NEEDED RESEARCH WITH RESPECT TO ENERGY USE IN AGRICULTURAL PRODUCTION*

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INTRODUCTION

The agricultural industry, like other industries, has become increasingly dependent upon energy resources such as electricity, fossil fuels, chemicals and fertilizers, largely due to relatively low energy prices. In the middle 1970s, however, energy prices rose sharply as a result of continuously rightward shifting energy demands and leftward shifting energy supplies due to dwindling domestic reserves and oil price increases by OPEC nations. Although the rapidly rising energy prices may have been viewed initially as a temporary phenomenon, most now agree that we are in an era of high energy prices. Carter and Youde [2] have discussed some impacts of the changing energy situation on U.S. agriculture.

In terms of energy use and any type of national energy policy, agriculture faces a dilemma. Although agricultural production alone uses only three to four percent of the total U.S. energy budget, production, processing and distribution of food and fiber together utilize almost twenty percent. On the surface, agricultural production uses too large a proportion of energy to be neglected from a national policy viewpoint but too small a proportion to receive serious consideration. Energy use in agricultural production, however, differs from energy use in non-agricultural production in terms of seasonality and the need for uninterrupted services. Poultry houses, unlike schools and steel factories, cannot be closed on weekends. Crop planting, harvesting, curing and drying have to be done during certain time periods. Due to the biological nature of agriculture, the interseasonal rate of substitution for fossil energy in many production activities is very low, and the impact of interrupted service is relatively large. One way or another, energy will be allocated to the agricultural sector. If the future entails limitations on quantities of energy available for purchase, then information concerning energy use in agricultural production and food processing and distribution is seriously needed to facilitate an efficient and equitable allocation.

This paper focuses on the use of fossil fuels; namely gasoline, diesel fuel, LP gas, fuel oil, natural gas and coal in agricultural production in the South and the U.S. Additionally, some needed research regarding energy use in agriculture is discussed.

REGIONAL DELINEATION AND DATA

The South includes the following thirteen states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia. The ensuing analyses are based on cross-sectional data provided by the Economic Research Service, United States Department of Agriculture. Under a jointly funded agreement with the Federal Energy Administration, estimates of the use of fossil energy by crops and livestock for 1974 were developed for all states from budget data.[1]

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[1] Refers to direct use of energy on the farm for crop and livestock production: mechanized feeding, space heating, farm business auto use, field operations, irrigation, fertilizer application and crop drying. Energy required to manufacture fertilizer, pesticides and herbicides is not included.

ENERGY USE IN CROP AND LIVESTOCK PRODUCTION

The usage pattern of fossil fuels in various types of agriculture is important since crop and livestock production require different quantities of fossil fuel. Comparisons of fossil energy use are made to determine key livestock and crop users and to point out differences between Southern and U.S. agricultural production.

Aggregate Crop and Livestock Enterprises

In 1974, approximately 1.0 billion gallons of gasoline, 0.8 billion gallons of diesel fuel, 0.5 billion gallons of LP gas, 0.2 billion gallons of fuel oil, 81 billion cubic feet of natural gas, and 21,450 tons of coal were used in crop and livestock production in the South. These numbers constitute roughly 33 percent of the gasoline, diesel fuel and LP gas, 70 percent of the fuel oil, 50 percent of the natural gas, and 65 percent of the coal required for U.S. agricultural production. The large percentages of fuel oil, natural gas and coal use in Southern agricultural production are attributable to several enterprises. Cotton, flue-cured tobacco and broiler production occur predominately in the South. Natural gas is used for cotton drying, fuel oil is used for flue-cured tobacco, and broilers require natural gas and coal for heating.

In both the South and the U.S. crop production requires a larger percentage of fossil energy, except coal, than does livestock production. As exhibited in Table 1, almost all fuel oil and natural gas use, and 70 to 90 percent of gasoline, diesel fuel and LP gas use are attributable to crop production. This piece of information is noteworthy in terms of a potential allocation program for energy distribution. Furthermore, the percentage of fossil energy use in Southern and U.S. crop production exceeds the percentage of total value of production attributable to crops. In livestock production, the reverse holds. Finally, with few exceptions, differences in the percentage of fossil energy used in crop and livestock production between the South and the U.S. are small.

