3.3 Energy

Agriculture uses energy directly for operating machinery and equipment on the farm and indirectly in the fertilizers and pesticides produced off the farm. On a much smaller scale, agriculture supplies energy in the form of alternative fuels such as ethanol. Since the late 1970's, total agricultural use of energy has fallen by about 30 percent while the amount of ethanol produced has risen to over 1 billion gallons per year.

Energy used to produce food at the farm level is classified as either direct or indirect. Direct energy is used on farms to run tractors for tilling, planting, cultivating, and harvesting, as well as to apply pesticides, use frost protection equipment, and operate irrigation pumps. Indirect energy is consumed off the farm for manufacturing fertilizers and pesticides.[1] The total use of energy in agricultural production is low relative to other U.S. producing sectors. For example, in 1992, industrial uses of energy accounted for about 31 quadrillion Btu's (see box, "What is a Btu?") or 37 percent of total energy consumed in the United States (USDOE, 1993a). In comparison, only about 2 percent of total energy use is accounted for by both direct and indirect agricultural uses of energy.

The agricultural sector is also beginning to play a more important role as a supplier of energy. The Clean Air Act Amendments of 1990 (CAA) have renewed interest in alternative fuels such as ethanol. While current ethanol production represents less than 1 percent of total gasoline use in the United States, the CAA creates opportunities for agriculture to increase its role as a supplier of energy by requiring the use of "oxygenated" fuels.

Energy and the Farm Sector: Current Situation

Farm fuel use was greater in 1992 than in 1991 because of lower energy prices and a slight increase in the number of acres planted and harvested (table 3.3.1). In 1993, partly because of flooding in the Midwest, harvested acreage declined and caused a decrease in preplanting, planting, cultivating, harvesting, and fertilizer and pesticide applications. As a result of these decreases, farm diesel fuel, gasoline, and liquefied petroleum (LP) gas use fell by about 4, 5, and 2 percent.

Fuel prices in the farm sector decreased in 1992 and were mixed in 1993 (table 3.3.2). Between October 1993 and January 1994, unleaded gasoline prices fell 11 cents per gallon, diesel fuel prices dropped 13 cents per gallon, and LP gas prices rose 0.4 cent. For 1994, prices have stabilized at slightly lower than 1993 levels.

U.S. agriculture's energy prices reflect international market conditions, particularly crude oil supplies by the Organization of Petroleum Exporting Countries (OPEC). U.S. oil demand also affects the world crude oil market. An increase in U.S. oil production or a decline in U.S. oil demand will lead to a decline in the world oil price. Decreased U.S. oil production or increased oil demand will increase the world oil price. Historically, each 1-percent increase in the U.S. price of imported crude oil has translated into a 0.7-percent rise in the farm price of gasoline and diesel fuel.

Table 3.3.1—Fuel purchased for onfarm use, 1974-92 [1, 2]

Year	Gasoline	Diesel	LP gas
	Billion gallons		
1974	3.7	2.6	1.4
1975	4.5	2.4	1.0
1976	3.9	2.8	1.2
1977	3.8	2.9	1.1
1978	3.6	3.2	1.3
1979	3.4	3.2	1.1
1980	3.0	3.2	1.1
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9
1986	1.7	2.9	0.7
1987	1.5	3.0	0.6
1988	1.6	2.8	0.6
1989	1.3	2.5	0.7
1990	1.5	2.7	0.6
1991	1.4	2.8	0.6
1992	1.6	3.1	NA

[1] Excludes Alaska and Hawaii.
[2] Excludes fuels used for household and personal business.
NA = Not available.
Source: USDA, NASS, 1981-91.

[1] Because of measurement difficulties, energy used to produce other inputs into agriculture, such as farm machinery and equipment, is not included in our definition of indirect energy.

