



# Energy Use in Agriculture: Background and Issues

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## Summary

Agriculture requires energy as an important input to production. Agriculture uses energy directly as fuel or electricity to operate machinery and equipment, to heat or cool buildings, and for lighting on the farm, and indirectly in the fertilizers and chemicals produced off the farm. In 2002, the U.S. agricultural sector used an estimated 1.7 quadrillion Btu of energy from both direct (1.1 quadrillion Btu) and indirect (0.6 quadrillion Btu) sources. However, agriculture's total use of energy is low relative to other U.S. producing sectors. In 2002, agriculture's share of total U.S. direct energy consumption was about 1%. Agriculture's shares of nitrogen and pesticide use—two of the major indirect agricultural uses identified by the U.S. Dept of Agriculture (USDA)—are significantly higher at about 56% and 67%, respectively.

U.S. farm production—whether for crop or animal products—has become increasingly mechanized and requires timely energy supplies at particular stages of the production cycle to achieve optimum yields. Energy's share of agricultural production expenses varies widely by activity, production practice, and locality. Since the late 1970s, total agricultural use of energy has fallen by about 28%, as a result of efficiency gains related to improved machinery, equipment, and production practices. Despite these efficiency gains, total energy costs of \$28.8 billion in 2003 represented 14.4% (5.2% direct and 9.3% indirect) of annual production expenses of \$198.9 billion. As a result, unexpected changes in energy prices or availability can substantially alter farm net revenues, particularly for major field crop production.

High fuel and fertilizer prices in 2004, and increasing energy import dependence for petroleum fuels and nitrogen fertilizers has led to concerns about the impact this would have on agriculture. High natural gas prices have already contributed to a substantial reduction in U.S. nitrogen fertilizer production capacity—over a 23% decline from 1998 through 2003. In the short run, price- or supply-related disruptions to agriculture's energy supplies could result in unanticipated shifts in the production of major crop and livestock products, with subsequent effects on farm incomes and rural economies. In the long run, a sustained rise in energy prices may have serious consequences on energy-intensive industries like agriculture by reducing profitability and driving resources away from the sector.

This report provides information relevant to the U.S. agricultural sector on energy use, emerging issues, and related legislation. It will be updated as events warrant.

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## Introduction

Agriculture, as a production-oriented sector, requires energy as an important input to production. U.S. farm production—whether for crop or animal products—has become increasingly mechanized and requires timely energy supplies at particular stages of the production cycle to achieve optimum yields.

Several key points that emerge from this report are:

- agriculture is reliant on the timely availability of energy, but has been reducing its overall rate of energy consumption;
- U.S. agriculture consumes energy both directly as fuel or electricity to power farm activities, and indirectly in the fertilizers and chemicals produced off farm;
- energy's share of agricultural production expenses varies widely by activity, production practice, and locality;
- at the farm level, direct energy costs are a significant, albeit relatively small component of total production expenses in most activities and production processes;
- when combined with indirect energy expenses, total energy costs can play a much larger role in farm net revenues, particularly for major field crop production; and
- energy price changes have implications for agricultural choices of crop and activity mix, and cultivation methods, as well as irrigation and post-harvest strategies.

This report provides background on the relationship between energy and agriculture in the United States. The first section provides background information on current and historical energy use in the U.S. agricultural sector and how this fits into the national energy-use picture. Energy's role in agriculture's overall cost structure is detailed both for present circumstances and for changes over time. Finally, this section examines how agriculture's energy-use pattern varies across activities and regions.

## Farm Energy Consumption Overview

At the farm level, energy use is classified as either direct or indirect. Direct energy use in agriculture is primarily petroleum-based fuels to operate cars, pickups, and trucks as well as machinery for preparing fields, planting and harvesting crops, applying chemicals, and transporting inputs and outputs to and from market.<sup>1</sup> Natural gas, liquid propane, and electricity also are used to power crop dryers and irrigation equipment. Electricity is used largely for lighting, heating, and cooling in homes and barns. Dairies also require electricity for operating milking systems, cooling milk, and supplying hot water for sanitation. (See **Table 1** for a listing

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<sup>1</sup> See CRS Report RL30758, *Alternative Transportation Fuels and Vehicles: Energy, Environment, and Development Issues*, for a description and cost comparison of the major fuels natural gas, LP gas or propane, and electricity, and the alternative fuels biodiesel, ethanol, and methanol.

of various direct and indirect energy uses by agriculture.) In addition, oils and lubricants are needed for all types of farm machinery.

Indirect energy is consumed off the farm for manufacturing fertilizers and pesticides. Because of measurement difficulties, energy used to produce other inputs for agriculture, such as farm machinery and equipment, is not included in USDA's definition of indirect energy.<sup>2</sup>

## Agriculture as a Share of U.S. Energy Use

### Direct Energy Use

In 2002, the U.S. agricultural sector (encompassing both crops and livestock production) used an estimated 1.1 quadrillion Btu<sup>3</sup> of total direct energy.<sup>4</sup> This represents slightly more than 1% of total U.S. energy consumption of 98 quadrillion Btu in 2002. (See **Figure 1**). In comparison, the non-agricultural component of the industrial sector is estimated to have used 31.4 quadrillion Btu (32%), while the transportation sector used 26.5 quadrillion Btu (27%).

As a result of its small share, significant changes in direct energy consumption by the U.S. agricultural sector are unlikely to have major implications for the overall supply and demand for energy in the United States. However, within the agricultural sector, changes in the supply and demand of energy can have significant implications for the profitability of U.S. agriculture as well as the mix of output and management practices.

**Table I. Energy Uses in Agricultural Production**

Direct Use of Energy	Fuel
Operating farm machinery and large trucks:	Diesel fuel
- field work (tractors, combines, mowers, balers, etc.)	
- input purchase and deliveries (large trucks)	
Operating small vehicles (cars and pickup trucks):	Gasoline
- farm management activities	
Operating small equipment:	Diesel fuel
- Irrigation equipment	Natural Gas (NG)
- Drying of grain or fruit	LP Gas (LP)
- Ginning cotton	Electricity (E)
- Curing tobacco	
- Heating for frost protection in groves and orchards	

<sup>2</sup> USDA, Economic Research Service (ERS), *Agricultural Resources and Environmental Indicators*, Agricultural Handbook No. 705, December 1994, p. 106.

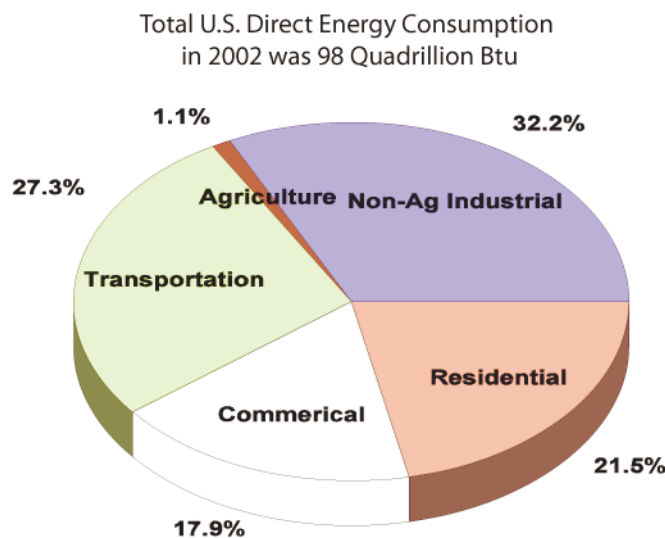
<sup>3</sup> See **Appendix**, "What Is a Btu?" for a definition.

<sup>4</sup> John Miranowski, "Energy Consumption in U.S. Agriculture," presentation at USDA conference on *Agriculture as a Producer and Consumer of Energy*, June 24, 2004; hereafter referred to as Miranowski (2004). Conference proceedings are available at <http://www.farmfoundation.org/projects/03-35EnergyConferencepresentations.htm>.

<b>Direct Use of Energy</b>	<b>Fuel</b>
<ul style="list-style-type: none"> <li>- Crop flammers</li> <li>- Heating/cooling of cattle barn, pig or poultry brooder, greenhouse, stock tanks, etc.</li> <li>- Animal waste treatment</li> <li>- Standby generators</li> </ul>	
General farm overhead	Electricity
<ul style="list-style-type: none"> <li>- Lighting for houses, sheds, and barns</li> <li>- Power for farm household appliances</li> </ul>	
Custom operations	Diesel, Gasoline, NG, LP, E
<ul style="list-style-type: none"> <li>- Field work (e.g., combining)</li> <li>- Drying</li> <li>- Other</li> </ul>	
Marketing	Diesel Gasoline
<ul style="list-style-type: none"> <li>- Transportation: elevator to terminal, processor, or port</li> <li>- Elevating</li> </ul>	
<b>Indirect Use of Energy</b>	<b>Fuel</b>
Fertilizer	Natural Gas (NG)
<ul style="list-style-type: none"> <li>- Nitrogen-based (NG is 75% to 90% of cost of prod.)</li> <li>- Phosphate (NG is 15% to 30% of cost of prod.)</li> <li>- Potash (NG is 15% of cost of prod.)</li> </ul>	
Pesticides (insecticides, herbicides, fungicides)	Petroleum or NG

**Source:** Assembled by CRS from various sources.



**Figure 1. In 2002, Agriculture Accounted for 1% of Total U.S. Direct Energy Use**

**Source;** Dept. of Energy, Energy Information Agency.

**Note:** Each user category includes primary energy plus electricity. Electric generation used 38.2 billion Btu of primary energy.

## Indirect Energy Use

In contrast to direct energy, agriculture's share of two important indirect energy uses—fertilizer and pesticide use—is significantly higher. According to the Government Accountability Office (GAO),<sup>5</sup> in 2002 agriculture accounted for about 56% (12 million out of about 21.4 million metric tons) of total U.S. nitrogen use.<sup>6</sup> Nitrogen fertilizer is the principal fertilizer used by the U.S. agricultural sector. (See the section "Fertilizer Production Costs" later in this report for more information.) Data on agriculture's share of phosphorous and potash fertilizer use was not readily available.

In addition, the U.S. Environmental Protection Agency (EPA) estimates that U.S. agriculture accounted for 67% of expenditures on pesticides in the United States in 2001 (the year for which data was most recently available).<sup>7</sup>

Although direct use of natural gas by agriculture is the smallest of any major energy source (see **Figure 2**), its importance is magnified by an indirect linkage with fertilizers, particularly nitrogenous fertilizers. Natural gas is the major feedstock of nitrogenous fertilizers and represents as much as 90% of the cost of production of anhydrous ammonia—the primary ingredient for most nitrogen fertilizers. Similarly, but to a smaller extent, natural gas is a significant cost

<sup>5</sup> Formerly the General Accounting Office.

<sup>6</sup> GAO, *Natural Gas: Domestic Nitrogen Fertilizer Production Depends on Natural Gas Availability and Prices*, GAO-03-1148, Sept. 2003, p. 4.

<sup>7</sup> U.S. EPA, *Pesticide Industry Sales and Usage: 2000 and 2001 Market Estimates*, May 2004, p.6.

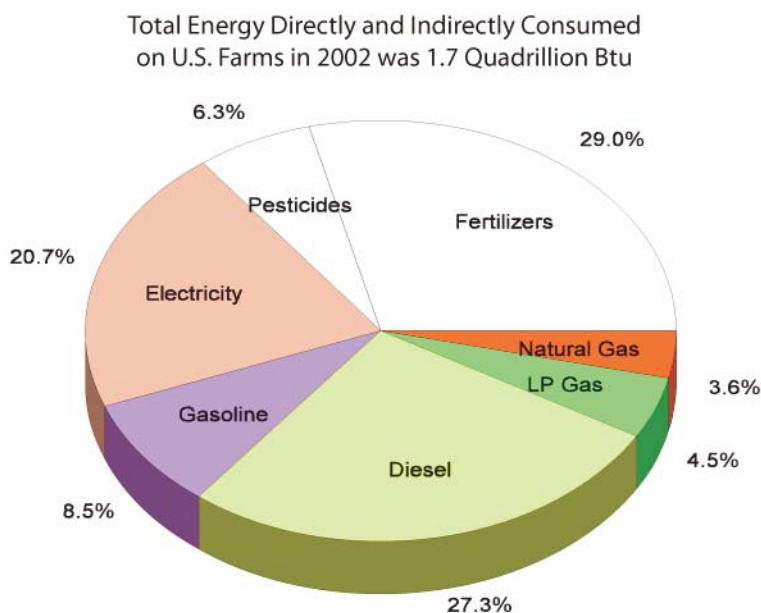
component in the production of both phosphate (15% to 30% of production costs) and potash (15%) fertilizers.

If fertilizers and pesticides were divided into their natural gas and petroleum components, the total direct and indirect consumption of natural gas would amount to over 26% of total energy consumption in the agricultural sector.

## Agriculture Sector Energy Use by Source

Of the estimated 1.7 quadrillion Btu of total energy used by the U.S. agricultural sector in 2002, 65% (1.1 quadrillion Btu) was consumed as direct energy (electricity, gasoline, diesel, LP gas,<sup>8</sup> and natural gas), compared with 35% (0.6 quadrillion Btu) consumed as indirect energy (fertilizers and pesticides).

**Figure 2. U.S. Farm Energy Use by Source, 2002**



Source: Miranowski (2004).

