Order Code RL32712

CRS Report for Congress
Received through the CRS Web

Agriculture-Based Renewable Energy Production

Updated February 28, 2006

Randy Schnepf
Specialist in Agricultural Policy
Resources, Science, and Industry Division

Agriculture-Based Renewable Energy Production

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 1.7 million megawatts in 1997 to an estimated 9.1 million 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 2005 (571 trillion Btu (British Thermal Units) out of 98,200 trillion Btu). Ethanol accounted for about 70% of agriculture-based energy production; wind energy systems for 29%; 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 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.

Contents

List of Figures

List of Tables

Agriculture-Based Renewable Energy Production

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

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

[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 Energy Production and Use by Agriculture," 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/].

enhance rural incomes and employment opportunities, while encouraging greater value-added for U.S. agricultural commodities.[5]

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

Energy source	Production		Consumption	
	Quadrillion Btu	**% of total**	**Quadrillion Btu**	**% 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].

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.

---

[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 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.

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.

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.

- **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.

Several additional criteria may be used for comparing different fuels, including performance, emissions, safety, and infrastructure needs. For more information on these additional criteria and others, see the Department of Energy (DOE), Energy Efficiency and Renewable Energy (EERE), Alternative Fuels Data Center, at [http://www.eere.energy.gov/afdc/altfuel/fuel_properties.html]; or see CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues*.

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[8] and about 0.3% of total U.S. energy consumption (see **Table 1**). In addition to ethanol production, several other renewable energy sources — biodiesel, wind, anaerobic digesters, and non-traditional biomass — also appear to offer particular advantages to the agricultural sector. Presently, the volume of agriculture-based energy produced from these emerging renewable sources is small relative to ethanol production. However, an expanding list of federal and state incentives, regulations, and programs that were

---

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

[8] 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/].

enacted over the past decade have helped to encourage more diversity in renewable energy production and use.

Agriculture-Based Biofuels

Biofuels are liquid fuels produced from biomass. Types of biofuels include ethanol, biodiesel, methanol, and reformulated gasoline components.[9] 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[10]

Ethanol, or ethyl alcohol, is an alcohol made by fermenting and distilling simple sugars. 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 (the world's largest ethanol producer), sugar cane is the primary feedstock. A significant percentage of trees and grasses are made up 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.

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:

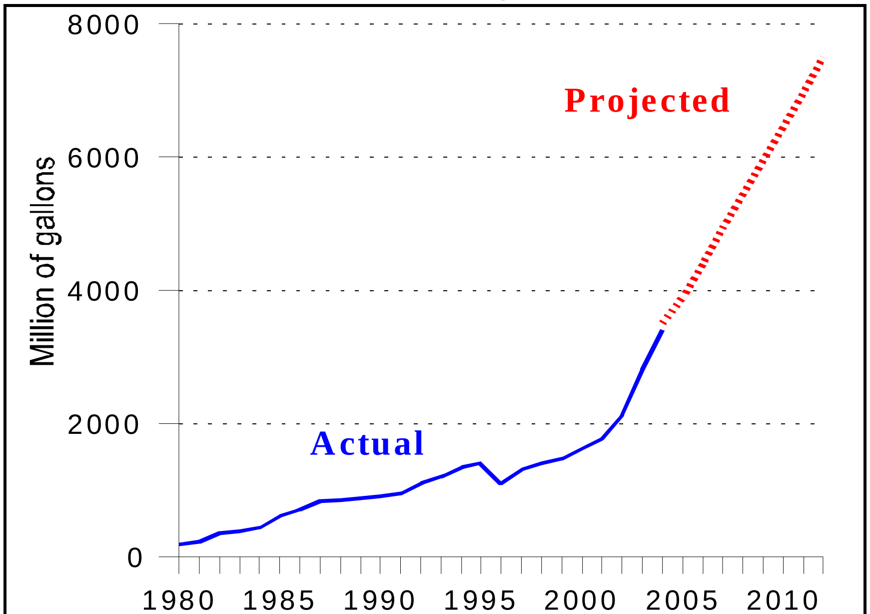
---

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

[10] For more information, see CRS Report RL30369, *Fuel Ethanol: Background and Public Policy Issues*.

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.[11] Ethanol production is projected to continue growing rapidly through at least 2012 on the strength of both the extension of existing and the addition of new government incentives (described below).

Figure 1. U.S. Ethanol Production, Actual 1980-2004 and Projected 2005-2012



Source: 1980-2004, American Coalition for Ethanol; [www.ethanol.org]; projections for 2005-2012 are based on Renewable Fuels Mandate of 7.5 billion gallons met entirely by domestic ethanol production.

In January 2006, existing U.S. ethanol plant capacity was a reported 4,336 million gallons per year, with an additional capacity of 1,946 million gallons per year under construction. U.S. ethanol production presently is underway or planned in 20 states centered around the central and western Corn Belt, where corn supplies are most plentiful (see **Table 2**).[12] Corn accounts for about 95% of the feedstocks used in ethanol production in the United States.