Livestock Enterprises and Crop Enterprises

Rank and percentage of the total value of production and fossil fuel use in the South and the U.S. by livestock enterprises are presented in Table 2. Types of livestock include beef cows and calves, beef feedlots, milk cows, broilers, layers, pullets, hogs, turkeys, sheep and lambs and miscellaneous poultry. Although differences exist in percentage of use, beef, dairy and hog enterprises are the major gasoline users in the South and the U.S., while beef and hog enterprises are the major users of diesel fuel. Broilers, pullets and turkeys dominate use of fuel oil, LP gas, natural gas and coal. On a per head basis, the major users of gasoline and LP gas are milk cows, while turkeys require the most fuel oil, natural gas and coal per head and beef cows the most diesel fuel.

In the South and the U.S., predominant users of fossil energy in agricultural production are crops. Rank and percentage of the total value of production and fossil fuel use in the South and the U.S. for selected crop enterprises are exhibited in Table 3. The crop enterprises include soybeans, corn, cotton, flue-cured tobacco, grain sorghum, winter wheat, rice, sugar cane, hay-other, burley tobacco, peanuts, oranges, corn silage, fresh vegetables and alfalfa. These fifteen crops account for 88 percent of total agricultural receipts in the South and 80 percent of U.S. receipts.

Unlike livestock production, the key energy users in Southern and U.S. crop production are not all the same. In the South, soybeans require the most gasoline, cotton the most diesel fuel, oranges the most fuel oil, flue-cured tobacco the most LP gas, and grain sorghum the most natural gas. In the U.S., corn uses the largest percentage of gasoline, diesel fuel and LP gas, oranges the largest percentage of fuel oil, and grain sorghum the largest percentage of natural gas. Since energy use in crop production is positively correlated with acreage and since energy use per acre in the South and the U.S. is similar, differences in major energy users in crop production are attributable to differences in acreage. On a per acre basis, oranges require the most gasoline, diesel fuel and fuel

TABLE 1. THE PERCENTAGE OF TOTAL VALUE OF PRODUCTION AND FOSSIL FUEL USED BETWEEN CROPS AND LIVESTOCK IN THE SOUTH AND THE U.S. (1974)

		US (%)	South (%)
Total value of production attributable to	crops	62.0	59.0
	livestock	38.0	41.0
Gasoline use attributable to	crops	77.9	70.6
	livestock	22.1	29.4
Diesel fuel use attributable to	crops	86.6	92.8
	livestock	13.4	7.2
Fuel oil use attributable to	crops	97.1	99.6
	livestock	2.9	0.4
LP gas use attributable to	crops	77.5	72.1
	livestock	22.5	27.9
Natural gas use attributable to	crops	97.2	96.8
	livestock	2.8	3.2
Coal use attributable to	crops	0.0	0.0
	livestock	100.0	100.0

SOURCE: The Economic Research Service, United States Department of Agriculture, under a jointly funded cooperative agreement with the Federal Energy Administration.

TABLE 2. RANK (R) AND PERCENTAGE (P)[a] OF TOTAL VALUE OF PRODUCTION AND FOSSIL FUEL USE IN THE SOUTH AND THE U.S. FOR SELECTED LIVESTOCK ENTERPRISES (1974)

	Total value of production				Gasoline				Diesel fuel				Fuel oil				LP gas				Natural gas				Coal			
	Region		US		Region		US		Region		US		Region		US		Region		US		Region		US		Region		US	
Livestock	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P
Beef Cows & Calves	1[b]	42.0	1[b]	39.2	1	58.7	1	38.4	1	66.0	1	49.8					8	0.3	6	3.4								
Beef Feedlots					9	1.0	4	9.4	3	11.3	2	24.5											6	0.2				
Milkcows	2	16.4	2	25.5	2	15.1	2	26.7									2	14.4	2	23.0								
Broilers	3	16.1	5	6.4	4	6.0	5	2.8					1	61.1	1	72.6	1	68.4	1	36.7	1	79.7	1	48.4	1	78.2	1	57.7
Chickens (Layers)	4[c]	12.4	4[c]	8.0	6	2.1	8	1.7	5	0.7	5	0.5	4	2.5	3	5.9	6	2.0	7	1.5	4	2.4	5	5.4				
Chickens (Pullets)					5	3.6	6	2.8	7	0.5	7	0.3	3	6.2	2	13.7	3	6.9	5	7.1	3	7.0	3	11.8	3	7.6	3	18.7
Hogs	5	5.9	3	18.1	3	9.8	3	14.1	2	20.6	3	22.6					5	5.3	3	15.1								
Turkeys	6	2.1	6	1.8	7	1.2	9	1.2	6	0.6	6	0.5	2	29.7	4	5.4	4	5.9	4	12.7	2	10.1	2	25.1	2	13.9	2	19.0
Sheep & Lambs	7	0.4	7	0.7	8	1.2	7	2.7	4	0.9	4	1.9																
Misc. Poultry	8	0.3	8	0.3	10	0.1	10	0.2					5	0.5	5	2.4	7	0.4	8	0.5	5	0.7	4	9.2	4	0.3	4	4.7