## Total Energy Use by Agriculture Has Declined Over Time

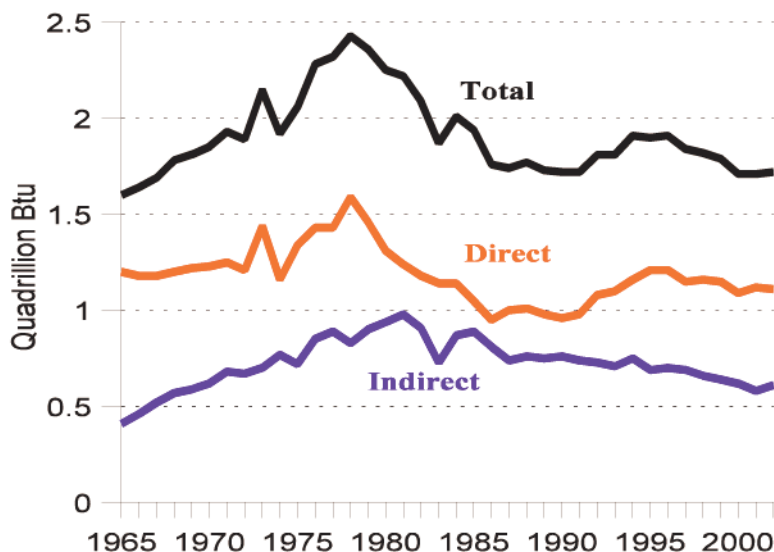
Agricultural energy use peaked at 2.4 quadrillion Btu in 1978.<sup>9</sup> The oil price shocks of the late 1970s and early 1980s forced the agricultural sector to become more energy efficient. Since the late 1970s, the direct use of energy by agriculture has declined by 26%, while the energy used to produce fertilizers and pesticides has declined by 31%. (See **Figure 3**.) Switching from gasoline-powered to more fuel-efficient diesel-powered engines, adopting conservation tillage practices

<sup>8</sup> LP (liquified petroleum) gas is the generic name for commercial propane and commercial butane gases.

<sup>9</sup> Miranowski (2004).

(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.<sup>10</sup>

**Figure 3. Energy Use on U.S. Farms, Direct vs. Indirect, 1965 to 2002**



Source: Miranowski, (2004).

### Composition of Energy Use Has Shifted Over Time

Gasoline's relative share as a source of farm energy has declined substantially over the past four decades, falling from a 41% share in 1965 to about a 9% share in 2002. (See **Figure 4**.) The direct use of natural gas and LP gas also experienced a decline in share, falling from a combined 15% to 8%. In contrast, diesel fuel and electricity both gained substantially, rising from 13% and 6% shares respectively in 1965 to 27% and 21% shares in 2002.

The shift away from gasoline-powered machinery toward diesel-powered machinery underlies the rise of diesel and decline of gasoline. Diesel is better performing than gasoline in terms of miles per gallon and miles per Btu. Diesel fuel also tends to be significantly cheaper on a gasoline-equivalent basis.<sup>11</sup> The overall decline in total direct energy use also reflects an important decline in the stock of agricultural machinery, equipment, and motor vehicles that has occurred since total farm machinery inventories peaked in 1979.<sup>12</sup> Capital depreciation exceeded capital expenditure in every year from 1980 through the mid-1990s.

The capital depletion was due to several factors including, first, increased machine efficiency and, second, shifts away from conventional tillage practices (which required working the soil many

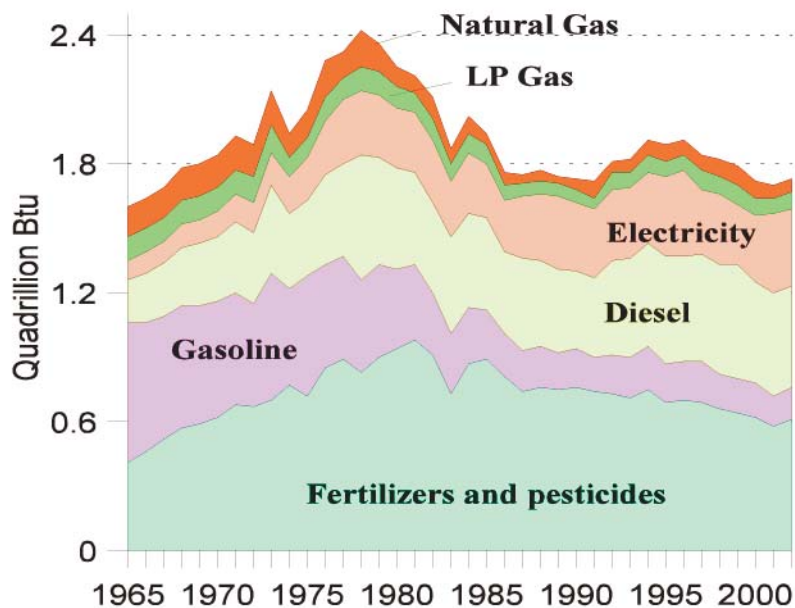
<sup>10</sup> USDA, ERS, *Agricultural Resources and Environmental Indicators*, Agricultural Handbook No. 705, December 1994, p. 108.

<sup>11</sup> See **Table A-1** for gasoline-equivalent prices.

<sup>12</sup> USDA, ERS, *Agricultural Resources and Environmental Indicators, 1996-97*, Agricultural handbook No. 712, July 1997, p. 145.

times prior to planting) toward reduced and no-till practices (which require fewer passes over the soil and, therefore, less fuel consumption). In addition, conservation tillage practices have helped to conserve soil moisture and nutrients (lowering the need for commercial fertilizers) and to prolong the useful life of tractors and equipment.

**Figure 4. Composition of Energy Use in U.S. Agriculture, 1965 to 2002**



Source: Miranowski, (2004).

Since 1965 fertilizer and pesticide use have exhibited a disjointed pattern as a share of energy source for U.S. agriculture, rising from a combined 25% share in 1965 to slightly above a 46% share in 1986, then declining to a 35% share by 2002. Increasing use of precision farming (i.e., computerized equipment that allows precise quantity and placement of inputs such as fertilizers and pesticides), conservation tillage, and crop residue management have all contributed to lower fertilizer volumes without sacrificing yield gains.<sup>13</sup> Plantings of genetically engineered crops such as Bt corn and Bt cotton, which require fewer pesticide applications, also have contributed to a reduced pesticide volume. In addition, improved pesticide products and expanded use of crop scouting services have contributed to lower pesticide volumes while maintaining or improving the level of pest control.

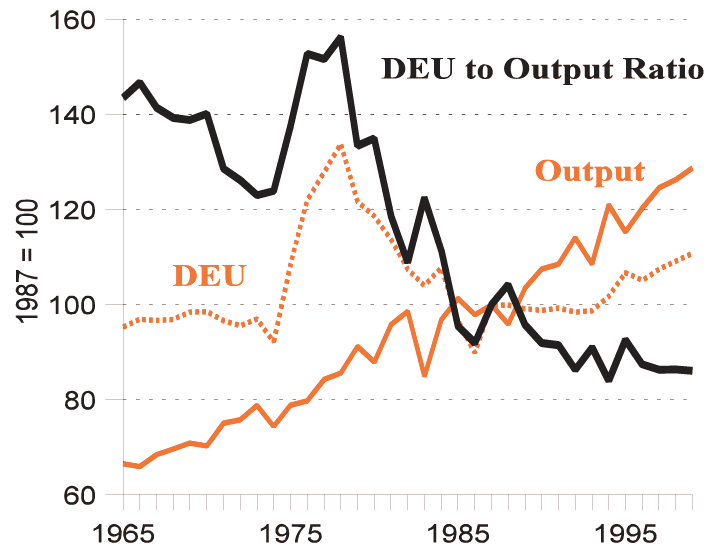
### Efficiency Gains in Farm Energy Use

The large declines in agricultural sector use of direct and indirect energy sources since the late 1970s has not come at the expense of lower output. Agriculture appears to have made dramatic efficiency gains in energy use. The gains are measured by sharply declining energy-use per unit of output indices for both direct and indirect energy categories.

<sup>13</sup> Ibid., pp. 149-150.

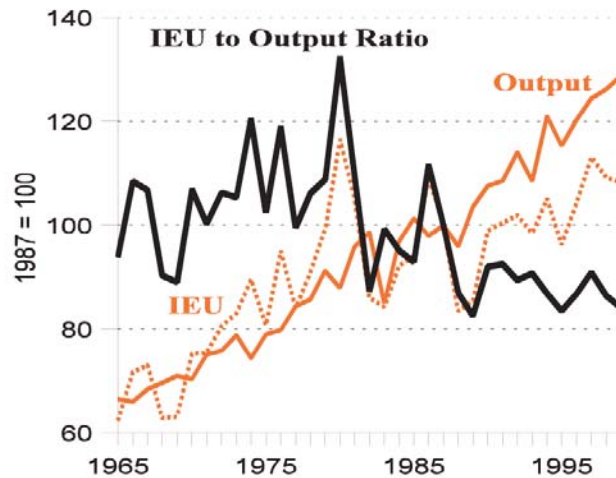
Since 1980, direct energy use (DEU) per unit of output has fallen almost continuously while total agricultural sector output has risen steadily (see **Figure 5**). Indirect energy use (IEU) per unit of output has also tracked downward, but with more variability than direct energy use (see **Figure 6**). Both direct and indirect energy use per unit of output appear to have plateaued somewhat in the 1990s.

**Figure 5. Direct Energy Use (DEU) and Output, 1965-99**



Source: USDA, Economic Research Service.

**Figure 6. Indirect Energy Use (IEU) and Output, 1965-99**



Source: USDA, Economic Research Service.

## Energy's Share of Agricultural Production Costs

Producers are slowly gaining more options for responding to energy price changes, but in the short term most energy price increases still translate into lower farm income. During the 2000-2003 period, U.S. farmers spent an annual average of nearly \$194 billion on total production expenses (see **Table 2**). Of this total, nearly 15%, or an estimated \$28.8 billion, was for energy expenses. Energy's share of annual farm production expenses varies from year to year with changes in planted acres, the crop and livestock mix, and relative energy prices.

**Table 2. U.S. Farm Production Expenditures, 1998-2003**

Expenditure Category <sup>a</sup>	Annual Expenses				Average:	
	2000	2001	2002	2003	2000-03	Share
	\$ Billion				\$ Billion	%
Total Energy Expenses	28.5	29.1	28.0	28.8	28.6	14.7%
Direct energy	10.0	10.2	10.1	10.4	10.2	5.2%
Fuels	7.0	6.7	6.5	6.7	6.7	3.5%
Electricity <sup>b</sup>	3.0	3.5	3.6	3.7	3.5	1.8%
Indirect energy	18.5	18.9	17.9	18.4	18.4	9.5%
Ag chemicals <sup>c</sup>	8.5	8.6	8.3	8.4	8.5	4.4%
Fertilizers <sup>d</sup>	10.0	10.3	9.6	10.0	10.0	5.1%
Livestock & poultry <sup>e</sup>	18.0	18.5	18.3	19.0	18.5	9.5%
Feed	24.5	24.8	24.9	27.0	25.3	13.0%
Labor	20.7	21.7	21.5	21.2	21.3	11.0%
Seeds, supplies, etc. <sup>f</sup>	19.9	20.9	21.1	20.3	20.6	10.6%
Farm services <sup>g</sup>	22.4	23.4	23.2	23.1	23.0	11.9%
Farm improvements <sup>h</sup>	8.7	8.3	8.5	12.1	9.4	4.8%
Machinery & vehicles	13.0	14.2	14.1	14.9	14.1	7.2%
Rent, interest, & taxes <sup>i</sup>	33.9	34.3	33.5	32.5	33.6	17.3%
Total expenditures	189.6	195.2	193.1	198.9	194.2	100%

**Source:** USDA, NASS, Farm Production Expenditures, 2003 Summary, July 2004, p. 27.

- Data excludes Alaska and Hawaii. Total includes production costs not allocated to any of the major expense categories; landlord and contractor share of farm production expenses.
- Electricity has not been included in NASS survey data since 1991. It is approximated as 15% of the original farm services expense category.
- Includes material and application costs.
- Includes lime and soil conditioners, as well as material and application costs.
- Includes purchases and leasing of livestock and poultry.
- Excludes bedding plants, nursery stock, and seed purchased for resale. Includes seed treatment, bedding and litter, marketing containers, power farm shop equipment, miscellaneous non-capital equipment and supplies, repairs and maintenance of livestock and poultry equipment, and capital equipment for livestock and poultry.

- g. Includes crop custom work, veterinary services, custom feeding, transportation costs, marketing charges, insurance leasing of machinery and equipment, miscellaneous business expenses, and utilities.
- h. Includes all expenditures related to new construction or repairs of buildings, fences, operator dwelling (if dwelling is owned by operation), and any improvements to physical structures of land.
- i. Rent includes public and private grazing fees.

## **Direct Energy Costs**

Demand for refined petroleum products such as diesel fuel, gasoline, and LP gas in agricultural production is determined mainly by the number of acres planted and harvested, weather conditions, and the prices for the various types of energy. Because the majority of energy used in the United States (and the world) is derived from either petroleum-based sources—such as gasoline, diesel, and LP gas—or natural gas, their prices tend to move together. This limits the success of switching among fuel sources to reduce energy costs.

During the 1960s and 1970s, direct energy costs (for inputs such as petroleum products and electricity) varied substantially as a share of total farm costs, ranging from 4% to 8% (see **Figure 7**). However, since the mid-1990s direct energy's share of total farm costs has averaged about 5%.

Electricity's share of production costs grew from about 0.7% in the mid-1970s to 1.9% by 1989, and has held fairly steady ever since as technological efficiency gains in electricity use have essentially offset price rises (see **Figure 8**). In contrast, fuel costs have declined as a share of production costs, falling from a 6.4% share in 1981 to average 3.3% since 1994, due in large part to efficiency improvements in farm machinery, as well as adoption of no- or minimum-tillage cultivation practices.