Corn-Based Ethanol. USDA projects that 1.6 billion bushels of corn (or 14.4% of total U.S. corn production) will be used from the 2005 corn crop to produce up to 4.3 billion gallons of ethanol during 2005/06 (September-August).[13] In

---

[11] For more information, see 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; hereafter referred to as Shapouri (2002).

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

[13] Corn use for ethanol: USDA, World Agricultural Outlook Board, *World Agricultural*
(continued...)

gasoline-equivalent gallons (GEG), this represents nearly 2.8 billion gallons.[14] Despite its rapid growth, ethanol production represents a minor part of U.S. gasoline consumption, with a projected 1.6% share in 2004 (2.2 billion GEG out of 136.4 billion gallons of total gasoline use).[15]

Table 2. Ethanol Production Capacity by State, January 2006

State	Currently Operating		Under Construction	Total	
	Million gal/yr	%	Million gal./yr.	Million gal/yr	%
Iowa	1,243	29	515	1,758	28
Nebraska	549	13	506	1,054	17
Illinois	724	17	107	831	13
Minnesota	496	11	98	594	9
South Dakota	455	10	128	583	9
Indiana	102	2	180	282	4
Wisconsin	188	4	40	228	4
Michigan	50	14	157	207	3
Kansas	167	4	40	207	3
Missouri	110	3	45	155	2
Others	253	6	54	383	6
U.S. Total	4,336	100%	1,946	6,282	100%

Source: Renewable Fuels Association, *Industry Statistics: U.S. Fuel Ethanol Production Capacity*, at [http://www.ethanolrfa.org/eth_prod_fac.html], January 2006.

Economic Efficiency. Ethanol's primary fuel competitor is gasoline. Wholesale ethanol prices, before incentives from the federal and state governments, are generally significantly higher than those of their fossil fuel counterparts. For example, during September 2005, the average retail price of E85 (a blend of 85% ethanol with 15% gasoline) was $3.35 per GEG, compared with $2.77 for regular grade gasoline (**Table 3**).[16] The price difference of 58¢ on an 85% blend implies that pure (100%) ethanol costs 68¢ per GEG more than gasoline. The federal production

---

[13] (...continued)
Supply and Demand Estimates, Feb. 9, 2006.

[14] Based on a conversion rate of 1.73 GEG per bushel of corn (2.66 gallons of ethanol per bushel of corn and 0.65 GEG per gallon of ethanol).

[15] 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].

[16] DOE, Energy Efficiency and Renewable Energy (EERE), *Alternative Fuel Price Report*, June 29, 2004, at [http://www.eere.energy.gov/afdc/resources/pricereport/price_report.html].

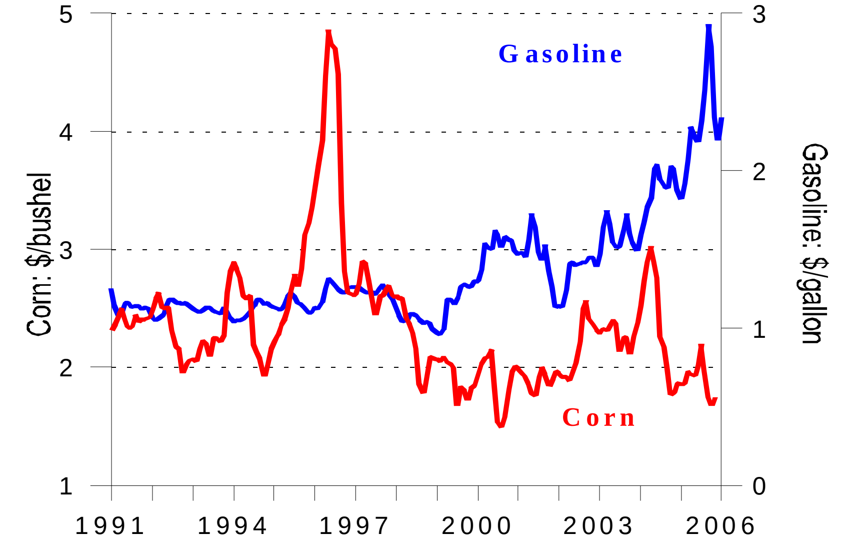
tax credit of 51¢ per gallon of pure ethanol (see below) offsets much of the price difference, thereby helping ethanol to compete in the marketplace.

Apart from government incentives, the economics underlying corn-based ethanol's market competitiveness hinge 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. Feedstock costs are the largest single cost factor in the production of ethanol. As a result, the relative relationship of corn to gasoline prices provides a strong indicator of the ethanol industry's well-being. A comparison of corn versus gasoline prices (**Figure 2**) suggests that the general trend since the late 1990s has clearly been in ethanol's favor as national average monthly gasoline prices have surged above the $2.00 per gallon level while corn prices have returned to (and below) the $2.00 per bushel level of the early 2000s.

Figure 2. Corn versus Gasoline Prices, 1991-2005



Source: Prices are monthly averages: Corn,No.2, yellow, Chicago; USDA, AMS; gasoline prices are national average retail, DOE, EIA.

