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Agriculture-Based Renewable Energy Production

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Summary

Since the late 1970s, U.S. policy makers at both the federal and state levels have enacted a variety of incentives, regulations, and programs to encourage the production and use of agriculture-based renewable energy. Motivations cited for these legislative initiatives include energy security concerns, reduction in greenhouse gas emissions, and raising domestic demand for U.S.-produced farm products.

Agricultural households and rural communities have responded to these government incentives and have expanded their production of renewable energy, primarily in the form of biofuels and wind power, every year since 1996. The production of ethanol (the primary biofuel produced by the agricultural sector) has risen from about 175 million gallons in 1980 to 3.9 billion gallons per year in 2005. Biodiesel production is at a much smaller level, but has also shown growth rising from 0.5 million gallons in 1999 to an estimated 75 million gallons in 2005. Wind energy systems production capacity has also grown rapidly, rising from 1,706 megawatts in 1997 to an estimated 9,149 megawatts by January 2006.

Despite this rapid growth, agriculture- and rural-based energy production accounted for only about 0.6% of total U.S. energy consumption in 2004. Looking just at agriculture-based energy production, ethanol accounted for about 74%, wind energy systems for 25%, and biodiesel energy output for 1%.

Key points that emerge from this report are:

- agriculture has been rapidly developing its renewable energy production capacity (primarily as biofuels and wind); however, this growth has depended heavily on federal and state programs and incentives;
- rising fossil fuel prices improve renewable energy's market competitiveness; however, significant improvement of existing technology or the development of new technology still is needed for current biofuel production strategies to be economically competitive with existing fossil fuels in the absence of government support; and
- a review of available data suggests that farm-based energy production is unlikely to be able to substantially reduce the nation's dependence on petroleum imports unless there is a significant decline in consumption. Also, other uses (food, animal feed, industrial processing, etc.) of biomass feedstocks are likely to be adversely impacted by rapid growth in their use for bioenergy.

This report provides background information on farm-based energy production and how this fits into the national energy-use picture. It briefly reviews the primary agriculture-based renewable energy types and issues of concern associated with their production, particularly their economic and energy efficiencies and long-run supply. Finally, this report examines the major legislation related to farm-based energy production and use. This report will be updated as events warrant.

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Introduction

Agriculture's role as a consumer of energy is well known.[1] However, under the encouragement of expanding government support the U.S. agricultural sector also is developing a capacity to produce energy, primarily as renewable biofuels and wind power. Farm-based energy production — biofuels and wind-generated electricity — has grown rapidly in recent years, but still remains small relative to total national energy needs. In 2004, ethanol, biodiesel, and wind provided 0.6% of U.S. energy consumption (**Table 1**). Ethanol accounted for about 74% of agriculture-based energy production in 2004; wind energy systems for 25%; and biodiesel for 1%.

In general, fossil-fuel-based energy is less expensive to produce and use than energy from renewable sources.[2] However, since the late 1970s, U.S. policy makers at both the federal and state levels have enacted a variety of incentives, regulations, and programs to encourage the production and use of cleaner, renewable agriculture-based energy.[3] These programs have proven critical to the economic success of rural renewable energy production. The benefits to rural economies and to the environment contrast with the generally higher costs, and have led to numerous proponents as well as critics of the government subsidies that underwrite agriculture-based renewable energy production.

Proponents of government support for agriculture-based renewable energy have cited national energy security, reduction in greenhouse gas emissions, and raising domestic demand for U.S.-produced farm products as viable justification.[4] In addition, proponents argue that rural, agriculture-based energy production can enhance rural incomes and employment opportunities, while encouraging greater value-added for U.S. agricultural commodities.[5]

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[1] For more information on energy use by the agricultural sector, see CRS Report RL32677, *Energy Use in Agriculture: Background and Issues*, by Randy Schnepf.

[2] Excluding the costs of externalities associated with burning fossil fuels such as air pollution, environmental degradation, and illness and disease linked to emissions.

[3] See section on "Public Laws That Support Agriculture-Based Energy Production and Use," below, for a listing of major laws supporting farm-based renewable energy production.

[4] For examples of proponent policy positions, see the National Corn Growers Association (NCGA) at [http://www.ncga.com/ethanol/main/index.htm], and the American Soybean Association (ASA) at [http://www.soygrowers.com/policy/].

[5] Several studies have analyzed the positive gains to commodity prices, farm incomes, and rural employment attributable to increased government support for biofuel production. For

(continued...)

In contrast, petroleum industry critics of biofuel subsidies argue that technological advances such as seismography, drilling, and extraction continue to expand the fossil-fuel resource base, which remains far cheaper and more accessible than biofuel supplies. Other critics argue that current biofuel production strategies can only be economically competitive with existing fossil fuels in the absence of subsidies if significant improvements in existing technologies are made or new technologies are developed.[6] Until such technological breakthroughs are achieved, critics contend that the subsidies distort energy market incentives and divert research funds from the development of other potential renewable energy sources, such as solar or geothermal, that offer potentially cleaner, more bountiful alternatives.

Still others question the rationale behind policies that promote biofuels for energy security. These critics question whether the United States could ever produce sufficient feedstocks of either starches, sugars, or vegetable oils to permit biofuel production to meaningfully offset petroleum imports.[7] Finally, there are those who argue that the focus on development of alternative energy sources undermines efforts to conserve and reduce the nation's energy dependence.

The economics underlying agriculture-based renewable energy production include decisions concerning capital investment, plant or turbine location (relative to feedstock supplies and by-product markets or power grids), production technology, and product marketing and distribution, as well as federal and state production incentives and usage mandates.[8] Several additional criteria may be used for comparing different fuels, including performance, emissions, safety, and infrastructure needs.[9] This report will discuss and compare agriculture-based energy production of ethanol, biodiesel, and wind energy based on three criteria:

- **Economic Efficiency** compares the price of agriculture-based renewable energy with the price of competing energy sources, primarily fossil fuels.

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[5] (...continued)
examples, see the "For More Information" section at the end of this report.

[6] Advocates of this position include free-market proponents such as the Cato Institute, and federal budget watchdog groups such as Citizens Against Government Waste and Taxpayers for Common Sense.

[7] For example, see R. Wisner and P. Baumel, "Ethanol, Exports, and Livestock: Will There be Enough Corn to Supply Future Needs?," *Feedstuffs,* no. 30, vol. 76, July 26, 2004.

[8] For more information on the economics underlying the capital investment decision see D. Tiffany and V. Eidman. *Factors Associated with Success of Fuel Ethanol Producers*, Dept of Appl. Econ., Univ. of Minnesota, Staff Paper P03-7, Aug. 2003; hereafter referred to as Tiffany and Eidman (2003). For a discussion of ethanol plant location economics see B. Babcock and C. Hart, "Do Ethanol/Livestock Synergies Presage Increased Iowa Cattle Numbers?" *Iowa Ag Review,* Vol. 12 No. 2, Spring 2006.

[9] For more information on these additional criteria and others, see CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues,* by Brent D. Yacobucci.

- **Energy Efficiency** compares energy output from agriculture-based renewable energy relative to the fossil energy used to produce it.
- **Long-Run Supply Issues** consider supply and demand factors that are likely to influence the growth of agriculture-based energy production.

Table 1. U.S. Energy Production and Consumption, 2004

Energy source	Production: Quadrillion Btu	Production: % of total	Consumption: Quadrillion Btu	Consumption: % of total
Total	**70.4**	**100.0%**	**99.7**	**100.0%**
Fossil Fuels	**56.0**	**80.1%**	**85.6**	**85.9%**
Petroleum and products	11.5	16.4%	40.1	40.2%
Coal	22.7	32.2%	22.4	22.4%
Natural Gas	21.8	31.0%	23.0	23.1%
Nuclear	**8.2**	**11.7%**	**8.2**	**8.3%**
Renewables	**6.1**	**8.7%**	**6.1**	**6.1%**
Hydroelectric power	2.7	3.9%	2.7	2.7%
Biomass	2.8	4.0%	2.8	2.9%
Wood, waste, other	2.4	3.4%	2.4	2.4%
Ethanol	0.4	0.6%	0.4	0.4%
Biodiesel	0.0	0.0%	0.0	0.0%
Geothermal	0.3	0.5%	0.3	0.3%
Solar	0.1	0.1%	0.1	0.1%
Wind	0.1	0.2%	0.1	0.1%

Source: Ethanol data: Renewable Fuels Association, [http://www.ethanolrfa.org]; biodiesel data: National Biodiesel Board, [http://www.biodiesel.org]; all other data: DOE, Energy Information Agency (EIA), Historical Data, Annual Energy Overview, Tables 1.2 and 1.3, [http://www.eia.doe.gov/emeu/aer/overview.html].

Agriculture's Share of Energy Production

In 2004, the major agriculture-produced energy source — ethanol — accounted for about 1.6% of U.S. gasoline motor-vehicle consumption[10] and about 0.3% of total U.S. energy consumption (see **Table 1**). In addition, the agricultural sector also

[10] Based on projected motor vehicle fuel use, DOE, Energy Information Agency (EIA), "Table 10. Estimated Consumption of Vehicle Fuels in the United States, 1995-2004," at [http://www.eia.doe.gov/cneaf/alternate/page/datatables/aft1-13_03.html]; and estimated ethanol use, Renewable Fuels Association, "Industry Statistics," at [http://www.ethanolrfa.org/industry/statistics/].

produced several other types of renewable energy — biodiesel, wind, anaerobic digesters, and non-traditional biomass. Presently, the volume of agriculture-based energy produced from these emerging renewable sources is small relative to ethanol production.

Renewable energy sources must compete with a large number of conventional petroleum-based fuels in the marketplace (see **Table 2**). However, an expanding list of federal and state incentives, regulations, and programs that were enacted over the past decade have helped to encourage more diversity in renewable energy production and use.

Table 2. Energy and Price Comparisons for Alternate Fuels, February 2006

Fuel type	Unit	Btu's per unit[a]	National Avg. Price: $ per unit	GEG[b]	National Avg. Price: $ per GEG
Gasoline: conventional	gallon	125,071	$2.23	1.00	$2.23
Ethanol (E85)[c]	gallon	90,383	$1.98	0.72	$2.75
Diesel fuel	gallon	138,690	$2.56	1.11	$2.31
Biodiesel (B20)	gallon	138,690	$2.64	1.11	$2.38
Propane	gallon	91,333	$1.98	0.74	$2.68
Compressed Natural Gas[d]	gallon	35,500	$0.56	0.28	$1.99
Natural Gas[e]	1,000 $ft.^3$	1,030,000	$9.34	8.24	$1.13
Biogas	1,000 $ft.^3$	10 x (% of methane)[f]	na	na	na
Electricity[g]	kilowatt-hour	3,413	5¢ - 9¢	na	na

Source: Prices are for Jan.-Feb. 2006; DOE, EIA, *Clean Cities Alternative Fuel Price Report*, Feb. 2006; [http://www.eere.energy.gov/afdc/resources/pricereport/price_report.html].

na = not applicable.

a. Conversion rates for petroleum-based fuels and electricity are from DOE, *Monthly Energy Review*, August 2004. A Btu (British thermal unit) is a measure of the heat content of a fuel and indicates the amount of energy contained in the fuel. Because energy sources vary by form (gas, liquid, or solid) and energy content, the use of Btu's provides a common benchmark for various types of energy.

b. GEG = gasoline equivalent gallon. The GEG allows for comparison across different forms — gas, liquid, kilowatt, etc. It is derived from the Btu content by first converting each fuel's units to gallons, then dividing each fuel's Btu unit rate by gasoline's Btu unit rate of 125,071, and finally multiplying each fuel's volume by the resulting ratio.

c. 100% ethanol has an energy content of 84,262 Btu per gallon.

d. Compressed natural gas (CNG) is generally stored under pressure at between 2,000 to 3,500 pounds per square inch (psi). The energy content varies with the pressure. For simplification, data in this table assumes that CNG is stored at 3,000 psi with an energy content of 35,500 Btu per gallon.

e. Natural Gas prices, $ per 1,000 cu. ft., are industrial prices for the month of Feb. 2006, from DOE, EIA, available at [http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm].

f. When burned, biogas yields about 10 Btu per percentage of methane composition. For example, 65% methane yields 650 Btu per cubic foot or 650,000 per 1,000 cu. ft.
g. Prices are for total industry electricity (all sectors) rates per kilowatt-hour for 2004; from DOE, EIA, available at [http://www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html].

Agriculture-Based Biofuels

Biofuels are liquid fuels produced from biomass. Types of biofuels include ethanol, biodiesel, methanol, and reformulated gasoline components.[11] The Biomass Research and Development Act of 2000 (P.L. 106-224; Title III) defines biomass as "any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials."

Biofuels are primarily used as transportation fuels for cars, trucks, buses, airplanes, and trains. As a result, their principal competitors are gasoline and diesel fuel. Unlike fossil fuels, which have a fixed resource base that declines with use, biofuels are produced from renewable feedstocks. Furthermore, under most circumstances biofuels are more environmentally friendly (in terms of emissions of toxins, volatile organic compounds, and greenhouse gases) than petroleum products. Supporters of biofuels emphasize that biofuel plants generate value-added economic activity that increases demand for local feedstocks, which raises commodity prices, farm incomes, and rural employment.

Ethanol

Ethanol, or ethyl alcohol, is an alcohol made by fermenting and distilling simple sugars.[12] As a result, ethanol can be produced from any biological feedstock that contains appreciable amounts of sugar or materials that can be converted into sugar such as starch or cellulose. Sugar beets and sugar cane are examples of feedstocks that contain sugar. Corn contains starch that can relatively easily be converted into sugar. In the United States corn is the principal ingredient used in the production of ethanol; in Brazil (traditionally the world's largest ethanol producer), sugar cane is the primary feedstock. Trees and grasses are made up of a significant percentage of cellulose which can also be converted to sugar, although with more difficulty than required to convert starch. In recent years, researchers have begun experimenting with the possibility of growing hybrid grass and tree crops explicitly for ethanol production. In addition, sorghum and potatoes, as well as crop residue and animal waste, are potential feedstocks.

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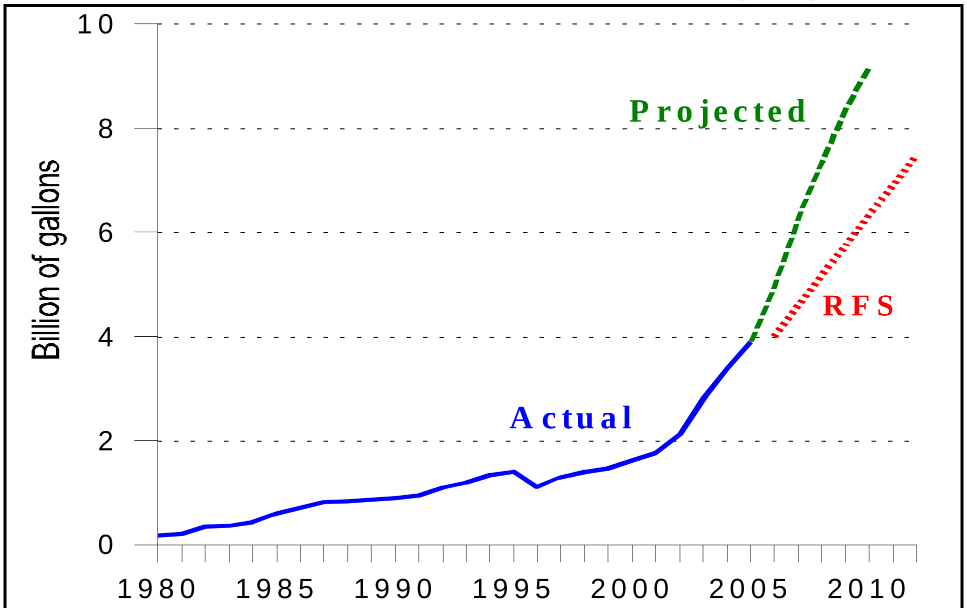
[11] For more information on alternative fuels, see CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues*, by Brent D. Yacobucci. See also DOE, National Renewable Energy Laboratory (NREL), *Biomass Energy Basics*, available at [http://www.nrel.gov/learning/re_biomass.html].