Table 3.3.2—Average U.S. farm fuel prices, 1981-94[1]

Year	Gasoline [2, 3]	Diesel [3, 4]	LP gas[3]
		$/gallon [5]	
1981	1.29	1.16	0.70
1982	1.23	1.11	0.71
1983	1.18	1.00	0.77
1984	1.16	1.00	0.76
1985	1.15	0.97	0.73
1986	0.74	0.58	0.55
1987	0.92	0.71	0.59
1988	0.93	0.73	0.59
1989	1.05	0.76	0.58
1990	1.17	0.95	0.83
1991	1.19	0.87	0.75
1992	1.15	0.82	0.72
1993	1.14	0.82	0.78
Jan. 1993	1.13	0.80	0.86
Apr. 1993	1.15	0.82	0.78
July 1993	1.13	0.79	0.73
Oct. 1993	1.15	0.87	0.73
Jan. 1994	1.04	0.74	0.74

[1] Based on surveys of farm supply dealers conducted by USDA, NASS.
[2] Leaded regular gasoline survey item discontinued after 1992, and unleaded gasoline survey item added Jan. 1993.
[3] Includes Federal, State, and local per-gallon taxes.
[4] Excludes Federal excise tax.
[5] Bulk delivery.

The share of total farm energy expenditures on gasoline, diesel fuel, LP gas, electricity, and lubricants represents about 5 percent of total farm production expenses. In 1992 (the most recent period for which data are available), farm energy expenditures on gasoline, diesel fuel, LP gas, electricity, and lubricants totaled $8.27 billion, up 14 percent from 1991 (table 3.3.3). This increase reflects a 14.6-percent rise in fuel and lubricant expenditures, a 13.4-percent increase in electricity expenditures for nonirrigation purposes, and an 11-percent rise in expenditures on electricity for irrigation. Between 1991 and 1992, total electricity expenditures increased by nearly 13 percent. Lower energy prices, higher crop yields, and a slight rise in the number of acres planted and harvested in 1992 accounted for these increases.

Energy Use Declines Over Time

Energy use by agriculture peaked in 1978 when the sector used about 2.2 quadrillion Btu's of energy. However, rapidly rising energy prices caused by oil price shocks in the early 1980's forced farmers to become more energy-efficient. Since 1978, the total

What is a Btu?

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. For example, 1 gallon of gasoline contains about 125,000 Btu's compared with 1,030 Btu's per cubic foot of natural gas. For fertilizers and pesticides, Btu's represent the energy used in production, packaging, transportation, and application. The use of Btu's allows the adding of various types of energy using a common benchmark.

Btu Conversion Chart

Gasoline	125,000 Btu's/gallon
Diesel fuel	138,690 Btu's/gallon
LP gas	93,300 Btu's/gallon
Natural gas	1,030 Btu's/cubic foot
Electricity	3,413 Btu's/kilowatthour
Nitrogen	55.21 million Btu's/ton
Phosphate	12.34 million Btu's/ton
Potash	10.43 million Btu's/ton
Pesticides	215.41 million Btu's/ton

Conversion rates for gasoline, diesel fuel, LP gas, natural gas, and electricity are from USDOE, 1993. Conversion rates for nitrogen, phosphate, potash, and pesticides are from Bhat, English, Turhollow, and Nyangito, 1993.

Table 3.3.3—Farm energy expenditures, 1989-92

Item	1989	1990	1991	1992
		$ billion		
Fuels and lubricants:				
Gasoline	1.44	1.65	1.50	1.72
Diesel	2.12	2.42	2.34	2.65
LP gas	0.38	0.53	0.44	0.65
Other	0.51	0.57	0.65	0.63
Electricity:				
Excluding irrigation	1.69	1.65	1.57	1.78
For irrigation	0.64	0.65	0.76	0.84
Total	6.78	7.47	7.26	8.27
		Percent		
Change from preceding year	-4.51	10.18	-2.81	13.91

Source: USDA, NASS, 1989-92.