SOURCE: The Economic Research Service, United States Department of Agriculture, under a jointly funded cooperative agreement with the Federal Energy Administration.

[a]Blank spaces indicate less than 0.1 percent use.

[b]Includes Beef Feedlots.

[c]Includes Layers and Pullets.

oil, flue-cured tobacco the most LP gas, and rice the most natural gas.

In short, the pattern of energy use in livestock and crop enterprises differs according to total, per head or per acre use. Further, differences exist in energy use between the South and the U.S. These dissimilarities may be attributed to differences in livestock and crop mix, temperature, climate, farm operations, livestock and crop prices, energy prices, interest rates, farm labor prices, fertilizer prices and technology. Simply put, these analyses are important from the standpoints of developing or modifying energy allocation programs, and of bringing to light potential opportunities for energy conservation. However, information pertaining to energy used in processing and distributing food and fiber must be obtained before valid conclusions concerning energy use in agriculture can be drawn. Finally, all analyses and comparisons of fossil energy use in agricultural production presented pertain to 1974 and hence give no insights about what has been happening to energy use over time. Data on energy use in agricultural production, processing and distribution over time are scarce and related analyses are lacking although Pimentel [11] has discussed energy inputs in U.S. corn production for the period 1945-1970.

RESEARCH NEEDS

Attention is devoted to the following general, but by no means exhaustive, research needs: (1) collection and reporting of data; (2) determination of direct and indirect impacts of high energy prices; (3) economically feasible options available to agricultural producers; (4) demand for different types of energy in various agricultural production enterprises; (5) supply of different types of energy; (6) manufacture of agricultural inputs; and (7) processing and distribution of food and fiber.

Collection and Reporting of Data

Data are not only an integral part of economic research and analysis but also an absolute necessity to evaluate policy issues. In general, a plethora of information pertains to agricultural outputs, but a paucity of data exists on agricultural inputs. Casler and Erickson [3], Coble and LePori [5], Cervinka, Chancellor, Coffelt, Curley and Dobie [4], and

TABLE 3. RANK (R) AND PERCENTAGE (P)[a] OF TOTAL VALUE OF PRODUCTION AND FOSSIL FUEL USE IN THE SOUTH AND THE U.S. FOR SELECTED CROP ENTERPRISES (1974)

	Total value of production				Gasoline				Diesel fuel				Fuel oil				LP gas				Natural gas			
	Region		US		Region		US		Region		US		Region		US		Region		US		Region		US	
Crop	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P
Soybeans	1	15.0	2	15.3	1	16.3	2	13.4	2	18.3	2	15.0					6	4.0	5	3.3	8	1.8	9	1.2
Corn	2	10.3	1	26.3	4	10.4	1	23.8	3	9.8	1	20.6	5	3.8	6	3.8	3	8.5	1	50.9	6	8.5	3	16.2
Cotton	3	10.2	6	4.2	3	11.4	7	3.7	1	21.7	3	8.9					4	6.9	9	2.4	2	16.2	4	12.8
Flue-cured Tobacco	4	8.2	15	1.6	9	3.8	17	0.9	11	1.9	23	0.6	2	31.1	2	21.9	1	47.3	2	14.9				
Grain Sorghum	5	6.6	7	3.1	5	8.6	8	3.4	5	7.9	7	4.5	10	0.0	13	0.0	5	6.0	4	3.5	1	27.5	1	18.2
Winter Wheat	6	6.2	3	9.1	2	11.8	4	10.1	4	9.8	4	8.6					8	3.4	8	2.0	4	12.2	6	8.9
Rice	7	5.8	12	2.0	8	4.7	15	1.2	6	6.9	9	3.0	9	0.2	12	0.1	2	8.6	7	2.9	3	15.9	5	9.0
Sugar Cane	8	5.8	16	1.5	16	1.3	24	0.5	9	3.9	17	1.6					16	0.3	28	0.1				
Hay-other	11	3.6	10	2.9	7	4.8	5	4.2	39	0.0	28	0.4					10	2.3	6	3.1			10	1.1
Burley Tobacco	9	4.2	19	1.3	14	1.7	23	0.5	26	0.2	34	0.1					11	1.8	15	0.7				
Peanuts	10	4.2	21	1.1	11	2.3	21	0.6	8	4.0	18	1.4					9	2.4	12	0.8	9	1.3	13	0.7
Oranges	12	2.7	22	1.0	6	5.1	14	1.6	7	4.6	12	1.8	1	48.5	1	43.4	13	0.7	22	0.2	12	0.2	15	0.3
Corn Silage	13	2.0	5	4.3	15	1.4	9	3.4	13	1.4	5	6.5					15	0.4	11	1.3	10	0.2	8	2.4
Vegetables (fresh)	14	1.9	8	3.0	13	1.9	11	1.8	14	1.2	14	1.6					14	0.5	19	0.3			16	0.3
Alfalfa	15	1.5	4	5.9	10	3.6	3	13.1	17	0.7	6	5.8					12	1.6	3	6.2	7	3.9	2	17.1