## **Indirect Energy Costs**

Indirect energy costs (for fertilizers and pesticides) have shown considerable variability over the past 40 years, ranging between 8% and 12% of total farm production expenses. The most notable cost-share movement occurred in 1974, when indirect energy costs experienced a sharp upward spike due to a jump in fertilizer prices. In 1971, USDA's Economic Stabilization Program had frozen U.S. fertilizer prices at the producer level.<sup>14</sup> These price controls were removed on October 25, 1973, and resulted in a rapid rise in U.S. fertilizer prices and expenditures. Since 1996, indirect energy's share of total farm costs has trended downward to about a 9% share in 2003.<sup>15</sup>

## ***Agricultural Chemical Costs***

Pesticides comprise the majority of agricultural chemical expenditures. Pesticides are commonly broken out into three major types—herbicides, insecticides, and fungicides. Defoliants, used primarily by cotton in the United States, are another major agricultural chemical grouping.

Pesticide's share of farm production expenses has grown significantly from less than a 1% share prior to 1960 to a high of nearly 5% in 1998. The cost share increase that occurred through 1980

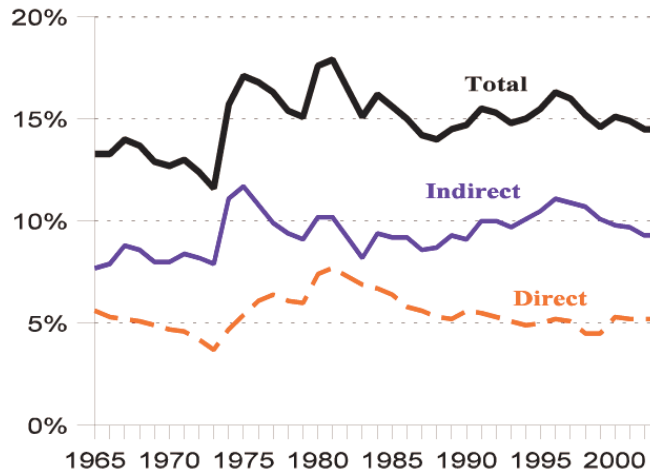
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<sup>14</sup> USDA, Economic Research Service, *Agricultural Outlook*, AO-1, June 1975, p. 9.

<sup>15</sup> Fertilizer use and energy costs are discussed in more detail in the following section, entitled "Fertilizer Production Costs."

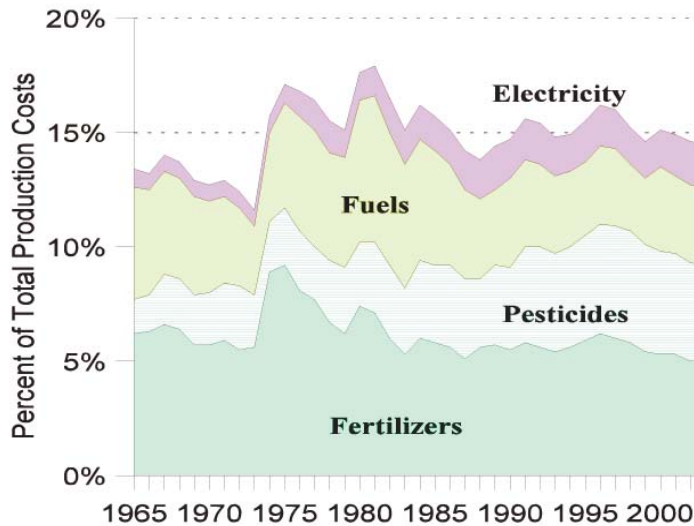
was attributable both to increased total use and to rising per-unit costs, while the increase in cost share between 1980 and 1998 was due almost solely to higher per-unit prices paid. The total pounds of active ingredients of farm chemicals applied to crops rose steadily from early 1960 until about 1980, after which total pounds applied remained relatively unchanged. However, quality improvements in the mix of pesticide ingredients, their ability to kill selected target pests, and the increasing ability of farmers to better target pesticide applications have continued through the 1990s. These and other quality improvements have limited growth in usage rates since 1980, but have contributed to increases in per-unit prices paid through the mid-1990s.

**Figure 7. Direct vs. Indirect Energy Cost Shares on U.S. Farms, 1965 to 2002**



Source: USDA, NASS.

**Figure 8. Energy Cost Shares by Source on U.S. Farms, 1965-2003**



Source: USDA, NASS.

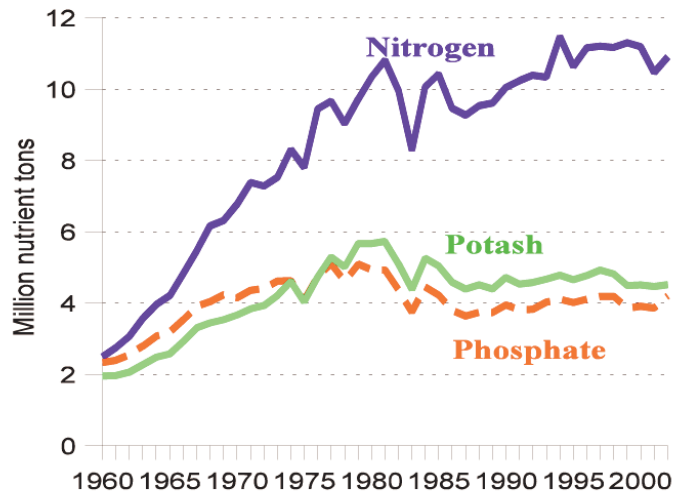


### Fertilizer Production Costs

In 2002, fertilizer expenditures accounted for about 5% of agricultural production expenses. However, they were the single largest outlay among farm energy expenditures, with a 34% share of the \$28 billion of total energy expenses in 2002. That same year, fertilizer also represented the largest single source of farm energy (measured in Btu's), with a 29% share.

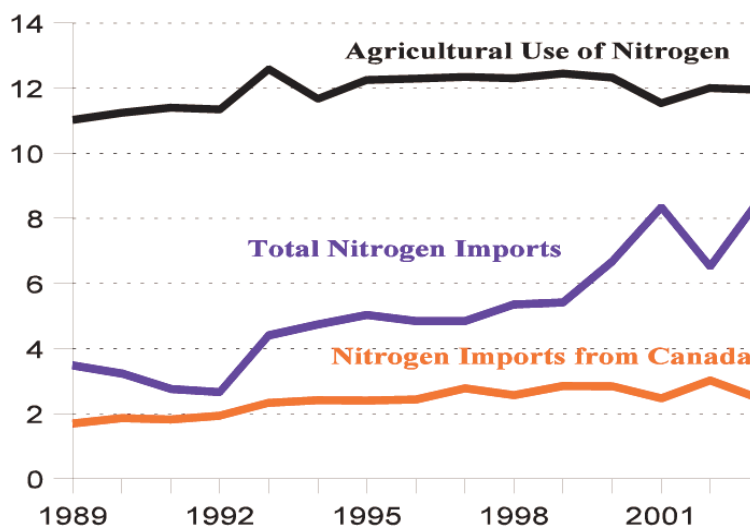
Total fertilizer use by U.S. agriculture has averaged nearly 20 million metric tons since 1991 (see **Figure 9**). Of this total, nitrogen-based fertilizers comprise the largest portion, with a 56% share compared with 24% for potash and 21% for phosphate. The demand for fertilizer depends on several factors, including soil type and fertility, climate, crop rotations, and relative prices of both inputs and outputs. Many, if not most, crops grown in the United States benefit from routine application of commercial fertilizers. Fertilizers provide nutrients that enhance both plant growth and crop yield.

**Figure 9. U.S. Commercial Fertilizer Use, 1965-2002**



**Source:** United Nations, Food and Agricultural Organization.

U.S. farms use an average of nearly 12 million metric tons of nitrogen fertilizers each year. Since 1992, the United States has imported an increasing share of its nitrogen needs (see **Figure 10**).

**Figure 10. U.S. Nitrogen Fertilizer Use, 1989- 2003**

**Sources:** Trade data—USDA, FATUS; use data—1996 to 2002 is from GAO, GAO-03-1148, September 2003; 1989 to 1995 is The Fertilizer Institute but adjusted to GAO scale.

Canada is the traditional source for most U.S. nitrogen imports (accounting for about 40% of total imports since 1989).<sup>16</sup> However, since 2000 the United States has increased the share of nitrogen imports from other sources, particularly from Middle Eastern countries such as Bahrain, Egypt, Kuwait, Qatar, and Saudi Arabia, but also from Bulgaria, China, Russia, Poland, Romania, Netherlands, Norway, Ukraine, Trinidad and Tobago, and Venezuela.

### Fertilizer Prices are Linked to Natural Gas Prices

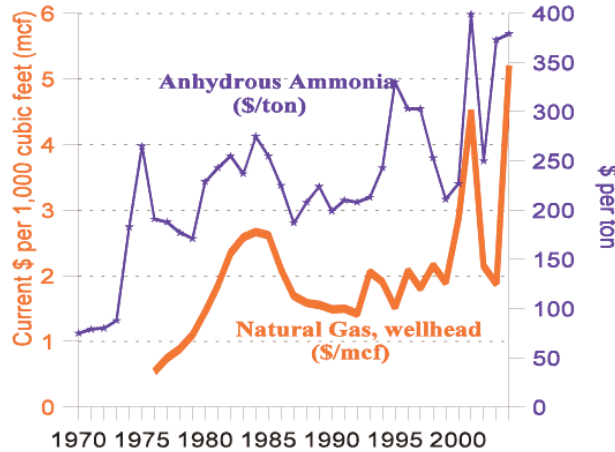
U.S. fertilizer production is closely linked to energy availability, particularly natural gas. Natural gas is the key ingredient in the production of anhydrous ammonia. Anhydrous ammonia is used directly as a nitrogen fertilizer and as the basic building block for producing most other forms of nitrogen fertilizers (e.g., urea, ammonium nitrate, and nitrogen solutions). Natural gas also is used as a process gas in the manufacture of these other nitrogenous fertilizers from anhydrous ammonia. As a result, natural gas accounts for 75% to 90% of costs of production for nitrogen fertilizers. In addition, natural gas is an important input in the production of diammonium or monoammonium phosphates (accounting for 15% to 30% of production costs), and potash (accounting for as much as 15% of the production cost).

Because fertilizer prices are closely linked to natural gas prices through anhydrous ammonia, these prices move in tandem as anhydrous ammonia prices follow natural gas prices, while the prices of other nitrogen fertilizers in turn follow anhydrous ammonia's price (see **Figure 11** and **Figure 12**). Phosphate and potash prices are less closely linked to natural gas than are prices for nitrogen fertilizers (see **Figure 13**).

<sup>16</sup> The Fertilizer Institute, available at <http://www.tfi.org/>.

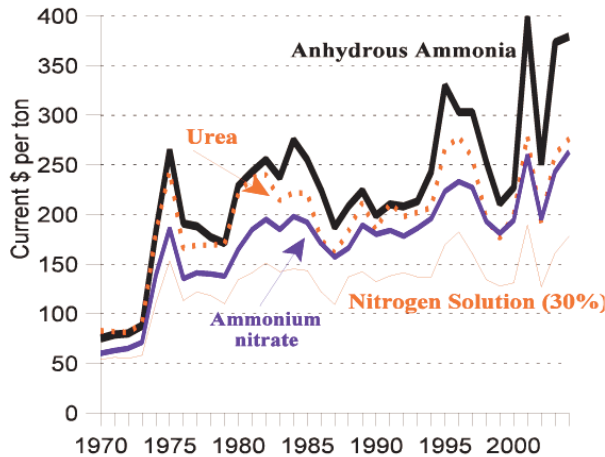
Higher fertilizer prices encourage two potential responses: (1) lower fertilizer application rates on the current farm planting mix; or (2) the planting and production of crops that are less dependent on fertilizer. Although nitrogen fertilizer application rates tend to be higher for various fruit and vegetable crops, field crops are planted on dramatically larger areas (see **Figure 14** and **Figure 15**). As a result, total fertilizer usage is highest for those crops that are planted to the greatest area—corn and wheat, with rice, cotton, and sorghum trailing far behind (see **Figure 16**).

**Figure 11. Anhydrous Ammonia and Natural Gas Prices**



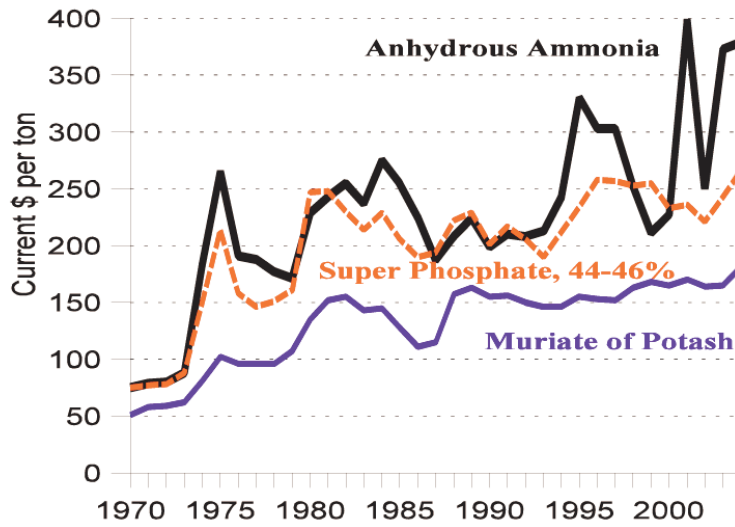
Sources: USDA, NASS, *Agricultural Prices*, April issue for fertilizer prices; DOE, EIA, for natural gas prices

**Figure 12. Nitrogen Fertilizer Prices**



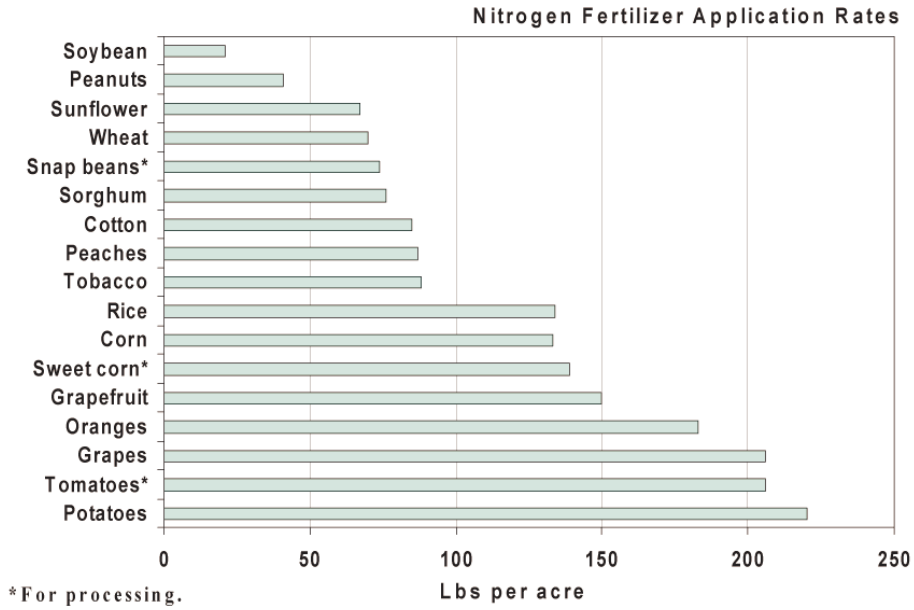
Source: USDA, NASS, *Agricultural Prices*, April issues.

