THE ECONOMICS OF CELLULOSIC ETHANOL

2007

Mike Woolverton
Kansas State University
mikewool@agecon.ksu.edu

Renewable Fuel Production Drivers

1. Energy Security

2. High Cost of Transportation Fuel

3. Post-peak Oil Shift to Alternative Energy

The Economic Importance of Energy

Agrarian Era:
Gross Domestic Product = f(Land)

Industrial Era:
Gross Domestic Product = f(Land, Labor, Capital, Entrepreneurship)

Service Era:
Gross Domestic Product = f(Energy, Intellectual Capital, Money, Entrepreneurship)

The Fossil Fuel Inventory

Type	Amount	Location
Oil	1,278 BBOE	78% E. Hemi.
Heavy Oil (Tar Sands)	608 BBOE	64% W. Hemi.
Bitumen (Oil Shale)	345 BBOE	88% W. Hemi.
Nat. Gas	1,239 BBOE	77% E. Hemi.
Coal	4,786 BBOE	Widely Dist. (60% in U.S., Russia, and China)

Global annual fossil fuel usage about 30 BBOE per year.

Source: en.wikipedia.org/wiki/Fossil_fuel

The Largest Economies and Oil, 2006

1.	United States	$13.201 Trillion
2.	Japan	4.340
3.	Germany	2.906
4.	China	2.668
5.	United Kingdom	2.345
6.	France	2.230
7.	Italy	1.845
8.	Canada	1.251
9.	Spain	1.224
10.	Brazil*	1.068
11.	Russia	.987
12.	India	.906

U.S. Oil Import Suppliers, 2007

1. Canada
2. Mexico
3. Saudi Arabia (OPEC)
4. Venezuela (OPEC)
5. Nigeria (OPEC)
6. Algeria (OPEC)
7. Iraq (OPEC)
8. Angola (OPEC)
9. Colombia
10. Kuwait (OPEC)

Source: Energy Information Administration

What would it take to replace gasoline made from imported oil?

To replace imports:
140 bil. gal. gasoline x 63% = 88.2 bil. gal.
88.2/.66 = 133.6 gal. ethanol/2.7 = 49.5 bil. bu. corn

2007 U.S. corn production = 13.2 billion bu.

To replace OPEC imports:
140 bil. gal. x 63% x 40% = 35.3 bil. gal. of gasoline
35.3/.66/2.7 = 19.8 bil. bu. of corn

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Growing Demand, Higher Price

Supply Response to High Price Results in Lower Price

Price Effect of an Interruption in OPEC Oil Imports

Small Increase in Supply, Large Decrease in Price

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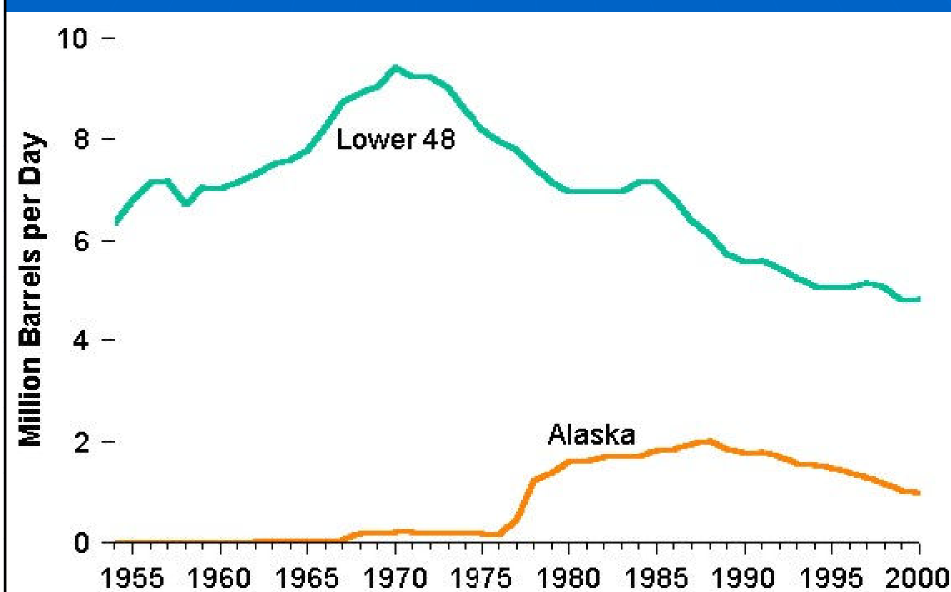
U.S. Domestic Oil Production

Source: U.S. Energy Information Agency



Sources of Total Renewable Energy Used, United States, 2006

Biomass (Biofuels)	48
Hydro	42
Geothermal	5
Wind	4
Solar	1

2007 Sense of Congress Resolution – 25% by 2025
Now 6%.

Net Energy Balance

Product	Energy Out/Energy In
Gasoline	.81
Ethanol from grain	1.67
Ethanol from cellulose	2.00
Diesel	.83
Bio-diesel	3.2

Source: Congressional Research Service, RL32712, May 18, 2006

U.S. Ethanol Industry at a Glance

	2006	2007
Number of operating ethanol plants:	97	134
Plants under construction or expanding:	35	76
Announced plants:	300 (17%)	100 (?)
Current production capacity: (BGPY)	4.8	7.3

- Projected production capacity: 7.3 BGPY end of 2007
  11.5 BGPY end of 2008
- Feedstock percentage:

Corn	97
Sorghum	2
Other	1

Ethanol Plant Economics

- Cost to build a 100 MGPY plant - $160 million
- Purchase about 37-39 million bushels of corn
  (240,000 acres)
- Daily water use: 1.5 million gallons
- Natural gas expense - $15 to $25 million
- Payroll expense about $2 million
- Distiller's Dried Grains income about $35 million
- CO^2 income about $4 million
- Goal 30% R.O.I.