[12] For more information, see CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci.

Figure 1. U.S. Ethanol Production: Actual and Projected, versus the Renewable Fuels Standard (RFS)



Source: 1980-2005, American Coalition for Ethanol; projections for 2006-2010 are from FAPRI, July 2006 Baseline Update; the RFS is graphed as if met entirely by domestic ethanol production.

Ethanol production has shown rapid growth in the United States in recent years (**Figure 1**). Several events contributed to the historical growth of ethanol production: the energy crises of the early and late 1970s; a partial exemption from the motor fuels excise tax (legislated as part of the Energy Tax Act of 1978); ethanol's emergence as a gasoline oxygenate; and provisions of the Clean Air Act Amendments of 1990 that favored ethanol blending with gasoline.[13] Ethanol production is projected to continue growing rapidly through at least 2010 on the strength of both the extension of existing and the addition of new government incentives including a per gallon tax credit of $0.51 and a Renewable Fuels Standard (RFS) of 7.5 billion gallons by 2012 (described below).

U.S. ethanol production presently is underway or planned in 20 states based primarily around the central and western Corn Belt, where corn supplies are most plentiful (see **Table 3**).[14] Corn accounts for about 95% of the feedstocks used in ethanol production in the United States. As of July 26, 2006, existing U.S. ethanol plant capacity was a reported 4,830 million gallons per year (MGPY), with an additional capacity of 2,431 MGPY under construction. Thus, total annual U.S. ethanol production capacity in existence or under construction as of July 26, 2006, was 7.3 billion gallons (just shy of the 7.5 billion gallon RFS mandated for 2012).

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[13] USDA, Office of Energy Policy and New Uses, *The Energy Balance of Corn Ethanol: An Update*, AER-813, by Hosein Shapouri, James A. Duffield, and Michael Wang, July 2002.

[14] See Renewable Fuels Association, *Industry Statistics*, at [http://www.ethanolrfa.org/industry/statistics/].

Table 3. Ethanol Production Capacity by State, July 26, 2006

State	Currently operating		Under construction	Total	
	Million gal/yr	%	Million gal./yr.	Million gal/yr	%
Iowa	1,510	31%	270	1,780	25%
Nebraska	556	12%	501	1,057	16%
South Dakota	585	12%	338	923	12%
Illinois	724	15%	107	831	12%
Minnesota	536	11%	58	594	9%
Indiana	102	2%	290	392	6%
Kansas	167	3%	95	262	3%
Wisconsin	193	4%	40	233	3%
Michigan	50	1%	157	207	3%
Missouri	110	2%	45	155	2%
Others	297	6%	530	826	8%
U.S. Total	4,830	100%	2,431	7,260	100%

Source: Renewable Fuels Association, *Industry Statistics: U.S. Fuel Ethanol Production Capacity*, at [http://www.ethanolrfa.org/industry/statistics/], July 26, 2006.

Ethanol Pricing Issues. From a national perspective, the ethanol industry is still nascent. As a result, marketing channels, pricing arrangements, and distribution networks are still evolving with both the rapid growth in production and the federally mandated use requirements. In early 2006, several market circumstances combined to push ethanol prices to levels substantially above gasoline prices (see **Figure 2**). In May, the spot market price per gallon for ethanol reached $3.75 in Chicago and $4.50 in New York, while the monthly average ethanol rack price, f.o.b. Omaha, reached $3.58 in June 2006.

These price surges generated considerable concern among consumers regarding possible price manipulation in the marketplace and the reliability of ethanol as a fuel source. However, a review of the circumstances suggests that two market phenomena appear to be the behind the rise in ethanol prices and the ethanol-to-gasoline price disparity — the general price rise in petroleum and natural gas markets,[15] and the elimination of the oxygen requirement for reformulated gasoline (legislated by the Energy Policy Act of 2005, P.L. 109-58), which resulted in a rapid shift from MTBE to ethanol by the automotive fuel industry and pushed near-term demand substantially above available ethanol supplies.[16]

Most dry-mill ethanol plants typically employ one or more of three pricing strategies for marketing their ethanol production: sell at the rack price to nearby

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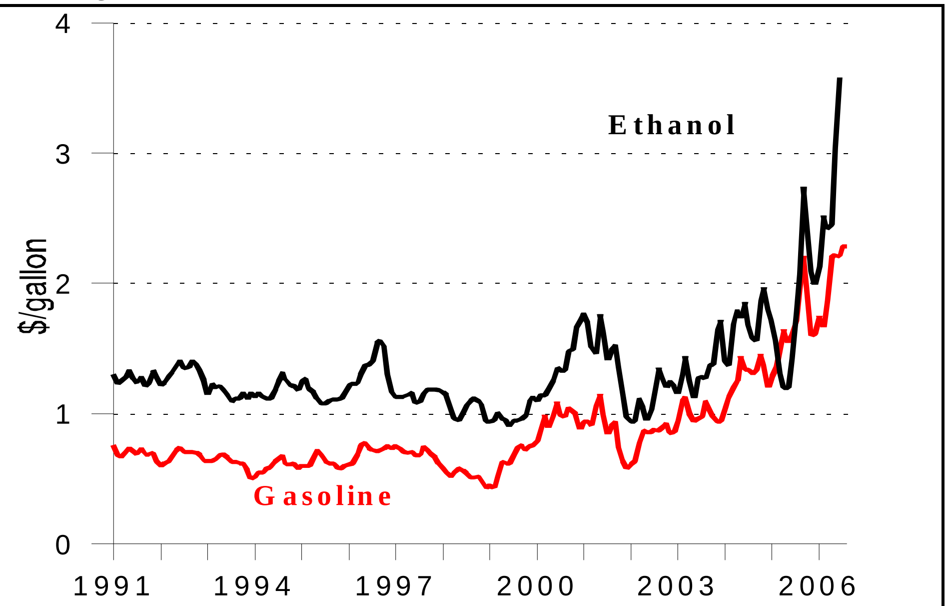
[15] For more information see CRS Report RL32530, *World Oil Demand and its Effect on Oil Prices*, by Robert Pirog; and CRS Report RS22233, *Oil and Gas: Supply Issues After Katrina and Rita*, by Robert L. Bamberger and Lawrence Kumins.

[16] For more information, see CRS Report RL33564, *Alternative Fuels and Advanced Technology Vehicles: Issues in Congress*, by Brent Yacobucci.

refinery and fuel blending sites; forward contract at a fixed price for future delivery; and forward contract where the ethanol price is based on a monthly futures contract price (e.g., the wholesale ethanol contract at either the Chicago or New York Boards of Trade or the wholesale gasoline contract at the New York Mercantile Exchange) plus a per-gallon premium.[17] Because a large portion of ethanol is sold under forward contract, the market is vulnerable to near-term, temporary price rises when demand exceeds available non-contracted supplies — as was the case in late 2005 and 2006 when the MTBE-phase-out-induced demand surged above existing supplies while the ethanol industry was already operating near full capacity. The ethanol-to-gasoline price disparity is expected to diminish gradually as more ethanol production capacity comes online.

Figure 2. Ethanol versus Gasoline Prices, 1991-2006



Source: Prices are monthly averages: gasoline prices are national wholesale DOE, EIA;. Ethanol are rack, f.o.b. Omaha, Nebraska Ethanol Board, Lincoln, NE. Nebraska Energy Office, Lincoln, NE.

Corn-Based Ethanol. USDA estimated that 1.6 billion bushels of corn (or 14.4% of total U.S. corn production) from the 2005 corn crop were used to produce ethanol during the 2005/06 (September-August) corn marketing year.[18] Ethanol's share of corn production is projected to expand to 20% (or 2.15 billion bushels) in 2006/07.[19] The Food and Agricultural Policy Research Institute (FAPRI) projects that by 2010, U.S. ethanol production will reach 9.2 billion gallons and use 27.6% (3.5 billion bushels) of the U.S. corn crop (see **Figure 1**).[20] Despite its rapid growth,

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[17] Tiffany and Eidman (2003), p. 20.

[18] Corn use for ethanol: USDA, World Agricultural Outlook Board, *World Agricultural Supply and Demand Estimates*, May 12, 2006.

[19] Ibid.

[20] FAPRI, July 2006 Baseline Update for U.S. Agricultural Markets, FAPRI-UMC Report (continued...)

ethanol production represents a minor part of U.S. gasoline consumption. In calendar 2005, U.S. ethanol production of 3.9 billion gallons accounted for about a 2% projected share of national gasoline use (2.6 billion gasoline-equivalent gallons (GEG) out of a projected 139.9 billion gallons).[21]

Economic Efficiency. Apart from government incentives, the economics underlying corn-based ethanol's market competitiveness hinge primarily on the following factors:

- the price of feedstocks, primarily corn;
- the price of the processing fuel, primarily natural gas or electricity, used at the ethanol plant;
- the cost of transporting feedstocks to the ethanol plant and transporting the finished ethanol to the user; and
- the price of feedstock co-products (for dry-milled corn: distillers dried grains; for wet-milled corn: corn gluten feed, corn gluten meal, and corn oil).

Higher prices for corn, processing fuel, and transportation hurt ethanol's market competitiveness, while higher prices for corn by-products and gasoline improve ethanol's competitiveness in the marketplace. Using 2002 data (see **Table 4**), USDA estimated that the average production cost for a gallon of ethanol was $0.958 when corn prices averaged about $2.32 per bushel and natural gas cost about $4.10 per 1,000 cubic feet (mcf). Feedstock costs are the largest expense item in the production of ethanol, representing about 57% of total ethanol production costs (net of by-product credits obtained by selling the DDGs and carbon dioxide) or about $0.55 per gallon. Each $1.00 increase in the price of corn raises the per gallon production cost of ethanol by about $0.36 per gallon ($0.54 per GEG).[22]

Processing fuel (usually natural gas) is the second largest expense representing about 14% of total costs or about $0.14 per gallon. Natural gas prices have risen substantially since 2002 (see **Figure 7**). However, because of its smaller cost share, each $1.00 increase in the price of natural gas only raises the per gallon production cost of ethanol by about $0.034 per gallon ($0.051 per GEG).

These ethanol production costs ignore capital costs (e.g., depreciation, interest charges, return on equity, etc.), which may play a significant role depending on market conditions. Capital costs for a 40 million gallon per year ethanol plant with

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[20] (...continued)
#12-06, University of Missouri.

[21] Based on a conversion rate of 1.73 GEG per bushel of corn (2.7 gallons of ethanol per bushel of corn and 0.67 GEG per gallon of ethanol). DOE, IEA, "Table 10. Estimated Consumption of Vehicle Fuels in the United States, 1995-2004," at [http://www.eia.doe.gov/cneaf/alternate/page/datatables/aft1-13_03.html]. CRS projections based on DOE/EIA data and extrapolated growth rates.

[22] Based on CRS simulations of an ethanol dry mill spreadsheet model developed by Tiffany and Eidman (2003).

an initial capital investment of $60 million (of which 60% is debt financed) have been estimated at roughly $0.14 per gallon assuming a 12% rate of return on equity.[23]

Table 4. Ethanol Dry Mill Cost of Production Estimates, 2002

Item	Unit	Value	Share
PRICES			
Ethanol (rack, f.o.b. Omaha)	$/gal.	$1.12	
Corn (average farm price received)	$/bushel	$2.32	
Distiller's Dried Grain (Lawrenceburg, IN)	$/short ton	$82.44	
COSTS			
Feedstock (Corn, Sorghum, or Other)	$/gal.	$0.803	
By-Product Credit	$/gal.	$0.258	
Distiller's Dried Grain	$/gal.	$0.252	
Carbon Dioxide	$/gal.	$0.006	
Net Feedstock Costs	$/gal.	$0.545	56.9%
Total Processing Costs	$/gal.	$0.413	43.1%
Processing Fuel Costs	$/gal.	$0.136	14.1%
Electricity Costs	$/gal.	$0.037	3.9%
Chemical Costs	$/gal.	$0.102	10.6%
Labor, Maintenance, & Repair Costs	$/gal.	$0.091	9.5%
Administrative & Miscellaneous Costs	$/gal.	$0.048	5.0%
Total Processing Costs & Net Feedstock Costs	$/gal.	$0.958	100.0%

Source: Ethanol prices from Nebraska Ethanol Board, Lincoln, NE. Nebraska Energy Office, Lincoln, NE; Corn and DDGS prices from ERS, USDA; Natural Gas prices from DOE/EIA; Ethanol cost of production data from Hosein Shapouri and Paul Gallagher, *USDA's 2002 Ethanol Cost-of-Production Survey*, AER 841, USDA, Office of Energy Policy and New Uses, July 2005.

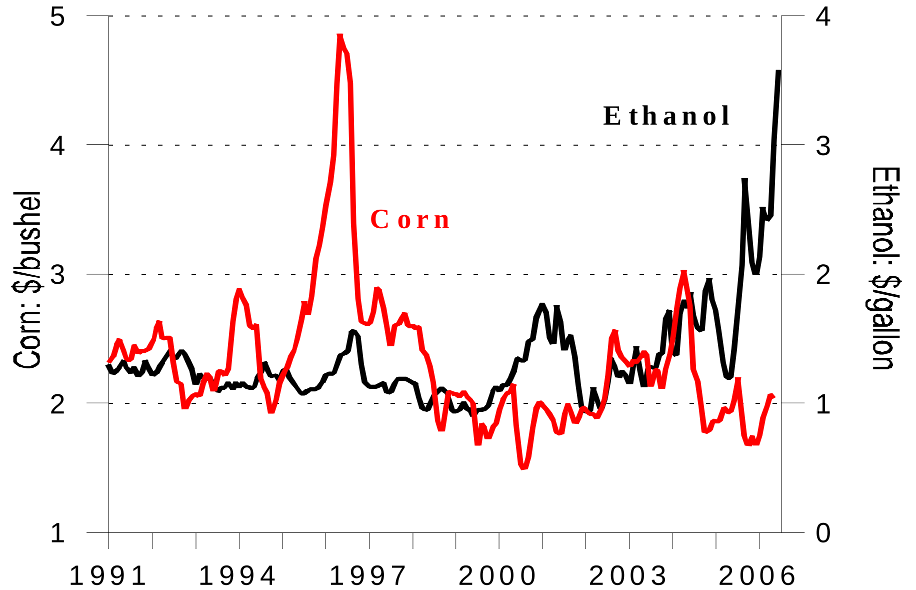
Because ethanol delivers only about 67% of the energy of a gallon of gasoline, the 2002 cost of production in gasoline equivalent gallons is $1.43. However, the federal tax credit (see below) of $0.51 per gallon of pure (100%) ethanol is a direct offset to the production costs. To date, ethanol has been used at low blend ratios (5% or 10%) with gasoline, functioning primarily either as an oxygenate or as a fuel extender. At higher blend ratios (e.g., 85% ethanol), ethanol competes directly with gasoline as a motor fuel.