**Figure 13. Phosphate, Potash, and Nitrogen Prices**



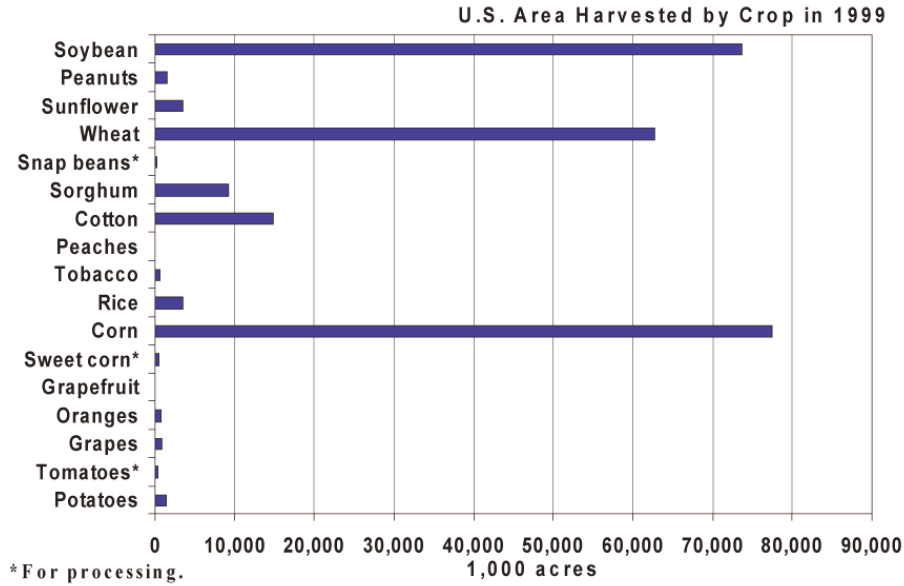
Source: USDA, NASS, *Agricultural Prices*, April issues.

**Figure 14. Fruits and Vegetables Apply More Nitrogen...**



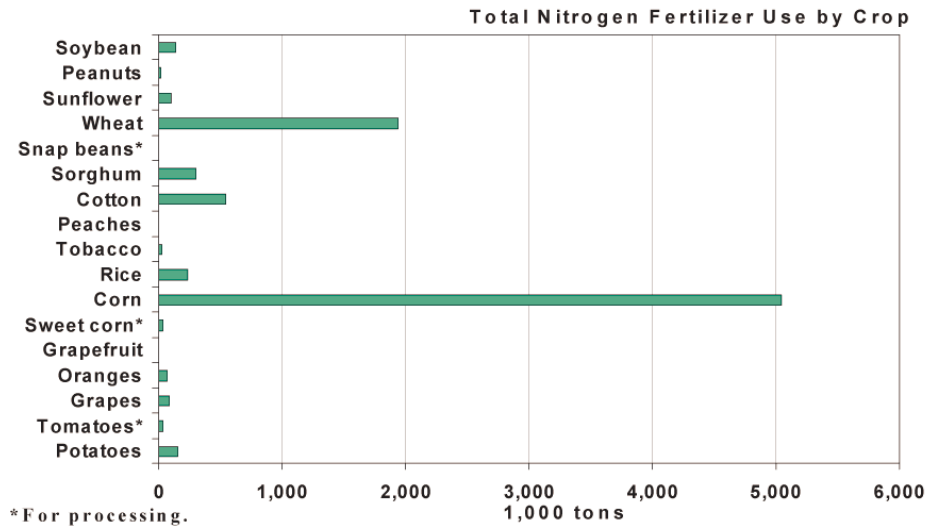
Source: The Fertilizer Inst. From NASS, USDA; data for most years is from 1998 or 1999.

**Figure 15. ...But Major Field Crops Harvest More Area**



Source: The Fertilizer Inst. From NASS, USDA; data for most years is from 1998 or 1999.

**Figure 16. Corn and Wheat Dominate Nitrogen Use**



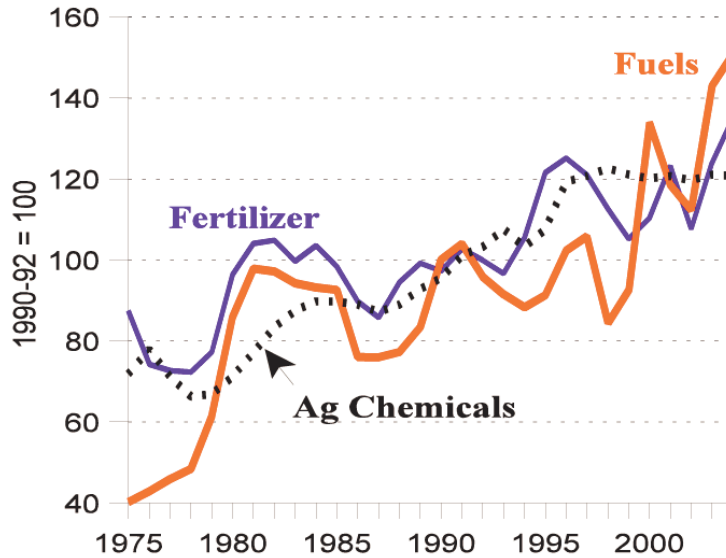
Source: The Fertilizer Inst. From NASS, USDA; data for most years is from 1998 or 1999.

### Agricultural Prices-Paid Index (PPI)

USDA's agricultural PPI suggests that fuel and fertilizer prices have been significantly more variable than pesticide prices (see **Figure 17**). The impact of possible oil or natural gas price rises on agriculture can be significant, especially for field crop production, given the dependence of farming on petroleum products and the limited scope for fuel switching. In addition, the

agricultural sector is particularly vulnerable to natural gas price increases due to the important role natural gas plays in the manufacturing of fertilizer.

**Figure 17. USDA Prices-Paid Index for Major Farm Production Inputs**



Source: USDA, NASS.

### Agricultural Energy Use by Activity

Total production expenses and the relative importance of energy costs vary greatly both by production activity and by region. Although there are many kinds of farm operations performed by the different farm types, nearly all mechanized field work, as well as marketing and management activities, involve machinery (such as tractors and harvesters) as well as trucks and cars that are dependent on petroleum fuels. Grain dryers and irrigation equipment are often more versatile in that they can be powered by petroleum fuels, natural gas, or electricity, while electricity is the primary source of power for lighting, heating, and cooling in homes, barns, and other farm buildings.

**Table 3. Farm Energy Costs (Value and Share) by Activity, 2002**

Activities <sup>a</sup>	Total Costs of Production (COP)	Total Energy Costs	Energy Share of COP	Share of Total U.S. Farm Energy Costs by Activity
	\$ million		%	%
<b>Crop Activities</b>	<b>80,343</b>	<b>18,364</b>	<b>22.9</b>	<b>76.4</b>
Major Field Crops	50,091	13,627	27.2	56.7
Vegetable & Fruits	19,737	3,759	19.0	15.6
Greenhouse & nursery <sup>b</sup>	10,514	979	9.3	4.1

Activities <sup>a</sup>	Total Costs of Production (COP)	Total Energy Costs	Energy Share of COP	Share of Total U.S. Farm Energy Costs by Activity
<b>Livestock Activities</b>	<b>95,857</b>	<b>5,701</b>	<b>5.9</b>	<b>23.7</b>
Beef cattle ranching	20,038	2,323	11.6	9.7
Aquaculture & other	5,617	445	7.9	1.9
Dairy cattle & milk prod.	18,451	1,241	6.7	5.2
Hog & pig farming	11,312	526	4.6	2.2
Poultry & egg prod.	17,649	534	3.0	2.2
Cattle feedlots	22,143	577	2.6	2.4
<b>United States</b>	<b>173,199</b>	<b>24,036</b>	<b>13.7</b>	<b>100.0</b>

**Source:** USDA, NASS, 2002 Census of Agriculture.

- a. Activities are organized by North American Industry Classification System (NAICS), see "Tables" of 2002 Census of Agriculture for details; available at <http://www.nass.usda.gov/census/census02/volume1/us/index1.htm>.
- b. Includes floriculture.

**Table 3** provides details from the 2002 *Agricultural Census* on energy costs, as well as the total production expenses by major agricultural production activity in the United States.<sup>17</sup> Clearly, those farm activities where energy costs play a larger role are more likely to see profits squeezed by rising energy costs.

According to census data, energy expenses in agricultural production in 2002 were \$24 billion, composed of \$18.4 billion on crops and \$5.7 billion on livestock production. Energy costs represented nearly 14% of total U.S. agricultural production costs. In terms of energy's share of costs within each major production activity, 23% of crop production expenses were attributable to energy costs, compared with only 6% for livestock production outlays. The higher the share of total production costs accounted for by energy, the more sensitive a production activity is to energy price or supply fluctuations.

## Major Field Crops

Major field crop production traditionally requires several passes over the field, either with a tractor pulling some type of equipment involved in field preparation, planting, cultivation, fertilizer and chemical applications, or harvesting, or with a specialized machine that may perform one or more of these functions. Fuel consumption depends on the fuel efficiency of the particular machine involved, the number of passes over the field (determined largely by the tillage practice employed), and the size of the field. Indirect energy use in the form of pesticides and fertilizers varies widely across crops and regions depending on weather and soil conditions as well as production practices.

<sup>17</sup> For more detail on types of energy expenditures across various crop and livestock activities, see **Appendix Tables A2-A4** at the end of this report.

A significant portion of U.S. field crop production is irrigated each year, requiring further energy to operate the pumping equipment. In 2002, approximately 55.3 million acres, or nearly 13% of the 434.2 million acres of cropland—for all field, forage, vegetable, and tree crops—were irrigated (see **Table 4**). The use of irrigation varies from year to year based on weather and soil moisture condition. For example, in 1997 nearly 16% (67.8 million acres) of the 425.2 million acres of total cropland were irrigated. Also, irrigation use can vary substantially based on the crop grown—100% of the 1997 rice crop was irrigated compared with only about 6% of wheat production.

Once harvested, most field crops require additional types of energy-related on-farm processing before being sold. Harvested crops with a high moisture content generally undergo drying to meet storage and processing requirements. Other crops, such as cotton and tobacco, require other types of energy outlays. Cotton must be ginned to separate the lint from seeds and foreign matter. Tobacco has to be cured—a process of heating and drying to develop and preserve the potential quality, flavor, and aroma of tobacco—before it can undergo processing into cigarettes or other products.

According to the *2002 Agricultural Census* (see **Table 3**), the highly aggregate category of “major field crops” was the largest agricultural energy user—both in total outlays at \$13.6 billion and as a share of production costs at 27%. Furthermore, “major field crop” energy expenses accounted for 29% of the total energy costs expended by U.S. agriculture.

**Table 4. Irrigated Area and Share by Activity, 2002**

Crop	Total Cropland	Irrigated Area	Irrigated Share
<b>Commodity Groups</b>	1,000 acres	1,000 acres	%
Fruit & tree nuts	6,790	4,585	67.5
Vegetable & melons	8,639	4,975	57.6
Cotton	14,590	4,766	32.7
Greenhouse & nursery	2,497	743	29.7
Other crops	54,176	8,850	16.3
Cattle feedlots	11,505	1,379	12.0
Oilseed & grain	204,555	19,473	9.5
Beef cattle ranching	89,838	7,771	8.6
Dairy cattle & milk prod.	19,231	1,379	7.2
Tobacco	3,576	112	3.1
U.S. Total	434,165	55,311	12.7
<b>Individual Crops</b>			
Rice	3,198	3,198	100.0
Orchards	5,330	4,374	82.1
Potatoes	1,266	1,033	81.6
Vegetables	3,433	2,360	68.7
Sugar cane (for sugar)	978	497	50.8



Crop	Total Cropland	Irrigated Area	Irrigated Share
Peanuts	1,223	463	37.8
Upland cotton	12,224	4,570	37.4
Sugar beets (for sugar)	1,366	472	34.5
Alfalfa hay	22,638	6,809	30.1
Tobacco	429	97	22.7
Forage	64,041	10,280	16.0
Corn for grain	68,231	9,710	14.2
Soybeans	72,400	5,460	7.5
Wheat for grain	45,520	2,910	6.4

Source: USDA, NASS, Agricultural Census, 2002.

