The Intersection of Energy and Agriculture: Implications of Rising Energy Demand

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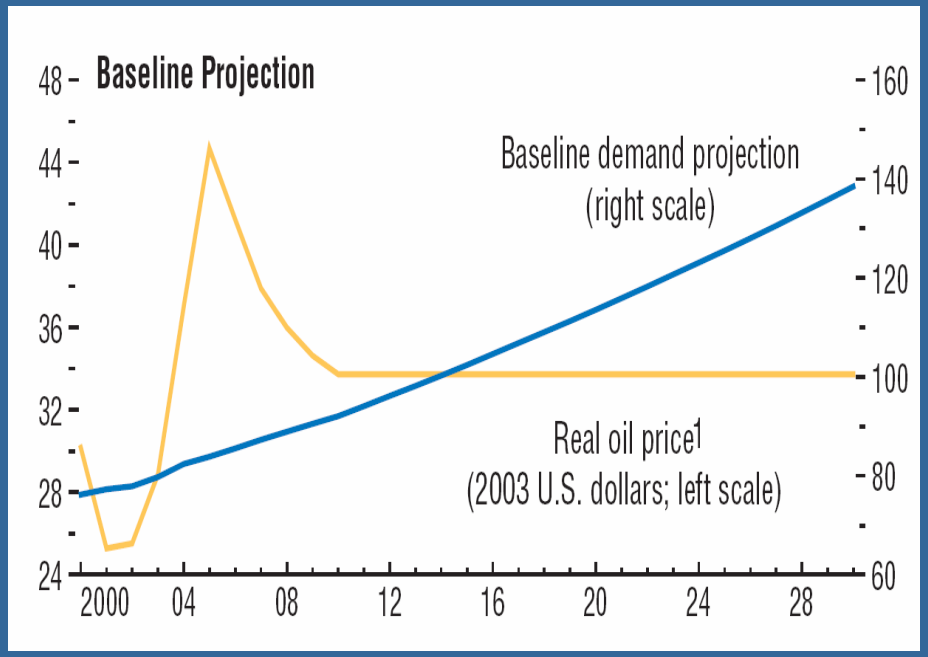
World Energy Outlook

- World energy consumption will increase 70 percent by 2030.
- Global oil demand in 2030: 116 million barrels per day.

World Energy Outlook

Long-term Oil Demand Projections

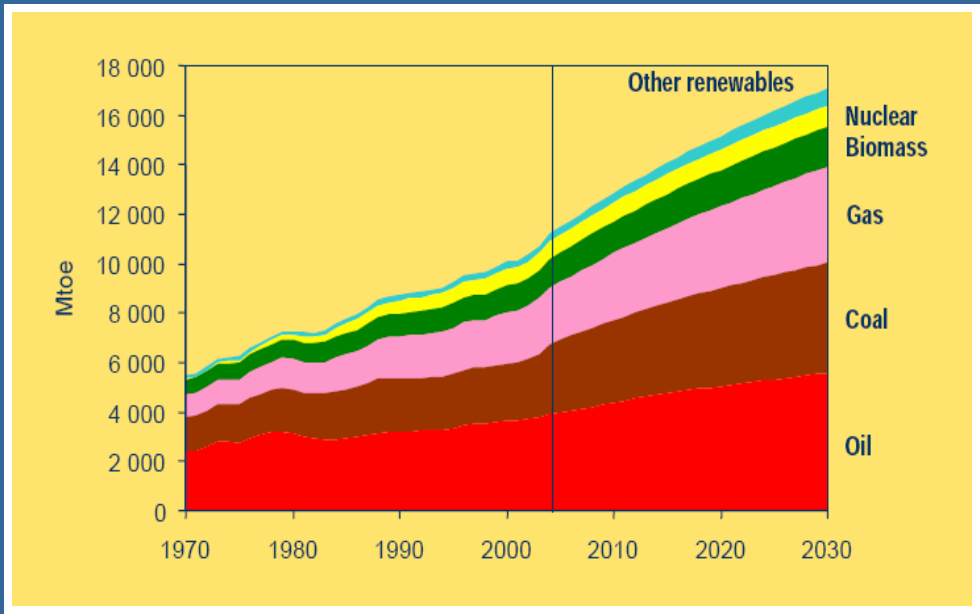
(millions of barrels a day)



IEA, DOE, IMF

World Energy Outlook

World Primary Energy Demand
(metric tons oil equivalent)



IEA, World Energy Outlook 2006

World Energy Outlook

- Transport demand accounts for 60 percent of growth in oil consumption.