Since corn is the largest expense in the production of ethanol, the relative relationship of corn to ethanol prices provides a strong indicator of the ethanol industry's well-being (see **Figure 3**). The general trend since mid-2004 has clearly been in ethanol's favor as average monthly ethanol rack prices (f.o.b. Omaha) have

[23] Ibid.

surged above the $2.00 per gallon level while corn prices have fluctuated around the $2.00 per bushel level. Since each bushel of corn yields approximately 2.75 gallons of ethanol, the profitability of ethanol production has escalated rapidly with the increase in ethanol prices. The federal production tax credit of 51¢ per gallon of pure ethanol (see below) further enhances the profitability in ethanol production and helps to explain the surge in ethanol production capacity over the past two years. A model simulation based on ethanol prices of $2.50 per gallon, corn prices of $2.20/bushel, and natural gas of $6.00/mcf, suggests that a 40 million gallon-per-year ethanol plant with initial capital of $60 million (of which 60% is debt financed) is able to entirely recover its investment capital in substantially less than a year.[24]

Figure 3. Corn versus Ethanol Prices, 1991-2006



Source: Prices are monthly averages: Corn, No.2, yellow, Chicago; USDA, AMS; Ethanol are rack, f.o.b. Omaha, Nebraska Ethanol Board, Lincoln, NE. Nebraska Energy Office, Lincoln, NE.

Government Support. Federal subsidies have played an important role in encouraging investment in the U.S. ethanol industry. The Energy Tax Act of 1978 first established a partial exemption for ethanol fuel from federal fuel excise taxes.[25] In addition to the partial excise tax exemption, certain income tax credits are available for motor fuels containing biomass alcohol. However, the different tax credits are coordinated such that the same biofuel cannot be claimed for both income and excise tax purposes. The primary federal incentives include:[26]

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[24] Ibid.

[25] For a legislative history of federal ethanol incentives, see GAO, *Tax Incentives for Petroleum and Ethanol Fuels*, RCED-00-301R, Sept. 25, 2000.

[26] For more information on federal incentives for biofuel production, see CRS Report RL33572, *Biofuels Incentives: A Summary of Federal Programs*, by Brent D. Yacobucci, or see section on "Public Laws That Support Agriculture-Based Energy Production and Use," below.

- a production tax credit of 51¢ per gallon of pure (100%) ethanol — the tax incentive was extended through 2010 and converted to a tax credit from a partial tax exemption of the federal excise tax under the American Jobs Creation Act of 2004 (P.L. 108-357);
- a small producer income tax credit (26 U.S.C. 40) of 10¢ per gallon for the first 15 million gallons of production for ethanol producers whose total output does not exceed 60 million gallons of ethanol per year (extended from 30 to 60 million under Sec. 1347 of P.L. 109-58);
- a Renewable Fuels Standard (RFS) (Energy Policy Act of 2005, P.L. 109-58) that mandates renewable fuels blending requirements for fuel suppliers — 4 billion gallons of renewable fuels must be blended into gasoline in 2006; the blending requirement grows annually until 7.5 billion gallons in 2012.

Also important was USDA's Bioenergy Program (7 U.S.C. 8108), which provided incentive payments (contingent on annual appropriations) on year-to-year production increases of renewable energy under during the FY2001 to FY2006 period. Indirectly, other federal programs support ethanol production by requiring federal agencies to give preference to biobased products in purchasing fuels and other supplies and by providing incentives for research on renewable fuels. Also, several states have their own incentives, regulations, and programs in support of renewable fuel research, production, and consumption that supplement or exceed federal incentives.

Energy Efficiency. The net energy balance (NEB) of a fuel can be expressed as a ratio of the energy produced from a production process relative to the energy used in the production process. An output/input ratio of 1.0 implies that energy output equals energy input. The critical factors underlying ethanol's energy efficiency or NEB include:

- corn yields per acre (higher yields for a given level of inputs improves ethanol's energy efficiency);
- the energy efficiency of corn production, including the energy embodied in inputs such as fuels, fertilizers, pesticides, seed corn, and cultivation practices;
- the energy efficiency of the corn-to-ethanol production process — clean burning natural gas is the primary processing fuel for most ethanol plants, but several plants (including an increasing number of new plants) are designed to use coal; and
- the energy value of corn by-products, which act as an offset by substituting for the energy needed to produce market counterparts.

Over the past decade, technical improvements in the production of agricultural inputs (particularly nitrogen fertilizer) and ethanol, coupled with higher corn yields per acre and stable or lower input needs, appear to have raised ethanol's NEB. About 79% of the corn used for ethanol is processed by "dry" milling (a grinding process) where the average conversion rate was estimated at 2.64 gallons of ethanol per bushel of corn; and about 21% is processed by "wet" milling plants (a chemical extraction process) which yields 2.68 gallons per bushel.[27] All new plants under construction or coming online are expected to dry mill corn into ethanol, thus the dry milling share will continue to rise for the foreseeable future.

In 2004, USDA economists reported that, assuming "best production practices and state of the art processing technology," the NEB of corn-ethanol (based on 2001 data) was a positive 1.67 — that is, 67% more energy was returned from a gallon of ethanol than was used in its production.[28] Other researchers have found much lower NEB values under less optimistic assumptions, leading to some dispute over corn-to-ethanol's representative NEB.[29] A recent study (Farrel et al, 2006) compared several major corn-to-ethanol NEB analyses and found that, when by-products are properly accounted for, the corn-to-ethanol process has a positive NEB (i.e., greater than 1.0) and that the NEB is improving with technology.[30] However, these studies clearly imply that inefficient processes for producing corn (e.g., excessive reliance on chemicals and fertilizer or bad tillage practices) or for processing ethanol (e.g., coal-based processing), or extensive trucking of either the feedstock or the finished ethanol long distances to plant or consumer, can result in a NEB less than 1.0.

Long-Run Supply Issues. Despite improving energy efficiency, the ability for domestic ethanol production to measurably substitute for petroleum imports is questionable, particularly when ethanol production depends almost entirely on corn as the primary feedstock. The import share of U.S. petroleum consumption was estimated at 54% in 2004, and is expected to grow to 70% by 2025.[31] Presently, ethanol production accounts for about 1.6% of U.S. gasoline consumption while using about 14% of the U.S. corn production. If the entire 2005 U.S. corn production of 11.1 billion bushels were dedicated to ethanol production, the resultant 30 billion gallons of ethanol (20.2 billion GEG) would represent about 14.5% of projected national gasoline use of 139.1 billion gallons.[32] In 2005, slightly more than 75 million acres of corn were harvested. Nearly 140 million acres would be needed to produce enough corn and subsequent ethanol to substitute for 50% of petroleum

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[27] Dry milling and wet milling production shares are from the Renewable Fuels Association, *Ethanol Industry Outlook 2006*. Ethanol yield rates are from Shapouri et al., AER 813 (2002), p. 9. According to USDA, dry milling is more energy efficient than wet milling, particularly when corn co-products are considered. These ethanol yield rates have been improving gradually overtime with technological improvements in the efficiency of ethanol processing from corn.

[28] H. Shapouri, J. Duffield, and M. Wang, *New Estimates of the Energy Balance of Corn Ethanol*, presented at 2004 Corn Utilization & Technology Conference of the Corn Refiners Association, June 7-9, 2004, Indianapolis, IN (hereafter cited as Shapouri (2004)).

[29] Professor David Pimentel, Cornell University, College of Agriculture and Life Sciences, has researched and published extensive criticisms of corn-based ethanol production.

[30] Alexander E. Farrel, Richard J. Plevin, Brian T. Turner, Andrew D. Jones, Michael O'Hare, and Daniel M. Kammen, "Ethanol Can Contribute to Energy and Environmental Goals," *Science*, vol. 311 (Jan. 27, 2006), pp. 506-508.

[31] DOE, EIA, *Annual Energy Outlook 2004 with Projections to 2025*.

[32] Based on USDA's Nov. 12, 2004, WASDE, and using comparable conversion rates.

imports (or 27% of total U.S. petroleum consumption).[33] Since 1970, corn harvested acres have never reached 76 million acres. Thus, barring a drastic realignment of U.S. field crop production patterns, corn-based ethanol's potential as a petroleum import substitute appears to be limited by a crop area constraint.

Domestic and international demand places additional limitations on corn use for ethanol production in the United States. Corn traditionally represents about 57% of feed concentrates and processed feedstuffs fed to animals in the United States.[34] Also, the United States is the world's leading corn exporter, with nearly a 66% share of world trade during the past decade. In 2005/06, the United States is expected to export about 19% of its corn production.

Growth in corn-for-ethanol use would reduce both exports and domestic feed use of corn unless accompanied by offsetting growth in domestic production. There is an inherent tradeoff in using a widely consumed agricultural product for a non-agricultural use. As corn-based ethanol production increases, so does total corn demand and corn prices. Higher corn prices, in turn, mean higher feed costs for cattle, hog, and poultry producers. The corn co-products from ethanol processing would likely substitute for some of the lost feed value of corn used in ethanol processing.[35] However, about 66% of the original weight of corn is consumed in producing ethanol and is no longer available for feed.[36] Higher corn prices would also likely result in lost export sales. International feed markets are very price sensitive as several different grains and feedstuffs are relatively close substitutes. A sharp rise in U.S. corn prices would likely result in a more than proportionate decline in corn exports.

Furthermore, as ethanol production increases, the energy needed to process the corn into ethanol (derived primarily from natural gas) would increase. For example, an estimated 209 billion cu. ft. of natural gas was used to process the 1.6 billion bushels of corn into ethanol from the 2005 crop.[37] The energy needed to process the entire 2005 corn crop of 11.1 billion bushels into ethanol would be approximately 1.5 trillion cubic feet of natural gas. Total U.S. natural gas consumption was an estimated 22.2 trillion cu. ft. in 2005.[38] The United States has been a net importer of natural gas since the early 1980s. Because natural gas is used extensively in electricity production in the United States, significant increases in its use as a

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[33] Assuming corn yields of 150 bushel per acre, and an ethanol yield of 2.7 gal/bu.

[34] USDA, ERS, *Feed Situation and Outlook Yearbook*, FDS-2003, Apr. 2003.

[35] For a discussion of potential feed market effects due to growing ethanol production, see Bob Kohlmeyer, "The Other Side of Ethanol's Bonanza," *Ag Perspectives* (World Perspectives, Inc.), Dec. 14, 2004; and R. Wisner and P. Baumel, "Ethanol, Exports, and Livestock: Will There be Enough Corn to Supply Future Needs?," *Feedstuffs*, no. 30, vol. 76, July 26, 2004.

[36] Shapouri (2004), p. 4.

[37] CRS calculations based on Shapouri (2004) energy usage rates: 49,733 Btu/gal of ethanol; 1.6 billion bushels of corn processed into 4.3 billion gallons at 2.7 gal/bu.

[38] DOE, EIA, *Annual Energy Outlook 2006 with Projections to 2030*, Table 1-Total Energy Supply and Disposition Summary; at [http://www.eia.doe.gov/oiaf/aeo/index.html].

processing fuel in the production of ethanol would likely result in substantial increases in both prices and imports of natural gas.

These supply issues suggest that corn's long-run potential as an ethanol feedstock is somewhat limited. According to the DOE, the cost of producing and transporting ethanol will continue to limit its use as a renewable fuel; ethanol relies heavily on federal and state support to remain economically viable; and the supply of ethanol is extremely sensitive to corn prices, as seen in 1996 when record farm prices received for corn led to a sharp reduction in U.S. ethanol production. Finally, DOE suggests that the ability to produce ethanol from low-cost biomass will ultimately be the key to making it competitive as a gasoline additive.[39]

In contrast to expanded biofuel production, research suggests that far greater fuel economies could be obtained by a small adjustment in existing vehicle mileage requirements. For example, an increase in fuel economy of one mile per gallon across all passenger vehicles in the United States has been estimated to cut petroleum consumption by more than all alternative fuels and replacement fuels combined.[40]

Ethanol from Cellulosic Biomass Crops.[41] Besides corn, several other agricultural products are viable feedstocks and appear to offer long-term supply potential — particularly cellulose-based feedstocks. For example, an emerging cellulosic feedstock with apparently large potential as an ethanol feedstock is switchgrass, a native grass that thrives on marginal lands as well as on prime cropland, and needs little water and no fertilizer. The opening of Conservation Reserve Program (CRP) land to switchgrass production under Section 2101 of the 2002 farm bill (P.L. 107-171) has helped to spur interest in its use as a cellulosic feedstock for ethanol production. Other potential cellulose-to-ethanol feedstocks include fast-growing woody crops such as hybrid poplar and willow trees, as well as waste biomass materials — logging residues, wood processing mill residues, urban wood wastes, and selected agricultural residues such as sugar cane bagasse and rice straw.

The main impediment to the development of a cellulose-based ethanol industry is the state of cellulosic conversion technology (i.e., the process of gassifying cellulose-based feedstocks or converting them into fermentable sugars). Currently, cellulosic conversion technology is rudimentary and expensive. As a result, no commercial cellulose-to-ethanol facilities are in operation in the United States, although plans to build several facilities are underway. On April 21, 2004, Iogen —

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[39] DOE, EIA, "Outlook for Biomass Ethanol Production and Demand," by Joseph DiPardo, July 30, 2002, available at [http://www.eia.doe.gov/oiaf/analysispaper/biomass.html]; hereafter referred to as DiPardo (2002).

[40] CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues*, by Brent D. Yacobucci.

[41] For more information on biomass from non-traditional crops as a renewable energy, see the DOE, EERE, Biomass Program, "Biomass Feedstocks," at [http://www1.eere.energy.gov/biomass/biomass_feedstocks.html]. See also, *Ethanol From Cellulose: A General Review*, P.C.Badger, Purdue University, Center for New Crops and Plant Products at [http://www.hort.purdue.edu/newcrop/ncnu02/v5-017.html].

a Canadian firm — became the first firm to successfully engage in the commercial production of cellulosic ethanol (from wheat straw) at a large-scale demonstration plant in Ottawa.[42]

Economic Efficiency. The conversion of cellulosic feedstocks to ethanol parallels the corn conversion process, except that the cellulose must first be converted to fermentable sugars. As a result, the key factors underlying cellulosic-based ethanol's price competitiveness are essentially the same as for corn-based ethanol, with the addition of the cost of cellulosic conversion.

Cellulosic feedstocks are significantly less expensive than corn; however, at present they are more costly to convert to ethanol because of the extensive processing required. Currently, cellulosic conversion is done using either dilute or concentrated acid hydrolysis — both processes are prohibitively expensive. However, the DOE suggests that enzymatic hydrolysis, which processes cellulose into sugar using cellulase enzymes, offers both processing advantages as well as the greatest potential for cost reductions. Current cost estimates of cellulase enzymes range from 30¢ to 50¢ per gallon of ethanol.[43] The DOE is also studying thermal hydrolysis as a potentially more cost-effective method for processing cellulose into sugar.

Based on the state of existing technologies and their potential for improvement, the DOE estimates that improvements to enzymatic hydrolysis could eventually bring the cost to less than 5¢ per gallon, but this may still be a decade or more away. Were this to happen, then the significantly lower cost of cellulosic feedstocks would make cellulosic-based ethanol dramatically less expensive than corn-based ethanol and gasoline at current prices.

Iogen's breakthrough involved the successful use of recombinant DNA-produced enzymes to break apart cellulose to produce sugar for fermentation into ethanol. Both the DOE and USDA are funding research to improve cellulosic conversion as well as to breed higher yielding cellulosic crops. In 1978, the DOE established the Bioenergy Feedstock Development Program (BFDP) at the Oak Ridge National Laboratory. The BFDP is engaged in the development of new crops and cropping systems that can be used as dedicated bioenergy feedstocks. Some of the crops showing good cellulosic production per acre with strong potential for further gains include fast-growing trees (e.g., hybrid poplars and willows), shrubs, and grasses (e.g., switchgrass).