Production expenditure data for 2003 from the Agricultural Resource Management Survey (ARMS) as reported by the Economic Research Service (ERS) of USDA suggests that there is considerable variation within the “oilseed and grain” category (see **Table 5**). According to ERS agricultural production cost estimates, energy costs represent about 29% to 30% of total production expenses of rice, barley, and peanuts, but only 14% of total production expenses of soybeans. For three of the four most extensively planted field crops in the United States—corn, wheat, and cotton (soybeans being the exception)—energy costs represented 22% to 27% of total production costs. As a result, year-to-year crop selection and profitability are potentially more sensitive to energy price and supply fluctuations for major U.S. program crops than otherwise indicated by the aggregate “major field crop” aggregation of **Table 3**.

**Table 5. Agricultural Production Expenditures for Energy by Major Crop, U.S. Average for 2003**

Crop	Area Planted 1,000 ac	Total Production Costs	Total Energy Costs	Direct Energy Costs	Indirect Energy Costs		
					Chemicals	Fertilizers	Total
				\$ per acre			
Rice	3,022	614.37	187.11	73.78	59.02	54.31	113.33
Sorghum	9,420	217.74	62.47	32.74	11.56	18.17	29.73
Peanuts	1,344	689.19	196.84	48.52	99.82	48.50	148.32
Corn	78,736	349.78	92.67	23.06	26.20	43.41	69.61
Barley	5,299	200.93	49.17	16.23	9.81	23.13	32.94
Cotton, all	13,479	545.25	130.44	38.59	55.94	35.91	91.85
Sugar beets	1,365	872.29	204.42	50.58	96.39	57.45	153.84
Wheat, all	61,700	191.41	41.07	10.98	6.95	23.14	30.09
Oats	4,601	156.03	27.00	7.85	1.87	17.28	19.15
Soybeans	73,404	238.49	33.04	8.73	16.92	7.39	24.31

Crop	Area Planted	Total Production Costs	Total Energy Costs	Direct Energy Costs	Indirect Energy Costs		
					Chemicals	Fertilizers	Total
<b>Share of Total Production Costs</b>				percent			
Rice		100.0	30.5	12.0	9.6	8.8	18.4
Sorghum		100.0	28.7	15.0	5.3	8.3	13.7
Peanuts		100.0	28.6	7.0	14.5	7.0	21.5
Corn		100.0	26.5	6.6	7.5	12.4	19.9
Barley		100.0	24.5	8.1	4.9	11.5	16.4
Cotton, all		100.0	23.9	7.1	10.3	6.6	16.8
Sugar beets		100.0	23.4	5.8	11.1	6.6	17.6
Wheat, all		100.0	21.5	5.7	3.6	12.1	15.7
Oats		100.0	17.3	5.0	1.2	11.1	12.3
Soybeans		100.0	13.9	3.7	7.1	3.1	10.2

**Source:** USDA, NASS, *Acreage*, June 30, 2003; and USDA, ERS, "U.S. Cost and Return Estimates;" retrieved from <http://www.ers.usda.gov/data/costandreturns/testpick.htm> on Oct. 1, 2004.

## Vegetables and Fruit

Fruit and vegetable production activities vary widely, from highly mechanized production with minimal labor input to labor-intensive with low levels of mechanization. Irrigation is also used widely in vegetable and fruit production (see **Table 4**), and chemicals and fertilizers are traditionally an important part of the production process (see **Figure 14**). In some citrus and other fruit growing areas, field heaters or windmills are used to minimize the potential effects of freezing temperatures. In 2002, "vegetable and melon" energy costs of \$2.0 billion accounted for 22% of their total production expenses (see **Table A-2**). In contrast, "fruit and tree nut" energy costs of \$1.7 billion represented 17% of total production expenses.

## Greenhouse, Nursery, and Floriculture

Energy-using activities—such as temperature regulation, plant disease and insect control, fertilization, and timely watering—comprised less than 10% of total production costs in greenhouse, nursery, and floriculture production.

## Beef Cattle Ranching

Pasture management and marketing activities are the primary energy-using activities involved in cow-calf and other cattle grazing operations. In several locations, pasture management involves irrigation, fertilization, and weed control. Energy costs accounted for about 12% of total beef cattle ranching expenses in 2002. Despite its low share of total production costs, cattle ranching accounts for a substantial share (nearly 12%) of national agriculture-related energy consumption—including over 15% of fuel expenses and 10% of fertilizer costs used by U.S. agriculture in 2002. The significant energy share is explained by the vast acreage involved in beef

cattle ranching in the United States (nearly 420 million acres) and the large number of animals marketed to feedlots or slaughter houses each year (in 2003, 18.4 million head of cattle and calves were slaughtered, while 11.8 million head were on feed as of July 1, 2004).

### **Aquaculture Production**

Aquaculture production includes fish farming of major fish species—catfish, salmon, etc.—as well as of shrimp and mussels. Energy needs vary with production processes and species, but can involve specialized breeding tanks as well as grow-out tanks for fingerlings. Temperature and water control, as well as lighting, are prime users of electricity. Aquaculture is grouped with “other animal production activities” in the 2002 agricultural census. Together, this composite category had energy costs of \$445 million, representing nearly 8% of total production expenses.

### **Dairy Cattle and Milk Production**

Dairy operations require electricity for operating milking systems, cooling milk, and supplying hot water for sanitation. Pasture management, feeding operations, and marketing activities also consume energy directly and indirectly. Total energy costs of \$1.2 billion for dairy and milk production in 2002 accounted for less than 7% of their total production expenses.

### **Cattle Feedlots**

Feedlot operations use energy to furnish feed and water to animals, to manage animal waste, and to market animals to packing plants and other slaughter houses. However, feedlot energy expenses of \$2.3 billion in 2002 accounted for less than 3% of total production costs. Purchasing feeder stock and feedstuffs dominated cost outlays.

### **Hog and Pork Production**

Most hog producers use some type of confinement production, with specialized, environmentally modified facilities. Central farrowing houses, nurseries, and hog barns require electricity for heating, cooling, feeding, and watering systems. Total energy costs of \$526 million for hog and pork production accounted for less than 5% of their total production expenses in 2002.

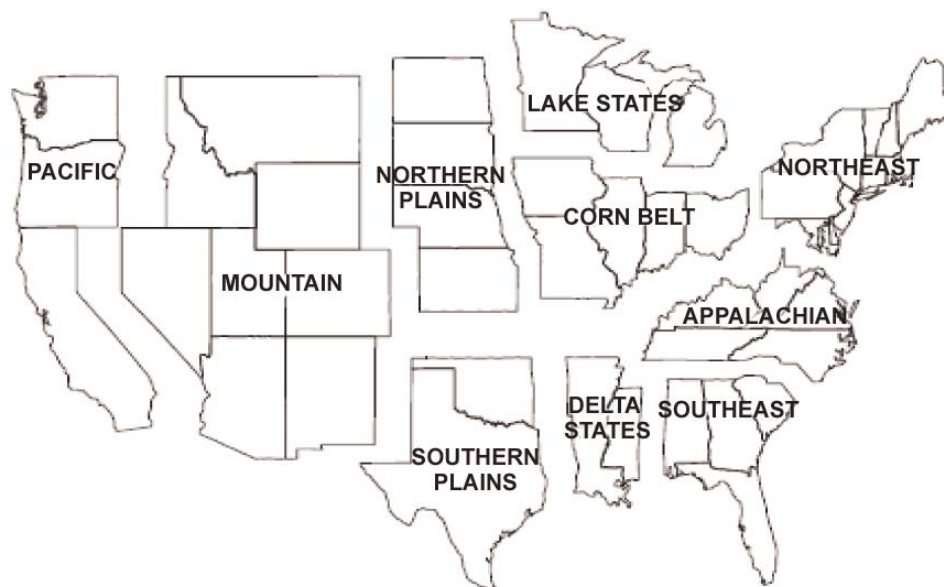
### **Poultry and Egg Production**

As with hog production, most poultry and egg production takes place in specialized buildings. Chickens do not need a lot of room, as long as they have adequate ventilation, proper nourishment, and clean fresh water round the clock. As a result, poultry brooding and grow-out houses require lighting, heating, cooling, feeding, and watering systems. Total energy costs of \$534 million for poultry and egg production in 2002 accounted for 3% of their total production expenses.

## Agricultural Energy Use by Region

Regional energy use is measured by annual survey data as reported by USDA's NASS in its annual report on farm production expenses.<sup>18</sup> Farm expenditures on energy by source for NASS's ten major agricultural production regions are presented in **Appendix Tables A5-A7** and provide the basis for the following discussion of regional energy uses.<sup>19</sup>

**Figure 18. U.S. Farm Production Expenditure Regions**



**Source:** USDA, NASS, *Farm Production Expenditures, 2003 Summary*, July 2004.

The Corn Belt (Illinois, Indiana, Iowa, Missouri, and Ohio), with its extensive area planted to corn and soybeans, is the dominant agricultural energy-using region, with a total energy bill of \$6.5 billion and accounting for 22% of total U.S. agricultural energy costs in 2002. However, nearly 75% (\$4.7 billion) of the Corn Belt's energy costs are in the form of indirect energy expenditures. The Corn Belt is the leading consumer of fertilizers and agricultural chemicals, with national cost-shares of 27% and 24%, respectively. Also noteworthy is the Corn Belt's nation-leading share (25%) of LP gas expenditures for agricultural production—used extensively for crop drying.

In contrast, the Pacific region (Washington, Oregon, and California)—which placed second in terms of total agricultural energy costs at \$4.2 billion—relied far more heavily on direct fuels (43% of total energy costs in the Pacific region). In particular, the Pacific dominated national electricity expenditures in agricultural production, with nearly \$1 billion in outlays in 2002 (accounting for 25% of national electricity costs in agricultural production).

<sup>18</sup> USDA, NASS, *Farm Production Expenditures, 2003 Summary*, July 2004.

<sup>19</sup> NASS's survey data includes direct responses on farm use of fuel, agricultural chemicals, and fertilizer. Farm electricity use is approximated as 15% of farm services outlays which includes operating irrigation equipment and farm utilities.

Both diesel and total fuel costs are highest in the regions with the largest planted crop area—the Corn Belt with 84.4 million acres and the Northern Plains (Kansas, Nebraska, North Dakota, South Dakota) with 81.8 million acres. Irrigation of field crops (another important source of energy demand) is most prevalent in the Southern Plains, Delta, Mountain, and Pacific regions, but may be found to some degree throughout major growing areas.

## **Agricultural Energy Use Issues**

### **Volatile, Rising Energy Prices**

#### **Import Dependency**

U.S. petroleum import dependency has been growing steadily over the past four decades. In 1970, U.S. petroleum imports accounted for 22% of domestic consumption; by 2003 the import share had grown to over 55% and is projected to reach 70% by 2025.<sup>20</sup> This problem is not unique to the United States, but is increasingly a problem for “Western industrial countries.” For example, Japan and OECD Europe (excluding the United Kingdom)<sup>21</sup> are also heavily dependent on imported oil as a share of domestic consumption, with 100% and 66% shares, respectively, in 2004.<sup>22</sup>

Because the United States depends on international sources for so much of its energy needs, U.S. energy prices reflect international market conditions, particularly crude oil supplies. This heavy import dependence renders the United States vulnerable to unexpected price movements and supply disruptions in international energy markets. Agriculture appears particularly vulnerable to energy price increases through both petroleum and natural gas markets, as well as fertilizer markets.

During the last three decades of the 20<sup>th</sup> century, the United States has been subjected to four major oil price shocks—1973-1974, following the Arab Oil Embargo of that same period; 1979-1980, following the Iranian crisis of 1979; 1990-1991, following the Persian Gulf war; and 1999-2000 resulting from unexpectedly strong global demand and tight supplies.<sup>23</sup> Some analysts have argued that reducing U.S. energy dependence on foreign sources might alleviate some or much of the energy price volatility, but that it would likely be associated with a relatively higher price level.<sup>24</sup>

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<sup>20</sup> Dept. of Energy (DOE), Energy Information Agency (EIA), *Annual Energy Outlook 2004 with Projections to 2025*, available at <http://www.eia.doe.gov/oiaf/aeo/gas.html>. Depending on low- and high-oil price assumptions, the projected petroleum import share for 2025 ranges from 65% to 75% of consumption.

<sup>21</sup> OECD Europe consists of Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

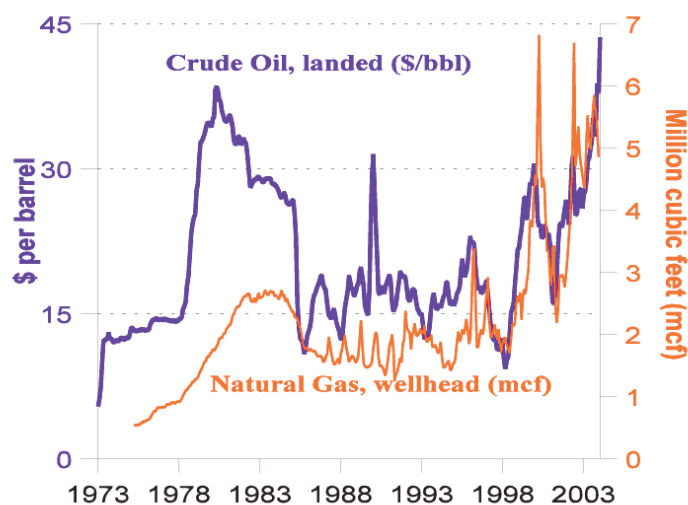
<sup>22</sup> DOE, EIA, *International Petroleum Information*.