SOURCE: The Economic Research Service, United States Department of Agriculture, under a jointly funded cooperative agreement with the Federal Energy Administration.

[a]Blank spaces indicate less than 0.1 percent use.

Robinson [13] as well as the Economic Research Service [7] estimated fossil energy requirements from engineering and budget data in different types of agricultural production for 1974. However, there is a need to gather and report time-series and cross-sectional data on observed quantities of various types of energy used and prices paid for various types of energy in different types of crop and livestock production and in food processing and distribution. Gopalakrishnan and Patrick [8] reported an acute dearth of reliable information on energy use for different sectors of the agricultural economy. In the absence of such data, formulation of a viable energy policy for the agricultural sector is almost impossible. Collecting and reporting data on energy in agriculture is essential, of the highest priority, and should be the responsibility of both state and federal statistical reporting agencies.

Impacts of Increased Energy Prices

Increased energy prices have both direct and indirect impacts upon the agricultural sector. Price increases of agricultural energy inputs directly influence costs of farm production, substitution among inputs, competitive positions of regions, and the supply response of agricultural production. Indirect impacts emerge as energy price increases affect price structures of other goods and services and the U.S. international trade position.

Rising energy prices directly increase agricultural production costs. Tweeten and Quance [15] estimated the impacts of input price changes on U.S. farm costs and revenues from 1958 to 1967. For factors with elastic demands, notably fertilizer, price increases increase net farm income, while for inputs with inelastic demands, rising prices decrease net farm income. Burton [1] conducted a sensitivity analysis of the impacts of increased energy input prices and decreased quantities of energy inputs on representative Virginia dairy farms. On the basis of Burton's study, should the government be faced with the choice of an energy conservation policy based on large price increases or on strict rationing, the latter would cause greater reductions in net farm income. Dvoskin and Heady [6] and Lehrman, Black and Connor [9] argued that even if prices doubled there would be little change in agricultural energy use, and there would be little effect on the level of output.

However, an outright restriction on quantities of energy input would decrease output levels, and given the inelastic nature of demands for most farm products, net farm incomes could rise. Research must consider further direct impacts of energy price increases and restrictions on quantities of energy on net income and wealth positions of farms by size, region and commodity group.

For the past two decades, fertilizer and fossil fuels have been substituted for land and labor. Input substitution is both a major short-run and long-run adjustment. In the short run, if real energy price increases continue, there may be an effort to substitute land and labor for fossil fuels and fertilizer. In addition, as fertilizer prices increase, substitution of animal manures and other organic materials for fertilizers may occur. Also, some additional marginal land may be brought into production, thus increasing the acreage under cultivation. Substitution among inputs, at least in the short run, may result in rightward shifts in the demand for non-energy factors and leftward shifts in the demand for energy inputs. In the long run, options available to producers may involve development of energy-reducing technology, reduced tillage methods, development of energy resources from organic material, waste energy utilization and residue management, solar energy in agriculture, and more efficient farm machinery. For example, Casler and Erickson [3] point out that a change from gasoline to diesel engines in tractors and combines has taken place in the agricultural sector. Some estimates indicate that by 1980 over 80 percent of farm tractors and 90 percent of self-propelled combines will be diesel powered. Manne [10] and Whittlesey and Butcher [16] state that a need exists to evaluate short-run and long-run adjustment possibilities. However, at the present time, insufficient data exist to assess energy-reducing technology and energy conservation possibilities. Energy policy in the agricultural sector should explicitly take into account the relative direct costs of input substitution, changes in the total system, and costs of these changes. In sum, impacts of trade-offs among energy and non-energy inputs in the short run and the long run merit investigation.

