Corn

01-02  04-05  07/08  10/11  13/14  16/17
International Impacts

• U.S. ethanol plants under construction to use 58 mil. tons of corn (doubling use)
  – 3.5 times the volume of Japan imports of U.S. corn
  – 130% of 2006 EU corn crop
  – 70% of global corn exports

• Other countries are expanding ethanol & biodiesel

• Strong negative impacts on animal ag.

• Sharply higher food costs

• Major risk-management challenges in Ag. & bioenergy
Mil. Tons U.S. Corn Use for Fuel Ethanol & Global Coarse Grain Exports

Global Coarse Grain Exports

U.S. Corn Use for Ethanol

Mil. Metric Tons

Other Countries with Ethanol Fuels

- Canada
- China
- EU
- Thailand

Countries considering ethanol fuels
- South Africa
- Ukraine
- Japan
Chinese Corn-Ethanol Plant
Background of U.S. Bioenergy Programs

- Began in early 1980s -- corn to ethanol
- Initial technology: wet milling
- Owned by large multinational firms
- Continual expansion since 1980s (except 1995-96 tight corn supplies)
- 10% ethanol, 90% gasoline blend in Midwest
- Ethanol use since 2003 expanding to coasts
- E-85 use small but expanding
U.S. Bioenergy Industries

- 2006-07 growth, 34% annually in ethanol, more rapid in biodiesel
- Primary feedstocks: corn & soy oil
- Investors: farmers, outside firms
- Both political parties strongly support expansion
- Availability of crop land -- limiting factor
- Some cellulose-ethanol plants being planned
- 10% ave. U.S. ethanol/gas in 4 years
- Major implications for livestock & food prices
New York Crude Oil Futures Prices
Goals of U.S. Bioenergy Programs

- 1980s: expand corn demand
- Now:
  - Facilitate clean air programs
  - Create rural jobs
  - Diversify energy sources
  - Create closed carbon circuit, recycling $\text{CO}_2$
- 45% of U.S. gasoline has ethanol blend
Corn-ethanol only partial solution to energy challenges

- Other feedstocks needed
  - Municipal wastes
  - Animal agriculture wastes
  - Forest product wastes
  - New crops

- New automotive technology
  - Hybrid gas/electric vehicles
  - New engine & vehicle designs
  - Hydrogen fuels & fuel cells

- Diversification of energy sources
- Incentives for increased mass transportation
- Wind power use increasing
U.S. government incentives for ethanol

- **Blending tax credit:** $0.51/gallon ($0.135/liter)
- **Tariff on imports:** $0.54/gal. ($0.143/liter)
- **Rural development loans** for small plants
- **Operating capital grants** up to $300,000
- **State incentives** & motor fuel tax reductions
- **Local government help** for roads, utilities
- **Local government property tax exemptions** for several years
- **Minnesota, Montana E-10% mandate**
- **Iowa-Minnesota goal of E-20% avg. blend**
- **Financial incentives for E-85 retail outlets**
- **Federal mandated production levels**
Size of U.S. biofuels industry

• 121 processing plants
• About 75 plants under construction or expanding
• About 235 more planned
• Processes 20% of U.S. corn crop for motor fuel
• Potential corn for ethanol, Sept. 2007-Aug. 2008: 30% of 2006 crop
• High corn prices pull land from other crops
Products of ethanol industry

• **Ethanol**
  - Ethanol yield: 2.75 gal./bu., 410 liters/metric ton of corn

• **CO₂**

• **Dry Distillers Grain & Solubles (DDGS)**
  - 0.3 ton/ton of corn
  - Protein content: 24-26%
  - Limited in some amino acids
## Corn Processing Plants in and Near Iowa, 5/04/07, Est. Mil. Bu.
### Processing Capacity, Ethanol & Other Processing Excl. Feed