<sup>23</sup> See CRS Report RL31608, *The Effects of Oil Shocks on the Economy: A Review of the Empirical Evidence*, for information on global oil shocks and their potential consequences to the U.S. economy.

<sup>24</sup> See CRS Report RS20727, *Energy Independence: Would It Free the United States From Oil Price Shocks?* for a discussion of energy independence and its potential consequences on the U.S. economy.

In the past two years, global markets have seen monthly average crude oil prices surge first to over \$31 per barrel in February 2003 (the highest price since 1981), then to a record \$43.60 per barrel in October 2004 (see **Figure 19**). On October 26, the daily spot market price (FOB) for West Texas Intermediate crude oil at Cushing, Oklahoma, reached a record \$56.37 per barrel. Natural gas prices have followed a similar pattern (but with substantially more variability than crude oil prices), and are presently at or near record high levels.<sup>25</sup> Since 1999, natural gas prices appear to be ratcheting upward to new levels. From January 1986 to July 1999, natural gas prices (wellhead) averaged \$1.86 per million cubic feet (mcf); from August 1999 to December 2002, they averaged \$3.42 per mcf; and since January 2003, they have averaged \$5.12 per mcf.

**Figure 19. Natural Gas vs. Crude Oil, Monthly Prices, January 1976 to July 2004**



**Source:** Monthly average price from DOE, EIA.

**Note:** Data for natural gas prices begins in January, 1976.

The federal government does not determine the price of natural gas; however, two federal agencies—the Federal Energy Regulatory Commission (FERC) and the Commodity Futures Trading Commission (CFTC)—play important roles in promoting competitive natural gas markets by deterring anticompetitive actions. In addition, the Energy Information Administration (EIA) is responsible for obtaining information about and analyzing trends in the natural gas market that are used by industry and government decision makers.

### Rising U.S. Demand for Natural Gas

Increased use of natural gas for electricity generation—due in part to more stringent air pollution standards under the Clean Air Act—has contributed to steadily rising demand in the United States.<sup>26</sup> This has permanently raised the demand for natural gas. In contrast, U.S. natural gas

<sup>25</sup> For more information on the market fundamentals underlying the natural gas market, see CRS Report RL32091, *Natural Gas Prices and Market Fundamentals*.

<sup>26</sup> DOE, EIA, *Annual Energy Outlook 2004 with Projections to 2025*, available at <http://www.eia.doe.gov/oiaf/aeo/gas.html#ngsc>.

production has grown slowly since the late 1980s. Since 1990, natural gas imports have supplied a growing share of domestic consumption.

Certain infrastructure constraints limit access to international supplies of natural gas. First, most natural gas is transported via pipeline. Lack of pipeline access limits the viability of offshore natural gas production in the Gulf of Mexico, where supplies are relatively abundant. Additionally, the pipeline requirement limits access to international supplies other than from neighboring Canada and Mexico. Second, the alternative to pipeline transport of natural gas is liquefaction into liquefied natural gas (LNG), where transportation is more feasible. However, costly infrastructure requirements for production, transportation, and importation, as well as local safety concerns, limit LNG accessibility.<sup>27</sup>

The tightening U.S. supply situation, and increasing dependence on imports, has contributed to higher natural gas prices, with immediate implications for farm fuel and fertilizer costs, as well as for U.S. fertilizer production.

## **Declining U.S. Fertilizer Production Capacity**

According to the GAO, total U.S. nitrogen consumption in 2002 was about 21.4 million short tons, of which agriculture used about 12 million tons (or 56%).<sup>28</sup> The U.S. manufacturing sector used over 9 million tons of nitrogen for industrial purposes such as promoting bacterial growth in waste treatment plants, making plastics, and as a refrigerant.

Fertilizer production, especially nitrogenous fertilizers, is very energy intensive. As mentioned earlier, natural gas accounts for a substantial portion (75% to 90%) of nitrogen fertilizer production costs, either directly as a feedstock or indirectly as a fuel to generate the electricity needed in production. U.S. fertilizer manufacturers are at a competitive disadvantage when domestic natural gas prices rise. Natural gas prices in foreign countries with major nitrogen production capabilities tend to be well below U.S. prices. For example, in early 2001, when U.S. prices for natural gas were about \$5 per million Btu, the price of gas in the Middle East was 60¢ per million Btu; 40¢ in North Africa; 70¢ in Russia; and 50¢ in Venezuela.<sup>29</sup>

As with natural gas, the federal government does not set or control prices for nitrogen fertilizer. Furthermore, nitrogen fertilizer products imported from other countries are generally not subject to U.S. trade restrictions such as quotas or tariffs.

U.S. fertilizer manufacturers can respond to periodic natural gas price spikes by closing plants temporarily, and resuming production when prices drop again. But higher prices sustained over the long run likely result in permanent loss of domestic production capacity. In recent years, high domestic natural gas prices have resulted in the idling and/or closing of a significant share of U.S. nitrogen production capacity. In 1998, U.S. ammonia plant production capacity was 21.4 million tons. From 1998/99 to 2003/04, 3.5 million tons of ammonia plant production capacity was closed and another 1.5 million tons was idled, leaving 16.3 million tons (76.5%) of active

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<sup>27</sup> For more information, see CRS Report RL32386, *Liquefied Natural Gas (LNG) in U.S. Energy Policy: Infrastructure and Market Issues*.

<sup>28</sup> GAO, *Natural Gas: Domestic Nitrogen Fertilizer Production Depends on Natural Gas Availability and Prices*, GAO-03-1148, Sept. 2003, p. 4.

<sup>29</sup> *Ibid.*

production capacity.<sup>30</sup> Declining nitrogen production suggests that either nitrogen use must fall or nitrogen imports must increase.

Advocates for the U.S. fertilizer industry—supported by the American Farm Bureau Federation (AFBF)—argue for changes in U.S. laws and regulations that would either encourage increases in the supply of natural gas, or that would discourage natural gas demand for power generation.<sup>31</sup> They suggest that increased access to federal lands that are currently off-limits to drilling and greater tax incentives for drilling could bolster domestic natural gas production. Alternately, they contend that relaxing environmental restrictions on coal plants, extending or expediting nuclear and hydro licenses, promoting use of clean coal technology, and prohibiting or taxing the use of natural gas as a fuel in power generating permits could all reduce domestic demand for natural gas as an energy source for power generation. However, a broad range of environmentalist organizations, renewable energy advocates, and urban pollution control groups decry these suggestions.<sup>32</sup>

In September 2003, the National Petroleum Council (NPC) produced a report, *Balancing Natural Gas Policy*, that examined the policy options to address the problem of high natural gas prices. The report recognized the likelihood of continued high natural gas prices “for years to come,” and concluded, among other options, that energy conservation and greater energy efficiency would have the biggest immediate potential to hold down prices.<sup>33</sup>

## High Fertilizer Prices

Higher natural gas prices have contributed to substantially higher nitrogen fertilizer prices (see **Figures 11 and 12**). In April of 1999, the wellhead price of natural gas was \$1.90 per 1,000 cubic feet (mcf), while the price of anhydrous ammonia was \$211 per short ton. Two years later, in April 2001, the wellhead price of natural gas had risen by 138% to \$4.52 mcf, while the anhydrous ammonia price had risen by 89% to \$399 per short ton. Because anhydrous ammonia is the principal ingredient in most nitrogen fertilizers, prices for the entire suite of nitrogen fertilizers are highly correlated and afford agricultural producers few cost-saving options other than either applying less nitrogen fertilizer or shifting to less nitrogen-demanding crops.

## Fertilizer Supply Shortages?

The nexus of sharply higher natural gas and fertilizer prices and declining domestic fertilizer production capacity came to a head in 2001 when, according to GAO, the U.S. fertilizer industry experienced a 25% decline in nitrogen production. However, GAO contends that the domestic

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<sup>30</sup> The Fertilizer Institute, *North American Fertilizer Capacity*, August 2003. Historical closings between 1998/99 and 2003/04 obtained in personal correspondence with C.F. Industries in April 2004. The fertilizer marketing year ends June 30.

<sup>31</sup> Fertilizer industry position is from personal conversations with Glen Buckley, C.F. Industries, Long Grove, IL; for details on the AFBF energy position, see <http://www.fb.org/issues/backgrd/energy04.pdf>.

<sup>32</sup> For examples, see the policy positions on clean energy espoused by the Sierra Club at <http://www.sierraclub.org/environment/>, the Natural Resources Defense Council at <http://www.nrdc.org/>, and the U.S. Public Interest Research Group at <http://www.uspirg.org/>.

<sup>33</sup> For more information on energy efficiency issues, see CRS Report IB10020, *Energy Efficiency: Budget, Oil Conservation, and Electricity Conservation Issues*. For information on the NPC and its report on natural gas policy, refer to <http://www.npc.org/>.



supply of nitrogen fertilizer “was adequate to meet farmers’ demand” due to two offsetting factors: first, U.S. nitrogen imports increased 43%; and second, farm use of nitrogen fertilizer declined by 7%.<sup>34</sup> Although these market adjustments served to keep supply and demand in balance, they did so at sharply higher fertilizer price levels. According to fertilizer industry officials, although natural gas and fertilizer prices subsided in 2002, their return to high levels in 2003 (see **Figure 11**) threaten to “irreversibly cripple” the U.S. fertilizer industry.<sup>35</sup>

## Farm Income and Energy Prices

In February 2004, USDA projected U.S. net cash farm income at \$55.9 billion.<sup>36</sup> However, since the initial forecast was made, the outlook for crop and livestock prices has eroded substantially due to record crop projections and falling commodity prices, while the outlook for production expenses has risen due to higher energy and fertilizer prices (see **Table 6**).

**Table 6. Fuel Price Changes, 2003 to 2004**

Fuel	Unit	Period	2003	2004	Change
			\$/unit		%
Natural Gas	mcf <sup>a</sup>	April	1.88	5.20	177
Gasoline	gallon	April-Oct.	1.61	1.96	21
Diesel fuel	gallon	April-Oct.	1.47	1.80	23
Producer Prices Paid Index			1990-92 = 100		%
Fuel		April-Oct.	133.9	161.8	21
Fertilizer		April-Oct.	125.0	136.8	10
Chemicals		April-Oct.	121.0	120.8	0

**Source:** DOE, EIA, for fuel prices at <http://www.eia.doe.gov>; and USDA, NASS, *Agricultural Prices*, various issues for producer prices paid index at <http://www.nass.usda.gov>.

a. mcf = 1,000 cubic feet.

Natural gas prices (wellhead) were running 177% above previous year levels, while national retail gasoline prices were 21% higher, diesel prices were 23% higher; and USDA’s prices paid index (PPI) for fuels and fertilizer were 21% and 10% higher, respectively, from a year earlier. The agricultural chemicals PPI showed no year-to-year change.

What do these energy price changes mean for farm incomes? Because individual farmers are “price-takers” and lack the capacity to quickly pass on higher costs through the food marketing chain, net farm income likely would be reduced in the short term by the equivalent amount of any rise in production expenses. Assuming composite fuel (natural gas, gasoline, diesel, etc.) and electricity prices are 21% higher, fertilizer prices are about 10% higher, and pesticide prices are

<sup>34</sup> GAO, *Natural Gas: Domestic Nitrogen Fertilizer Production Depends on Natural Gas Availability and Prices*, GAO-03-1148, Sept. 2003, p. 3.

<sup>35</sup> *Ibid.*, p. 1.

<sup>36</sup> USDA, ERS, “Farm Income and Costs: Farm Sector Income,” February 6, 2004; available at <http://www.ers.usda.gov/briefing/FarmIncome/nationalestimates.htm>.

unchanged (in accordance with the USDA PPI), then total energy costs would be about \$3.6 billion (or 8.4%) higher in 2004 than originally projected.<sup>37</sup> Assuming roughly similar energy usage rates, this would represent a direct reduction from net cash income. However, the higher fuel costs would likely ripple through several other production expenditure categories such as marketing costs and custom services, further cutting into the agricultural sector's net returns. The bottom line is that the agricultural sector will likely feel the pinch of higher energy prices directly in the form of substantially lower net cash income than originally projected in 2004. If farmers perceive the energy price changes as likely to persist into 2005, then substantial crop and activity mix changes are likely to ensue.

### **Price Responsiveness to Energy Price Changes**

Higher natural gas prices increase farm energy costs directly through higher fuel costs, and indirectly through higher fertilizer and pesticide costs. How agricultural producers respond to energy price changes depends on both the time frame under consideration (i.e., within season versus across seasons) and the producer's expectation of whether the price change is only temporary or will persist into the future.

If producers perceive an energy price change as temporary (lasting only for the current crop season), their response may be limited to some small-scale efforts to economize on fuel use, perhaps by switching to fuel-saving cultivation methods (such as minimum or no-till production),<sup>38</sup> by applying smaller volumes of fertilizers and pesticides per acre than originally planned, or by switching between fuels (such as from natural gas to propane) if meaningful price differences exist. However, in the short run (within a single growing season), once crops have been planted and major inputs (such as fertilizers, pesticides, and fuels) have been purchased, a producer's response to energy and fertilizer cost increases may be fairly limited.

If an energy price change is perceived as permanent, a producer is more likely to adjust the farm's activity mix and production practices from one season to the next to compensate for the new revenue-cost structure.

Economic studies have attempted to measure year-to-year producer responsiveness to changes in prices. In the aggregate, studies suggest that a 10% rise in fuel prices is associated with about a 6% decline in use.<sup>39</sup> Fertilizer and pesticide use are also negatively related to changes in their prices. A 10% rise in prices induces a 6.6% decrease in fertilizer use and a 5.3% decline in pesticide use. As with energy use, changes in fertilizer and pesticide use may be obtained by switching to less intensive production methods, or to crops that use fewer inputs. However, the ability for a producer to implement such changes is greatly diminished once a crop is planted and the production strategy has been set in motion. Instead, producers tend to respond to input price changes by altering their crop and activity mix from season to season. As a result, unexpected within-season price changes can have unavoidable impacts on farm income.