Further, rising energy prices may directly influence competitive positions of regions. The competitive position of a region in production of a particular commodity may improve or deteriorate as a result of increased input costs. Commodity and regional characteristics, such as elasticities of demand, climate and technology, need to be known in order to determine impacts of higher energy prices on interregional competition.

Sensitivity of farmers to increased energy prices warrants examination to determine the impact on the supply of farm products. Estimates of the elasticity of supply with respect to energy prices should be useful in providing insights as to the relative responsiveness of farmers to relative price changes of energy inputs. Also, special attention needs to be devoted to production activities in which curtailment of quantities of energy results in large costs and reductions in quantities supplied. These are production activities where, in the short run, there is little opportunity to alter energy use, i.e. hatching, brooding, drying, curing and other similar activities.

Increased energy prices are likely to indirectly affect price structures of other goods and services and the U.S. international trade position. Energy-related products account for a large percentage of wholesale price increases and retail price increases which, in turn, may result in a substitution among products in the short run. Within the limits of product alternatives and consumer demand, commodities that are relatively less dependent on energy inputs may be substituted for commodities that are relatively more dependent. In addition, the income and wealth distribution within the national economy may be affected [12]. Further, since U.S. agriculture has become heavily dependent on export markets, increased energy prices may influence the world demand for U.S. agricultural products through their impacts on prices of other products, balance of payments and economic growth rates. Simply put, there is little information regarding direct energy impacts on product prices, economic growth rates, balance of payments and income and wealth distribution.

Demand for and Supply of Energy

To assess the impacts which higher energy prices and restrictions on quantities of energy may have in the agricultural sector, information about the economic factors that influence supply of and demand for energy is needed. Little is known about these major factors and how sensitive the quantities demanded of various types of energy in different types of agriculture are to price changes in both the short and long runs. Estimates of elasticities and cross-elasticities may be very useful in providing insights as to the relative responsiveness of farmers and producers of energy and related inputs to relative price changes and changes in certain other measurable variables. For example, if the quantities demanded of energy inputs are not responsive to price changes, then the prices of energy factors will not be very effective allocators of limited quantities. On the other hand, if price changes affect quantities demanded, then the different effects in different types of agriculture need to be known. A quantitative analysis of factors affecting the demand for energy in various types of agricultural use is of paramount importance in developing or modifying allocation programs for energy distribution. Whether allocation of energy is done by legislative and administrative procedures or through market forces depends on the nature of the energy demands.

Understanding the nature of the supply of different types of energy is just as important as understanding the nature of the demands. The key issue is lack of information concerning the supply response to changes in energy prices. Moreover, research is needed to identify the magnitudes of the economic factors affecting the quantities supplied. Further, institutional factors merit examination in order to determine the impediments, the stickiness in and the physical limits of the quantities supplied of different types of energy.

The quantitative analyses of supply of and demand for different types of energy may bring to light new opportunities for energy conservation and more efficient methods of energy allocation. In sum, agricultural economists, producers of energy and related inputs, and farmers presently do not fully comprehend the magnitude and influence of the economic factors that affect supply of and demand for energy in the agricultural sector. Research in this area may provide a useful guide for the direction of further agricultural policy concerning energy.

Options Available to Individual Producers

Although the agricultural sector has become heavily dependent on energy resources, stoppage of agricultural production in the wake of rising energy prices and potential limitations on quantities of energy is not economically feasible. An evaluation of the economically viable options available to individual producers is needed. First, outright energy minimization may lead to undesirable results, such as a decrease in yields. Second, substitution of one energy input for another in different stages of the production process may not necessarily result in any reduction in energy requirements. In addition, research must consider the implications of different management practices concerning energy use for farms by size, region and commodity group. Finally, although research on new energy-reducing technology is crucial, there is a need to assess this technology in terms of the relative direct costs, changes in the total system, indirect costs due to these changes, economic feasibility to individual producers, and energy requirements for the research and development itself.