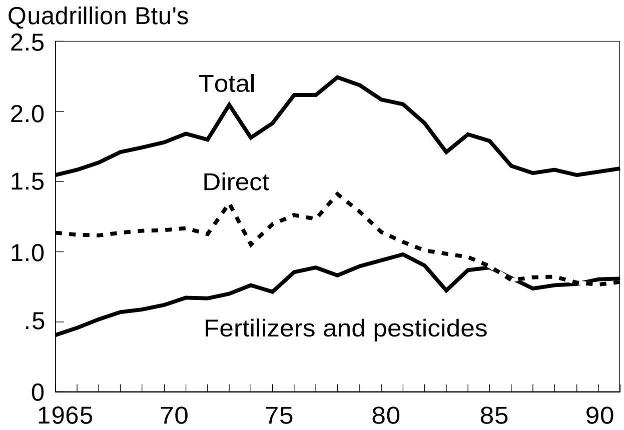
amount of energy used by the agricultural sector has fallen by almost 30 percent (fig. 3.3.1). Since 1978, the direct use of energy (gasoline, diesel, LP gas, natural gas, and electricity) has declined by over 40 percent while the energy used to produce fertilizers and pesticides has increased by almost 5 percent. Switching from gasoline-powered to diesel-powered engines, adopting conservation tillage practices (which tend to use less energy), changing to larger, multifunction machines, and creating new methods of crop drying and irrigation contributed to this decline in energy use.

In addition to the absolute decline in farm energy use over time, the composition of energy use has changed significantly. For example, while gasoline use fell from 42 percent of total energy use in 1965 to only 10 percent in 1991, the share of diesel fuel increased from 13 percent to 23 percent (fig. 3.3.2). This change represents the shift away from gasoline-powered machinery toward diesel-powered machinery. However, the 30-percent decline in the use of gasoline and diesel fuel combined reflects the overall decline in the stock of agricultural machinery, equipment, and motor vehicles. From 1979 to 1986, gross farm capital expenditures for machinery, equipment, and motor vehicles fell by over 50 percent (USDA, 1994). Since 1986, gasoline and diesel use have continued to decline while farm capital expenditures have increased, reflecting improvements in the efficiency of agricultural machinery and equipment.

The only significant increase in energy use in agriculture relates to fertilizers and pesticides.[2] In 1991, manufacturing and applying fertilizers and pesticides accounted for 51 percent of the total energy used in agriculture, up from 26 percent of total use in 1965. The total amount of energy use associated with fertilizers and pesticides has doubled since 1965. The overall increase in farm energy use was caused by greater fertilizer and pesticide use by the agricultural sector, because energy efficiency in fertilizer and pesticide production has increased. Bhat and others (1993) estimated that the energy used in the production of nitrogen and phosphorous nutrients has fallen by 13 and 54 percent since 1979. Similarly, Preston, Adler, and Schipper (1992) estimated that the energy intensity in the chemicals sector as a whole has fallen by 24 percent since 1980.

[2] Pesticides represent less than 10 percent of the total energy used in the fertilizer and pesticide category.

Figure 3.3.1
Energy use in agriculture, 1965-91



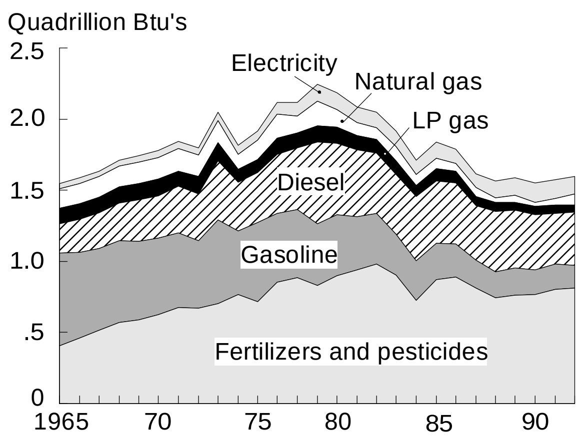
Source: USDA, ERS estimates.

The decrease in farm energy use over time has not come at the expense of lower output. While farm energy use has decreased by almost 30 percent since 1978, agricultural output has increased by almost 30 percent (Economic Report of the President, 1994). One measure of energy efficiency, the ratio of energy use to agricultural output, has fallen by 45 percent since 1978 (fig. 3.3.3). The agricultural sector's improved efficiency is also manifest in the ratio of energy to land in farms, which has fallen by 24 percent since 1978 (fig. 3.3.4).

