AGRICULTURE IN AN ENERGY-HUNGRY WORLD

K. C. Schneeberger and Harold F. Breimyer

Energy is a complex and pervasive subject, whose frontiers are still in the process of being defined. Many of the data are in dispute. Technical judgments do not agree. Conflicts of interest abound. The Nixon Administration, in its allocation plans for summer 1973 and January 1974, gave farmers top priority for fuel – ahead of hospitals, firemen, and police. Critics called this "cockeyed," preferring to put other sectors of the economy ahead of agriculture.

Moreover, the energy situation appears in a different light to the scientist, engineer, economist, environmentalist, industrialist, national security analyst, farmer, and, of course, the consumer. Various segments within agriculture view the energy situation differently depending on whether they are net consumers or net producers of energy. To agriculture, the energy situation revolves around those combustible hydrocarbons, petroleum and natural gas. This paper will be so posed. The main objectives herein are: (1) to develop an overview as it relates primarily to production agriculture, (2) to note some of the short-term and long-term aspects of an energy shortage, and (3) to suggest some implications for future agricultural economics research.

SOME BASE STATISTICS

Three-fourths of the United States energy consumption comes from oil and gas [8]. As of the early 1970's, fossil fuels were the primary energy sources:

Source	% of U. S. Energy Supply
Petroleum	43
Natural gas	33
Coal	20
Hydroelectric	3
Nuclear	1

All these except hydroelectric are depletable resources. Manifestly, estimates of the size of remaining reserves differ widely. For example, estimates of oil and gas reserves range from six to 40 years [3, 4, 10, 16]. Yet, regardless of which figures are the more reliable, it is indisputable that the well is literally about to run dry.

Where is energy used? A study for the Office of Emergency Preparedness (OEP) categorized the United States energy consumption as transportation, 25 percent; industry, 29 percent; electric utilities, 25 percent, and residential/commercial, 21 percent [13, 18]. Agriculture is in the latter category and, according to the OEP study, represents only 3 to 4 percent of the United States energy consumption. However, the agriculture component is confined to direct energy use. It does not include the energy required to manufacture the machinery and other inputs or to transport and process the outputs.

The potential availability of alternative energy sources also is a matter of wide dispute. However, fully equivalent replacements are not in sight. Not before the mid-1980's will major new energy sources be operational. Most estimates for the year 2,000 still have 60-75 percent of the United States energy coming from fossil fuels. And most new sources are less versatile than oil and gas.

In the meantime, the price of fossil fuel will escalate. Estimates begin from a doubling or tripling during the 1970's to a five-fold increase by the end of the century [4, 8, 14]. Furthermore, there is serious question as to how prices will be established and what other allocative mechanisms may be employed.

K. C. Schneeberger is associate professor and Harold F. Breimyer is professor of agricultural economics and extension economist at the University of Missouri.

AGRICULTURE'S STAKE

Some agriculturalists have questioned the concern over the potential energy shortage since agriculture is a small user, relatively, of energy. This is a naive position and probably fails to fully recognize the dependence agriculture has on fuel, natural gas, and chemicals. Energy resources were about 12 percent of United States farm expenditures in 1970, but are as great as 20 percent and higher in some areas [20]. To ignore the impact of a doubling of price is unwise.

As another example, 90 percent of the anhydrous ammonia used in the United States is directly dependent upon natural gas. All 86 American plants which produce NH_3 use the Haber-Bosch process by combining N_2 and H_2 under high temperature and pressure. Natural gas is the source of H_2 in all cases [5]. A TVA study has determined that under present price conditions the Haber-Bosch process is only 30 percent as expensive as the next best alternative.

The great expansion in agricultural productivity has been closely tied to energy resources. Even the heralded improved varieties served to make use of the natural gas-based nitrogen fertilizers. Grogan and Everett [7] have suggested that energy resources (fuel, fertilizer, chemicals) have accounted for 60-80 percent of the corn productivity increase since 1940. The substitution of inexpensive fuel and fertilizer for land and labor was in its time, economically well-founded. Land and labor prices have nearly tripled since 1950, while fuel and fertilizer have remained relatively cheap (Table 1).

Tied up in this whole matter is the ease of portability of fuels and nitrogen which has facilitated the rapid increases in technology and productivity that has characterized the agriculture of recent decades.

ENERGY EFFICIENCY

It has not been uncommon to extol the increasing productivity of American agriculture (e.g., each farmer feeds 48 other people, etc.) and to talk in terms of labor efficiency and greater production per unit of land while almost totally ignoring the contribution of energy resources. Gavett [5] has suggested that it is time to put more emphasis on energy efficiency.

Economists are accustomed to the concept of efficiency – ratio of output per unit of input. In the case of energy, efficiency may be defined in terms of conversion of energy, as in using natural gas to turn generators to produce electricity, or the use of seed, fertilizer and fuel to produce corn. In either case, the inputs are converted to British Thermal Units (BTU'S) or kilocalories (kcal), and the outputs can be measured in the same units. In cases like the internal combustion engine, the energy output is much less than the energy input. (For example, five-sixths of the energy used in transportation is discarded as waste heat and gases [5, 9]).