Government Support. Although no commercial cellulosic ethanol production has occurred yet in the United States, two provisions of the 2002 farm bill (P.L. 107-171) and several provision of the Energy Policy Act of 2005 (EPACT; P.L. 109-58) have encouraged research in this area. The first provision (Section 2101) allows for the use of Conservation Reserve Program lands for wind energy generation and biomass harvesting for energy production and has helped to spur interest in hardy biofuel feedstocks that are able to thrive on marginal lands. Another provision

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[42] For more information visit Iogen Corporation's website at [http://www.iogen.ca/].

[43] DOE, EERE, *Biomass Program*, "Cellulase Enzyme Research," available at [http://www1.eere.energy.gov/biomass/cellulase_enzyme.html].

(Section 9008) provides competitive funding for research and development projects on biofuels and bio-based chemicals in an attempt to motivate further production and use of non-traditional biomass feedstocks.[44] EPACT's biomass provisions are discussed later in the report (see "Public Laws That Support Agriculture-Based Energy Production and Use," below).

Energy Efficiency. The use of cellulosic biomass in the production of ethanol yields a higher net energy balance compared to corn — a 34% net gain for corn vs. a 100% gain for cellulosic biomass — based on a 1999 comparative study.[45] While corn's net energy balance (under optimistic assumptions concerning corn production and ethanol processing technology) was estimated at 67% by USDA in 2004, it is likely that cellulosic biomass's net energy balance would also have experienced parallel gains for the same reasons — improved crop yields and production practices, and improved processing technology.

Long-Run Supply Issues. Cellulosic feedstocks have an advantage over corn in that they grow well on marginal lands, whereas corn requires fertile cropland (as well as timely water and the addition of soil amendments). This greatly expands the potential area for growing cellulosic feedstocks relative to corn. For example, in 2001 nearly 76 million acres were planted to corn, out of 244 million acres planted to the eight major field crops (corn, soybeans, wheat, cotton, barley, sorghum, oats, and rice). In contrast, that same year the United States had 433 million acres of total cropland (including forage crops and temporarily idled cropland) and 578 million acres of permanent pastureland, most of which is potentially viable for switchgrass production.[46]

A 2003 USDA study suggests that if 42 million acres of cropped, idle, pasture, and CRP acres were converted to switchgrass production, 188 million dry tons of switchgrass could be produced annually (at an implied yield of 4.5 metric tons per acre), resulting in the production of 16.7 billion gallons of ethanol or 10.9 billion GEG.[47] This would represent about 8% of U.S. gasoline use in 2004. Existing research plots have produced switchgrass yields of 15 dry tons per acre per year, suggesting tremendous long-run production potential. However, before any supply potential can be realized, research must first overcome the cellulosic conversion cost issue through technological developments.

In a 2005 study of U.S. biomass potential, USDA concluded that U.S. forestland and agricultural land had the potential to produce over 1.3 billion dry tons per year

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[44] For more information, see Biomass Research and Development Initiative, USDA/DOE, at [http://www.biomass.govtools.us/].

[45] Argonne National Laboratory, Center for Transportation Research, *Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas*, ANL/ESD-38, by M. Wang, C. Saricks, and D. Santini, Jan. 1999, as referenced in DOE, DiPardo (2002).

[46] United Nations, Food and Agricultural Organization (FAO), FAOSTATS.

[47] USDA, Office of Energy Policy and New Uses (OEPNU), *The Economic Impacts of Bioenergy Crop Production on U.S. Agriculture*, AER 816, by Daniel De La Torre Ugarte et al., Feb. 2003; available at [http://www.usda.gov/oce/reports/energy/index.htm].

of biomass — 368 million dry tons from forestlands and 998 million dry tons from agricultural lands — while still continuing to meet food, feed, and export demands.[48] According to the study, this volume of biomass would be more than ample to displace 30% or more of current U.S. petroleum consumption.

USDA's very optimistic assessment is tempered somewhat by a 2005 University of Minnesota study that uses the results from three major biofuels studies to estimate the potential supplies of biofuels from both corn-based ethanol and cellulosic-based ethanol from biomass crops and crop residue.[49] The analysis suggests that about 130.4 million tons of biomass could be produced directly from switchgrass with another 130.5 million tons from crop residue. If the biomass total of 260.9 million tons were converted to ethanol at a rate of 89.7 gallons per ton, it would produce 23.4 billion gallons of anhydrous ethanol. Adding 2% denaturant yields 23.9 billion gallons. Adding an additional 7 billion gallons of corn-based ethanol brings the total to 30.9 billion gallons or about 22.7% of total U.S. gasoline consumption in 2004.

Methane from an Anaerobic Digester

An anaerobic digester is a device that promotes the decomposition of manure or "digestion" of the organics in manure by anaerobic bacteria (in the absence of oxygen) to simple organics while producing biogas as a waste product.[50] The principal components of biogas from this process are methane (60% to 70%), carbon dioxide (30% to 40%), and trace amounts of other gases. Methane is the major component of the natural gas used in many homes for cooking and heating, and is a significant fuel in electricity production. Biogas can also be used as a fuel in a hot water heater if hydrogen sulfide is first removed from the biogas supply. As a result, the generation and use of biogas can significantly reduce the cost of electricity and other farm fuels such as natural gas, propane, and fuel oil.

By early 2005, there were 100 digester systems in operation at commercial U.S. livestock farms, with an additional 94 planned for construction.[51] EPA estimates that anaerobic digester biogas systems are technically feasible at about 7,000 dairy and swine operations in the United States. The majority of existing systems are farm

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[48] USDA and DOE. *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, April 2005; available at [http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf].

[49] Eidman, Vernon R. *Agriculture's Role in Energy Production: Current Levels and Future Prospects*, paper presented at a conference, "Energy from Agriculture: New Technologies, Innovative Programs and Success Stories," Dec. 14-15, 2005, St. Louis, Missouri. The three studies used to generate the estimate are listed in the "For More Information" section as FAPRI (2005); Ugarte et al (2003); and Gallagher et al (2003).

[50] For more information on anaerobic digesters, see Appropriate Technology Transfer for Rural Areas (ATTRA), *Anaerobic Digestion of Animal Wastes: Factors to Consider*, by John Balsam, Oct. 2002, at [http://www.attra.ncat.org/energy.html#Renewable]; or Iowa State University, Agricultural Marketing Resource Center, *Anaerobic Digesters*, at [http://www.agmrc.org/agmrc/commodity/biomass/].

[51] U.S. Environmental Protection Agency (EPA), *AgStar Digest*, Winter 2006; available at [http://www.epa.gov/agstar/].

owned and operated using only livestock manure, and are found in the dairy production zones of California, Wisconsin, Pennsylvania, and New York. In 2005, they are estimated to have generated over 130 million kWh and to have reduced nethane emissions by over 30,000 metric tons.

Anaerobic digestion system proposals have frequently received funding under the Renewable Energy Program (REP) of the 2002 farm bill (P.L. 107-171, Title IX, Section 9006). For example, in 2004 37 anaerobic digester proposals from 26 different states were awarded funding under the REP.[52] Also, the AgStar program — a voluntary cooperative effort by USDA, EPA, and DOE — encourages methane recovery at confined livestock operations that manage manure as liquid slurries.

Economic Efficiency. The primary benefits of anaerobic digestion are animal waste management, odor control, nutrient recycling, greenhouse gas reduction, and water quality protection. Except in very large systems, biogas production is a highly useful but secondary benefit. As a result, anaerobic digestion systems do not effectively compete with other renewable energy production systems on the basis of energy production alone. Instead, they compete with and are cost-competitive when compared to conventional waste management practices according to EPA.[53] Depending on the infrastructure design — generally some combination of storage pond, covered or aerated treatment lagoon, heated digester, and open storage tank — anaerobic digestion systems can range in investment cost from $200 to $500 per Animal Unit (i.e., per 1,000 pounds of live weight). In addition to the initial infrastructure investment, recurring costs include manure and effluent handling, and general maintenance. According to EPA, these systems can have financially attractive payback periods of three to seven years when energy gas uses are employed. On average, manure from a lactating 1,400-pound dairy cow can generate enough biogas to produce 550 Kilowatts per year.[54] A 200-head dairy herd could generate 500 to 600 Kilowatts per day. At 6¢ per kilowatt hour, this would represent potential energy cost savings of $6,000 to $10,000 per year.

The principal by-product of anaerobic digestion is the effluent (i.e., the digested manure). Because anaerobic digestion substantially reduces ammonia losses, the effluent is more nitrogen-rich than untreated manure, making it more valuable for subsequent field application. Also, digested manure is high in fiber, making it valuable as a high-quality potting soil ingredient or mulch. Other cost savings include lower total lagoon volume requirements for animal waste management systems (which reduces excavation costs and the land area requirement), and lower cover costs because of smaller lagoon surface areas.

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[52] USDA, News Release No. 0386.04, Sept. 15, 2004; *Veneman Announces $22.8 Million to Support Renewable Energy Initiatives in 26 States*, available at [http://www.usda.gov/Newsroom/0386.04.html]. For funding and program information on the Renewable Energy and Energy Efficiency Program, see [http://www.rurdev.usda.gov/rd/energy/].

[53] EPA, OAR, *Managing Manure with Biogas Recovery Systems*, EPA-430-F-02-004, winter 2002.

[54] ATTRA, *Anaerobic Digestion of Animal Wastes: Factors to Consider*, Oct. 2002.

Government Support. Federal assistance in the form of grants, loans, and loan guarantees is available under USDA's Renewable Energy Program (2002 farm bill, Title IX, Section 9006) and Rural Development Programs (Title VI, Sections 6013, 6017, and 6401). See the section below on public laws for more details.

Energy Efficiency. Because biogas is essentially a by-product of an animal waste management activity, and because the biogas produced by the system can be used to operate the system, the energy output from an anaerobic digestion system can be viewed as achieving even or positive energy balance. The principal energy input would be the fuel used to operate the manure handling equipment.

Long-Run Supply Issues. Anaerobic digesters are most feasible alongside large confined animal feeding operations (CAFOs). According to EPA, biogas production for generating cost effective electricity requires manure from more than 500 cows at a dairy operation or at least 2,000 head of swine at a pig feeding operation. As animal feeding operations steadily increase in size, the opportunity for anaerobic digestion systems will likewise increase. In addition, some digester systems may qualify for cost-share funds under USDA's Environmental Quality Incentives Program (EQIP).

Biodiesel

Biodiesel is an alternative diesel fuel that is produced from any animal fat or vegetable oil (such as soybean oil or recycled cooking oil). About 90% of U.S. biodiesel is made from soybean oil. As a result, U.S. soybean producers and the American Soybean Association (ASA) are strong advocates for greater government support for biodiesel production.

According to the National Biodiesel Board (NBB), biodiesel is nontoxic, biodegradable, and essentially free of sulfur and aromatics. In addition, it works in any diesel engine with few or no modifications and offers similar fuel economy, horsepower, and torque, but with superior lubricity and important emission improvements over petroleum diesel.[55] Biodiesel is increasingly being adopted by major fleets nationwide. The U.S. Postal Service, the U.S. military, and many state governments are directing their bus and truck fleets to incorporate biodiesel fuels as part of their fuel base.

U.S. biodiesel production has shown strong growth in recent years, increasing from under 1 million gallons in 1999 to an estimated 75 million gallons in 2005 (**Figure 4**). However, U.S. biodiesel production remains small relative to national diesel consumption levels. In 2004, biodiesel production of 33 million gallons represented 0.08% of the 43,852 million gallons of diesel fuel used nationally for vehicle transportation.[56] In addition to vehicle use, 17,892 million gallons of diesel fuel were used for heating and power generation by residential, commercial, and

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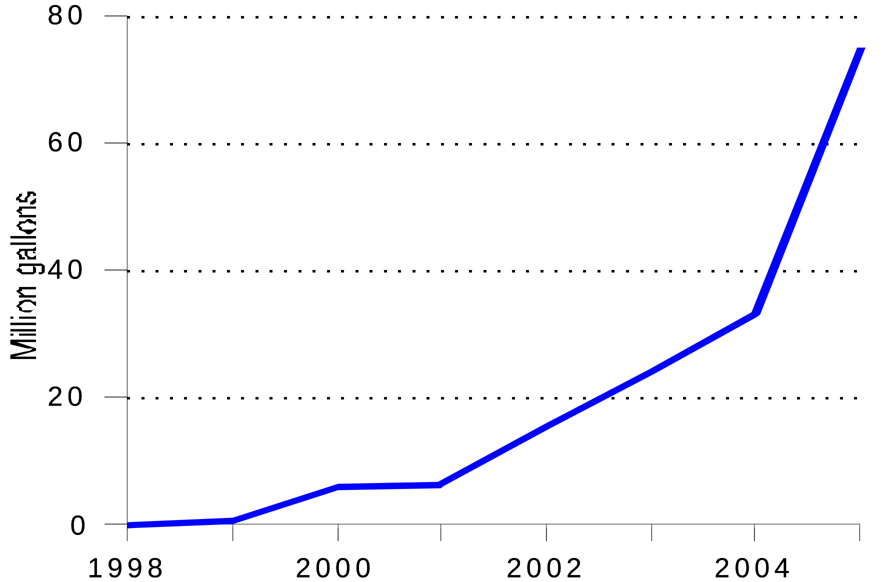
[55] For more information, visit the National Biodiesel Board at [http://www.biodiesel.org].

[56] Biodiesel consumption estimates are from DOE, IEA, "Alternatives to Traditional Transportation Fuels 2003, Estimated Data."

industry, and by railroad and vessel traffic in 2004, bringing total U.S. diesel fuel use to nearly 62,384 million gallons (**Table 5**).

Figure 4. U.S. Biodiesel Production, 1998-2005



Source: 1998-2004: DOE, EIA, [http://www.eia.doe.gov/cneaf/alternate/page/datatables/aft1-13_03.html]; and 2005: National Biodiesel Board; [www.biodiesel.org.]

According to the NBB, as of May 1, 2006, there were 65 companies producing and marketing biodiesel commercially in the United States, and another 50 new firms that are reportedly under construction or are scheduled to be completed within the next 18 months.[57] The NBB reported that early 2006 U.S. biodiesel production capacity (within the oleochemical industry) was an estimated 395 million gallons per year, but would add another 713.7 million gallons within the next 18 months. Because many of these plants also can produce other products such as cosmetics, estimated total capacity (and capacity for expansion) is far greater than actual biodiesel production.

Economic Efficiency. The cost of producing biodiesel is generally more than the cost of producing its fossil fuel counterpart. A 2004 DOE study suggests that, since the cost of the feedstock (whether vegetable oil or restaurant grease) is the largest single component of biodiesel prodcution, the cost of producing biodiesel varies substantially with the choice of feedstock.[58] For example, in 2004/05 it costs $0.67 to produce a gallon of petroleum-based diesel, compared with about $2.54 to produce a gallon of biodiesel from soybean oil, and $1.41 from restaurant grease (all prices are quoted in 2002 dollars).

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[57] A description of biodiesel production capacity with maps of existing and proposed plants is available at [http://www.biodiesel.org/resources/fuelfactsheets/default.shtm].

[58] Radich, Anthony. "Biodiesel Performance, Costs, and Use," Modeling and Analysis Papers, DOE/EIA, June 2004; available at [http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/].

