Energy and the U.S. Food System: An Overview

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Modern food systems are unique among human activities because they consume fuels and electricity, but they are increasingly called upon to supply energy, notably liquid fuels for transportation. This duality creates interesting and complex interactions between the agricultural and energy sectors of the economy, and between firms and households that produce food and those that consume food and energy. Agricultural policy now ripples through the energy sector, energy policy affects the farm sector, and environmental policy impacts farmers, food and energy processers, and all consumers of food and fuel.

Energy Use in the Food System

Industrial agriculture is an energy-intensive activity. Farmers use energy directly in the form of fuel and electricity used to grow harvest, process and transport food, and indirectly through the energy embodied in capital, chemicals, fertilizers and other material inputs. The reliance on energy makes farm production costs—and therefore the health of the farm sector and rural communities—vulnerable to changes in the price of energy. In recent years direct energy has accounted for 5-7% of farm expenditures, with indirect energy accounting for another 9-10% of farm expenditures. The cost of energy can be much higher for energy intensive operations, such as heavily irrigated grains in the Great Plains. Higher energy prices in the early 1980s stimulated a wave of energy-conserving changes in technology and management that has improved the overall energy efficiency of the farm sector. We lack a deep understanding of the vulnerability of specific crops, regions and communities to future energy price shocks.

Energy use by agriculture accounts for 2-3 percent of total energy use, but that may rise to about 15% if one includes the energy used in the processing, wholesale/retail, marketing/distribution, transportation, restaurant, and home preparation stages of the food supply chain. We lack a current understanding of the energy demands of the food system because no integrative and systemic research has been done since the early 1980s.

Biofuels

The demand for biofuels, particularly ethanol from corn and biodiesel, is a major force in the U.S. food and energy systems. Beginning with the Energy Tax Act of 1978 and continuing through the Emergency Economic Stabilization Act of 2008, government incentives have encouraged investment in the ethanol industry. In addition, technical improvements in biofuel energy systems, growing concern about climate change, and rising oil import dependence have strengthened demand for biofuels. Climate change has generated significant demand for transportation fuels with lower carbon intensities than conventional motor gasoline. Ethanol and biodiesel use doubled from 2004 to 2007. To support this trend, about 30% of corn acreage in the U.S in 2008 was devoted to ethanol.

Impacts on food prices

Biofuels provide significant economic opportunities for farmers and ranchers, rural communities and related industries such as biorefineries. Also of concern are the potential risks associated with biofuels. Using more corn for energy production could exert additional upward pressure on corn prices, potentially influencing livestock feed markets and meat prices. The sharp rise in food prices in 2007 coincided with a surge in ethanol production, suggesting a cause-and-effect relationship. However, food prices are determined in an international market by a complex interplay of financial, economic, political and environmental forces, of which biofuels are just one ingredient. There is a considerable range of opinion on this issue.

Food versus fuel

The growth of biofuels and the concurrent rise in food prices have also spurred the "food versus fuel " debate. Critics of biofuels question whether corn growers can satisfy demand for both renewable fuels and traditional uses like livestock and poultry feed, food processing and exports. Ethicists question the morality of using food for fuel when hunger and malnutrition persist in the world. The counter-arguments are (1) the corn used for ethanol would have been fed largely to livestock, not humans, (2) famers will respond by planting more corn acreage, (3) corn demand for ethanol is just one factor in determining the price of food, and (4) malnutrition and hunger are largely political issues, not agricultural land use issues.

Net energy balance

The net energy balance corn-to-ethanol has swirled controversy since the late 1970s. Energy return on investment (EROI) is the ratio of the energy delivered by a process to the energy used directly and indirectly in that process. Early work suggested that the EROI for ethanol was less than 1, i.e., it was a net energy loser. Recent work suggests an EROI from 1.5 to 1.8, although significant debate centers on appropriate system boundaries and data. This EROI is significantly smaller than that for conventional motor gasoline made from crude oil.

Environmental issues

The environmental costs of biofuels are another important issue. Biofuels are renewable, lending them an important advantage over petroleum-based fuels. But the feedstocks for biofuels are produced by agricultural operations that have significant environmental impacts. These include emissions to land, air, and weather, soil erosion, land conversion and its associated impacts on biodiversity and ecosystem services, and water use, among others.