The Manufacture of Agricultural Inputs

Rising fossil fuel prices will have a direct affect on the manufacture of other agricultural energy inputs, namely fertilizer, pesticides, insecticides and petroleum products (kerosene, motor oil and grease). Increases in the prices of fossil fuel directly effect an upward shift in the cost structures of the firms that produce these other energy inputs. Few studies of energy consider the implications of changes in the manufacturing costs of fertilizers, chemicals and petroleum products on agricultural production.

Food Processing and Distribution

Up to this point, focus has been primarily on research needs in agricultural production. Agricultural production, however, uses only about three percent of the total U.S. energy budget. Processing and distribution of food and fiber, however, require 12 to 17 percent. Energy requirements for food processing and distribution are therefore four to six times larger than energy requirements for agricultural production. Because of the interdependency between food processing and distribution and agricultural production, impacts of high energy prices in food processing and distribution quickly work their way into agricultural production. For these reasons, research in the area of demand for and use of different types of energy in food processing and distribution is of paramount importance. Before valid conclusions concerning energy use in agriculture can be drawn, information pertaining to the energy used in processing and distributing food and fiber must be obtained.

Priorities and Procedures

Good data are a necessary condition for reliable and useful analyses of energy use in all aspects of agriculture. Data currently available are engineering or budget estimates which are conditionally normative and based on rigid assumptions. There is a dire need for collecting, assembling and reporting observed quantities and prices of energy used in agricultural production, in manufacturing of agricultural inputs and in food processing and distribution. Data should be collected and assembled on a sufficiently disaggregated basis to permit analysis of energy-use behavior of decision-making units from farm level production to food retailing. Such a massive date collecting and assembling task can be accomplished only if state and federal statistical reporting agencies cooperate and coordinate their efforts.

Analyses which provide information about the parameters of demand relationships for energy in agricultural activities from production through food retailing are of highest research priority. These analyses provide information about the energy demand behavior of firms which is fundamental to understanding energy use in agriculture and to formulating policies aimed at changing energy use. Equally important are analyses which provide information about the supply parameters of energy. Little is known about the response of quantities of energy to their own price changes and to changes in other key factors that affect supply response. Any meaningful energy policy must consider energy supplies in conjunction with energy demands.

Two technical approaches have been used in examining the usage patterns and supply and demand relationships for energy in agriculture: (1) projecting total agricultural energy requirements, allocating these requirements among different agricultural subsectors and estimating energy use in different agricultural enterprises; and (2) linear programming or input-output analyses to assess impacts of energy price and quantity restrictions on agricultural activities. However, these conditionally normative approaches fail to take into account, in most cases, substitution among energy sources and changes in relative prices. The models usually require some stringent assumptions which limit applicability of the results, and they provide little information about economic factors that influence the supply and demand for energy. In short, the projection and linear programming and input-output approaches may be too restrictive to adequately portray the opportunities and responses available to the agricultural sector. Many of the analyses concerned with energy use in agriculture have yielded results with limited usefulness, and emphasis needs to be given to more positive approaches which can provide information about the economic structure of energy use in U.S. agriculture.

CONCLUSION

Key livestock and crop users of fossil energy and differences in energy use between Southern and U.S. agricultural production were identified. These are important from the standpoint of developing or modifying energy allocation programs and of bringing to light potential opportunities for energy conservation.

Information about direct and indirect energy impacts on costs and revenues of farm production, short-run and long-run substitution among inputs, competitive positions of regions, supply response of agricultural production, economic growth rates, balance of payments, and income and wealth distribution is lacking. Little is known about the economic factors that influence the supply for various types of energy and the demand for different types of energy in different types of agriculture. In addition, the relative responsiveness of farmers and producers of energy and related inputs to relative price changes and changes in certain other measurable variables is virtually unknown. Further, a paucity of reliable data exists on energy use in agriculture. In the absence of such data, formulation of a viable energy policy for the agricultural sector would be almost impossible. Finally, research must consider energy conserving options available to individual producers, to manufacturers of agricultural inputs, and most of all to food processors and distributors. Research in these areas should provide useful guides for the direction of future agricultural policy concerning energy.

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