Table 5. U.S. Diesel Fuel Use, 2004

U.S. Diesel Use in 2004	Total: Million gallons[a]	Total: %	Hypothetical scenario: 1% of total use[b]: Million gallons	Hypothetical scenario: 1% of total use[b]: Soybean oil equivalents: million pounds[a]
Total Vehicle Use	43,852	70%	439	3,377
On-Road	37,125	60%	371	2,859
Off-Road	2,861	5%	29	220
Military	359	1%	4	28
Farm	3,508	6%	35	270
Total Non-vehicle Use	18,532	30%	185	1,427
All uses	62,384	100%	624	4,804

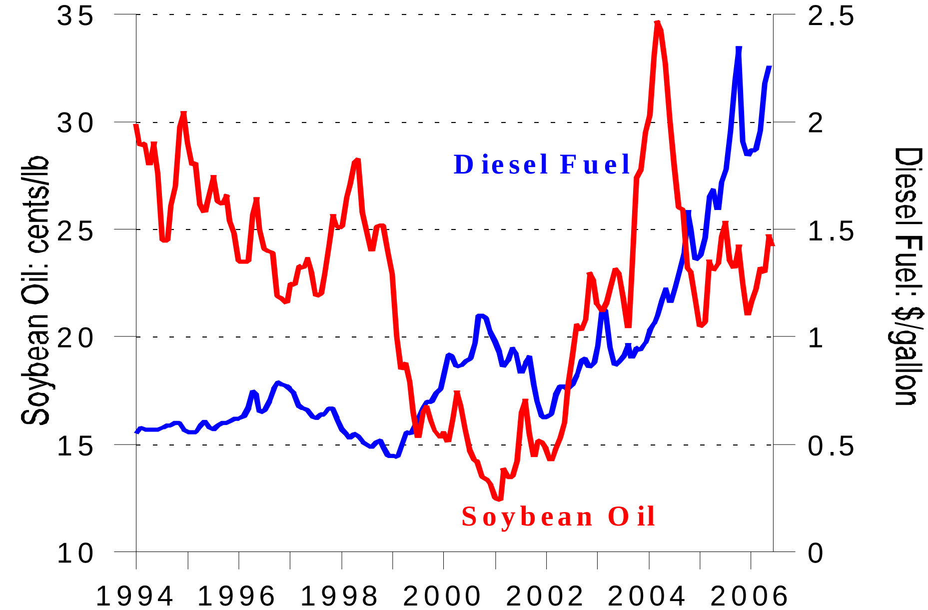
Source: DOE, EIA, *U.S. Annual Adjusted Sales of Distillate Fuel Oil by End Use*.

a. Pounds are converted from gallons of oil using a 7.7 pounds-to-gallon conversion rate.
b. Hypothetical scenario included for comparison purposes only.

The production cost differentials manifest themselves at the retail level as well. During January-February 2006, the retail price of B20 (a blend of 20% biodiesel with 80% conventional diesel) averaged $2.64 per gallon compared with $2.56 for conventional diesel fuel (**Table 2**). The approximate price difference of 8¢ on a 20% blend implies that pure (100%) biodiesel costs as much as 40¢ more per gallon to produce. However, this price differential is more than offset by the current federal tax credit of $1.00 per gallon available to producers of agriculture-based biodiesel (see next section for details).

The prices of biodiesel feedstocks, as well as petroleum-based diesel fuel, vary over time based on domestic and international supply and demand conditions. About 7.5 pounds of soybean oil are needed to produce a gallon of biodiesel. A comparison of the relative price relationship between soybean oil and petroleum diesel is indicative of the general economic viability of biodiesel production (**Figure 5**). As diesel fuel prices rise relative to biodiesel or biodiesel feedstocks, and/or as biodiesel production costs fall through lower commodity prices or technological improvements in the production process, biodiesel becomes more economical. In addition, federal and state assistance helps to make biodiesel more competitive with diesel fuel.

Figure 5. Soybean Oil vs. Diesel Fuel Price, 1994-2006



Source: No. 2 diesel fuel commercial price: DOE, EIA; soybean oil, Decatur, IL: USDA, FAS "Oilseed Circular."

Government Support. The primary federal incentives for biodiesel production are somewhat similar to ethanol and include the following.[59]

- A production excise tax credit signed into law on October 22, 2004, as part of the American Jobs Creation Act of 2004 (Sec. 1344; P.L. 109-58). Under the biodiesel production tax credit, the subsidy amounts to $1.00 for every gallon of agri-biodiesel (i.e., virgin vegetable oil and animal fat) that is used in blending with petroleum diesel. A 50¢ credit is available for every gallon of non-agri-biodiesel (i.e., recycled oils such as yellow grease). However, unlike the ethanol tax credit, which was extended through 2010, the biodiesel tax credit expires at the end of calendar year 2008.
- A small producer income tax credit (Sec. 1345; P.L. 109-58) of 10¢ per gallon for the first 15 million gallons of production for biodiesel producers whose total output does not exceed 60 million gallons of biodiesel per year.
- Incentive payments (contingent on annual appropriations) on year-to-year production increases of renewable energy under USDA's Bioenergy Program (7 U.S.C. 8108).

Indirectly, other federal programs support biodiesel production by requiring federal agencies to give preference to biobased products in purchasing fuels and other supplies and by providing incentives for research on renewable fuels. Also, several states have their own incentives, regulations, and programs in support of renewable

[59] See also section on "Public Laws That Support Agriculture-Based Energy Production and Use," below.

fuel research, production, and consumption that supplement or exceed federal incentives.

Energy Efficiency. Biodiesel appears to have a significantly better net energy balance than ethanol, according to a joint USDA-DOE 1998 study that found biodiesel to have an NEB of 3.2 — that is, 220% more energy was returned from a gallon of pure biodiesel than was used in its production.[60] In contrast, the study authors point out that petroleum diesel has an NEB of 0.83 — that is, 17% less energy was returned from a gallon of petroleum diesel than was used in its life cycle from source to user.

Long-Run Supply Issues. Both the ASA and the NBB are optimistic that the federal biodiesel tax incentive will provide the same boost to biodiesel production that ethanol has obtained from its federal tax incentive.[61] However, many commodity market analysts are skeptical of such claims. They contend that the biodiesel industry still faces several hurdles: the retail distribution network for biodiesel has yet to be established; the federal tax credit, which expires on December 31, 2008, does not provide sufficient time for the industry to develop; and potential domestic oil feedstocks are relatively less abundant than ethanol feedstocks, making the long-run outlook more uncertain.

In addition, biodiesel production confronts the same limited ability to substitute for petroleum imports and the same type of consumption tradeoffs as ethanol production. As an example consider a hypothetical scenario (as shown in **Table 6**) whereby 1% of current vehicle diesel fuel use were to originate from biodiesel sources (excluding non-vehicle use). This hypothetical mandate would require about 439 million gallons of biodiesel (compared to current production of about 75 million gallons) or approximately 3.4 billion pounds of vegetable oil. During 2004, a total of 32.9 billion pounds of vegetable oils and animal fats were produced in the United States (**Table 6**); however, most of this production was committed to other food and industrial uses. Uncommitted biodiesel feedstocks (as measured by the available stock levels on September 30, 2004) were 2.1 billion pounds. Thus, after exhausting all available feedstocks, an additional 1.3 billion pounds of oil would be needed to meet the hypothetical 1% biodiesel blending requirement. This is equivalent to the 1.3 billion pounds of soybean oil exported by the United States in 2004/05.

If U.S. soybean oil exports were to remain unchanged, the deficit biodiesel feedstock could be obtained either by reducing U.S. whole soybean exports by about 127 million bushels (then crushing them for their oil) or by expanding soybean production by approximately 3.0 million acres (assuming a yield of about 42 bushels per acre). Of course, any area expansion would likely come at the expense of some other crop such as corn, cotton, or wheat. A further possibility is that U.S. oilseed

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[60] DOE, National Renewable Energy Laboratory (NREL), *An Overview of Biodiesel and Petroleum Diesel Life Cycles*, NREL/TP-580-24772, by John Sheehan et al., May 1998, available at [http://www.biodiesel.com/Biodiesel%20Life%20Cycle.pdf].

[61] For more information, see NBB, "Ground-Breaking Biodiesel Tax Incentive Passes," at [http://www.biodiesel.org/resources/pressreleases/gen/20041011_FSC_Passes_Senate.pdf].

producers could shift towards the production of higher-oil content crops such as canola or sunflower.

Table 6. U.S. Potential Biodiesel Feedstocks, 2004-2005

Oil type	Wholesale price[a] $/lb	Oil Production, 2004-05		Ending Stocks: Sept. 30, 2005	
		Million pounds	Million gallons[b]	Million pounds	Million gallons[b]
Crops		**24,022**	**3,120**	**1,614**	**210**
Soybean	28.6	19,360	2,514	1,076	140
Corn	27.7	2,392	311	153	20
Cottonseed	28.9	957	124	109	14
Sunflowerseed	34.1	265	34	40	5
Canola	33.1	601	78	68	9
Peanut	57.6	126	16	99	13
Flaxseed/linseed	48.5	265	34	45	6
Safflower	69	56	7	24	3
Animal fat & other[d]		**8,924**	**1,130**	**307**	**40**
Lard	26.4	775	101	14	2
Edible tallow	19.7	1,779	231	22	3
Inedible tallow	na	4,847	629	231	30
Yellow grease	11.6	1,523	198	40	5
Total supply		**32,946**	**4,279**	**1,921**	**249**

Source: USDA, ERS, *Oil Crops Yearbook*, OCS-2006, March 2006, Table 31. Rapeseed was calculated by multiplying oil production by a 40% conversion rate. The inedible tallow and yellow grease supplies come from Dept of Commerce, Bureau of Census, *Fats and Oils, Production, Consumption and Stocks, Annual Summary 2005*.

na = not available.

a. Average of monthly price quotes for vegetable oils are for 2004/05 marketing years (Oct. to Sept.). USDA, ERS, *Oil Crops Outlook*, OCS-2006. Lard and edible tallow prices are for calendar 2004. Yellow grease price is 1993-95 average from USDA, ERS, AER 770, Sept. 1998, p. 9.
b. Pounds are converted to gallons of oil using a 7.7 pounds-to-gallon conversion rate.
c. Rapeseed oil, f.o.b., Rotterdam; USDA, FAS, *Oilseeds: World Market and Trade*, various issues.
d. Production and stock data for "Animal Fat & Other" is for calendar 2004.

The bottom line is that a small increase in demand of fats and oils for biodiesel production could quickly exhaust available feedstock supplies and push vegetable oil prices significantly higher due to the low elasticity of demand for vegetable oils in food consumption.[62] Rising vegetable oil prices would reduce or eliminate

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[62] ERS reported the U.S. own-price elasticity for "oils & fats" at -0.027 — i.e., a 10% increase in price would result in a 0.27% decline in consumption. In other words, demand (continued...)

biodiesel's competitive advantage vis-à-vis petroleum diesel, even with the federal tax credit. At the same time, increased oilseed crushing would begin to disturb feed markets.

As with ethanol production, increased soybean oil production (dedicated to biodiesel production) would generate substantial increases in animal feeds in the form of high-protein meals. When a bushel of soybeans is processed (or crushed), nearly 80% of the resultant output is in the form of soybean meal, while only about 18%-19% is output as soybean oil. Thus, for every 1 pound of soybean oil produced by crushing whole soybeans, over 4 pounds of soybean meal are also produced.

Crushing an additional 127 million bushels of soybeans for soybean oil would produce over 3 million short tons (s.t.) of soybean meal. In 2004/05, the United States produced 40.7 million s.t. of soybean meal. An additional 3 million s.t. of soybean meal (an increase of 7.3%) entering U.S. feed markets would compete directly with the feed by-products of ethanol production (distillers dried grains, corn gluten feed, and corn gluten meal) with economic ramifications that have not yet been fully explored.[63] Also similar to ethanol production, natural gas demand would likely rise with the increase in biodiesel processing.[64]

Wind Energy Systems

In 2004, electricity from wind energy systems accounted for about 0.1% of U.S. total energy consumption (**Table 1**). However, wind-generated electricity was a much larger share of electricity used by the U.S. agriculture sector (28%), and of total direct energy used by U.S. agriculture (9%).[65] According to the American Wind Energy Association (AWEA), total installed wind energy production capacity has expanded rapidly in the United States since the late 1990s, rising from 1,848 megawatts (MW) in 1998 to a reported 9,141 MW through 2005 (**Figure 6**).[66] By May 2006, the AWEA reported that the U.S. wind industry was on pace to install an additional 3,000 MW in 2006. About 86% of production capacity is in 10 predominantly midwestern and western states (see **Table 7**). (See "Box: Primer on

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[62] (...continued)
declines only negligibly relative to a price rise. Such inelastic demand is associated with sharp price spikes in periods of supply shortfall. USDA, ERS, *International Evidence on Food Consumption Patterns*, Tech. Bulletin No. 1904, Sept. 2003, p. 67.

[63] For a discussion of potential feed market consequences from domestic ethanol industry expansion, see Wisner and Baumel in *Feedstuffs*, no. 30, vol. 76, July 26, 2004.

[64] Assuming natural gas is the processing fuel, natural gas demand would increase due to two factors: (1) to produce the steam and process heat in oilseed crushing and (2) to produce methanol used in the conversion step. NREL, *An Overview of Biodiesel and Petroleum Diesel Life Cycles*, NREL/TP-580-24772, by John Sheehan et al., May 1998, p. 19.

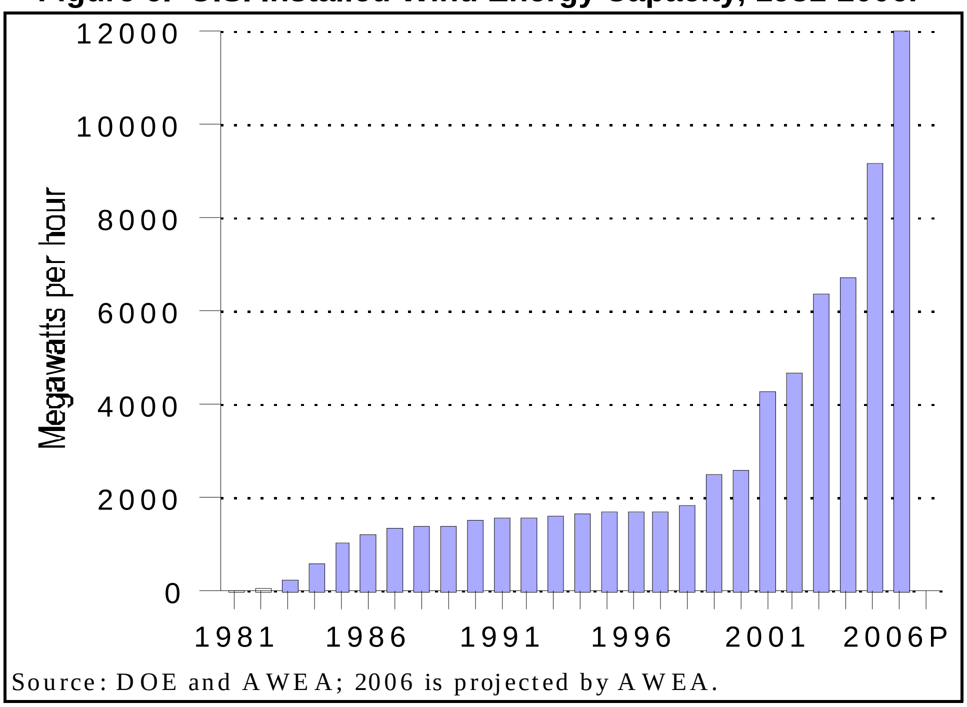
[65] Data for agricultural use of wind-generated electricity is for 2003. For more information on energy consumption by U.S. agriculture, see CRS Report RL32677, *Energy Use in Agriculture: Background and Issues*, by Randy Schnepf.

[66] American Wind Energy Association (AWEA), at [http://www.awea.org/projects/].

Measuring Electric Energy" later in this report for a description of megawatts and other energy terminology.)

