Cooperative Extension College of Agriculture Washington State University Pullman, Washington 99164

AGRIBUSINESS MANAGEMENT

AGRICULTURAL'S ENERGY APPETITE

Norman Whittlesey and Ken D. Duft*

The Arab oil embargo has been lifted. Gasoline rationing will be avoided. The long lines at the pump have been lessening and the "panic buying" so evident a month ago has now been replaced with a more realistic pattern of consumer purchases. So what, you might ask, has been the end result of this winter's so-called "energy crisis?" The most obvious end result has been a dramatic increase in the price of all forms of fuel and energy-related products. A second less obvious, but perhaps more important, impact has been a greatly enhanced consciousness of this country's energy consumption patterns. Most experts agree that even with unlimited access to Arab and North Shore oil, if our current "rate of increase" in the consumption of energy continues, most accessible sources will be consumed in about 100 years.

Even if the experts have erred in their projections by as much as 50 years, some implications are patently clear. Every major sector of the United States economy will, during the next decade, be subjected to a major public review of its energy consumption patterns. In our opinion, thus review will prove to be even more forceful than those actions of environmentalists in recent years. Each sector will be asked to defend its current use of, and future need for energy. Furthermore, their activities will be thoroughly scrutinized for any signs of the inefficient use of energy and penalties assigned where wastage is evident. Agriculture will be no exception. It will also be asked to defend its current energy use and predict its future needs. This paper is designed to provide some factual support to agriculture's energy appetite, particularly as it relates to the Pacific Northwest and Washington State.

Agriculture as a National Consumer

The United States agricultural sector was not always an energy-intensive industry. It was agricultural research and technology, which, over the years, contributed to the substitution of energy (largely in the form of fossil fuel) for human and animal power. So successful has this substitution been that one farmer now has the food and fiber production potential to provide for the needs of 40-50 persons.

Strangely enough, of all the energy used in agricultural production in the United States, less than half is consumed in the more obvious forms, i.e., consumed directly on farms by tractors, pumps, and other machinery. The remainder is consumed in a less obvious manner, i.e., in the production and delivery of farm production inputs such as fertilizers and chemicals.

Moreover, if one considers the total energy consumed in the process of placing food on the tables of United States consumers, only about 18 percent is attributable to the agricultural production phase, while food processing and household preparation consume 33 and 30 percent respectively. Transportation and the merchant (wholesale and retail) trades consume the remaining 3 and 16 percent.

From an even broader perspective, we find that the total United States food system (production through consumption)

* Associate Agricultural Economists, Department of Agricultural Economics, Washington State University, Pullman, Washington.

WASHINGTON STATE UNIVERSITY & U.S. DEPARTMENT OF AGRICULTURE COOPERATING

consumes only between 12 and 15 percent of the nation's total daily consumption of 46.3 million barrels of crude oil (equivalent in 1970).

Washington's Energy Use

Washington's energy consumption pattern is very similar to that of its neighboring states of Idaho and Oregon. The three Pacific Northwest states are, however, somewhat distinct from the rest of the nation as it regards the existing composition of energy sources. Washington, for example, has very small quantities of domestic oil, gas, and coal. On the other extreme, it has very large resources of hydroelectric power. As one might expect, therefore, the state exports hydroelectricity and imports substantial quantities of oil and natural gas.

Agriculture is Washington State's second largest contributor to its gross domestic product. Yet agriculture is not a large consumer of energy in comparison to other industries. For example, if one looks at the BTU's of energy consumed in 1971, he discovers that production agriculture consumed slightly less than 20 trillion. Other industries such as paper and pulp, aluminum manufacture, transportation services, automotive and domestic heating consumed in excess of 60 trillion BTU's each in Washington State.

Looking at fuel consumption alone, Washington farms consumed 51.5 million gallons of gasoline and 33.8 million gallons of diesel valued at $28,075,000 in 1969. This rate of consumption represented only 3.1 percent of all fuel consumed in Washington that year. It should become apparent by now that any restriction on fuel usage by agriculture will not have a very major influence on Washington's total consumption. Conversely, assigning a high priority to agriculture during periods of short supply will have a nominal impact on the availability of fuel elsewhere within Washington's economy.

Crop Production Requirements

If we define crop production to include all those activities associated with the growing and harvesting of crops, energy consumed in conducting such activities would include fuel consumed by tillage (excluding fertilization), planting and harvesting equipment, and on-farm transportation vehicles. Also included would be electricity for farmsteads and irrigation pumps, and fuel for orchard heating.