Agriculture Expected To Play a Larger Role as a Supplier of Energy

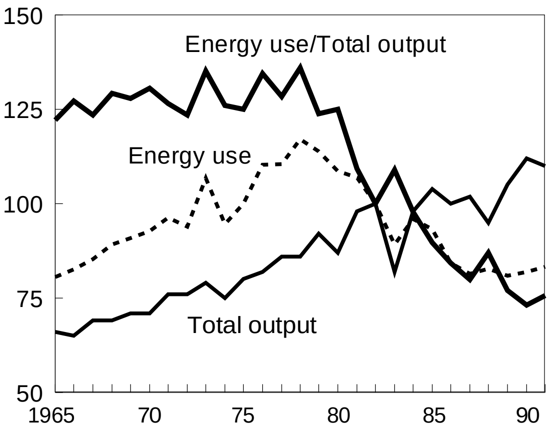
While the agricultural sector continues to use less energy to produce output, it is expected to play a larger role as a supplier of energy. The Clean Air

Figure 3.3.2
Composition of energy use in agriculture, 1965-92



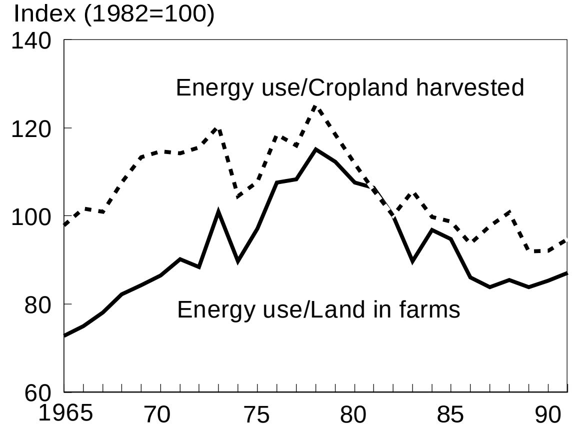
Source: USDA, ERS estimates.

Figure 3.3.3
Energy use and total output in agriculture, 1965-91



Source: USDA, ERS estimates.

Figure 3.3.4
Energy use per acre in agriculture, 1965-91



Source: USDA, ERS estimates.

Act Amendments of 1990 (CAA) have renewed interest in alternative fuels, especially ethanol, ETBE (ethyl tertiary butyl ether), and MTBE-blends (methyl tertiary butyl ether).

The Oxygenated Fuels Program of the CAA began in November 1992 and is intended to reduce carbon monoxide (CO) emissions in 39 cities not meeting air quality standards for CO (fig. 3.3.5). The EPA (1987) attributes 66 percent of all CO emissions (80 percent in many urban areas) to imperfect combustion in motor vehicles. One answer to the problem of imperfect combustion is to increase the amount of oxygen in gasoline. The CAA mandates the addition of oxygen into gasoline to reduce CO emissions. Adding ethanol, ETBE, and MTBE-blends to gasoline (creating "oxygenated" blends) increases the air/fuel ratio, improves the combustion of gasoline, and reduces exhaust emissions, including the amount of CO released into the atmosphere.

In addition to the Oxygenated Fuels Program, the CAA requires cleaner, reformulated gasoline in the nine cities with the most severe ozone pollution in 1990 (fig. 3.3.5). The Reformulated Gasoline Program began January 1, 1995, and is designed to control summertime ozone and reduce toxic emissions year-round. To control ozone, CAA mandates a 15-percent reduction in baseline total volatile organic compounds (VOC's) and toxic emissions, and forbids any increase in nitrogen oxides (NOx). VOC's such as hydrocarbons and NOx react with sunlight to produce ozone. In addition, reformulated gasoline is required to contain at least 2 percent oxygen. The Reformulated Gasoline Program operates year-round, unlike the Oxygenated Fuel Program, which operates only in winter months. However, controls on VOC's emissions vary by season. During the summer, the Ried Vapor pressure of gasoline may be limited to control VOC's. Therefore, areas in nonattainment for both ozone and CO may require different levels of oxygenation throughout the year.

The Environmental Protection Agency (EPA) has also issued a rule for a renewable oxygenate requirement for reformulated gasoline. The rule requires that starting on December 1, 1994, 15 percent of the oxygen contained in reformulated gasoline be derived from renewable resources like corn or other biomass. On January 1, 1996, and thereafter, the renewable oxygenated requirement becomes a 30-percent mandate.