<table>
<thead>
<tr>
<th>Operating Plants</th>
<th>Planned or under construction, Il</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albert Lea, MN</td>
<td>Ashton - E</td>
</tr>
<tr>
<td>Albert City</td>
<td>Atlantic - P</td>
</tr>
<tr>
<td>Ashton</td>
<td>Belmond - P</td>
</tr>
<tr>
<td>Blair, NE'</td>
<td>Blair, NE' - E</td>
</tr>
<tr>
<td>Blairstown</td>
<td>Blenco - P</td>
</tr>
<tr>
<td>Cedar Rapids</td>
<td>Buffalo - P</td>
</tr>
<tr>
<td>Charles City</td>
<td>Butter County - P</td>
</tr>
<tr>
<td>Clinton</td>
<td>Burlington expansion E</td>
</tr>
<tr>
<td>Coon Rapids</td>
<td>Cedar Rapids - Penford - C</td>
</tr>
<tr>
<td>Corning (may go to 38 mil. Bu.)</td>
<td>Columbus Junction - P</td>
</tr>
<tr>
<td>Denison</td>
<td>Coon Rapids - E-P</td>
</tr>
<tr>
<td>Eddyville</td>
<td>Council Bluffs - C</td>
</tr>
<tr>
<td>Emmetsburg</td>
<td>Creston - P</td>
</tr>
<tr>
<td>Faribank</td>
<td>Des Moines P</td>
</tr>
<tr>
<td>Ft. Dodge</td>
<td>Dexter - C</td>
</tr>
<tr>
<td>Galva</td>
<td>Dyersville - P</td>
</tr>
<tr>
<td>Goldfield</td>
<td>Emmetsburg - E</td>
</tr>
<tr>
<td>Gowrie</td>
<td>Fairmont, MN (1/2 of 76 mil. Bu.)</td>
</tr>
<tr>
<td>Hanlontown</td>
<td>Ft. Dodge new plant - P</td>
</tr>
<tr>
<td>Hopkinton (Uses sugar &amp; strach)</td>
<td>Garner-P</td>
</tr>
<tr>
<td>Iowa Falls</td>
<td>Ft. Dodge Expansion - C</td>
</tr>
<tr>
<td>Jewell</td>
<td>Green County - P</td>
</tr>
<tr>
<td>Keokuk</td>
<td>Grinnell - C</td>
</tr>
<tr>
<td>Lakota</td>
<td>Hancock co. - P</td>
</tr>
<tr>
<td>Luvurne, MN</td>
<td>Hartly - C</td>
</tr>
<tr>
<td>Marcus</td>
<td>Hinton - P</td>
</tr>
<tr>
<td>Mason City</td>
<td>Manchester - P</td>
</tr>
<tr>
<td>Muscatine</td>
<td>Marcus expansion - E</td>
</tr>
<tr>
<td>Nevada</td>
<td>Marion co. - P</td>
</tr>
<tr>
<td>Sioux Center</td>
<td>Marshalltown - P</td>
</tr>
<tr>
<td>Steamboat Rock</td>
<td>Merrill - C</td>
</tr>
<tr>
<td>W. Burlington</td>
<td>New Hampton - P</td>
</tr>
<tr>
<td></td>
<td>Odebolt - P</td>
</tr>
</tbody>
</table>

**Sub-total, operating 1,088**

*Total excludes out-of-state*

### Processing

<table>
<thead>
<tr>
<th>Planned, Part I</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADM Expansion (Cedar Rapids &amp; Clinton)</td>
</tr>
<tr>
<td>Akron - P</td>
</tr>
<tr>
<td>Arthur - P</td>
</tr>
<tr>
<td>Wesley - P</td>
</tr>
<tr>
<td>W. Des Moines - P</td>
</tr>
</tbody>
</table>

**Partial Sub-total, planned 337**

**Total, planned 1,776**

*P = Proposed, C = Under Construction, E = Expansion of existing plant*
<table>
<thead>
<tr>
<th>Iowa Corn Processing, 5/3/07</th>
<th>No. plants</th>
<th>Mil. Bu.</th>
<th>of '06 Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total operating</td>
<td>30</td>
<td>1,088</td>
<td>53.1%</td>
</tr>
<tr>
<td>Total Under Construction or expansion</td>
<td>10</td>
<td>447</td>
<td>21.8%</td>
</tr>
<tr>
<td>Total Planned, not yet under construction</td>
<td>33</td>
<td>1,329</td>
<td>64.8%</td>
</tr>
<tr>
<td>Grand Total (adjusting for plant expansions)</td>
<td>70</td>
<td>2,864</td>
<td>139.7%</td>
</tr>
</tbody>
</table>
Iowa Corn Processing Plants, 2002
### Iowa Corn Production, Use & Excess for Export out of State, Mil. Bu.