Energy consumed in the tillage, planting, and harvesting operations varies dramatically from one crop to another. For example, a crop such as summer fallow wheat is a low volume consumer of energy while potatoes and alfalfa are more energy demanding. WSU researchers have constructed production budgets for each of the above-mentioned crops in an attempt to determine the level of "energy dependence" for each. Their estimate of the total costs (including fertilizer) producing an acre of wheat (excluding land costs) is $45.44. Of this total amount, $1.75 worth of fuel is included; i.e., about 1.2 gallons of gasoline and 6.5 gallons of diesel is consumed in the production of one acre of wheat. Hence, of the total production costs, energy consumption accounts for only 3.9 percent (1973 estimates). Furthermore, for an acre of alfalfa hay production $2.73 worth of fuel is required, but this constitutes only 2.1 percent of total production costs. Similar data for an acre of late potatoes are $9.42 worth of fuel, or 1.6 percent of total production costs. It is interesting to note that while total fuel requirements per acre increase for those crops considered to be more resource intensive, energy costs comprise a decreasing proportion of total production costs.

It would be most inappropriate to consider Washington agriculture without some mention of its fruit trees. Fruit trees are also energy consumers as Washington now has about 25,000-30,000 acres of orchards, which require some form of frost protection in the average year. This protective activity may consume from 5-10 million gallons of fuel oil each year. Depending on the methods employed, the costs of frost protection may vary from as low as $1.30 per acre per hour to as high as $7. Yakima Valley weather records indicate that for an average year, there will be ten frosty nights requiring a total of 26 hours of protection. Again, fuel consumption during this period will range from 1,025 gallons of fuel oil per acre for an open pot system to 455 gallons of propane per acre for the propane heating system.

As long as we have a national policy, which lists agricultural production as a "prime user" of fuels, there would appear to be no problem of adequate supplies. Fuel costs will undoubtedly continue to rise. Such a rise will have a nominal impact on the per acre total production costs for field crops. In fact, prices received for many of Washington's agricultural commodities have, this past year, risen more rapidly than have fuel costs, suggesting that fuel is now cheaper than before relative to the value of product produced. The effects of rising fuel costs will, however, be more pronounced in Washington tree fruit areas, particularly in those area requiring more extensive freeze protection. Yet fuel availability may be an even bigger problem in those areas as on-farm storage is limited and any gap in the supply pipeline or an interruption in supplier deliveries could prove to be disastrous.

Farmstead Electricity Usage

Electrical consumption for farmstead activities has increased in the United States from 8,484 annual kilowatt-hours per farm in 1960 to about 14,000 annual kilowatt-hours per farm in 1972. It is likely that Washington farms consume more electricity than the average United States farm and there appears to be no impending shortage of this energy source in the Pacific Northwest in the immediate future. As was the case with fuel usage, the use of electricity for farmstead activities contributes such a small portion of total farm costs that even with continuing price increases; the economic impact will be nominal.

Energy for Irrigation

While the farmstead consumption of electricity is not of major proportions, the use of electricity for irrigation purposes represents a substantially different picture. Of the 5.5 million acres of irrigated land in the Pacific Northwest, about 1.3 million acres are located in Washington. Of this acreage, about 81 percent is utilized as harvested cropland, with most of the remainder pastured. In addition, irrigated Washington agriculture has always believed that a large potential for additional irrigation development exists within the state. Such beliefs have been based on a long series of studies, which shows that with water and land generally available, the rising demand for food and increased prices will make such expansion economically feasible. Unfortunately most studies have restricted their consideration of limiting factors to the field of prices, land, and water. The element most often ignored is the availability of electrical power needed to apply the water.

The failure to consider electricity availability is substantially aggravated by the fact that most of Washington's land now subject to irrigation development is located some distance from and above the prime water source. Furthermore, the new lands are located in more rolling terrain making it necessary to use sprinkler systems rather than rill-gravity flow. Sprinkler systems, of course, are more demanding of electrical power. Estimates are that as the total use of electricity (GWH) for irrigation increases to 21,140 in the year 2020 from 3,000 in 1968, the proportion attributable to sprinkler systems will grow to 96 percent in 2020 from 57 percent in 1968. In short, the average energy use per sprinkler irrigated acre will increase from 950 kwh in 1968 to 1,200 kwh in 1980 and 2,000 kwh in the year 2020.

To place these irrigation energy use rates into proper perspective, it is best to consider the electrical requirements for lifting and pumping a given quantity of water (one acre foot) various distances at different rates of pressure. One soon discovers that as the lift and the pressure are increased, electrical requirements grow dramatically. For example, a deep well sprinkler irrigation system lifting 1.5 acre feet of water 200 vertical feet for the purpose of growing an acre of wheat will use 750 kwh of electricity or an equivalent of more than 75 gallons of diesel fuel. This level of energy consumption constitutes nearly ten times the power usage of all other field production activities. Similarly, applying 42 inches of water to an acre of alfalfa requires 20 times the energy requirements of all other field operations.