Table 1. QUANTITIES AND PRICES OF SELECTED FARM ENERGY INPUTS; 1950=100

Year	Labor	Fertilizer and Lime	Fuel and Oil
	Quantities[a]		
1950	100	100	100
1960	67	169	119
1965	55	250	125
1970	45	353	129
1972	44	383	131
	Prices[a]		
1950	100	100	NA[b]
1960	148	106	100
1965	171	106	105
1970	255	103	117
1972	278	109	117

Sources: [a]1972 Handbook of Agricultural Charts. [b]Missouri Farm Facts.

The energy efficiency coefficient is highly dependent upon how the inputs are defined. Is the "free" input solar energy to be included among the total inputs? What about livestock energy efficiency? The coefficient generated is vastly different for the measure that counts the energy value of the feedstuffs as the input as compared to the measure based upon the energy inputs required to produce the feed.

Pimentel, et al., [14] of Cornell have estimated the efficiency of energy use in United States corn production. They estimate that 3.7 million kcal of fossil fuel were used on an average acre in 1970 to produce about 8 million kcal, 81 bushels of grain (Table 2). That is an efficiency of roughly 2.2. Their inputs do not include solar energy, although it is a major source. The Cornell study also estimates that kcal output per kcal input was about 2.9 in 1950, and they contend energy efficiency has decreased over the 20-year period even though corn production per acre has increased markedly.

Pimental, et al., say that corn is about average among crops in energy efficiency. However, they acknowledge their investigation is still in the

Table 2. ENERGY INPUTS ON AN AVERAGE ACRE OF CORN, U.S., 1970

Item	Energy (kcal)
Labor	4,900
Machinery	884,000
Gasoline	797,000
Nitrogen	1,288,000
Phosphorous and Potassium	127,200
Seed	68,000
Irrigation	34,000
Insecticides and Herbicides	22,000
Drying	120,000
Electricity	310,000
Transportation	70,000
Total Inputs	3,725,100
Corn Yield (81 bu./acre)	8,164,800
Energy Efficiency (kcal output/kcal input)	2.2

Source: [14]

preliminary stages and plan more study. They also encourage attention to other aspects of energy efficiency in agriculture before the situation becomes critical. In efficiency, livestock fed concentrates come out with a much poorer showing than crops. Yet, the beef cow grazing on pasture may have a very high efficiency – measured in terms of fossil fuel-based energy.

SHORT-TERM ASPECTS OF THE ENERGY SHORTAGE

Irrespective of agriculture's minor claim on energy supplies and any allocation in its favor, the industry will not escape having to make adjustments. Indeed, it has already had to begin doing so.

Energy Conservation

A measure that higher fuel prices directly encourage is energy husbandry. Some trends are favorable. For example, purchases of tractors have run strongly to diesel in recent years. Since the diesel motor is a more efficient converter of energy than the gasoline motor, the trend is likely to be accelerated. Reduced or minimum tillage will, likewise, get a boost.

A major opportunity for energy conservation may lie in on-farm and off-farm grain handling and transportation. A Stanford study reported a 350 percent saving in energy in transporting grain by rail as opposed to truck. Other sources suggest savings of 10:1 for rail vs. truck. Of course, this assumes some of the logistics problems of rail car utilization can be improved. Similar energy savings are possible in the movement of inputs. Fertilizer materials generally make five or more separate movements from material source to the point of farm application. According to one estimate, the cost of meeting Michigan fertilizer demand could be reduced by 25 to 33 percent by improved efficiency in the production and distribution of materials. Much of the cost saving would be in energy saving [2].

Agronomic Practices

Much of the increasing productivity of non-legume crops has been based on monoculture, which in turn rested on cheap nitrogen [1]. As nitrogen fertilizer becomes more costly there may be revived interest in rotation and/or shift to species that have high nitrogen fixing capabilities. Anyone projecting the future supply of soybeans must include the inducement of higher cost nitrogen as an endogenous variable.

Substitution of animal and human waste for mineral nitrogen is now being practiced on a limited scale in this country and has widespread use in other parts of the world. Although there is disagreement on the nutritional value of wastes, there is agreement that the technology is available to recycle the wastes. According to one source, the livestock industry produces 1.7 billion tons of manure per year, over 50 percent of which is produced in feedlots and confinement houses. Recycling only 10 percent of the animal waste would have provided 10 tons of waste to 30 percent (17.0 million acres) of the 1970 harvest corn acreage [12, 17].

Competitive Structure

Higher energy costs are likely to favor producers closer to processing and to main lines of transportation. There will be the usual pressures on land prices in areas with favorable economic position. The balance between regions that has evolved over time may be recast drastically. The original economics of von Thunen may come back into vogue, as favored regions re-intensify and more remote ones revert to extensive agriculture.