<table>
<thead>
<tr>
<th>5/04/07</th>
<th>2005-06</th>
<th>2006/07 processing</th>
<th>Current &amp; Planned plants @ rated capacity</th>
<th>Current &amp; Planned plants @ 120% capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 corn crop</td>
<td>2,163</td>
<td>2,163</td>
<td>2,163</td>
<td></td>
</tr>
<tr>
<td>Less feed use</td>
<td>700</td>
<td>700</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Less processing</td>
<td>1,088</td>
<td>2,864</td>
<td>3,437</td>
<td></td>
</tr>
<tr>
<td>Plus corn replaced by DGS</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td><strong>Avail. For Export</strong></td>
<td>420</td>
<td>-1,356</td>
<td>-1,929</td>
<td></td>
</tr>
<tr>
<td>2006 Mil. Harv. Acres</td>
<td><strong>12.4</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield, 2005, Bu./A.</td>
<td><strong>173</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 Trend Yield, Bu/A.</td>
<td><strong>159</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009 Trend Yld., Bu/A.</td>
<td><strong>167</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield needed to maintain exports (@ '05 A.)</td>
<td><strong>317.7</strong></td>
<td><strong>363.9</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acreage needed @ 2005 yield</td>
<td><strong>22.8</strong></td>
<td><strong>26.1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acreage needed @ 2009 trend yield</td>
<td>23.6</td>
<td>27.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acreage needed @ 2005 yield +15 Bu./A.</td>
<td>21.0</td>
<td>24.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006 Iowa acres: corn</td>
<td>12.7</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mil. Planted A. soybeans</td>
<td>10.1</td>
<td>10.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>0.2</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay</td>
<td>1.6</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Returning CRP est.</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 2005 corn yld. + 15 bu.: <strong>Total acres</strong></td>
<td><strong>25.6</strong></td>
<td><strong>25.6</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Implied Soybean Acres</strong></td>
<td><strong>5.8</strong></td>
<td><strong>1.7</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Change in Corn Acres vs. 2006</strong></td>
<td><strong>10.1</strong></td>
<td><strong>13.4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acres of Corn after Corn</td>
<td><strong>2.7 mil. A.</strong></td>
<td><strong>15.2</strong></td>
<td><strong>22.3</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Needed corn Acres @ 188 bu./A. state avg. in 2010*
Iowa Current & Potential 2012 Crop Acreages

With IA. Corn yld. + 15 bu./A. from 2005

- Corn
- Cont. corn
- Soybeans
- Hay
- Oats
- CRP

Mil. Acres

2005-06
All Plants @ capacity
Plants @ cap. + 20%
Figure 2. Existing & Planned U.S. Corn Processing Plants

Blue = Operating
Red = construction
Green = planned
Pink = Expansion of Existing plants

8/30/06
Figure 3. U.S. Corn Production, Domestic Use, & Availability for Exports--Proj. to 2012

(a) Prod’n needed to maintain exports, & (b) with 300 mil. Bu. To China + 5% annual China growth

- Production
- Feed Use Adj. For DGS
- Trend
- Total Processing
- Energy bill
- Avail. For Exports-Constant area

R. Wisner

5.5 Bil. Bu for ethanol
How Much More U.S. Construction to Reach 5.5 Bil. Bu. (140 mil. T.) Corn for Ethanol?

• Operating plants:
  -- 2.15 Bil. Bu. (54.6 mil. Tons)
• Plants under construction:
  -- 2.0 Bil. Bu. (50.8 mil. Tons)
• Plants soon to build:
  -- 0.2 Bil. Bu. (5.08 mil. Tons)

Total: 4.35 Bil. Bu. (110.4 mil. Tons)

Capacity needed:
  1.15 Bil. Bu. (29.2 mil. Tons)
  (About 29 plants @ 423 mil. Liters/yr.)
Monthly Premium of Ethanol over Unleaded Gasoline, Omaha Rack Prices,

Avg. of All Months

$ per Gallon

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


2006

2007
Approximate Maximum Price Ethanol Plants to Pay for Corn with Varying Crude Oil Prices

- With Minnesota costs
- With USDA costs

Source of data: http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_12.xls

Level to greatly slow or halt U.S. ethanol

$ per Barrel

2004 2009 2014 2019 2024 2029
Ethanol Economics

- $0.026/liter increase in ethanol price raises break-even Corn price $11.03/ton
- $39.40/ton rise in corn price increases cost/gal. $0.095/liter