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<sup>37</sup> Calculated by applying hypothetical price changes to data projections provided by USDA, ERS, *2004 Farm Income Forecast*, available at <http://www.ers.usda.gov/Briefing/FarmIncome/nationalestimates.htm>.

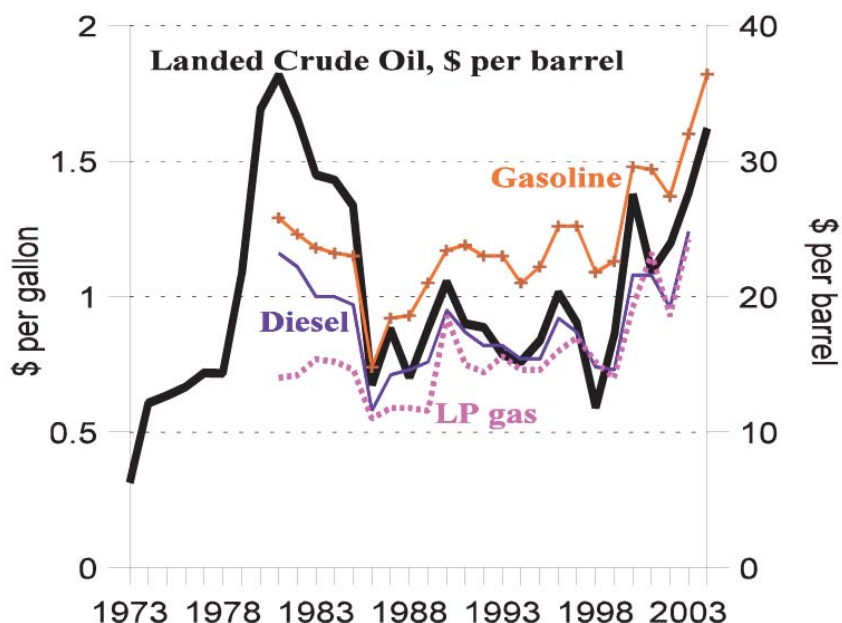
<sup>38</sup> In 2002, 37% of the area planted to the top 22 crops (281.6 million acres) was cultivated under some type of conservation tillage, according to the Conservation Technology Information Center at <http://www.ctic.purdue.edu/CTIC/CTIC.html>.

<sup>39</sup> Miranowski (2004).

## Prices of Most Fuel Sources Tend to Move Together

Demand for refined petroleum products in agricultural production is determined mainly by the number of acres planted and harvested, the production practice used to produce the crops, weather conditions, and the relative prices for the various types of energy. Because the majority of energy used in the United States (and the world) is derived from petroleum-based sources—gasoline, diesel, LP gas, and natural gas—their prices tend to move together. This limits the success of switching among fuel sources to reduce energy costs (see **Figure 20**).

**Figure 20. U.S. Farm Fuel vs. Crude Oil Annual Prices, 1973-2003**



Source: DOE, EIA, and Mranowski (2004).

## Food Price Effects?

A sustained increase in energy prices could be translated into higher food prices for consumers. Energy use adds to food production costs and consumer food prices beyond the farm gate in three stages: (1) food manufactured with energy-intensive technologies, (2) transportation of food products to regional markets in climate controlled cargo containers, and (3) storage and distribution of food items in environmentally controlled facilities. Food retailers are likely to use considerably more energy than the average retailer to control the environment for perishable food products around the clock, according to ERS.

ERS estimates that 3.5% of the cost of food is attributable to energy expenses, and 4% is attributable to transportation expenses (see **Figure 21**). (The energy bill includes only the costs of electricity, natural gas, and other fuels used in food processing, wholesaling, retailing, and food-service establishments. Transportation fuel costs, except for those incurred for food wholesaling, are excluded.)

Farmers receive 19¢ for every \$1 of consumer expenditures on food. This means that 81¢ of the consumer food dollar is attributable to the marketers of food. These food processors, transporters, wholesalers, and retailers have a greater capability than farmers for passing on their higher energy costs through the production-marketing system, and eventually to the consumer.

**Figure 21. Distribution of a Dollar Spent on Food, 2000**



Source: "Food Marketing and Price Spreads: USDA Marketing Bill," ERS, USDA, available at <http://www.ers.usda.gov/Briefing/FoodPriceSpreads/bill/>.

## Conclusions

Agriculture uses a small proportion of the nation's energy. However, direct and indirect energy inputs are critical to agricultural production. Higher and unstable energy prices can make agriculture unprofitable. As a result, agriculture may have to find ways to become more energy independent.

## Public Laws and Bills Affecting Energy Use by Agriculture

Several provisions of the 2002 farm bill are designed to encourage the production and use of renewable energy sources such as biofuels, wind energy systems, solar energy, and small-scale hydropower systems.<sup>40</sup> In addition, other federal and state laws provide incentives for renewable energy research and production.<sup>41</sup> However, agricultural energy production remains very small by

<sup>40</sup> USDA, *2002 Farm Bill*, Title IX—Energy, online information available at [http://www.usda.gov/farmbill/energy\\_fb.html](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*.

<sup>41</sup> For more information, see *State and Federal Incentives and Laws*, at DOE's Alternative Fuels Data Center, at [http://www.eere.energy.gov/afdc/laws/incen\\_laws.html](http://www.eere.energy.gov/afdc/laws/incen_laws.html).

any standard. In 2002, the combined production of biofuels, wind, and solar energy systems contributed only about 0.5% of total U.S. energy consumption.<sup>42</sup>

None of the current energy provisions in the 2002 farm bill directly address the difficulties confronting the U.S. nitrogen fertilizer production sector due to steadily rising natural gas prices. Certain provisions of pending energy legislation (S. 2095) make partial attempts to address the natural gas shortage; however, energy legislation has had a difficult time moving through Congress. In late 2003, energy legislation (H.R. 6, H.Rept. 108-375) stalled in Congress, primarily over its high cost and a dispute related to a liability protection provision for MTBE (ethanol's principal oxygenate competitor).<sup>43</sup> Senator Domenici introduced a revised version of the bill (S. 2095) on February 12, 2004, with a lower estimated cost and without a controversial provision on the fuel additive MTBE. However, S. 2095 also appears to have stalled. Major non-tax provisions related to agricultural energy use and production in the conference measure and S. 2095 include:<sup>44</sup>

- **Renewable Fuels Standard (RFS)**—Both versions of pending energy legislation include an RFS requiring that 3.1 billion gallons of renewable fuel be used in 2005, increasing to 5.0 billion gallons by 2012 (as compared to 2.1 billion gallons used in 2002).
- **Alaska Gas Pipeline**—Alaska's North Slope currently holds 30 trillion cubic feet of undeveloped proven natural gas reserves, about 18% of total U.S. reserves (or a little less than one-and-a-half years of U.S. consumption at current rates). Both bills presume a public need for the gas and would provide \$18 billion in loan guarantees for construction of a natural gas pipeline from Alaska to Alberta, where it would connect to the existing midwestern pipeline system.
- **Energy Efficiency Standards**—New statutory efficiency standards would be established for several consumer and commercial products and appliances. For certain other products and appliances, DOE would be empowered to set new standards. For motor vehicles, funding would be authorized for the National Highway Traffic Safety Administration (NHTSA) to set Corporate Average Fuel Economy (CAFE) levels as provided in current law.
- **Energy Production on Federal Lands**—To encourage production on federal lands, royalty reductions would be provided for marginal oil and gas wells on public lands and the outer continental shelf. Provisions are also included to increase access to federal lands by energy projects—such as drilling activities, electric transmission lines, and gas pipelines.

It is noteworthy that neither bill includes a provision for a Renewable Energy Portfolio Standard (RPS). An RPS aims to encourage electricity production from renewable energy resources such as from wind energy systems.

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<sup>42</sup> DOE, EIA, Table 1.2, "Energy Production by Source, 1949-2003," and Table 1.3, "Total U.S. Energy Consumption by Source."

<sup>43</sup> For the status of pending energy legislation and additional related bill contents, see CRS Issue Brief IB10116, *Energy Policy: The Continuing Debate and Omnibus Energy Legislation*, at <http://www.congress.gov/erp/ib/pdf/IB10116.pdf>. For a discussion of the tax provisions in the bills, see CRS Issue Brief IB10054, *Energy Tax Policy*.

<sup>44</sup> For more information, see CRS Report RL32204, *Omnibus Energy Legislation, 108<sup>th</sup> Congress: 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*.

## Appendix. Tables

### What Is a Btu?<sup>45</sup>

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 allows the adding of various types of energy using a common benchmark (see **Table A-1**).

**Table A-1. Btu Conversion Chart**

Fuel type	Unit	Btu's per unit	GEG <sup>a</sup>	Average Price: \$ per GEG <sup>b</sup>
Direct Energy Types				
Gasoline (conventional)	gallon	125,071 Btu	1.00	\$1.99
Ethanol <sup>c</sup>	gallon	76,000 Btu	0.61	na
Ethanol (E85)	gallon	83,361 Btu	0.67	\$2.52 - \$2.99
Diesel fuel	gallon	138,690 Btu	1.11	\$1.54
Biodiesel (B20)	gallon	138,690 Btu	1.11	\$1.56 - \$1.90
Natural Gas <sup>d</sup>	1,000 cubic foot	1,030 Btu	0.88	\$1.16 - \$1.75
LP gas or Propane	gallon	91,333 Btu	0.73	\$1.92 - \$3.08
Electricity	kilowatt-hour	3,413 Btu	na	na
Indirect Energy Types				
Pesticides	pound	97,914 Btu	na	na
Nitrogen	pound	25,095 Btu	na	na
Phosphate	pound	5,609 Btu	na	na
Potash	pound	4,741 Btu	na	na

**Source:** Conversion rates for petroleum-based fuels and electricity are from the DOE, *Monthly Energy Review*, August 2004. Conversion rates for nitrogen, phosphate, potash, and pesticides are from Mahadev Bhat, Burton English, Anthony Turhollow, and Hezron Nyangito, *Energy in Synthetic Fertilizers and Pesticides: Revisited*, Research Report # ORNL/Sub/90-99732/2, Oak Ridge National Laboratory, Oak Ridge, Tennessee, Jan. 1995.

**Note:** na = not applicable.

- 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 125,000; finally multiplying each fuel's volume by the resulting ratio.
- Prices are for mid-June 2004. The retail price per gallon has been converted to price per GEG units. DOE, *The Alternative Fuel Price Report*, June 29, 2004.
- Net heat content used here. Gross heat content is 84,262 Btu per barrel.
- Converted to gallons as 4.62 million Btu per barrel or 110,000 Btu per gallon.

<sup>45</sup> The material for this appendix is taken from "What is a Btu?," *Agricultural Resources and Environmental Indicators*, Agr. Handbook No. 705, Economic Research Service, USDA, December 1994.

**Table A-2. U.S. Farm Energy Costs in Production, by Activity, 2002**

Activities <sup>a</sup>	Cropland 1,000 ac.	Total Production Costs	Total Energy Costs	Direct Energy Costs			Indirect Energy Costs		
				Fuel & oils	Utilities <sup>b</sup>	Total Direct	Chemicals	Fertilizers <sup>c</sup>	Total Indirect
\$ million									
<b>Crop Activities</b>	<b>294,822</b>	<b>80,343</b>	<b>18,364</b>	<b>3,996</b>	<b>2,630</b>	<b>6,625</b>	<b>6,648</b>	<b>7,722</b>	<b>14,371</b>
Oilseed & grain	204,555	35,584	9,824	1,963	753	2,716	3,179	4,683	7,862
Vegetable & melons	8,639	9,184	2,011	359	408	766	869	784	1,653
Fruit & tree nuts	6,790	10,553	1,747	302	491	793	924	521	1,446
Cotton	14,590	3,513	1,259	215	125	340	656	388	1,044
Greenhouse & nursery <sup>d</sup>	2,497	10,514	979	394	381	775	237	348	585
Tobacco	3,576	1,280	356	96	37	133	109	151	260
Other crops <sup>e</sup>	54,175	9,715	2,188	667	435	1,102	674	847	1,521
<b>Livestock Activities</b>	<b>139,343</b>	<b>95,857</b>	<b>5,701</b>	<b>2,681</b>	<b>2,243</b>	<b>4,923</b>	<b>992</b>	<b>2,028</b>	<b>3,021</b>
Beef cattle ranching	89,838	20,038	2,323	1,029	527	1,556	314	980	1,294
Dairy cattle & milk prod.	11,505	18,451	1,241	488	625	1,113	267	486	753
Cattle feedlots	19,231	22,143	577	231	147	378	125	220	346
Poultry & egg prod.	3,020	17,649	534	411	451	862	60	63	123
Hog & pig farming	6,288	11,312	526	215	244	458	156	156	312
Aquaculture & other	7,991	5,617	445	267	226	493	66	112	178
Sheep & goat farming	1,470	647	55	40	23	63	4	11	15
<b>United States</b>	<b>434,165</b>	<b>173,199</b>	<b>24,036</b>	<b>6,675</b>	<b>4,875</b>	<b>11,550</b>	<b>7,609</b>	<b>9,751</b>	<b>17,360</b>

Source: USDA, NASS, 2002 Census of Agriculture.

- a. Activities are organized by North American Industry Classification System (NAICS), see "Appendix A" of *2002 Census of Agriculture* for details; available at <http://www.nass.usda.gov/census/census02/volume1/us/index1.htm>.
- b. Includes electricity, telephone charges, internet fees, and water purchased in 2002.
- c. Includes lime and soil conditioners.