When completely phased in, the EPA rule could increase the demand for ethanol by 500 million gallons per year. Any increase in ethanol production will create an additional outlet for corn (an input to ethanol production) and increase the supply of high-protein animal feeds (a byproduct of ethanol production). If ethanol production increases by 500 million gallons per year, the demand for corn would increase by about 200 million bushels per year. USDA estimates corn prices could increase 4-8 cents per bushel over the next 2 years as a result of EPA's rule. Increases in ethanol production will also reduce the cost of USDA commodity programs by raising grain prices, thus lowering deficiency payments to producers.

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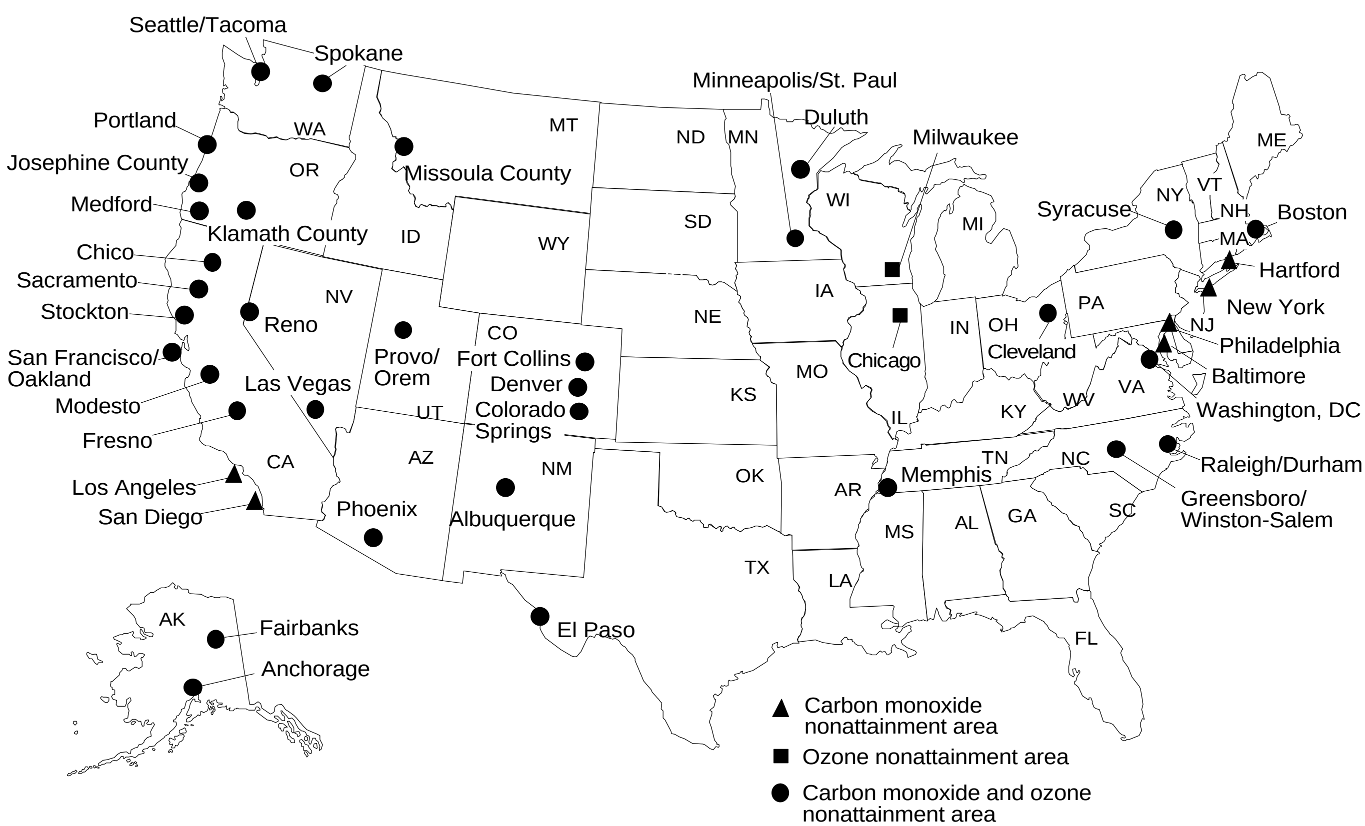
Figure 3.3.5

Carbon monoxide and ozone nonattainment areas, 1993



Source: U.S. Department of Energy, EIA, 1993.