Government Support. Federal subsidies help ethanol to overcome its higher cost relative to gasoline. The Energy Tax Act of 1978 first established a partial exemption for ethanol fuel from federal fuel excise taxes.[17] 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:[18]

- 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 USC 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; and
- 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 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;
- the energy efficiency of corn production, including the energy embodied in inputs such as fertilizers, pesticides, seed corn, and cultivation practices;
- the energy efficiency of the corn-to-ethanol production process — 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;[19] and

---

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

[18] For more information, see section on "Public Laws That Support Energy Production and Use by Agriculture," later in this report.

[19] 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

(continued...)

- the energy value of corn by-products.

Table 3. Energy and Price Comparisons for Alternate Fuels, September 2005

Fuel type	Unit	Btu's per unit[a]	National Ave. Price: $ per unit	GEG[b]	National Ave. Price: $ per GEG
Gasoline: conventional	gallon	125,071	$2.77	1.00	$2.77
Ethanol (E85)[c]	gallon	90,383	$2.41	0.72	$3.35
Diesel fuel	gallon	138,690	$2.81	1.11	$2.53
Biodiesel (B20)	gallon	138,690	$2.91	1.11	$2.62
Propane	gallon	91,333	$2.56	0.74	$3.46
Compressed Natural Gas[d]	gallon	35,500	$0.59	0.28	$2.12
Natural Gas[e]	1,000 $ft.^3$	1,030,000	$10.00	8.24	$1.21
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 Sept. 2005; DOE, EIA, *Clean Cities Alternative Fuel Price Report*, Sept. 2005; [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 Sept. 2005, 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].

---

[19] (...continued)
(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.

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. 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.[20] This compares with an NEB of 0.81 for gasoline — that is, 19% less energy is returned from a gallon of gasoline than is used in its life cycle from source to user.[21] Other researchers have found much lower NEB values under less optimistic assumptions.[22]

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 U.S. petroleum import share is estimated at 54% of domestic consumption in 2004 and is expected to grow to a 70% share by 2025.[23] Presently, ethanol production accounts for about 1.6% of U.S. gasoline consumption while using about 12% 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 28.6 billion GEG of ethanol would represent about 13.3% of projected national gasoline use of 139.1 billion gallons.[24] In 2005, slightly more than 75 million acres of corn were harvested. Nearly 143 million acres would be needed to produce enough corn and subsequent ethanol to substitute for 50% of petroleum imports (or 27% of total U.S. petroleum consumption).[25] 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.[26] Also, the United States is the world's leading corn exporter, with nearly a 66% share of world trade during the past decade. In 2003/04, the United States exported nearly 19% of its corn production.

---

[20] 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 referred to as Shapouri (2004).

[21] Minnesota Dept. of Agr., *Energy Balance/Life Cycle Inventory for Ethanol, Biodiesel and Petroleum Fuels*, at [http://www.mda.state.mn.us/ethanol/balance.html].

[22] Professor David Pimentel, Cornell University, College of Agriculture and Life Sciences, has researched and published extensive criticisms of corn-based ethanol production. For example, see [http://www.news.cornell.edu/Chronicle/01/8.23.01/Pimentel-ethaol.html].

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

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

[25] Assuming yields of 150 bushel per acre.

[26] USDA, ERS, *Feed Situation and Outlook Yearbook*, FDS-2003, April 2003.

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.[27] However, about 66% of the original weight of corn is consumed in producing ethanol and is no longer available for feed.[28] 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 (derived primarily from natural gas) needed to process the corn into ethanol would increase. For example, the energy needed to process the entire 2004 corn crop into ethanol would be approximately 1.6 trillion cubic feet of natural gas (or 1.4 trillion cu. ft. more than is currently used).[29] Total U.S. natural gas consumption was about 22.6 trillion cu. ft. in 2003. 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 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.[30]

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

---

[27] 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.

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

[29] CRS calculations based on DOE energy usage rates.

[30] 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).

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.[31]

Ethanol from Cellulosic Biomass Crops.[32] Besides corn, several other agricultural products are viable feedstocks and appear to offer long-term supply potential — particularly cellulose-based feedstocks. 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 converting cellulose-based feedstocks 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 — 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.[33] In addition, pilot facilities are operational in both the United States and Canada.

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

---

[31] CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues*, p. 24.

[32] 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].

[33] Christopher J. Chipello,"Iogen's Milestone: It's Selling Ethanol Made of Farm Waste," *Wall Street Journal*, April 21, 2004.

50¢ per gallon of ethanol.[34] 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) 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 (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.[35]

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.[36] While corn's net energy balance (under optimistic assumptions concerning corn production and ethanol processing technology) has been 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.

---

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

[35] For more information, see Biomass Research and Development Initiative, USDA/DOE, at [http://www.bioproducts-bioenergy.gov].

[36] 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, January 1999, as referenced in DOE, DiPardo (2002).

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.[37]

A 2003 BFDP 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.[38] This would represent about 8% of U.S. gasoline use in 2003. 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.

Methane from an Anaerobic Digester[39]

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. 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.

---

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

[38] 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].

[39] 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/anaerobicdigesters/anerobicdigesters.htm].