- d. Includes floriculture.
- e. Includes hay, sugar cane, sugar beets, and all other crops.



**Table A-3. Energy Cost Shares of Total Production Costs, by Activity, 2002**

Activities <sup>a</sup>	Total Production Costs	Total Energy Costs	Direct Energy Costs			Indirect Energy Costs		
			Fuel & oils	Utilities <sup>b</sup>	Total Direct	Chemicals	Fertilizers <sup>c</sup>	Total Indirect
Percent								
<b>Crop Activities</b>	<b>100%</b>	<b>22.9</b>	<b>5.0</b>	<b>3.3</b>	<b>8.2</b>	<b>8.3</b>	<b>9.6</b>	<b>17.9</b>
Oilseed & grain	100%	27.6	5.5	2.1	7.6	8.9	13.2	22.1
Vegetable & melons	100%	21.9	3.9	4.4	8.3	9.5	8.5	18.0
Fruit & tree nuts	100%	16.6	2.9	4.7	7.5	8.8	4.9	13.7
Cotton	100%	35.8	6.1	3.6	9.7	18.7	11.0	29.7
Greenhouse & nursery <sup>d</sup>	100%	9.3	3.7	3.6	7.4	2.3	3.3	5.6
Tobacco	100%	27.8	7.5	2.9	10.4	8.5	11.8	20.3
Other crops <sup>e</sup>	100%	22.5	6.9	4.5	11.3	6.9	8.7	15.7
<b>Livestock Activities</b>	<b>100%</b>	<b>5.9</b>	<b>2.8</b>	<b>2.3</b>	<b>5.1</b>	<b>1.0</b>	<b>2.1</b>	<b>3.2</b>
Beef cattle ranching	100%	11.6	5.1	2.6	7.8	1.6	4.9	6.5
Dairy cattle & milk prod.	100%	6.7	2.6	3.4	6.0	1.4	2.6	4.1
Cattle feedlots	100%	2.6	1.0	0.7	1.7	0.6	1.0	1.6
Poultry & egg prod.	100%	3.0	2.3	2.6	4.9	0.3	0.4	0.7
Hog & pig farming	100%	4.6	1.9	2.2	4.0	1.4	1.4	2.8
Aquaculture & other	100%	7.9	4.8	4.0	8.8	1.2	2.0	3.2
Sheep & goat farming	100%	8.5	6.2	3.6	9.7	0.6	1.7	2.3
<b>United States</b>	<b>100%</b>	<b>13.7</b>	<b>3.8</b>	<b>2.8</b>	<b>6.6</b>	<b>4.3</b>	<b>5.5</b>	<b>9.9</b>

Source: USDA, NASS, 2002 Census of Agriculture.

- a. Activities are organized by North American Industry Classification System (NAICS), see "Appendix A" of *2002 Census of Agriculture* for details; available at <http://www.nass.usda.gov/census/census02/volume1/us/index1.htm>.
- b. Includes electricity, telephone charges, internet fees, and water purchased in 2002.

- c. Includes lime and soil conditioners.
- d. Includes floriculture.
- e. Includes hay, sugar cane, sugar beets, and all other crops

**Table A-4. U.S. Energy Cost Shares by Activity, 2002**

Activities <sup>a</sup>	Total Production Costs	Total Energy Costs	Direct Energy Costs			Indirect Energy Costs		
			Fuel & oils	Utilities <sup>b</sup>	Total Direct	Chemicals	Fertilizers <sup>c</sup>	Total Indirect
Percent								
<b>Crop Activities</b>	<b>45.6</b>	<b>76.3</b>	<b>59.8</b>	<b>54.0</b>	<b>57.4</b>	<b>87.0</b>	<b>79.2</b>	<b>82.6</b>
Oilseed & grain	20.2	40.8	29.4	15.5	23.5	41.6	48.0	45.2
Vegetable & melons	5.2	8.4	5.4	8.4	6.6	11.4	8.0	9.5
Fruit & tree nuts	6.0	7.3	4.5	10.1	6.9	12.1	5.3	8.3
Cotton	2.0	5.2	3.2	2.6	2.9	8.6	4.0	6.0
Greenhouse & nursery <sup>d</sup>	6.0	4.1	5.9	7.8	6.7	3.1	3.6	3.4
Tobacco	0.7	1.5	1.4	0.8	1.2	1.4	1.5	1.5
Other crops <sup>e</sup>	5.5	9.1	10.0	8.9	9.5	8.8	8.7	8.7
<b>Livestock Activities</b>	<b>54.4</b>	<b>23.7</b>	<b>40.2</b>	<b>46.0</b>	<b>42.6</b>	<b>13.0</b>	<b>20.8</b>	<b>17.4</b>
Beef cattle ranching	11.4	9.7	15.4	10.8	13.5	4.1	10.1	7.4
Dairy cattle & milk prod.	10.5	5.2	7.3	12.8	9.6	3.5	5.0	4.3
Cattle feedlots	12.6	2.4	3.5	3.0	3.3	1.6	2.3	2.0
Poultry & egg prod.	10.0	2.2	6.2	9.3	7.5	0.8	0.6	0.7
Hog & pig farming	6.4	2.2	3.2	5.0	4.0	2.0	1.6	1.8
Aquaculture & other	3.2	1.8	4.0	4.6	4.3	0.9	1.1	1.0
Sheep & goat farming	0.4	0.2	0.6	0.5	0.5	0.1	0.1	0.1
<b>United States</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

Source: USDA, NASS, 2002 Census of Agriculture.

- a. Activities are organized by North American Industry Classification Ssystem (NAICS), see “Appendix A” of *2002 Census of Agriculture* for details; available at <http://www.nass.usda.gov/census/census02/volume1/us/index1.htm>.
- b. Includes electricity, telephone charges, internet fees, and water purchased in 2002.
- c. Includes lime and soil conditioners.
- d. Includes floriculture.

e. Includes hay, sugar cane, sugar beets, and all other crops.

**Table A-5. U.S. Farm Energy Costs in Production, by Region, 2003**

Regions <sup>a</sup>	Area Planted 1,000 ac	Total Production Costs	Total Energy Costs	Direct Energy Costs						Indirect Energy Costs			
				Diesel	Gas	LP Gas	Other Fuel <sup>b</sup>	Total Fuels	Electricity <sup>c</sup>	Total Direct	Chemicals	Fertilizers	Total Indirect
				\$ million									
Corn Belt	84,425	35,810	6,362	564	230	225	71	1,090	542	1,632	2,030	2,700	4,730
Pacific	11,014	32,300	4,173	395	246	54	105	800	983	1,783	1,280	1,110	2,390
No. Plains	81,844	26,070	4,076	603	247	81	99	1,030	416	1,446	1,200	1,430	2,630
Lake States	35,022	19,290	2,987	373	139	134	44	690	347	1,037	880	1,070	1,950
So. Plains	34,904	17,170	2,308	388	213	43	106	750	368	1,118	430	760	1,190
Appalachian	16,164	16,250	2,074	235	171	92	32	530	294	824	510	740	1,250
Mountain	24,902	16,510	1,994	291	202	54	23	570	344	914	440	640	1,080
Southeast	8,472	12,850	1,965	172	97	111	29	409	276	685	570	710	1,280
Delta	15,761	9,850	1,844	251	90	78	21	440	204	644	710	490	1,200
Northeast	12,650	12,800	1,289	158	125	48	59	390	249	639	300	350	650
<b>U.S. Total</b>	<b>325,158</b>	<b>198,900</b>	<b>29,069</b>	<b>3,430</b>	<b>1,760</b>	<b>920</b>	<b>589</b>	<b>6,699</b>	<b>4,020</b>	<b>10,719</b>	<b>8,350</b>	<b>10,000</b>	<b>18,350</b>

**Source:** Area data is for major crops: USDA, NASS, *Acreage*, June 30, 2004. Farm production expenses data: USDA, NASS, *Farm Production Expenditures, 2003 Summary*, July 2004.

- a. The 14 regions consist of the following states: Northeast: CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT; Lake States: MI, MN, WI; Corn Belt: IL, IN, IA, MO, OH; Northern Plains: KS, NE, ND, SD; Appalachian: KY, NC, TN, VA, WV; Southeast: AL, FL, GA, SC; Delta: AR, LA, MS; Southern Plains: OK, TX; Mountain: AZ, CO, ID, MT, NV, NM, UT, WY; and Pacific: CA, OR, WA.
- b. Other fuels includes natural gas, coal, fuel oil, kerosene, wood, etc.
- c. Electricity is approximated as 15% of farm services expenses.

**Table A-6. Energy Cost Shares of Total Production Costs, by Region, 2003**

Regions <sup>a</sup>	Total Production Costs	Total Energy Costs	Direct Energy Costs							Indirect Energy Costs		
			Diesel	Gas	LP Gas	Other Fuel <sup>b</sup>	Total Fuels	Electricity <sup>c</sup>	Total Direct	Chemicals	Fertilizers	Total Indirect
Percent												
Corn Belt	100%	17.8	1.6	0.6	0.6	0.2	3.0	1.5	4.6	5.7	7.5	13.2
Pacific	100%	12.9	1.2	0.8	0.2	0.3	2.5	3.0	5.5	4.0	3.4	7.4
No. Plains	100%	15.6	2.3	0.9	0.3	0.4	4.0	1.6	5.5	4.6	5.5	10.1
Lake States	100%	15.5	1.9	0.7	0.7	0.2	3.6	1.8	5.4	4.6	5.5	10.1
So. Plains	100%	13.4	2.3	1.2	0.3	0.6	4.4	2.1	6.5	2.5	4.4	6.9
Appalachian	100%	12.8	1.4	1.1	0.6	0.2	3.3	1.8	5.1	3.1	4.6	7.7
Mountain	100%	12.1	1.8	1.2	0.3	0.1	3.5	2.1	5.5	2.7	3.9	6.5
Southeast	100%	15.3	1.3	0.8	0.9	0.2	3.2	2.1	5.3	4.4	5.5	10.0
Delta	100%	18.7	2.5	0.9	0.8	0.2	4.5	2.1	6.5	7.2	5.0	12.2
Northeast	100%	10.1	1.2	1.0	0.4	0.5	3.0	1.9	5.0	2.3	2.7	5.1
U.S. Total	100%	14.6	1.7	0.9	0.5	0.3	3.4	2.0	5.4	4.2	5.0	9.2

**Source:** Area data is for major crops: USDA, NASS, *Acreage*, June 30, 2004. Farm production expenses data: USDA, NASS, *Farm Production Expenditures, 2003 Summary*, July 2004.

- a. The 14 regions consist of the following states: Northeast: CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT; Lake States: MI, MN, WI; Corn Belt: IL, IN, IA, MO, OH; Northern Plains: KS, NE, ND, SD; Appalachian: KY, NC, TN, VA, WV; Southeast: AL, FL, GA, SC; Delta: AR, LA, MS; Southern Plains: OK, TX; Mountain: AZ, CO, ID, MT, NV, NM, UT, WY; and Pacific: CA, OR, WA.
- b. Other fuels includes natural gas, coal, fuel oil, kerosene, wood, etc.
- c. Electricity is approximated as 15% of farm services expenses.

**Table A-7. Regional Shares of U.S. Energy Costs by Type, 2003**

Regions <sup>a</sup>	Total Production Costs	Total Energy Costs	Direct Energy Costs							Indirect Energy Costs		
			Diesel	Gas	LP Gas	Other Fuel <sup>b</sup>	Total Fuels	Electricity <sup>c</sup>	Total Direct	Chemicals	Fertilizers	Total Indirect
Percent												
Corn Belt	18.0	21.9	16.4	13.1	24.5	12.1	16.3	13.5	15.2	24.3	27.0	25.8
Pacific	16.2	14.4	11.5	14.0	5.9	17.8	11.9	24.5	16.6	15.3	11.1	13.0
No. Plains	13.1	14.0	17.6	14.0	8.8	16.8	15.4	10.3	13.5	14.4	14.3	14.3
Lake States	9.7	10.3	10.9	7.9	14.6	7.5	10.3	8.6	9.7	10.5	10.7	10.6
So. Plains	8.6	7.9	11.3	12.1	4.7	18.0	11.2	9.1	10.4	5.1	7.6	6.5
Appalachian	8.2	7.1	6.9	9.7	10.0	5.4	7.9	7.3	7.7	6.1	7.4	6.8
Mountain	8.3	6.9	8.5	11.5	5.9	3.9	8.5	8.5	8.5	5.3	6.4	5.9
Southeast	6.5	6.8	5.0	5.5	12.1	4.9	6.1	6.9	6.4	6.8	7.1	7.0
Delta	5.0	6.3	7.3	5.1	8.5	3.6	6.6	5.1	6.0	8.5	4.9	6.5
Northeast	6.4	4.4	4.6	7.1	5.2	10.0	5.8	6.2	6.0	3.6	3.5	3.5
<b>U.S. Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

**Source:** Area data is for major crops: USDA, NASS, *Acreage*, June 30, 2004. Farm production expenses data: USDA, NASS, *Farm Production Expenditures, 2003 Summary*, July 2004.

- a. The 14 regions consist of the following states: Northeast: CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT; Lake States: MI, MN, WI; Corn Belt: IL, IN, IA, MO, OH; Northern Plains: KS, NE, ND, SD; Appalachian: KY, NC, TN, VA, WV; Southeast: AL, FL, GA, SC; Delta: AR, LA, MS; Southern Plains: OK, TX; Mountain: AZ, CO, ID, MT, NV, NM, UT, WY; and Pacific: CA, OR, WA.
- b. Other fuels includes natural gas, coal, fuel oil, kerosene, wood, etc.
- c. Electricity is approximated as 15% of farm services expenses.

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