What Is Behind the Rapid Growth of Installed Capacity? Over the past 20 years, the cost of wind power has fallen approximately 90%, while rising natural gas prices have pushed up costs for gas-fired power plants, helping to improve wind energy's market competitiveness.[67] In addition, wind-generated electricity production and use is supported by several federal and state financial and tax incentives, loan and grant programs, and renewable portfolio standards. By September 2005, renewable portfolio standards (RPSs) had been adopted by 21 states and the District of Columbia. An RPS requires that utilities must derive a certain percentage of their overall electric generation from renewable energy sources such as wind power.[68] Environmental and energy security concerns also have encouraged interest in clean, renewable energy sources such as wind power. Finally, rural incomes receive a boost from companies installing wind turbines in rural areas. Landowners have typically received annual lease fees that range from $2,000 to $5,000 per turbine per year for up to 20 years depending on factors such as the project size, the capacity of the turbines, and the amount of electricity produced.

Figure 6. U.S. Installed Wind Energy Capacity, 1981-2006P



Economic Efficiency. The per-unit cost of utility-scale wind energy is the sum of the various costs — capital, operations, and maintenance — divided by the annual energy generation. Utility-scale wind power projects — those projects that generate at least 1 MW of electric power annually for sale to a local utility — account

[67] AWEA, *The Economics of Wind Energy*, Mar. 2002.

[68] AWEA, "State-Level Renewable Energy Portfolio Standards," Sept. 2, 2005; available at [http://www.awea.org/pubs/factsheets/0509-RPS_Progresses_in_States.pdf].

for over 90% of wind power generation in the United States.[69] For utility-scale sources of wind power, a number of turbines are usually built close together to form a wind farm.

In contrast with biofuel energy, wind power has no fuel costs. Instead, electricity production depends on the kinetic energy of wind (replenished through atmospheric processes). As a result, its operating costs are lower than costs for power generated from biofuels. However, the initial capital investment in equipment needed to set up a utility-scale wind energy system is substantially greater than for competing fossil or biofuels. Major infrastructure costs include the tower (30 meters or higher) and the turbine blades (generally constructed of fiberglass; up to 20 meters in length; and weighing several thousand pounds). Capital costs generally run about $1 million per MW of capacity, so a wind energy system of 10 1.5-MW turbines would cost about $15 million. Farmers generally find leasing their land for wind power projects easier than owning projects. Leasing is easier because energy companies can better address the costs, technical issues, tax advantages, and risks of wind projects. In 2004, less than 1% of wind power capacity installed nationwide was owned by farmers.[70]

Table 7. Installed Wind Energy Capacity by State, January 24, 2006

State	Megawatts	Share	Cumulative %
California	2,150	23.5%	23.5%
Texas	1,995	21.8%	45.3%
Iowa	836	9.1%	54.4%
Minnesota	744	8.1%	62.6%
Oklahoma	475	5.2%	67.8%
New Mexico	407	4.4%	72.2%
Washington	390	4.3%	76.5%
Oregon	338	3.7%	80.2%
Wyoming	288	3.1%	83.3%
Kansas	264	2.9%	86.2%
Others	1,264	13.8%	100.0%
U.S. Total	9151	100.0%	100.0%

Source: AWEA, [http://www.awea.org/projects/].

[69] GAO, *Wind Power*, GAO-04-756, Sept. 2004, p. 66.

[70] Ibid., p. 6.

While the financing costs of a wind energy project dominate its competitiveness in the energy marketplace, there are several other factors that also contribute to the economics of utility-scale wind energy production. These include:[71]

- the wind speed and frequency at the turbine location — the energy that can be tapped from the wind is proportional to the cube of the wind speed, so a slight increase in wind speed results in a large increase in electricity generation;
- improvements in turbine design and configuration — the taller the turbine and the larger the area swept by the blades, the more productive the turbine;
- economies of scale — larger systems operate more economically than smaller systems by spreading operations/maintenance costs over more kilowatt-hours;
- transmission and market access conditions (see below); and
- environmental and other policy constraints — for example, stricter environmental regulations placed on fossil fuel emissions enhance wind energy's economic competitiveness; or, alternately, greater protection of birds or bats,[72] especially threatened or endangered species, could reduce wind energy's economic competitiveness.

A modern wind turbine can produce electricity for about 4.3¢ to 5.8¢ per kilowatt hour. In contrast to wind-generated electricity costs, modern natural-gas-fired power plants produce a kilowatt-hour of electricity for about 5.5¢ (including both fuel and capital costs) when natural gas prices are at $6 per million Btu's (or equivalently per 1,000 cu.ft.).[73]

Wellhead natural gas prices have shown considerable volatility since the late 1990s (**Figure 7**), but spiked sharply upward in September 2005 following Hurricane Katrina's damage to the Gulf Coast petroleum and natural gas importing and refining infrastructure. Prices have fallen back substantially from their October 2005 peak of $10.97 per 1,000 cu.ft., however, market conditions suggest that the steady price rise that has occurred since 2002 is unlikely to weaken anytime soon.[74] As of May 10, 2006, the Henry Hub wellhead price of natural gas was quoted at $6.50 per 1,000 cu.ft. If natural gas prices continue to be substantially higher than average levels in the 1990s, wind power is likely to be competitive in parts of the country where good wind resources and transmission access can be coupled with the federal production tax credit.

Government Support. In addition to market factors, the rate of wind energy system development for electricity generation has been highly dependent on federal

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[71] AWEA, *The Economics of Wind Energy*, at [http://www.awea.org].

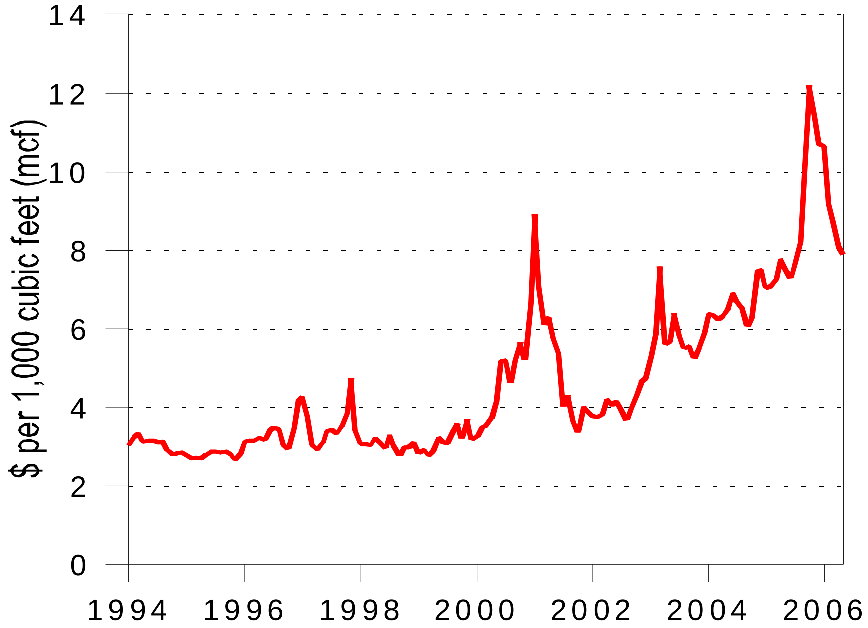
[72] Justin Blum, "Researchers Alarmed by Bat Deaths From Wind Turbines," *Washington Post*, by Jan. 1, 2005.

[73] Rebecca Smith, "Not Just Tilting Anymore," *Wall Street Journal*, Oct. 14, 2004.

[74] For a discussion of natural gas market price factors, see CRS Report RL32677, *Energy Use in Agriculture: Background and Issues*, by Randy Schnepf.

government support, particularly a production tax credit that provides a 1.8¢ credit for each kilowatt-hour of electricity produced by qualifying turbines built by the end of 2007 for a 10-year period.[75] A proviso that may limit the usefulness of the tax credit is a restriction under current U.S. tax law (IRC § 469) whereby individuals are not eligible to deduct any losses incurred in businesses they do not actively participate in. Legislation (H.R. 2007) has been introduced to allow passive investors that provide capital for wind energy facilities and projects to be eligible for up to a $25,000 passive loss deduction in the Internal Revenue Code (IRC). Currently, the $25,000 passive loss offset is only available for oil, gas, and real estate investments.

Figure 7. Natural Gas Price, Wholesale, 1994-2006



Source: DOE, EIA; monthly average wholesale (City Gate) price.

The inclusion of the federal tax credit reduces the cost of producing wind-generated electricity to 2.5¢ to 4¢ per kilowatt hour. In some cases the tax credit may be combined with a five-year accelerated depreciation schedule for wind turbines, as well as with grants, loans, and loan guarantees offered under several different programs.[76] To the extent that they offset a substantial portion (30% to 40%) of the price risk and initial financing charges, government incentives often provide the catalyst for stimulating new investments in rural wind energy systems.

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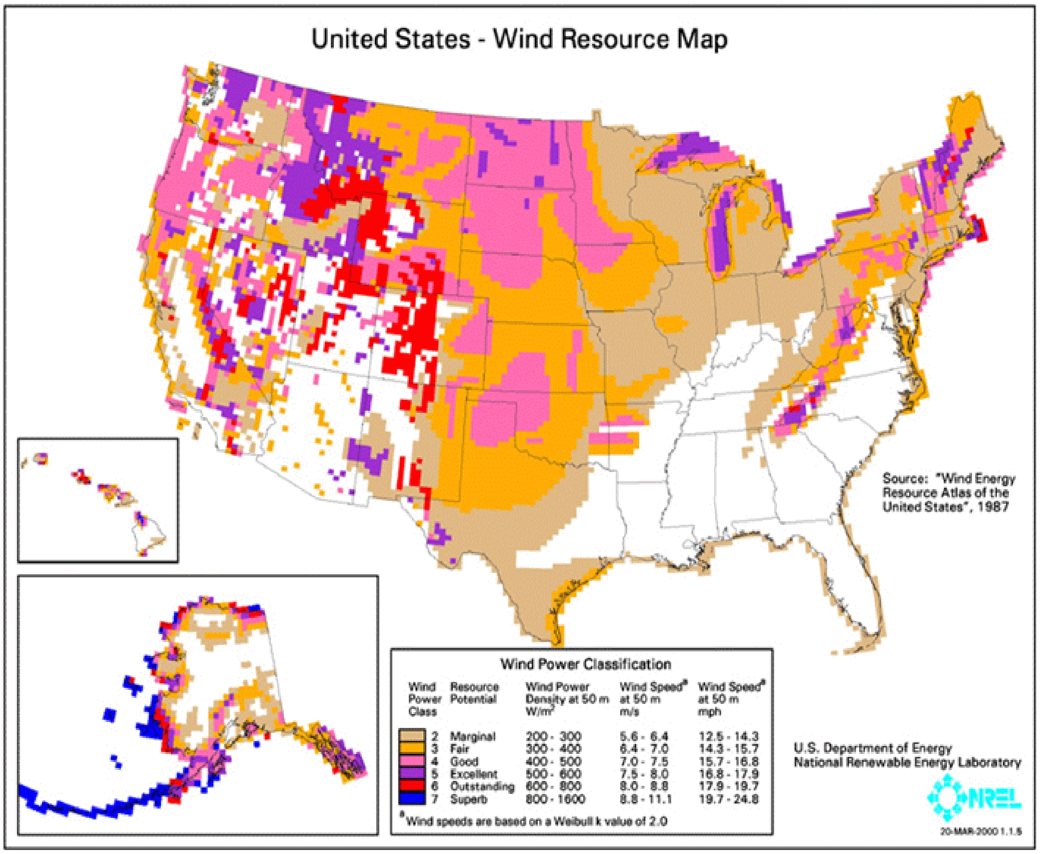
[75] The federal production tax credit was initially established as a 1.5¢ tax credit in 1992 dollars in the Energy Policy Act of 1992 (P.L. 102-146). The tax credit was extended in the American Jobs Creation Act of 2004 (P.L. 108-357; Sec. 710) with an adjustment for annual inflation that raised it to its current value of 1.8¢ per kWh.

[76] A five-year depreciation schedule is allowed for renewable energy systems under the Economic Recovery Tax Act of 1981, as amended (P.L. 97-34; Stat. 230, codified as 26 U.S.C. § 168(e)(3)(B)(vi)).

Long-Run Supply Issues. Despite the advantages listed above, U.S. wind potential remains largely untapped, particularly in many of the states with the greatest wind potential, such as North and South Dakota (see **Figure 8**). Factors inhibiting growth in these states include lack of either (1) major population centers with large electric power demand needed to justify large investments in wind power, or (2) adequate transmission capacity to carry electricity produced from wind in sparsely populated rural areas to distant cities.

Figure 8. U.S. Areas with Highest Wind Potential



Areas considered most favorable for wind power have average annual wind speeds of about 16 miles per hour or more. The minimum wind velocity needed for electricity production by a wind turbine is 10 miles per hour.[77] The turbines operate at higher capacity with increasing wind speed until a "cut-out speed" is reached at about 50 miles per hour. At this speed the turbine is stopped and the blades are turned 90 degrees out of the wind and parked to prevent damage.

The DOE map of U.S. wind potential confirms that the most favorable areas tend to be located in sparsely populated regions, which may disfavor wind-generated electricity production for several reasons. First, transmission lines may be either inaccessible or of insufficient capacity to move surplus wind-generated electricity to distant demand sources. Second, transmission pricing mechanisms may disfavor

[77] Tiffany, Douglas G. *Economic Analysis: Co-generation Using Wind and Biodiesel-Powered Generators*, Staff Paper P05-10, Dept of Applied Econ., Univ. of Minn., Oct. 2005.

moving electricity across long distances due to distance-based charges or according to the number of utility territories crossed. Third, high infrastructure costs for the initial hook-up to the power grid may discourage entry, although larger wind farms can benefit from economies of scale on the initial hook-up. Fourth, new entrants may see their access to the transmission power grid limited in favor of traditional customers during periods of heavy congestion. Finally, wind plant operators are often penalized for deviations in electricity delivery to a transmission line that result from the variability in available wind speed.

Environmental Concerns. Three potential environmental issues — impacts on the visual landscape, bird and bat deaths, and noise issues — vary in importance based on local conditions. In some rural localities, the merits of wind energy appear to have split the environmental movement. For example, in the Kansas Flint Hills, local chapters of the Audubon Society and Nature Conservancy oppose installation of wind turbines, saying that they would befoul the landscape and harm wildlife; while Kansas Sierra Club leaders argue that exploiting wind power would help to reduce America's dependence on fossil fuels.

Box: Primer on Measuring Electric Energy

News stories covering electric generation topics often try to illustrate the worth of a megawatt in terms of how many homes a particular amount of generation could serve. However, substantial variation may appear in implied household usage rates. So what really is a megawatt (MW) and how many homes can one MW of generation really serve?

Basics. A watt (W) is the basic unit used to measure electric power. Watts measure instantaneous power. In contrast, a watt-hour (Wh) measures the total amount of energy consumed in an hour. For example, a 100 W light bulb is rated to consume 100 W of power when turned on. If a 100 W bulb were on for 4 hours it would consume 400 Wh of energy. A kilowatt (kW) equals 1,000 W and a megawatt (MW) equals 1,000 kW or 1 million W. Electricity production and consumption are measured in kilowatt-hours (kWh), while generating capacity is measured in kilowatts or megawatts. If a power plant that has 1 MW of capacity operated nonstop (i.e, 100%) during all 8,760 hours in the year, it would produce 8,760,000 kWh.

More realistically, a 100 MW rated wind farm is capable of producing 100 MW during peak winds, but will produce much less than its rated amount when winds are light. As a result of these varying wind speeds, over the course of a year a wind farm may only average 30 MW of power production. On average, wind power turbines typically operate the equivalent of less than 40% of the peak (full load) hours in the year due to the intermittency of the wind. Wind turbines are "on-line" — actually generating electricity — only when wind speeds are sufficiently strong (i.e., at least 9 to 10 miles per hour).