By late 2002, there were 41 digester systems in operation at commercial U.S. livestock farms, with an additional 30 expected to be in operation by 2003.[40] 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 9008). In 2004, 37 anaerobic digester proposals from 26 different states were awarded funding under the REP.[41] 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.[42] 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.[43] A 200-head dairy herd could generate 500 to 600 Kilowatts per day. At 6¢ per kWh, this would represent potential energy cost savings of $6,600 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.

---

[40] U.S. Environmental Protection Agency (EPA), The AgStar Program, Guide to Operational Systems, U.S. Operating Digesters by State, available at [http://www.epa.gov/agstar/operation/bystate.html].

[41] 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/].

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

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

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 USDA, biogas production for generating cost effective electricity requires manure from more than 150 large animals. As animal feeding operations steadily increase in size, the opportunity for anaerobic digestion systems will likewise increase.

Biodiesel

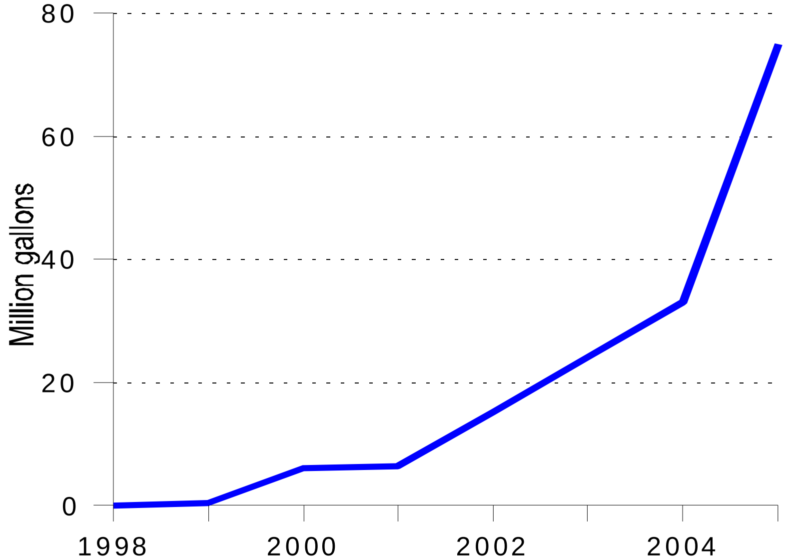
Biodiesel is an alternative diesel fuel that is produced from any animal fat or vegetable oil (such as soybean oil or recycled cooking oil). About 90% of U.S. biodiesel is made from soybean oil. As a result, U.S. soybean producers and the American Soybean Association (ASA) are strong advocates for greater 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.[44] 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.

---

[44] NBB, "Biodiesel 2005 Backgrounder," at [http://www.biodiesel.org/pdf_files/fuelfactsheets/ qbackgrounder.PDF].

Figure 3. 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.]

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 3**). 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.[45] In addition to vehicle use, 17,892 million gallons of diesel fuel were used for heating and power generation by residential, commercial, and industry, and by railroad and vessel traffic in 2004, bringing total U.S. diesel fuel use to nearly 62,384 million gallons (**Table 4**).

As of January 2006, there were 53 companies producing and marketing biodiesel commercially in the United States, and another 35 new firms that have reported their plans to construct dedicated biodiesel plants in the near future.[46] The NBB reported that early 2006 U.S. biodiesel production capacity (within the oleochemical industry) was an estimated 354 million gallons per year, but would add another 278 million gallons within the next 18 months based on the number of ongoing biodiesel projects. 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.

---

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

[46] National Biodiesel Board (NBB), "U.S. Biodiesel Production Capacity," January 2006, available at [http://www.nbb.org/pdf_files/fuelfactsheets/Production_Capacity.pdf]. A map of biodiesel plants is available at [http://www.nbb.org/buyingbiodiesel/producers_marketers/ProducersMap-active.pdf].

Table 4. 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.

Economic Efficiency. Biodiesel is generally more expensive than its fossil fuel counterpart. For example, during September 2005, the average retail price of B20 (a blend of 20% biodiesel with 80% conventional diesel) averaged $2.91 per gallon compared with $2.81 for conventional diesel fuel (**Table 3**).[47] The approximate price difference of 10¢ on a 20% blend implies that pure (100%) biodiesel costs as much as 50¢ more per gallon to produce.

The prices of biodiesel feedstocks, as well as petroleum-based diesel fuel, vary over time based on domestic and international supply and demand conditions (**Figure 4**). As diesel fuel prices rise relative to biodiesel, 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.

Government Support. The primary federal incentive for biodiesel production are somewhat similar to ethanol and include the following.[48]

- 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. 108-357). 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

[47] DOE, EERE, *Alternative Fuel Price Report*, June 29, 2004, available at [http://www.eere.energy.gov/afdc/resources/pricereport/ price_report.html].

[48] See also section on "Public Laws That Support Energy Production and Use by Agriculture" later in this report.

diesel. A 50¢ credit is available for every gallon of non-agri-biodiesel (i.e., recycled oils such as yellow grease).

- A small producer income tax credit (Sec. 1345; P.L. 108-357) 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.
- 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).