World Energy Outlook

- IEA (2004): Remaining oil resources can sustain 70 years of consumption at projected average annual rate from 2003-2030.

World Energy Outlook

Projections of Non-OPEC Oil Supply

(millions of barrels a day)

	International Energy Agency (IEA)					U.S. Department of Energy (DoE)				
	2002	2004	2010	2020	2030	2002	2010	2020	2025	2030[2]
United States and Canada[3]	10.5	. . .	11.0	9.1	7.6	11.1	11.3	10.5	. . .	9.9
Mexico	3.7	. . .	4.4	4.2	3.0	3.7	4.2	4.6	. . .	5.0
OECD Europe	6.9	. . .	5.0	3.2	2.3	6.8	6.4	5.5	. . .	4.6
Russia	8.0	. . .	10.3	11.1	11.4	7.6	10.0	10.3	. . .	11.3
Other transition economies	2.0	. . .	4.4	4.9	5.5	1.8	3.5	5.6	. . .	8.0
China	3.5	. . .	3.4	2.8	2.3	3.3	3.6	3.5	. . .	3.3
Other Asia	2.6	. . .	2.4	1.9	1.2	2.5	2.6	2.7	. . .	2.5
Central and South America	3.8	. . .	4.9	5.8	6.4	3.8	4.5	5.9	. . .	6.9
Africa	3.1	. . .	4.6	5.1	4.6	2.9	3.8	5.4	. . .	8.1
Rest of world	3.0	. . .	2.4	2.0	1.6	2.9	3.3	3.6	. . .	4.0
Nonconventional oil[4]	1.7	. . .	3.9	6.8	10.7	1.5	2.8	5.0	. . .	5.4
Total	48.8	50.4	57.2	56.9	56.6	48.0	56.0	63.2	65.0	69.0

Oil prices of $50 per barrel (in 2005 dollars)

IEA, DOE, IMF

World Energy Outlook

- 70 percent of energy demand growth will be outside OECD countries
- 60 percent of demand growth from developing countries, esp. Asia
- 1/5 of demand growth will be in China. If per capita energy consumption in China rises to that of U.S., global demand will double.

World Energy Outlook

- OECD countries become more dependent on oil imports.
- Annual CO2 emissions grow 14 gigatons by 2030. China accounts for 40 percent.
- Unconventional energy sources (incl. biofuels) grow from 1.8 mb/d to 11.5 mb/d or 10 percent of world oil supply.
- Coal use in China triples.

World Energy Outlook

World marketed energy consumption

Region	2003	2010	2015	2020	2025	2030	Average Annual Percent Change, 2003-2030
OECD	**234.3**	**256.1**	**269.9**	**281.6**	**294.5**	**308.8**	**1.0**
North America	118.3	131.4	139.9	148.4	157.0	166.2	1.3
Europe	78.9	84.4	87.2	88.7	91.3	94.5	0.7
Asia	37.1	40.3	42.8	44.4	46.1	48.0	1.0
Non-OECD	**186.4**	**253.6**	**293.5**	**331.5**	**371.0**	**412.8**	**3.0**
Europe and Eurasia	48.5	56.5	62.8	68.7	74.0	79.0	1.8
Asia	83.1	126.2	149.4	172.8	197.1	223.6	3.7
Middle East	19.6	25.0	28.2	31.2	34.3	37.7	2.4
Africa	13.3	17.7	20.5	22.3	24.3	26.8	2.6
Central and South America	21.9	28.2	32.5	36.5	41.2	45.7	2.8
Total World	**420.7**	**509.7**	**563.4**	**613.0**	**665.4**	**721.6**	**2.0**

World Energy Outlook

World Oil Prices ($US2004 per barrel)

EIA

Solutions

- Conservation
  - CAFÉ standards
- New oil discoveries
  - OPEC would have to spend $350 billion by 2030 to reach 60 mbd capacity.
- New sources of energy
  - Hydrogen fuel cell, electric
  - **Biofuels**

Biofuels

- Key Drivers:
  - Energy prices
  - R&D
  - Economic growth and growing energy demand
  - Environmental regulation (carbon taxation, low CAFÉ standards, regulation of sand and tar, etc.)
- Growth will increase energy demand and enhance biofuels.
- Environmental policies will lead to conservation, reducing demand for all fuels, bio, fossil or otherwise, but impact will be greater on fuels other than biofuels.