SUMMARY AND PROJECTIONS

Agriculture as both a heavy user and important producer of energy will be forced to make major adjustments. They range from micro-enterprise adjustments, such as turning to lower energy rations that produce less fatty beef, to macro-industry rebalancing that may reverse the long trend to use human labor sparingly and fossil fuel very generously. The figures for 1972, which suggested more labor employed in agriculture than in previous recent years, may be a portent of the future. Agriculture may begin to employ more labor and fewer commercial inputs, notably fuel and fertilizer.

For agricultural economists the challenge is self-revealing. Like our forebearers, we may go back to working hand-in-glove with production scientists, figuring out new input combinations and enterprise choices that will adjust optimally to new price relationships for inputs and outputs. We will not neglect the possibility of producing more energy, as from livestock waste or the cellulose from forages that has been regarded as useless. We will recapture our lost skills in regional economics.

But above all that, we will redirect our expertise in policy. Not mentioned above, but interlacing all the issues of conserving energy is the concern with environmental protection. Although the anti-environmentalists like to shout that the energy crisis will now deliver us from all concessions to the environmentalist crowd, that probably is a benighted view. We will continue to reconcile various considerations in the usual halting, grudging, and imperfect fashion.

If we leap even a little farther and higher in our dreaming, we find ourselves allying with the sociologists and political scientists in considering how a tightening of the resource base not just for agriculture but for the entire economy, threatens so many of our lifestyles, our moral and value systems, the role of government, and the never-stable mix of market and nonmarket forces that give some degree of order to our highly mixed economy.

REFERENCES

[1] "Agriculture and the Energy Crisis." News release to Associated Press from agriculture editor's office, University of Missouri, Columbia, May 23, 1973.

[2] Bell, David M., et al., *Resource Adjustment in the Fertilizer Industry; With Emphasis on Michigan.* Economic Research Service, (Marketing Research) Report No. 974, Oct. 1972.

[3] Chase Manhattan Bank. *Outlook for Energy in the United States to 1985.* A report of the Energy Economics Division, June 1972.

[4] Decker, G. L., and Robert S. Spencer. "Energy Crisis Drives Up Chemical Costs." *Chemical Engineering Progress.* 68:15-18, Feb. 1972.

[5] Gavett, Earle E. "Agriculture and the Energy Crisis." Paper presented to the National Conference on Agriculture and the Energy Crisis in Lincoln, Neb. April 10-11, 1973.

[6] Griliches, Zvi. "Hybrid Corn: An Explanation in the Economics of Technological Change." *Econometrica,* 25:501-522, Oct. 1957.

[7] Grogan, C., and H. L. Everett. *Personal Communications.* Department of Plant Breeding, Cornell University, as reported in Pimentel, et al., [14].

[8] Hammond, Allen L. "Energy Options: Challenge for the Future." *Science,* 177:875-76, Sept. 1972.

[9] . "Conservation of Energy: The Potential for More Efficient Use." *Science,* 178:1079-81, Dec. 1972.

[10] . "Energy Needs: Projected Demands and How to Reduce Them." *Science,* 178:1186-88, Dec. 1972.

[11] Maugh, Thomas H., II. "Fuel From Wastes: A Minor Energy Source." *Science,* 178:599-601, Nov. 1972.

[12] Miner, J. R., ed. *Farm Animal - Waste Management.* North Central Regional Research Publication 206, Iowa Agricultural Experiment Station Special Report No. 67, May 1971.

[13] Office of Emergency Preparedness. "The Potential for Energy Conservation." A staff study for the Executive Office of the President, Oct. 1972.

[14] Pimentel, David, et al. *Corn, Food and the Energy Crisis.* Entomology and Section of Ecology and Systematics Departmental Report 73-1, Cornell University, March 1973.

[15] Resources for the Future."Rx for 'The Energy Crisis': A Long-Term Policy Base." In Annual Report 1972, Washington, D.C., Sept. 1972.

[16] "Resources: Using Them Up." *Newsweek,* May 21, 1973.
[17] Schaeffer, John R. "A National Issue: Disposing of Municipal Waste on the Land." In *Proceedings of Disposal of Treated Municipal Effluent on Land,* University of Missouri, March 1973.
[18] Stanford Research Institute. "Patterns of Energy Consumption in the United States." Office of Science & Technology, Washington, D.C., 1972.
[19] U.S. Dept. of Agriculture. *1972 Handbook of Agricultural Charts.* Handbook 439, Oct. 1972.
[20] . Economic Research Service. *Farm Cost Situation.* FCS-43, Feb. 1972.
[21] "Why a Fuel Crisis." *U.S. News and World Report.* Feb. 19, 1973.
[22] Wilson, Thomas W., Jr. *World Energy, The Environment and Political Action.* Summary of Second International Environmental Workshop, International Institute for Environmental Affairs, Washington, D.C., 1972.