- Ethanol prod’n cost $0.318/liter (Univ. of Minnesota-@$80/ton corn)

- May 8,’07 Iowa ethanol price: $0.556/liter

- Recent margin: $0.143/liter (34%) (incl.$0.119/liter subsidy)

- Drops to zero @ corn price of about $200/ton in IA -- up 48-50% from May 4 price
- Other variables: DDGS price, Natural Gas
- Note: Plant construction costs have risen sharply
140 Mil. Tons Corn for ethanol

Figure 2. US CORN YIELD 1970-2005 & Projected to 2012

Trend, 1970-'05

China Importing Corn

China exporting

Trend, 1980-'05

Trend, 1990-'05

Includes yields needed with 8.8 mil. extra corn A.
5.5 Bil. Bu. For Ethanol

Figure 4. Extra U.S. Corn Acres Needed to Maintain Exports & Projected Ethanol

- With China not importing corn
- With China as corn importer

- Trend yield, 1990-05
- DGS reducing corn feeding
- New acres: yield 85% of trend
- No major droughts

Mill. Acres vs. 2005

Figure 3. U.S. Planted Acreage of Major Grains, Oilseeds, and Cotton

Source of data: USDA, NASS
<table>
<thead>
<tr>
<th>State</th>
<th>Mil. Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLINOIS</td>
<td>1.03</td>
</tr>
<tr>
<td>INDIANA</td>
<td>0.29</td>
</tr>
<tr>
<td>IOWA</td>
<td>1.92</td>
</tr>
<tr>
<td>MICHIGAN</td>
<td>0.26</td>
</tr>
<tr>
<td>MINNESOTA</td>
<td>1.76</td>
</tr>
<tr>
<td>MISSOURI</td>
<td>1.55</td>
</tr>
<tr>
<td>OHIO</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.10</strong></td>
</tr>
</tbody>
</table>

Includes wetlands, buffer strips, etc.
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>IL</td>
<td>152</td>
<td>136</td>
<td>-10.5%</td>
</tr>
<tr>
<td>IN</td>
<td>156</td>
<td>121</td>
<td>-22.4%</td>
</tr>
<tr>
<td>KS</td>
<td>127</td>
<td>116</td>
<td>-8.7%</td>
</tr>
<tr>
<td>KY</td>
<td>142</td>
<td>102</td>
<td>-28.2%</td>
</tr>
<tr>
<td>MO</td>
<td>133</td>
<td>105</td>
<td>-21.1%</td>
</tr>
<tr>
<td>NE</td>
<td>147</td>
<td>128</td>
<td>-12.9%</td>
</tr>
<tr>
<td>NC</td>
<td>125</td>
<td>83</td>
<td>-33.6%</td>
</tr>
<tr>
<td>OH</td>
<td>138</td>
<td>88</td>
<td>-36.2%</td>
</tr>
<tr>
<td>PA</td>
<td>98</td>
<td>68</td>
<td>-30.6%</td>
</tr>
<tr>
<td>SD</td>
<td>109</td>
<td>95</td>
<td>-12.8%</td>
</tr>
<tr>
<td>TN</td>
<td>132</td>
<td>107</td>
<td>-18.9%</td>
</tr>
<tr>
<td>TX</td>
<td>118</td>
<td>113</td>
<td>-4.2%</td>
</tr>
<tr>
<td>US</td>
<td>138.2</td>
<td>130</td>
<td>-5.9%</td>
</tr>
</tbody>
</table>

Trend Yld. 25 yr. 138 140
Trnd. 1970-05 137.3 139.2
# Illinois Corn Yields: Drought Tolerant?

<table>
<thead>
<tr>
<th>Region</th>
<th>2004</th>
<th>2005</th>
<th>% chg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW</td>
<td>184</td>
<td>140</td>
<td>-24</td>
</tr>
<tr>
<td>NE</td>
<td>174</td>
<td>129</td>
<td>-26</td>
</tr>
<tr>
<td>WEST</td>
<td>192</td>
<td>141</td>
<td>-27</td>
</tr>
<tr>
<td>E.SE.</td>
<td>175</td>
<td>139</td>
<td>-21</td>
</tr>
<tr>
<td>SW</td>
<td>158</td>
<td>133</td>
<td>-16</td>
</tr>
<tr>
<td>SE</td>
<td>158</td>
<td>130</td>
<td>-18</td>
</tr>
</tbody>
</table>
Iowa Gross Processing Margins for Ethanol, January 2000 - March 2007

$ per Gal.