Implications for Agriculture

- Higher cost of inputs
  - Water (esp. cost of conveyance)
  - Fertilizer, etc.
- Higher transport costs
- Pressure on land for food crops
- Pressure on environmental lands
- Trade
- Rural development / farm income

Implications for Agriculture: Water

- Demand for biofuels increases demand for water.
- Higher energy costs will increase the costs of water pumping, conveyance, and desalinization.
- Higher value of water will demand efficient allocation (markets) and conservation (precision technologies).

Implications for Agriculture: Production

- Higher energy prices will have direct and indirect effects on agricultural production.
- Direct effects: power processing machinery
- Indirect effects:
  - Upstream: cost increases among inputs like fertilizers, pesticides and water.
  - Downstream: cost increases associated with transportation and distribution

Implications for Agriculture: Production

- Heterogeneity of cost-price vulnerability across commodities.
- Greater vulnerability in agriculture than other sectors, excepting agro-chemicals and transport services.
- Livestock and field crops most vulnerable.
- May see shift in structure of ag industry with production closer to market; Land values near cities increase.

Implications for Agriculture: Production

- Biofuels will increase demand for inputs; Higher energy prices will reduce demand for inputs. Net effect is unclear.

Implications for Agriculture: Production

Global and Relative Cost-Price Pass Through

Agriculture			Food Processing			Other Sectors		
Activities	Direct	Global	Activities	Direct	Global	Activities	Direct	Global
Cattle	1.6	5.0	Milk	0.1	2.8	AirTransport	5.7	9.7
OtherLivestock	1.5	4.6	Coffee/Tea	0.0	2.5	ChemFertilizer	3.9	7.6
OtherCrops	2.1	4.6	FoodMfg	0.2	2.2	TruckTransport	2.5	5.2
Hay	1.9	4.3	SnackFood	0.2	2.0	PublicTransport	2.8	5.0
AquaCulture	1.4	4.3	Meat	0.0	1.5	WaterTransport	1.4	3.8
Cotton	1.9	4.0	OtherProcFood	0.1	1.5	VehicleTransport	1.3	3.7
Citrus	1.4	3.3	FoodProcess	0.0	1.5	HouseHold	1.0	2.9
Grapes	1.3	3.0	OtherBeverage	0.0	1.1	OtherTransport	1.4	2.9
TreeNuts	1.3	3.0	Wine	0.0	1.0	Labor	0.0	2.8
OtherVegetable	1.0	2.8	PoultryProd	0.0	0.6	Capital	0.0	2.1
Berries	1.0	2.5	Baking	0.0	0.6	Chemical	0.7	2.1
Rice	1.1	2.5	SeaFood	0.0	0.5	WholsalRetlTrade	0.2	1.8
Poultry	0.4	2.2				OtherServices	0.1	1.4
Forest	0.3	1.5				ChemPesticides	0.4	1.1
Fishery	0.6	1.1				OtherMfg	0.1	1.1
OilseedGrain	0.4	0.9				Metal	0.1	0.8
OtherPrimary	0.4	0.8				Electron	0.0	0.7
Floral	0.2	0.6				Vehicle	0.1	0.6
Nursery	0.2	0.6				TextilesApparel	0.1	0.6
Mushroom	0.0	0.1				Machinery	0.1	0.5