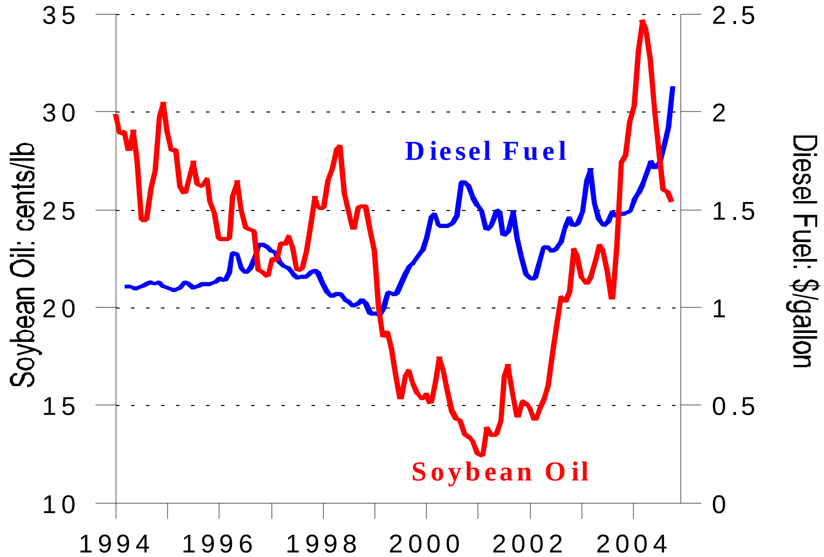
Indirectly, other federal programs support biodiesel production by requiring federal agencies to give preference to biobased products in purchasing fuels and other supplies and by providing incentives for research on renewable fuels. Also, several states have their own incentives, regulations, and programs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

At current prices, the federal tax credit would make biodiesel very competitive with petroleum-based diesel fuel, as the 20¢ tax credit on a gallon of B20 would more than offset the 10¢ price difference with conventional diesel. However, unlike the ethanol tax credit, which was extended through 2010, the biodiesel tax credit expires at the end of calendar year 2008. In addition to the production tax credit, USDA's Bioenergy Program (7 U.S.C. 8108) provides incentive payments (contingent on annual appropriations) on year-to-year production increases of renewable energy.

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.[49] 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.

[49] 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.afdc.doe.gov/pdfs/3812.pdf].

Figure 4. Soybean Oil vs Diesel Fuel Prices, 1994 to 2005



Source: diesel fuel: DOE, EIA; soybean oil: USDA, FAS "Oilseed Circular."

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.[50] 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 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. If, under a hypothetical scenario (as shown in **Table 4**), 1% of current vehicle diesel fuel use were to originate from biodiesel sources, this 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 2003, a total of 31.7 billion pounds of vegetable oils and animal fats were produced in the United States (**Table 5**); 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, 2003) were 2.1 billion pounds. Thus, an additional 1.3 billion pounds of soybean oil would be needed after exhausting all available feedstocks. This is equivalent to the 1.3 billion pounds of soybean oil exported by the United States in 2004/05.

---

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

Table 5. U.S. Potential Biodiesel Feedstocks, 2002/03

Oil type	Wholesale price[a] $/lb	Oil Production, 2002/03		Ending Stocks: Sept. 30, 2003	
		Million pounds	Million gallons[b]	Million pounds	Million gallons[b]
Crops		23,050	2,994	1,834	238
Soybean	20.6	18,435	2,394	1,486	193
Corn	22.3	2,453	319	114	15
Cottonseed	25.7	725	94	40	5
Sunflowerseed	26.4	320	42	25	3
Canola	23.6[c]	541	70	55	7
Peanut	44.5	286	37	50	6
Flaxseed/linsee	na	201	26	45	6
Safflower	na	89	12	19	2
Rapeseed	23.6[c]	0	0	0	0
Animal fat & other		8,698	1,130	299	39
Lard	18.1	262	34	9	1
Edible tallow	16.9	1,974	256	26	3
Inedible tallow	na	3,690	479	221	29
Yellow grease	11.6	2,772	360	43	6
Total supply		31,748	4,123	2,134	277

Source: USDA, ERS, *Oil Crops Yearbook*, OCS-2003, October 2003. 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 2002.*
na = not available.
a. Average of monthly price quotes for 2000/01 to 2003/04 marketing years (Oct. to Sept.). USDA, ERS, *Oil Crops Outlook*, various issues. Yellow grease price is a 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.

If soybean oil exports were to remain unchanged, the deficit biodiesel feedstocks 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 2.5 million acres (assuming a yield of about 50 bushels per acre). A further possibility is that U.S. producers could shift towards the production of higher-oil content oilseeds such as canola or sunflower.

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.[51] At the same time, it 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.[52] Also similar to ethanol production, natural gas demand would likely rise with the increase in biodiesel processing.[53]

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%), or of total direct energy used by U.S. agriculture (9%).[54] Total installed wind energy production capacity has expanded rapidly in the United States since the late 1990s, rising from 1,848 megawatts (MW)[55] in 1998 to a reported 9,141 MW by January 24, 2006

---

[51] 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 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.

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

[53] 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.