Average MW per Household. In its 2004 analysis of the U.S. wind industry, the Government Accountability Office (GAO) assumed that an average U.S. household consumed about 10,000 kWh per year (GAO, *Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities*, GAO-04-756, Sept. 2004). However, the amount of electricity consumed by a typical residential household varies dramatically by region of the country. According to 2001 Energy Information Administration (EIA) data, New England residential homes consumed the least amount of electricity, averaging 653 kWh of load in a month, while the East South Central region, which includes states such as Georgia and Alabama and Tennessee, consumed nearly double that amount at 1,193 kWh per household. The large regional disparity in electric consumption is driven by many factors including the heavier use of air conditioning in the South. As a result, a 1 MW generator in the Northeast would be capable of serving about twice as many households as the same generator located in the South because households in the Northeast consume half the amount of electricity as those in the South.

So how many homes can a wind turbine rated at 1 MW really serve? In the United States, a wind turbine with a peak generating capacity of 1 MW, rated at 30% annual capacity, placed on a tower situated on a farm, ranch, or other rural land, can generate about 2.6 million kilowatt-hours [=(1MW)*(30%)*(8.76 kWh)] in a year which is enough electricity to serve the needs of 184 (East South Central) to 354 (New England) average U.S. households depending on which region of the country you live in.

Source: Bob Bellemare, UtiliPoint International Inc., Issue Alert, June 24, 2003; available at [http://www.utilipoint.com/issuealert/article.asp?id=1728].

Public Laws That Support Agriculture-Based Energy Production and Use

This section provides a brief overview of the major pieces of legislation that support agriculture-based renewable energy production. Federal support is provided in the form of excise and income tax credits; loans, grants, and loan guarantees; research, development, and demonstration assistance; educational program assistance; procurement preferences; and user mandates.[78]

Clean Air Act Amendments of 1990 (CAAA; P.L. 101-549)

The Reformulated Gasoline and Oxygenated Fuels programs of the CAAA have provided substantial stimuli to the use of ethanol.[79] In addition, the CAAA requires the Environmental Protection Agency (EPA) to identify and regulate air emissions from all significant sources, including on- and off-road vehicles, urban buses, marine engines, stationary equipment, recreational vehicles, and small engines used for lawn and garden equipment. All of these sources are candidates for biofuel use.

Energy Policy Act of 1992 (EPACT; P.L. 102-486)

Energy security provisions of EPACT favor expanded production of renewable fuels. Provisions related to agriculture-based energy production included:

- EPACT's alternative-fuel motor fleet program implemented by DOE requires federal, state, and alternative fuel providers to increase purchases of alternative-fueled vehicles. Under this program, DOE has designated neat (100%) biodiesel as an environmentally positive or "clean" alternative fuel.[80]
- A 1.5¢ per kilowatt/hour production tax credit (PTC) for wind energy was established. The PTC is applied to electricity produced during a wind plant's first ten years of operation.

Biomass Research and Development Act of 2000 (Biomass Act; Title III, P.L. 106-224)

The Biomass Act (Title III of the Agricultural Risk Protection Act of 2000 [P.L. 106-224]) contains several provisions to further research and development in the area of biomass-based renewable fuel production.

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[78] For more information on federal incentives for biofuel production, see CRS Report RL33572, *Biofuels Incentives: A Summary of Federal Programs*, by Brent D. Yacobucci.

[79] CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci.

[80] NBB, "Biodiesel Emissions," at [http://www.biodiesel.org/pdf_files/fuelfactsheets/emissions.pdf].

- (Sec. 304) The Secretaries of Agriculture and Energy shall cooperate with respect to, and coordinate, policies and procedures that promote research and development leading to the production of biobased fuels and products.
- (Sec. 305) A Biomass Research and Development Board is established to coordinate programs within and among departments and agencies of the Federal Government for the purpose of promoting the use of biofuels and products.
- (Sec. 306) A Biomass Research and Development Technical Advisory Committee is established to advise, facilitate, evaluate, and perform strategic planning on activities related to research, development, and use of biobased fuels and products.
- (Sec. 307) A Biomass Research and Development Initiative is established under which competitively awarded grants, contracts, and financial assistance are provided to eligible entities undertaking research on, and development and demonstration of, biobased fuels and products.[81]
- (Sec. 309) The Secretaries of Agriculture and Energy are obliged to submit an annual joint report to Congress accounting for the nature and use of any funding made available under this initiative.[82]
- (Sec. 310) To undertake these activities, Commodity Credit Corporation (CCC) funds of $49 million per year were authorized for FY2002-FY2005.

Biomass-related program funding levels were expanded through FY2007 by Section 9008 of the 2002 farm bill (P.L. 107-171) which also made available (until expended) new funding of $5 million in FY2002 and $14 million in each of FY2003-FY2007. Subsequently, Title II of the Healthy Forest Restoration Act of 2003 (P.L. 108-148) raised the annual authorization from $49 million to $54 million. Finally Sections 942-948 of the Energy Policy Act of 2005 (P.L. 109-58) raised the annual authorization from $54 million to $200 million starting in FY2006, and extended it through FY2015. In addition to new funding, many of the original biomass-related provisions were expanded and new provisions were added by these same laws as described below.

Energy Provisions in the 2002 Farm Bill (P.L. 107-171)[83]

In the 2002 farm bill, three separate titles — Title IX: Energy, Title II: Conservation, and Title VI: Rural Development — each contain programs that

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[81] The official website for the Biomass Research and Development Initiative may be found at [http://www.biomass.govtools.us/].

[82] This report is available at [http://www.biomass.govtools.us/].

[83] USDA, *2002 Farm Bill*, "Title IX — Energy," online information available at [http://www.ers.usda.gov/Features/Farmbill/titles/titleIXenergy.htm]. For more information, see CRS Report RL31271, *Energy Provisions of the Farm Bill: Comparison of the New Law with Previous Law and House and Senate Bills*, by Brent D. Yacobucci.

encourage the research, production, and use of renewable fuels such as ethanol, biodiesel, and wind energy systems.

Federal Procurement of Biobased Products (Title IX, Section 9002). Federal agencies are required to purchase biobased products under certain conditions. A voluntary biobased labeling program is included. Legislation provides funding of $1 million annually through the USDA's Commodity Credit Corporation (CCC) for FY2002-FY2007 for testing biobased products. USDA published final rules in the *Federal Register* (vol. 70, no. 1, pp. 41-50, January 3, 2005). The regulations define what a biobased product is under the statue, identify biobased product categories, and specify the criteria for qualifying those products for preferred procurement.

Biorefinery Development Grants (Title IX, Section 9003). Federal grants are provided to ethanol and biodiesel producers who construct or expand their production capacity. Funding for this program was authorized in the 2002 farm bill, but no funding was appropriated. Through FY2006, no funding had yet been proposed; therefore, no implementation regulations have been developed.

Biodiesel Fuel Education Program (Title IX, Section 9004). Administered by USDA's Cooperative State Research, Education, and Extension Service, competitively awarded grants are made to nonprofit organizations that educate governmental and private entities operating vehicle fleets, and educate the public about the benefits of biodiesel fuel use. Final implementation rules were published in the *Federal Register* (vol. 68, no. 189, September 30, 2003). Legislation provides funding of $1 million annually through the CCC for FY2003-FY2007 to fund the program. As of January 2006, only two awardees — the National Biodiesel Board and the University of Idaho — had been selected.[84]

Energy Audit and Renewable Energy Development Program (Title IX, Section 9005). This program is intended to assist producers in identifying their on-farm potential for energy efficiency and renewable energy use. Funding for this program was authorized in the 2002 farm bill, but through FY2006 no funding has been appropriated. As a result, no implementation regulations have been developed.

Renewable Energy Systems and Energy Efficiency Improvements (Renewable Energy Program) (Title IX; Section 9006). Administered by USDA's Rural Development Agency, this program authorizes loans, loan guarantees, and grants to farmers, ranchers, and rural small businesses to purchase renewable energy systems and make energy efficiency improvements.[85] Grant funds may be used to pay up to 25% of the project costs. Combined grants and loans or loan guarantees may fund up to 50% of the project cost. Eligible projects include those that derive energy from wind, solar, biomass, or geothermal sources. Projects using energy from those sources to produce hydrogen from biomass or water are also eligible. Legislation provides that $23 million will be available annually through the

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[84] These awardees were selected in August 2003; more information is available at [http://www.biodiesel.org/usda/].

[85] For more information on this program, see [http://www.rurdev.usda.gov/rbs/farmbill/index.html].

CCC for FY2003-FY2007 for this program. Unspent money lapses at the end of each year. Final implementation rules, including program guidelines for receiving and reviewing future loan and loan guarantee applications, were published in the *Federal Register* (vol. 708, no. 136, July 18, 2005).

Prior to each fiscal year, USDA publishes a Notice of Funds Availability (NOFA) in the *Federal Register* inviting applications for the Renewable Energy Program, most recently on March 28, 2005, when the availability of $22.8 million (half as competitive grants, and half for guaranteed loans) was announced. Not all applications are accepted. On September 14, 2005, USDA announced that $21 million in grants for FY2006 were offered to 150 applicants for renewable energy and energy efficient projects in 32 states.[86]

USDA estimates that loans and loan guarantees would be more effective than grants in assisting renewable energy projects, because program funds would be needed only for the credit subsidy costs (i.e., government payments made minus loan repayments to the government). USDA estimated that offering $11.4 million as loan guarantees funding would equate to as much as $200 million in annual program support.[87]

Hydrogen and Fuel Cell Technologies (Title IX, Section 9007). Legislation requires that USDA and DOE cooperate on research into farm and rural applications for hydrogen fuel and fuel cell technologies under a memorandum of understanding. No new budget authority is provided.

Biomass Research and Development (Title IX; Section 9008).[88] This provision extends an existing program — created under the Biomass Research and Development Act (BRDA) of 2000 — that provides competitive funding for research and development projects on biofuels and bio-based chemicals and products, administered jointly by the Secretaries of Agriculture and Energy. Under the BRDA, $49 million per year was authorized for FY2002-FY2005. Section 9008 extended the $49 million in budget authority through FY2007, and added new funding levels of $5 million in FY2002 and $14 million for FY2003-FY2007 — unspent funds may be carried forward, making the additional funding total $75 million for FY2002-FY2007. (The $49 million in annual funding for FY2002-FY2007 was raised to $54 million for that same period by P.L. 108-148, then raised to $200 million per year for FY2006-FY2015 by Sec. 941 of P.L. 109-58; see below). On October 6, 2005, USDA announced that 11 biomass research, development and demonstration projects were selected to receive $12.6 million for the Biomass Research and Development Initiative.[89] The total value of the projects is nearly $19 million, including cost sharing of the private-sector partners.

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[86] USDA News Release 0372.05, Sept. 14, 2005.

[87] USDA News Release 0261.05, July 15, 2005. For more information on the broader potential of loan guarantees see, GAO, *Wind Power*, GAO-04-756, Sept. 2004, pp. 54-55.

[88] For more information, see the joint USDA-DOE website at [http://www.biomass.govtools.us/].

[89] USDA, News Release No. 0426.05, Oct. 6, 2005.

Cooperative Research and Development — Carbon Sequestration (Title IX; Section 9009). This provision amends the Agricultural Risk Protection Act of 2000 (P.L. 106-224, Sec. 221) to extend through FY2011 the one-time authorization of $15 million of the Carbon Cycle Research Program, which provides grants to land-grant universities for carbon cycle research with on-farm applications.

Bioenergy Program (Title IX; Section 9010). This is an existing program (7 C.F.R. 1424) in which the Secretary makes payments from the CCC to eligible bioenergy producers — ethanol and biodiesel — based on any year-to-year increase in the quantity of bioenergy that they produce (fiscal year basis). The goal is to encourage greater purchases of eligible commodities used in the production of bioenergy (e.g., corn for ethanol or soybean oil for biodiesel). The Bioenergy Program was initiated on August 12, 1999, by Executive Order 13134. On October 31, 2000, then-Secretary of Agriculture Glickman announced that, pursuant to the executive order, $300 million of discretionary CCC funds ($150 million in both FY2001 and FY2002) would be made available to encourage expanded production of biofuels. The 2002 farm bill extended the program and its funding by providing that $150 million would be available annually through the CCC for FY2003-FY2006. The final rule for the Bioenergy Program was published in the *Federal Register* (vol. 68, no. 88, May 7, 2003).

The FY2003 appropriations act limited spending for the Bioenergy Program funding for FY2003 to 77% ($115.5 million) of the $150 million; however, the full $150 million was eventually spent.[90] In FY2004, no limitations were imposed. However, a $50 million reduction from the $150 million was contained in the FY2005 appropriations act, followed by a $90 million reduction in the FY2006 appropriations act.

Renewable Energy on Conservation Reserve Program (CRP) Lands (Title II; Section 2101). This provision amends Section 3832 of the Farm Security Act of 1985 (1985 farm bill) to allow the use of CRP lands for biomass (16 USC 3832(a)(7)(A)) and wind energy generation (16 USC 3832(a)(7)(B)) harvesting for energy production.

Rural Development Loan and Grant Eligibility Expanded to More Renewables (Title VI). Section 6013 — Loans and Loan Guarantees for Renewable Energy Systems — amends Section 310B of the Consolidated Farm and Rural Development Act (CFRDA) (7 U.S.C. 1932(a)(3)) to allow loans for wind energy systems and anaerobic digesters. Section 6017(g)(A) — Business and Industry Direct and Guaranteed Loans — amends Section 310B of CFRDA (7 U.S.C. 1932) to expand eligibility to include farmer and rancher equity ownership in wind power projects. Limits range from $25 million to $40 million per project. Section 6401(a)(2) — Value-Added Agricultural Product Market Development Grants — amends Section 231 of CFRDA (7 U.S.C. 1621 note; P.L.106-224) to expand eligibility to include farm- or ranch-based renewable energy systems. Competitive grants are available to assist producers with feasibility studies, business plans,

[90] USDA, FSA, Bioenergy Program Archives, 2003 Program Activity, available at [http://www.fsa.usda.gov/DACO/bioenergy/bio_dacoArchive.htm].

marketing strategies, and start-up capital. The maximum grant amount is $500,000 per project.

Additional support for renewable energy projects is available in the form of various loans and grants from USDA's Rural Development Agency under other programs such as the Small Business Innovation Research (SBIR) grants and Value-Added Producer Grants (VAPG).[91] In keeping with a trend started in 2003, USDA is giving priority consideration to grant applications that dedicate at least 51% of the project costs to biomass energy.

The Healthy Forest Restoration Act of 2003 (P.L. 108-148)

Title II of P.L. 108-148 amended the Biomass Act of 2000 by expanding the use of grants, contracts, and assistance for biomass to include a broader range of forest management activities. In addition, Sec. 201(b) increased the annual amount of discretionary funding available under the Biomass Act for FY2002-FY2007 from $49 million to $54 million (7 USC 8101 note). Section 202 granted authority to the Secretary of Agriculture to establish a program to accelerate adoption of biomass-related technologies through community-based marketing and demonstration activities, and to establish small-scale businesses to use biomass materials. It also authorized $5 million annually to be appropriated for each of FY2004-FY2008 for such activities. Finally, Sec. 203 established a biomass utilization grant program to provide funds to offset the costs incurred in purchasing biomass materials for qualifying facilities. Funding of $5 million annually was authorized to be appropriated for each of FY2004-FY2008 for this biomass utilization grant program.

The American Jobs Creation Act of 2004 (P.L. 108-357)

The American Jobs Creation Act — signed into law on October 22, 2004 — contains two provisions (Sections 301 and 701) that provide tax exemptions for three agri-based renewable fuels: ethanol, biodiesel, and wind energy.