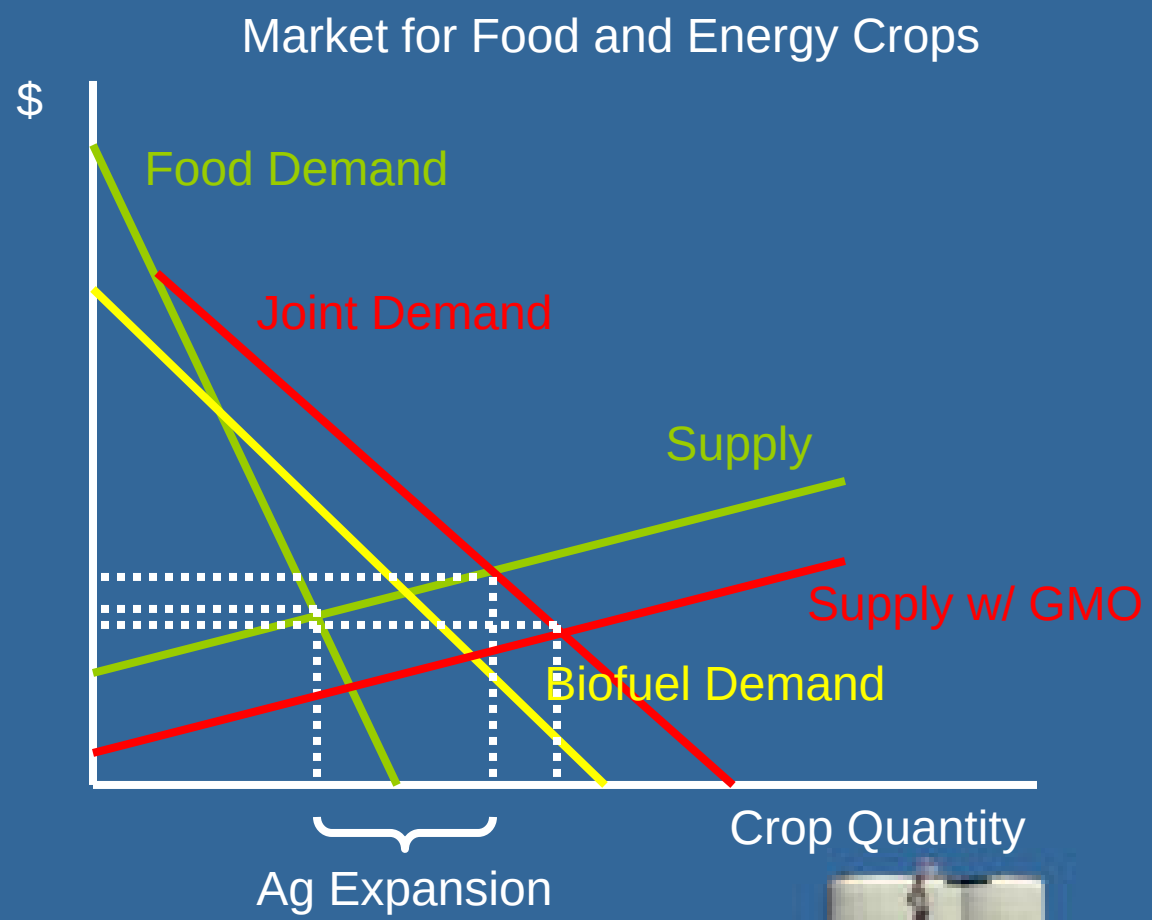
Direct = Oil & Natural Gas Costs as a Percent in Total Costs *Global = Percent Change in Total Cost*

Implications for Agriculture: Land

- In the 19th century, significant land was devoted to fueling transportation; fossil fuels allowed us to move away from agriculture as a source of transport fuel in the 20th century.

- Increasing energy prices
  => greater demand for biofuels
  => more land devoted to growing energy crop
  => less land for food and environment

Implications for Agriculture: Land



Implications for Agriculture: Land

- Biofuels will increase the price of food.
  - Rising food prices may be absorbed in developed countries, but poor regions may suffer, i.e. tortillas in Mexico.

- High energy prices may reduce demand for food (income and price effect).

Implications for Agriculture: Land

- Livestock market effects:
  - Higher feed prices will cause livestock prices to go up and consumption to go down.
  - Livestock facilities may relocate near ethanol plants to take advantage of ethanol co-product.

- Increased demand for land will lead to less conservation and an expansion of the agricultural land base.
  - Environmental pressure: Bringing CRP land into production of energy crop.

Implications for Agriculture: Land

Economical Switchgrass Production (Includes CRP, idled land)