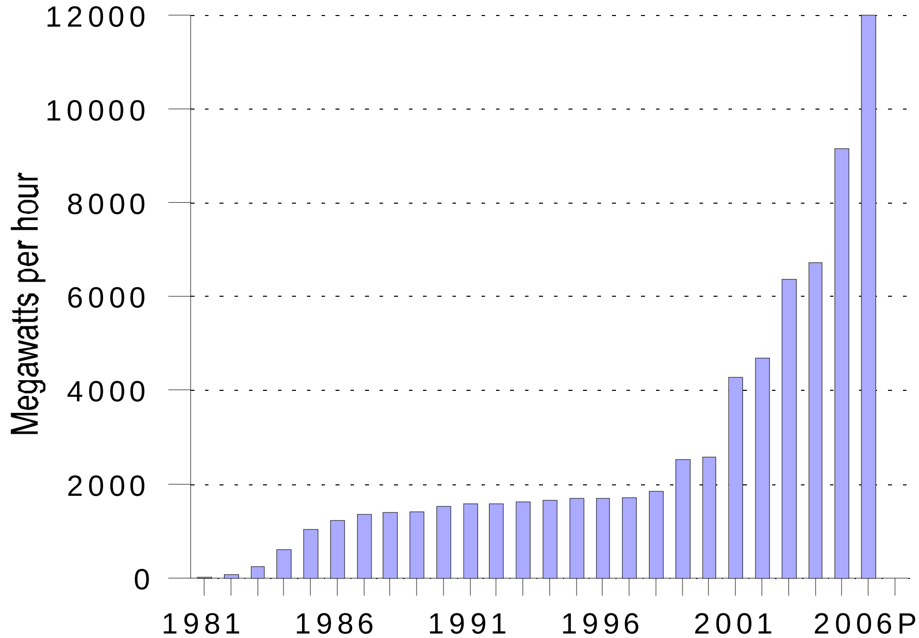
[54] Data for agricultural use of wind-generated electricity is for 2003. For more information on energy consumption by U.S. agriculture, see CRS Report RL32677, *Energy Use in Agriculture: Background and Issues*.

[55] A watt is the basic unit used to measure electric power. A kilowatt (kW) equals 1,000 watts and a megawatt (MW) equals 1,000 kW or 1 million watts. 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 operates nonstop

(continued...)

(**Figure 5**).[56] About 86% of production capacity is in 10 predominantly midwestern and western states (**Table 6**).

Figure 5. U.S. Installed Wind Energy Capacity, 1981-2003



Source: DOE and AWEA; 2006 is projected by AWEA.

In the United States, a wind turbine with a generating capacity of 1 MW, placed on a tower situated on a farm, ranch, or other rural land, can generate enough electricity in a year — between 2.4 to 3 million kilowatt-hours (kWh) — to serve the needs of 240 to 300 average U.S. households.[57] However, 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).

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.[58] In addition, wind-generated electricity production and use is supported by several federal and state financial and

---

[55] (...continued)
during all 8,760 hours in the year, it will produce 8,760,000 kWh.

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

[57] An average U.S. household consumes roughly 10,000 kWh per year. Government Accountability Office (GAO), *Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities*, GAO-04-756, Sept. 2004; hereafter referred to as GAO, *Wind Power*, GAO-04-756, Sept. 2004.

[58] AWEA, *The Economics of Wind Energy*, March 2002.

tax incentives, loan and grant programs, and renewable portfolio standards. As of October 2004, renewable portfolio standards have been implemented by 17 states and require that utilities must derive a certain percentage of their overall electric generation from renewable energy sources such as wind power.[59] 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 depending on factors such as the project size, the capacity of the turbines, and the amount of electricity produced.

Table 6. 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/].

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 for over 90% of wind power generation in the United States.[60] 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

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

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

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 megawatt of capacity, so a wind energy system of 10 1.5-megawatt 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. Less than 1% of wind power capacity installed nationwide is owned by farmers.[61]

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:[62]

- 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,[63] especially threatened or endangered species, could reduce wind energy's economic competitiveness.

Government Support. In addition to market factors, the rate of wind energy system development for electricity generation has been highly dependent on federal 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.[64] In some cases the tax credit may be combined with a five-year accelerated depreciation schedule for wind turbines, as well as with

---

[61] Ibid., p. 6.

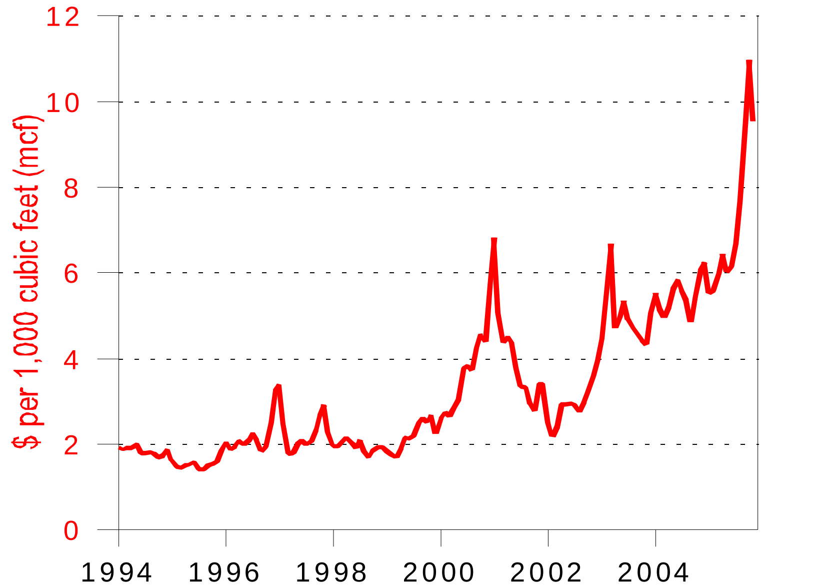
[62] AWEA, *The Economics of Wind Energy*; at [http://www.awea.org].