The impact of biofuels on the global carbon cycle is an area of intense investigation and debate. Many "wells to wheels" life cycle analyses suggest that corn to ethanol reduces greenhouse gas emissions by about 20% compared to conventional motor gasoline. That reduction has been questioned recently by ecologists studying the land use implications of the diversion of land to feedstock production. The net impact on carbon emissions depends on the type, amount, and location of land cover and land use change caused by an increase in the demand for biofuels.

Some plausible changes in global land cover associated with an increase in the demand for biofuels could actually increase carbon emissions relative to conventional gasoline. A particular concern in the U.S is the possible conversion of conservation land back to corn and soybean production to meet the demand for biofuels, which has significant impacts on the above and

Data Needs

- Readily available data on amounts, types, and prices of fuel and electricity used by commodity and by region in U.S. agriculture
- Readily available and up-to-date data on the energy required to manufacture chemicals, fertilizers, and other material inputs to U.S. agriculture.
- Readily available data and systematically collected data on biorefineries akin to what EIA and EPA collect for oil refineries and power plants.
- Readily available data and technology characterizations for key, controversial technologies such as corn-to-ethanol
- Integration of modeling and data collection efforts across agencies and federal labs in regard to biofuels (e.g., DOE/EIA, USDA/ERS/NASS/AMS, and DOT)

Research Questions

- How would various policies to mitigate climate change (e.g., a carbon tax) impact (a) energy use in agriculture, and (b) the derived demand for energy via impacts on the demand for ethanol?
- How have the energy direct and indirect energy costs of specific agricultural commodities and processes changed over time? What forces have generated those changes?
- What is the current demand for energy by the overall food system in the U.S.
- How would a major shift to a lower EROI transportation fuel affect overall patterns of energy use in the economy?

Data Sources and Indicators for Energy and Agriculture

Indicators and Trends	Data Sources	Comments
ENERGY USE IN AGRICULTURE		
Direct Energy use in Agriculture		
• Types of fuel and electricity used	Various USDA publications; peer-reviewed literature	No fuel-specific data reported in regular publication series; no seasonal data
• Amounts used	Various USDA publications; peer-reviewed literature	No quantity data reported in regular publication series; must be derived from financial data; no seasonal data
• Energy use by activity	Largely in peer-reviewed, trade and gray literature	A lot of the data are old and thus reflect out-dated technology
• Prices and costs paid by farmers	NASS, Farm Production Expenditures Annual Summary	
• Fraction of national energy use by on-farm energy use	Peer reviewed literature, industry and trade publications	Studies suggest about 2-3%
Indirect Energy Use in Agriculture		
• Energy embodied in machinery, fertilizers, chemicals, etc.	Physical quantities of inputs: ERS Cost of Production data by year, crop, region	No central data source for energy intensities needed to convert physical quantities to energy
Energy Use in Food Processing, Transport, Marketing, Preparation		
• Energy intensity of specific products/processes	Peer reviewed literature, industry and trade publications	No central data source; ad hoc studies of specific commodities or processes; lack of consistent methodology
• Fraction of national energy use by food system	Peer reviewed literature, industry and trade publications	Studies suggest about 15% of, but most are pre-1990s
Energy Efficiency Indicators		
Agricultural output per unit energy input	Output data: ERS Indicators: Various USDA publications; peer-reviewed literature	Limited by availability of energy data as described above
Life cycle analysis of specific crops/foods	Largely in peer-reviewed literature	
Extent of conservation tillage	CTIC/MRCS biennial crop reside survey	
Extent of low-water use irrigation		No systematic data available
Vulnerability to/Impacts of Energy Prices		
Energy fraction of farm production expenses	NASS, Farm Production Expenditures Annual Summary	
Fraction of food costs attributable to energy	Largely in peer-reviewed literature	
Fraction rural HH income spent on	U.S. Bureau of Census	