Dollars per Bushel

Gross margin per Bu. of Corn
Gross margin per Gallon of Ethanol
Figure 6. U.S. Soy Production, Use, & Exports to 2012
With 5.5 bil. Bu. Corn for ethanol

Assumes trend yields. Increased DGS Prod'n in 2012-13 replaces soybean meal from about 440 mil. bu. of soybeans
5.5 bil. Gallons of Ethanol

U.S. Wheat Acres & Projections to 2012
With Expanding Corn Ethanol

Wheat acres shift to soybeans, & to corn in
East Corn Belt & Northern Plains

Mil. Acre shifts to corn:
Hay: 1.0 mil
CRP: 3.0
Coton: 0.6
S. Red wheat: 4.3
Other wheat: 0.4; oats 1.0
Potential U.S. DGS demand by 2012

- COF @ 20% of ration  7.1 mil. T.
- Dairy @ 20% of ration  6.13 mil. T.
- Hogs @ 15% of ration  6.72 mil. T.

Total  19.95 mil. T.

Potential production  46.8 Mil. T.

5.5 Bil. Bu for ethanol

With 6.5 bil. Bu.: 51.8 Mil. T
Implications for U.S. and World Livestock, Poultry & Food Costs

- U.S. supplies 2/3 of world corn exports, 20-25% of wheat & 35-40% of cotton exports
- Costs of livestock & poultry feed to double
- Large increase in variability of feed & food costs
- Food aid availability?
- Accelerated ag expansion into areas with fragile eco systems
- Shift livestock industries from U.S. to South America?
- Rural employment implications in U.S.
Infrastructure Needs of bioenergy Market
(Time Frame: 3 to 4 years)

Sharp Increases in:

- *Inputs for corn production*
- Corn receiving, drying, storage, farm transporting infrastructure
- Efficient rail shipping of ethanol & DDGS
- More tank cars for ethanol movement
- Electric power generation
- Water supply systems
- Research on pipelines for ethanol
- Retail facilities for E-85, E-20 & E-30 stations
U.S. Cellulose Ethanol

- At least 2 pilot plants being developed
- Expect extensive U.S. government emphasis

Potential Feedstocks:
- DDGS
- Corn stover
- Prairie grasses
- Forest wastes
- Municipal wastes

Research for Major handling & storage challenges
Environmental Issues for Research: ethanol

- Impact on groundwater supplies
- Long-term effects, mono-culture ag.
- Allowable maximum removal of corn stover & grasses
  - Soil erosion impacts
  - Soil organic matter impacts
  - Diminished wildlife habitats
  - Water quality impacts from more fertilizer
Key Issues for Agriculture

• **Alternative feedstocks:** which ones, how soon? Biomass, sweet sorghum, sugar beets, high-oil crops, cane sugar, others

• **Differential impacts on livestock & poultry species**

• **Environmental:** continuous corn, off-take of biomass, erosion-prone land

• **Efficient use of distillers grain, including new uses**

• **Risk Management:** livestock, crops, ethanol
Key Issues for Agriculture, II

- Future transition of corn-ethanol plants to other feedstocks
- Policy issues: import tax, blending credit, LDPs, CCPs, E-85 vs. E-10, pipeline possibilities, vehicle redesigning, Hydrogen sources
- Global developments: EU biodiesel, Brazil export potential, Asia, S. Africa bioenergy & global grain supply, demand & prices
- Infrastructure needs: grain handling & storage, transportation, ethanol & DDGS transport
- High Prices encourage oil exploration & conservation
What Could Change Prospects of Tightening Global Grain Supply?

• Accelerated corn yield increases
• Crude oil price collapse
• Early break-through in economical cellulose conversion
• U.S. Ethanol import tax removed – longer term impacts
• U.S. $0.51 blending credit reduced or made variable
• Declining global livestock feeding
http://www.econ.iastate.edu/faculty/wisner/