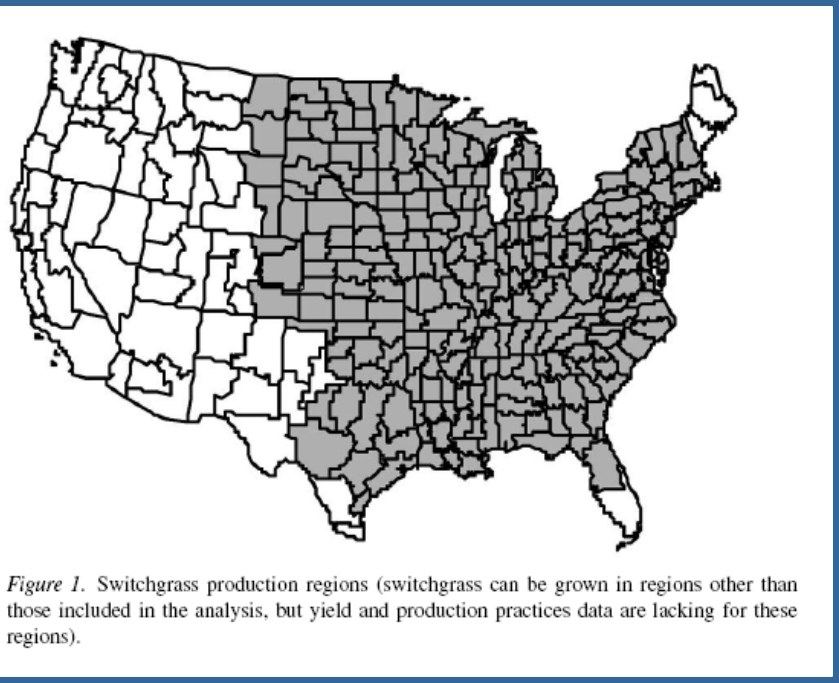


Figure 1. Switchgrass production regions (switchgrass can be grown in regions other than those included in the analysis, but yield and production practices data are lacking for these regions).

Walsh et al. 2003

Mitigating Costs of Biofuels

- Agricultural biotechnology
  - Higher food and energy crop yields
    => reduce pressure on food prices
    => reduce land in food production (assuming inelastic food demand).
  - Reduces use of inputs (chemicals) on expanded ag land.
  - Improves net energy content and net carbon emissions of biofuels.
  - **May increase land in biofuel production depending on elasticity of demand
    => effect on natural habitat uncertain.
- New biofuels

Mitigating Costs of Biofuels

Biofuel Technologies

Feedstock Type	Type of Biofuel	Major Crops in Temperate Climes	Major Crops in Tropical Climes	Conversion Technology	End-use	Technology maturity	Commercial Maturity
Sugar and Starch	**Ethanol**	Corn, Sugarbeet	Sugarcane, Sorghum, Cassava	Fermentation	Transportation	High	High
Oil Seeds	**Biodiesel**	Soy, Rapeseed	Palm, Jatropha, Pongamia, Castor	Transesterification	Transportation or Electricity	High	Low
Wood	**Producer gas**	Willow, Poplar	Eucalyptus, Acacia	Gasification, Direct Combustion, Cofiring, Pyrolysis	Electricity or heating	High	Low
Municipal Solid Waste (MSW), Ag. Residues	**Producer gas or Biogas or Ethanol**	MSW	MSW	Gasification, Direct - Combustion, Pyrolysis, Anaerobic - digestion	Electricity or heating or Transportation	High	Low
Sugarcane Bagasse				Combustion	Electricity	High	High
Cellulosic sources	**Ethanol**	Switchgrass, Corn Stover, Agri. Residues	Bagasse, Agricultural residues	Chemical and biological treatment	Transportation	Very low	None

Implications for Agriculture: Farm Income

- Market Power in Corn Seed and Corn Processing Markets
  - Monsanto, Dupont
  - Archer-Daniel-Midland, Cargill
- Firms with market power upstream (seed) and downstream (processing) capture subsidy.
  - Reduces subsidy-induced production increase
  - Reduces benefit to farmers.
- Twenty percent of $6 billion total ethanol bill may be captured by multinationals.
- Potential to aid developing countries (especially equatorial countries.)

Biofuels in Perspective

- Corn is a bad choice for biofuel crop—but it's the best we have in the U.S.
- Sugarcane is better.
- The North needs switchgrass.
- South can grow sugarcane, sorghum, and palmoil.
- Efficiency of crop use is crucial; Cannot afford to waste residue.
- Some residue must be left to restore land.

Research Agenda

- Understand energy markets and the role of agriculture in energy—develop models that integrate biofuels to the energy market.
- Understand economic growth in developing world: how it affects energy, fuels, and agriculture.
- Develop better theory on trade of inputs like energy.
- Ag can effect climate change by sequestration and reducing emissions as biofuels replace fossil fuels. Need to develop capacity to understand how climate change policies will interact with energy demand to affect biofuels.
- Understand the production economics of biofuels.
- The Economics of RandD and regulation of biofuels

Research Agenda

- The new economics of land with demand for biofuels.
- New agenda for ag policy: justification for ag policy may go down because earnings may go up. On the other hand, may need policy to assure food supply.
- Biofuel impact on natural resources: water, pesticides, environmental preservation, biodiversity.
- Biofuels and the economics of development. Structural transition in Asia presents challenges and opportunities for other continents.
- Biofuels within an economic context: what is the optimal trajectory of rewewable and nonrenewable technologies and how can policy affect it?

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