income and electricity		
On-Farm Energy Conservation		
• Tillage	NRCS Conservation Estimator	
• Animal Housing	NRCS Conservation Estimator	
• Fertilizer	NRCS Conservation Estimator	
• Irrigation	NRCS Conservation Estimator	
BIOFUELS		
General Information		
• Demand for biofuels by type/source	DOE/EIA, Monthly and Annual Reviews	
• Use of biofuels by type/source	DOE/EIA, Monthly and Annual Reviews	
• Prices of biofuels	DOE/EIA, Monthly and Annual Reviews	
• Forecasts of future market conditions	DOE/EIA, Short Term and Annual Energy Outlooks	
Ethanol		
• Production, Consumption, Stocks of ethanol for transportation fuel	DOE/EIA, Petroleum Supply Monthly and Annual; Annual Energy Review EIA, Alternatives to Traditional Transportation Fuels USDA, Agricultural Long-Term Projections (forecasts) RFA, Ethanol Energy Statistics	EIA has recently changed the way it reports ethanol use; moving from "oxygenate" report to "petroleum supply" report
• Ethanol Feedstocks	ERS, Feed Outlook (monthly) ERS, Feed Grains Database. ERS, Agricultural Baseline Database (forecasts) AMS, Bioenergy Market News Reports.	
• Ethanol Prices	AMS: National Weekly Ethanol Summary, National Weekly Ag Energy Round-Up, Bioenergy Market News Reports. EERE: Alternative Fuel Price Report AGMRC: "Renewable Energy"	
• Ethanol plants, production capacity	RFA, Ethanol Energy Statistics	
• Ethanol Imports and Exports	ERS, Feed Grains Database FAS, US Trade Internet System RFA, Ethanol Energy Statistics	
• Number and type of alternative fuel vehicles	EIA, Alternatives to Traditional Transportation Fuels	
• Ethanol coproducts	ERS, Feed Yearbook (NASS), Ethanol Co-Products Used For Livestock Feed AMS, Corn Belt Feedstuffs DOE/EIA, Petroleum Supply Monthly and Annual; Annual Energy Review	

• Grain Demand for Ethanol production	ERS, Feed Grains Database ERS, Feed Outlook, Feed Year in Review	
Ethanol-Environmental Issues		
Greenhouse gas emissions	CTA, Biomass Energy Databook (Biofuels) Peer reviewed and government literature	Wide range of estimates of ethanol compared to conventional fuels based on choice of data and system boundary, and treatment of impact to biofuels son global commodity markets and land use change
Net energy balance	CTA, Biomass Energy Databook (Biofuels); Peer reviewed literature; trade and industry publications	Wide range of estimates of ethanol compared to conventional fuels based on choice of data and system boundary
INTERNATIONAL		
Global ethanol production, use	RFA, Ethanol Energy Statistics IEA, Statistics-Renewables	
Global grain production, trade, and prices	FAO, FAOSTAT	
FOOD, FUEL, LAND		
Land used for biofuel production		
Impact of biofuels on grain/food prices	Peer-reviewed, government, industry, NGO literature	Wide range of estimates; determined by complex array of forces in regional, national, and global commodity markets
Competition for land	ERS, Commodity Costs and Returns	Tacks the relative costs and returns for corn, crops competing with corn for land,

USDA = U.S. Department of Agriculture
NASS = National Agricultural Statistics Services, U.S. Department of Agriculture http://www.nass.usda.gov/
ERS = Economic Research Service, U.S. Department of Agriculture http://www.ers.usda.gov/
NRCS = Natural Resource Conservation Service, U.S. Department of Agriculture
http://www.nrcs.usda.gov/index.asp
CTIC = Conservation Technology Information Center http://www.conservationinformation.org/
EIA = U.S. Department of Energy, Energy Information Administration http://www.eia.doe.gov/
EERE = U.S. Department of Energy, Energy Efficiency and Renewable Energy http://www.eere.energy.gov/
AMS = U.S. Department of Agriculture, Agricultural Marketing Service, http://www.ams.usda.gov/AMSv1.0/
AGMRC = U.S. Department of Agriculture, Agricultural Marketing Resource Center
http://www.agmrc.org/renewable_energy/
FAS = U.S. Department of Agriculture, Foreign Agricultural Service, http://www.fas.usda.gov/ustrade/
RFA = Renewable Fuels Association, http://www.ethanolrfa.org/industry/statistics/
FAO = Food and Agriculture Organization of the United Nations http://faostat.fao.org/default.aspx
CTA = Center for Transportation Analysis, Oak Ridge National Laboratory, http://cta.ornl.gov/cta/
IEA – International Energy Agency, http://www.iea.org/Textbase/stats/index.asp