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

[64] 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 such that it is currently valued at 1.8¢ per kWh.

grants, loans, and loan guarantees offered under several different programs.[65] A modern wind turbine can produce electricity for about 2.5¢ to 4¢ per kilowatt hour (including the government subsidy). This implies that the federal production tax credit amounts to 31% to 41% of the cost of production of wind energy. 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.[66]

Figure 6. Natural Gas Price, Wellhead, 1998 to 2005



Source: DOE, EIA; monthly average wellhead (wholesale) price

As of February 1, 2006, the Henry Hub wellhead price of natural gas was quoted at $8.71 per MMBtu. Wellhead natural gas prices have shown considerable volatility since the late 1990s (**Figure 6**); however, market conditions suggest that the sharp price rise that has occurred since 2002 is unlikely to weaken anytime soon.[67] 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.

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 (**Figure 7**). Factors inhibiting

---

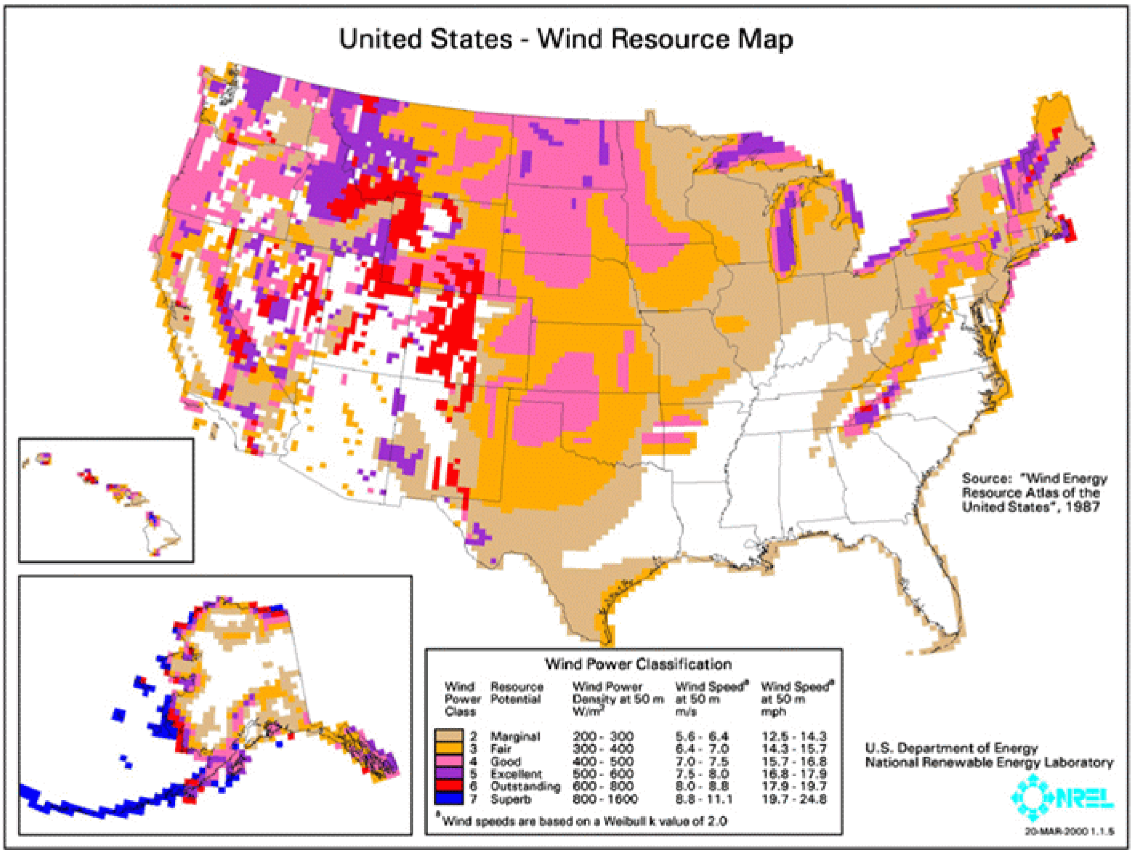
[65] A five-year depreciation schedule is allowed for renewable energy systems under the Economic Recovery Tax Act of 1981, as amended (P.L. 97-34; Stat. 230, codified as 26 U.S.C. § 168(e)(3)(B)(vi)).