Corn Usage Estimates (Millions of Bushels)

	USDA/WASDE 2006/07	USDA/WASDE 2007/08 est.
Feed and Residual	5,598	5,650[1] (+1%)
Food, Seed, and Industrial	1,371	1,390[2] (+1%)
Ethanol for Fuel	2,117	3,200 (+51%)
Net Exports	2,125	2,450 (+15%)
Ending Stocks	1,304	1,797 (+38%)
Total Usage	12,515	14,487 (+16%)
Production	10,535	13,168 (+25%)

[1] Assumes DDGS retain 30% of the feed value of corn and are included in the feed and residual category by the USDA.

[2] Industrial, food, and seed less ethanol.

Corn Starch Ethanol Production Projections

(Billions of Gallons and Bushels)

	Eth. Pdn.	Conversion	Corn Usage	Corn Pdn.[1]	% of Pdn.
2007	7.3	2.65	2.9	13.168	22.0
2008	11.5	2.72	4.2	12.717	33.0
2009	13.4	2.75	4.9	13.395	36.5
2010	14.0	2.77	5.1	13.953	36.6
2011	15.0[2]	2.80	5.4	14.359	37.6

[1] Assumes a 3.0 bushel per year increase in trend line yield and the commercialization of drought tolerant corn seed in 2009.

[2] Assumes the mandate for ethanol blending is increased to 15 billion gallons per year.

Switchgrass Costs, Popp and Hogan, University of Arkansas, 2007

- Production Cost ≈ $25/tn

(Assumed 12 year life of the stand; $200 per year cost to establish and maintain the crop; zero yield first year, 3 tons per A. second year, 5 tons per A. years 3 through 12)

- Harvest Cost: bales ≈ $39/tn; modules ≈ $46/tn
- Transportation Cost:
  bales - $4.50/tn ($3.60/loaded mile X 25 mile haul)
  modules - $3.70/tn ($34 per module plus $1.60/loaded mile X 25 mi.)
- Other Considerations:
  - 50 mil. Gal. plant would require 128 loads of bales per day or 196 modules; 45-60,000 truck loads per year
  - bales would be handled up to four times before processing; must dispose of bale wrap at grinding; integrity of modules
- Assuming $25 per ton profit for the producer, raw material cost for the ethanol plant would be $93.50 to $99.70 per dry ton

Corn vs. Cellulosic Ethanol

	Corn	Cellulosic
Capital cost per gallon	$1.60	$5.00 est.
Raw mat. cost per ton	$120-160	$94-100
Enzyme cost per ton	$3.15	$33.00
Ethanol yield per dry ton	100-110 gal.	75-90 gal.
Conversion process	simple	complex
Processing time, days	2	7
Cost of prod. per gallon	$1.10	$2.20 est.

Sources: Testimony of Keith Collins, USDA Chief Economist, 26 Aug. 2006; Popp and Hogan presentation at Farm Foundation Conference 12-13 April 2007; and M. Woolverton calculations.

Billion Ton Supply of Biomass, 2050

Findings:

1,366 mil. tons of biomass
428 mil. tons ag. crop residues
377 mil. tons perennial crops
368 mil. tons forest biomass
106 mil. tons process wastes
87 mil. tons grain

Source: Biomass as Feedstock for a Bioenergy and Bioproducts Industry: Technical Feasibility of a Billion Ton Annual Supply of Biomass. USDOE/USDA, April 2005

Critique of the Billion Ton Study

- Technical feasibility does not necessarily mean economic feasibility
- Underestimated increase in corn production
- Overestimated crop residue removal
- Overestimated the ability of energy crops to bid acres away from traditional crops
- Ignored weather related yield variability

Comparative Grain Prices, Dollars per Bushel

	Ave.[1]	Now[2]
Wheat	$3.36	$9.53
Corn	2.27	4.20
Grain Sorghum	2.20	4.15
Soybeans	5.64	10.82

[1] Average price per bushel, 2000-2007.
[2] Kansas City cash truck bids, 13 December 2007.

Kansas Hay Prices, $ Per Ton

Alfalfa	
Horse: (sm sq)	$200
Dairy: (lg sq) mid-quality	135
Feedyard: ground, dlvd	113
Grass	
Bluestem, burmuda, brome: (lg sq)	98
Sudan: (lg sq)	70
Mulch: (lg sq or rd[1])	50
Stover	
Straw: (lq sq)	49
Corn Stalks: (lq sq)	40
Milo Stalks: (lg sq)	33

Source: USDA, Kansas Hay Report, 14 Dec. 2007
[1] Large round bales usually sell for a $5 per ton discount.

Land in Crops

(Millions of acres)

	5 yr. Ave.	07/08USDA	Proj. 08/09
Corn	79.6	93.6	88.0 (-6%)
Soybeans	74.2	63.7	70.0 (+10%)
Hay	62.4	61.8	61.8 (--)
Wheat	59.5	60.4	62.2 (+3%)
Cotton	14.1	10.9	10.0 (-8%)
Grain Sorghum	8.1	7.7	7.4 (-4%)
Principle Crops	297.9	298.1	299.4
CRP		35.9	34.9 (-3%)

Total crop land in the United States – 441.6 million acres

Crop Acres Coming Out of CRP, 2007–2017, Millions of Acres

Source: USDA, FSA

Cellulosic Ethanol Conclusions

- High initial investment calls for economies of size, but the large tonnages required, logistical costs, and slow speed of processing will keep plant capacities small and unit cost of output high.
- Grain will provide the basic feedstock for ethanol plants supplemented by a cellulosic feedstock stream when available.
- Cellulosic industry development will require substantial federal subsidies and/or a strict usage mandate.