Federal Fuel Tax Exemption for Ethanol (Section 301). This provision provides for an extension and replaces the previous federal ethanol tax incentive (26 U.S.C. 40). The tax credit is revised to allow for blenders of gasohol to receive a federal tax exemption of $0.51 per gallon for every gallon of pure ethanol. Under this volumetric orientation, the blending level is no longer relevant to the calculation of the tax credit. Instead, the total volume of ethanol used is the basis for calculating the tax.[92] The tax credit for alcohol fuels was extended through December 31, 2010.

Federal Fuel Tax Exemption for Biodiesel (Section 301). This provision provides for the first ever federal biodiesel tax incentive — a federal excise tax and income tax credit of $1.00 for every gallon of agri-biodiesel (i.e., virgin vegetable oil and animal fat) that is used in blending with petroleum diesel; and a 50¢

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[91] For more information see [http://www.rurdev.usda.gov/rd/energy/].

[92] For more information, see the American Coalition for Ethanol, *Volumetric Ethanol Excise Tax Credit (VEETC)* at [http://www.ethanol.org/veetc.html]

credit for every gallon of non-agri-biodiesel (i.e., recycled oils such as yellow grease). The tax credits for biodiesel fuels were extended through December 31, 2006 (extended through 2008 by P.L. 109-58; see below).

Federal Production Tax Exemption for Wind Energy Systems (Section 710). This provision renews a federal production tax credit (PTC) that expired on December 31, 2003. The renewed tax credit provides a 1.5¢ credit (adjusted annually for inflation) for a 10-year period for each kilowatt-hour of electricity produced by qualifying turbines that are built by the end of 2005 (extended through 2007 by P.L. 109-58; see below). The inflation-adjusted PTC stood at 1.8¢ per kWh as of December 2003.

Energy Policy Act of 2005 (EPACT; P.L. 109-58)

The Energy Policy Act of 2005 — signed into law on August 8, 2005 — contains several provision related to agriculture-based renewable energy production including the following.[93]

National Renewable Fuels Standard (RFS) (Sec. 1501). Requires that 4.0 billion gallons of renewable fuel be used domestically in 2006, increasing to 7.5 billion gallons by 2012.

Minimum Quantity of Ethanol from Cellulosic Biomass (Sec. 1501). For calendar 2013 and each year thereafter, the RFS volume shall contain a minimum of 250 million gallons derived from cellulosic biomass.

Special Consideration for Cellulosic Biomass or Waste Derived Ethanol (Sec. 1501). For purposes of the RFS, each gallon of cellulosic biomass ethanol or waste derived ethanol shall be counted as the equivalent of 2.5 gallons of renewable fuel.

Small Ethanol Producer Credit Adjusted (Sec. 1347). The definition of a small ethanol producer was extended from 30 million gallons per year to 60 million gallons per year. Qualifying producers are eligible for an additional tax credit of 10¢ per gallon on the first 15 million gallons of production.

Biodiesel Tax Credit Extension Through 2008 (Sec. 1344). Extends the $1.00 per gallon biodiesel tax credit through 2008.

Small Biodiesel Producer Credit Established (Sec. 1345). Agri-biodiesel producers with a productive capacity not in excess of 60 million gallons are eligible for an additional tax credit of 10¢ per gallon on the first 15 million gallons of production.

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[93] For more information, see CRS Report RL32204, *Omnibus Energy Legislation: Comparison of Non-Tax Provisions in the H.R. 6 Conference Report and S. 2095*, by Mark Holt and Carol Glover, coordinators; and CRS Report RL32078, *Omnibus Energy Legislation: Comparison of Major Provisions in House- and Senate-Passed Versions of H.R. 6, Plus S. 14*, by Mark Holt, coordinator.

Funding Support for Research, Development, and Demonstration of Alternate Biofuel Processes. Several alternate forms of assistance including (Sec. 1512) grants for conversion assistance of cellulosic biomass, waste-derived ethanol, and approved renewable fuels; (Sec. 1514) establish a demonstration program for advanced biofuel technologies; (Sec. 1515) extend biodiesel feedstock sources to include animal and municipal waste; and (Sec. 1516) provide loan guarantees for demonstration projects for ethanol derived from surgarcane, bagasse, and other sugarcane byproducts.

Wind PTC Extension Through 2007 (Sec. 1301). Provides a two-year extension through December 31, 2007, for the production tax credit for wind; maintains the PTC inflation adjustment factor of current law; and (Sec. 1302) extends the PTC to agricultural cooperatives.

Agricultural Biomass Research and Development Programs (Sec. 942-948). This section of EPACT provides several amendments to the BRDA as follows. Section 941 updates BRDA to intensify focus on achieving the scientific breakthroughs (particularly with respect to cellulosic biomass) required for expanded deployment of biobased fuels, products, and power, including:

- increased emphasis on feedstock production and delivery, including technologies for harvest, handling and transport of crop residues;
- research and demonstration (R&D) of opportunities for synergy with existing biofuels production, such as use of dried distillers grains (DDGs) as a bridge feedstock;
- support for development of new and innovative biobased products made from corn, soybeans, wheat, sunflower, and other raw agricultural commodities;
- ensuring a balanced and focused R&D approach by distributing funding by technical area (20% to feedstock production; 45% to overcoming biomass recalcitrance; 30% to product diversification; and 5% to strategic guidance), and within each technical area by value category (15% to applied fundamentals; 35% to innovation; and 50% to demonstration); and
- increasing annual program authorization from the current $54 million to $200 million for 10 years — FY2006-FY2015.

Section 942 expands the production incentives for cellulosic biofuels by directing the Secretary of Energy to establish a program of production incentives to deliver the first billion gallons of annual cellulosic biofuels production by 2015. Funds are allocated for proposed projects through set payments on a per gallon basis for the first 100 million gallons of annual production, followed by a reverse auction competitive solicitation process to secure low-cost cellulosic biofuels production contracts. Production incentives are awarded to the lowest bidders, with not more than 25% of the funds committed for each auction awarded to a single bid. Awards may not exceed $100 million in any year, nor $1 billion over the lifetime of the program. The first auction shall take place within one year of the first year of annual production of 100 million gallons of cellulosic biofuels, with subsequent auctions each year thereafter until annual cellulosic biofuels production reaches 1 billion gallons. Funding of $250 million, until expended, is authorized to carry out this section subject to appropriations.

Section 943 corrects the Biobased Procurement Program authorized under Section 9002 of the 2002 farm bill by applying the provision to federal government contractors. The program currently requires federal agencies to give preference to biobased products for procurement exceeding $10,000 when suitable biobased products are available at reasonable cost. This provision would expand the requirement to federal contractors. It also directs the Architect of the Capitol, the Sergeant at Arms of the Senate, and the Chief Administrative Officer of the House of Representatives to comply with the Biobased Procurement Program for procurement of the United States Capitol Complex. Furthermore, it directs the Architect of the Capitol to establish within the Capitol Complex a program of public education regarding its use of biobased products.

Sections 944-946 establish USDA grants programs to assist small biobased businesses with marketing and certification of biobased products (Sec. 944; funding of $1 million is authorized for FY2006, and such sums as necessary thereafter); to assist regional bioeconomy development associations and Land Grant institutions in supporting and promoting the growth of regional bioeconomies (Sec. 945; funding of $1 million is authorized for FY2006, and such sums as necessary thereafter); and for demonstrations by farmer-owned enterprises of innovations in pre-processing of feedstocks and multiple crop harvesting techniques, such as one-pass harvesting, to add value and lower the investment cost of feedstock processing at the biorefinery (Sec. 946; annual funding of $5 million is authorized for FY2006-FY2010).

Section 947 establishes a USDA program of education and outreach consisting of (1) training and technical assistance for feedstock producers to promote producer ownership and investment in processing facilities; and (2) public education and outreach to familiarize consumers with biobased fuels and products. Annual funding of $1 million is authorized for FY2006-FY2010.

Finally, Section 948 requires a report on the economic potential of biobased products through the year 2025 as well as the economic potential by product area (within one year of enactment or by August 8, 2006) , and analysis of economic indicators of the biobased economy (within two years of enactment or by August 8, 2007).

Agriculture-Related Energy Bills in 109th Congress

Several additional bills have been introduced in the 109th Congress that seek to enhance or extend current provisions in existing law that support agriculture-based energy production and use. Many of these bills emphasize expanded production and use of biofuels and other renewable energy sources. Examples of these include H.R. 140; H.R. 622; H.R. 737; H.R. 983; H.R. 4409; H.R. 4897; H.R. 5010; H.R. 5296; S. 326; S. 427; S. 1210; S. 1229; S. 1609; S. 2025; S. 2398; S. 2401; and S. 2571.

In addition, several bills have been introduced that seek to provide incentives for the production and use of alternative fuel vehicles. See CRS Issue Brief IB10128, *Alternative Fuels and Advanced Technology Vehicles: Issues in Congress*, by Brent

D. Yacobucci for a listing of proposed legislation on alternative fuel vehicles. See CRS Report RS22351, *Tax Incentives for Alternative Fuel and Advanced Technology Vehicles*, by Brent D. Yacobucci for a description of existing alternative-fuel vehicle tax incentives.

State Laws and Programs

Several state laws and programs influence the economics of renewable energy production and use by providing incentives for research, production, and consumption of renewable fuels such as biofuels and wind energy systems.[94] In addition, demand for agriculture-based renewable energy is being driven, in part, by state Renewable Portfolio Standards (RPS) that require utilities to obtain set percentages of their electricity from renewable sources by certain target dates.

The amounts and deadlines vary, but as of January 2006, 34 states had laws instituting RPSs requiring, at a minimum, that state vehicle fleets procure certain volumes or percentages of renewable fuels. In several states, the RPS applied state-wide on all motor vehicles; for example see Minnesota Statutes Section 239.77 which requires that all diesel fuel sold or offered for sale in the state for use in internal combustion engines must contain at least 2% biodiesel fuel by volume. This mandate was to take effect by June 30, 2005, provided certain market conditions were met.[95]

For More Information

Renewable Energy

DOE, Energy Information Agency (EIA), [http://www.eia.doe.gov/].

DOE, National Renewable Energy Laboratory (NREL), *Renewable Energy*, [http://www.nrel.gov/].

USDA, Oak Ridge National Laboratory, Energy Efficiency and Renewable Energy Program, *Renewable Energy*, [http://www.ornl.gov/sci/eere/renewables/index.htm].

USDA, Office of the Chief Economist, Office of Energy Policy and New Uses (OEPNU), [http://www.usda.gov/oce/energy/index.htm].

The Sustainable Energy Coalition, [http://www.sustainableenergy.org/].

Eidman, Vernon R. "Agriculture as a Producer of Energy," presentation at USDA conference *Agriculture as a Producer and Consumer of Energy*, June 24, 2004.

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[94] For more information on state and federal programs, see *State and Federal Incentives and Laws*, at the DOE's Alternative Fuels Data Center, [http://www.eere.energy.gov/afdc/laws/incen_laws.html].

[95] For more information on Minnesota vehicle fuel acquisition requirements, visit [http://www.eere.energy.gov/afdc/progs/view_ind_mtx.cgi?reg/REQ/MN/0].

Biofuels

CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci.

CRS Report RL33564, *Alternative Fuels and Advanced Technology Vehicles: Issues in Congress*, by Brent D. Yacobucci.

CRS Report RL33572, *Biofuels Incentives: A Summary of Federal Programs*, by Brent D. Yacobucci.

American Coalition for Ethanol, [http://www.ethanol.org/].

Renewable Fuels Association (RFA), [http://www.ethanolrfa.org/].

The Distillery and Fuel Ethanol Worldwide Network, [http://www.distill.com/].

The National Biodiesel Board (NBB), [http://www.biodiesel.org/].

DOE, Energy Efficiency and Renewable Energy (EERE), *Alternative Fuels Data Center*, [http://www.eere.energy.gov/afdc/].

Eidman, Vernon R. *Agriculture's Role in Energy Production: Current Levels and Future Prospects*, paper presented at a conference, "Energy from Agriculture: New Technologies, Innovative Programs and Success Stories," Dec. 14-15, 2005, St. Louis, Missouri; available at [http://www.farmfoundation.org/projects/documents/EIDMANpaperrevisedTOPOST12-19-05.pdf].

Environmental Protection Agency (EPA), Fuels and Fuel Additives, *Alternative Fuels*, [http://www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm].

Economic Benefits of Biofuel Production

De La Torre Ugarte, D., M. Walsh, H. Shapouri, and S. Slinsky. *The Economic Impacts of Bioenergy Crop Production on U.S. Agriculture*, AER 816, USDA, Office of the Chief Economist (OCE), Office of Energy Policy and New Uses (OEPNU), Feb. 2003; available at [http://www.usda.gov/oce/reports/energy/AER816Bi.pdf].

Food and Agricultural Policy Research Institute (FAPRI), *Implications of Increased Ethanol Production for U.S. Agriculture*, FAPRI-UMC Report #10-05, August 22, 2005; available at [http://www.fapri.missouri.edu/].

Gallagher, P. Otto, H. Shapouri, J. Price, G. Schamel, M. Dikeman, and H. Brubacker, *The Effects of Expanding Ethanol Markets on Ethanol Production, Feed Markets, and the Iowa Economy*, Staff Paper #342, Dept. of Economics, Iowa St. Univ., June 30, 2001.

Gallagher, P., E. Wailes, M. Dikeman, J. Fritz, W. Gauther, and H. Shapouri, *Biomass From Crop Residues: Cost and Supply Estimates*, AER 819, USDA, OCE, OEPNU, March 2003; available at [http://www.usda.gov/oce/reports/energy/AER819.pdf].

Radich, Anthony. "Biodiesel Performance, Costs, and Use," Modeling and Analysis Papers, DOE/EIA, June 2004; available at [http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/].

Shapouri, Hosein, James Duffield, Andrew McAloon, Michael Wang. "The 2001 Net Energy Balance of Corn-ethanol." Paper presented at the Corn Utilization and Technology Conference, June 7-9, 2004, Indianapolis, IN.

Shapouri, Hosein; James A. Duffield, and Michael Wang. *The Energy Balance of Corn Ethanol: An Update*. USDA, Office of the Chief Economist, Office of Energy Policy and New Uses. Agricultural Economic Report (AER) No. 813, July 2002; available at [http://www.usda.gov/oce/reports/energy/index.htm].

Swenson, Dave S. *Input-Outrageous: The Economic Impacts of Modern Biofuels Production*, Iowa State University webpapers, June 2006; available at [http://www.econ.iastate.edu/research/webpapers/paper_12644.pdf].

Tiffany, Douglas G. and Vernon R. Eidman. *Factors Associated with Success of Fuel Ethanol Producers*, Dept of Applied Economics, Univ. of Minnesota, Staff Paper P03-7, August 2003.

Urbanchuk, J. M. *The Contribution of the Ethanol Industry to the American Economy in 2004*, March 12, 2004, available at [http://www.ncga.com/ethanol/pdfs/EthanolEconomicContributionREV.pdf]

Urbanchuk, J. M. and J. Kapell, *Ethanol and the Local Community*, June 20, 2002, available at [http://www.ncga.com/ethanol/pdfs/EthanolLocalCommunity.pdf].

Urbanchuk, J. M. *An Economic Analysis of Legislation for a Renewable Fuels Requirement for Highway Motor Fuels*, November 7, 2001.

Anaerobic Digestion Systems

The Agricultural Marketing Research Center, *Bio-Mass/Forages*, at [http://www.agmrc.org/agmrc/commodity/biomass/].

Wind Energy Systems

American Wind Energy Association (AWEA), [http://www.awea.org/].

DOE, Wind Energy Program, [http://www.eere.energy.gov/RE/wind.html].

The Utility Wind Interest Group, [http://www.uwig.org].

Tiffany, Douglas G. *Co-Generation Using Wind and Biodiesel-Powered Generators*, Dept of Applied Econ., Univ. of Minnesota, Staff Paper P05-10, October 2005.