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

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

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 7. 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 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 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.

Public Laws That Support Energy Production and Use by Agriculture

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.[68]

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.[69] 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.[70]
- 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.

---

[68] For information on federal tax credits for renewable energy, see CRS Report IB10054, *Energy Tax Policy*, by Salvatore Lazzari. For more information on federal production tax credits for biofuels, see CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues*, by Brent D. Yacobucci.

[69] CRS Report RL30369, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci and Jasper Womach.

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

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.

- (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.[71]
- (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.[72]
- (Sec. 310) To undertake these activities, Commodity Credit Corporation (CCC) funds of $5 million in FY2002 and $14 million in each of FY2003-FY2007 are made available until expended. An additional $200 million is authorized for each of FY2006-FY2015.

---

[71] The official website for the Biomass Research and Development Initiative may be found at [http://www.bioproducts-bioenergy.gov/default.asp].

[72] This report is available at [http://www.bioproducts-bioenergy.gov/publications.asp].

Energy Provisions in the 2002 Farm Bill (P.L. 107-171)[73]

In the 2002 farm bill, three separate titles — Title IX: Energy, Title II: Conservation, and Title VI: Rural Development — each contain programs that 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 — have been selected.[74]

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.

---

[73] USDA, *2002 Farm Bill*, "Title IX — Energy," online information available at [http://www.usda.gov/farmbill/energy_fb.html]. 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*.

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

Renewable Energy Systems and Energy Efficiency Improvements (Renewable Energy Program) (Title IX; Section 9006).[75] 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. 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 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.[76]

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.[77]

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).[78] 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,

---

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

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

[77] 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, p. 54-55.

[78] For more information, see the joint USDA-DOE website at [http://www.bioproducts-bioenergy.gov/].

$49 million per year was authorized for FY2002-FY2005. Section 9008 extends the budget authority through FY2007, but with new funding levels of $5 million in FY2002 and $14 million for FY2003-FY2007 — unspent funds may be carried forward, making the funding total $75 million for FY2002-FY2007. An additional $49 million annually in discretionary funding is also provided for FY2002-FY2007 (raised to $54 million by P.L. 108-148; 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.[79] The total value of the projects is nearly $19 million, including cost sharing of the private-sector partners.

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. 211) 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 2002 farm bill extended the program through FY2006 and expanded its funding by providing that $150 million 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. 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.

Loans and Loan Guarantees for Renewable Energy Systems (Title VI; Section 6013). This provision 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.

Business and Industry Direct and Guaranteed Loans (Title VI; Section 6017(g)(A)). This provision amends Section 310B of CFRDA (7 U.S.C. 1932) to include farmer and rancher equity ownership in wind power projects. Limits range from $25 million to $40 million per project.

---

[79] USDA, News Release No. 0426.05, October 6, 2005.

Value-Added Agricultural Product Market Development Grants (Title VI; Section 6401(a)(2)). This provision amends Section 231 of CFRDA (7 U.S.C. 1621 note; P.L.106-224) to include farm- or ranch-based renewable energy. Competitive grants are available to assist producers with feasibility studies, business plans, marketing strategies, and start-up capital. Maximum grant amount is $500,000 per project.

Additional support in the form of various loans and grants is available from USDA's Rural Development Agency under other programs such as the Small Business Innovation Research (SBIR) grants and Value-Added Producer Grants (VAPG). For example, on March 4, 2005, USDA announced the availability of $14.3 million in grants for value-added agriculture business ventures under the VAPG.[80] 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). Sec. 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 (AJCA) contains two provisions (Section 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

---

[80] For more information see [http://www.rurdev.usda.gov/rbs/coops/vadg.htm].

of the tax credit. Instead, the total volume of ethanol used is the basis for calculating the tax.[81] 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¢ 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 (P.L. 109-58)

The Energy Policy Act of 2005 contains several provision related to agriculture-based renewable energy production including the following.[82]

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 2006 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.

---

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

[82] 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*; and CRS Report RL32078, *Omnibus Energy Legislation: Comparison of Major Provisions in House- and Senate-Passed Versions of H.R. 6, Plus S. 14*.

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.

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.

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. Many of these bills emphasize expanded production and use of biofuels and other renewable energy sources. Examples of these include H.R. 4409 and S. 2025; S. 1609; and S. 1210.

In addition, several bills have been introduced that seek to provide incentives for the production and use of alternative fuel vehicles. See CRS Report IB10128, *Alternative Fuels and Advanced Technology Vehicles: Issues in Congress*, for a listing of proposed legislation on alternative fuel vehicles. See CRS Report RS22351, *Tax Incentives for Alternative Fuel and Advanced Technology Vehicles*, 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.[83] 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.

---

83 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].

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.[84]

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.

Biofuels

CRS Report RL30369, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci and Jasper Womach.

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/].

---

[84] 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].

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

Food and Agricultural Policy Research Institute (FAPRI), *Impacts of Increased Ethanol & Biodiesel Demand*, FAPRI-UMC Report #13-01, October 2001, available at [http://www.fapri.missouri.edu/].

P. Gallagher, D. 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.

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].

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].