It should, by now, be apparent that Washington agriculture's total energy appetite is, or could be, largely dominated by irrigation activities, alone. Finally, it cannot be overlooked that the agricultural use of water for irrigation eliminates its availability for hydroelectric generation. The two activities, therefore, are competitive in nature. In fact, depending upon the location within the state, electric power generation sacrificed by withdrawing an acre-foot of water for irrigation may be as great as the power consumed in pumping it. One may wish to speculate, therefore, that the true cost of energy for irrigation is twice that discussed. The need to allow for pump-back storage facilities and off-peak power use must become major elements for consideration in any future, large-scale irrigation development.

Fertilizer Production

Of all the fertilizer elements upon which our agricultural economy has now become so reliant, nitrogen is the most directly affected by energy availability. All elements consume energy in the process of their manufacture, but hydrocarbon fuel is the major resource component from which nitrogen is produced. As a result, anhydrous ammonia (83% N) requires 38,127 cubic feet of natural gas per ton manufactured while phosphate and potash require, at the maximum, only 4,173 cubic feet per ton manufactured.

The demand for all three-fertilizer elements is expected to increase 5 percent annually for the next decade. Nitrogen production, in particular, is not expected to increase at even half this rate. During 1972, the United States produced 11.4 million tons of anhydrous ammonia. This required 456 billion cubic feet of natural gas or about 2 percent of the total United States consumption that year.

The current nitrogen shortage will likely be with us for some time unless some major changes occur. The fertilizer industry appears unwilling to build new production facilities without long-term contracts for natural gas. The costs of constructing a large plant (1,000 tons per day) plus the necessary terminals and distribution facilities have reached astronomical proportions (estimates suggest $87 million). In addition, the cost of natural gas, if it is available, has quadrupled and access to an uninterruptible source of natural gas has become almost impossible.

Nitrogen prices have already doubled those of a year ago. Yet despite the higher prices, supply will still fall short of demand. If the shortage were to fall wholly on specific crops or in specific geographical regions, the results could be severe. Luckily, the current distribution system is uniform enough to avoid the latter possibility. Also crop yield response to fertilizer is such that a 10-20 percent reduction in application rate will not dramatically reduce yields. It becomes extremely important, therefore, that fertilizer shortages be evenly distributed among areas, farms, and crops.

Some short-run solutions to the immediate problem include the following:

1. Reduce agricultural exports of fertilizer thereby damaging our balance of payments situation.

2. Import more foreign nitrogen also damaging our balance of payments.

3. Legislatively guarantee that sufficient domestic supplies of natural gas will be reserved for the fertilizer industry, thereby reducing supplies to other sectors of our economy.

In the long-run, some other possible solutions are listed below:

1. Substitute plant protein for animal protein in the United States diet, thereby reducing the demand for agricultural output.

2. Substitute alternative hydrogen sources such as coal in place of natural gas in ammonia production.

3. Better utilize human and animal organic wastes as a fertilizer substitute.

4. Change crop rotations to take advantage of the natural nitrogen producing character of legume crops.

5. Further advancement in our knowledge of ways to achieve a more efficient use of fertilizers.

Transportation and Processing Requirements

It would be in gross error to neglect the transportation and processing activities in our consideration of agriculture's energy appetite. Without both activities, of course, agricultural production serves no purpose.

Nationwide, transportation consumes one quarter of all the energy consumed in the United States. In Washington State, this relative rate of consumption is estimated to be slightly higher. The transportation of agricultural products has, over the years, become more energy intensive as it makes greater use of less energy efficient modes of transportation. For example, as one looks at the various modal requirements for energy in BTU's consumed per ton mile transported, the pipeline is the most energy efficient at 400-500; followed by barge, 680-710; railroads, 670-750; truck, 2,500-3,500; and air, 42,000. These data suggest that there is almost a 4-fold increase in energy use when an agricultural commodity is moved via truck rather than by rail or barge. Washington's transportation requirements are accelerated by the fact that most of the major consuming markets for its domestic products are located some distance from the Pacific Northwest. In fact, if one analyzes the movement of Washington's eleven major agricultural commodities and calculates the energy required to move the total tonnage to its destination, the equivalent of 128 million gallons of diesel fuel is required. This level of fuel consumption exceeds the total amount of gasoline and diesel used in Washington for field crop production and orchard heating operations.

In view of the above, if we are going to implement policies designed to reduce our current level of energy consumption, then serious consideration should be given towards channeling the movement of agricultural commodities toward the less energy intensive modes. Shipment by truck or air should be used only when speed and quality of service are critical to the successful marketing of the commodity, or where the seasonal effects have rendered these modes underutilized

In 1972, an estimated $408 million worth of Washington farm products moved from farm to food processors located within the state or elsewhere. The local processing industry is a significant user of energy, consuming an estimated 17.5 trillion BTU's in 1972. This rate of consumption represents 7 percent of all energy used by all Washington-based manufacturers and nearly equals the quantity of all fuel and electricity used directly in agriculture. Any reduction in energy supplies will, therefore, have a detrimental effect on local processors, many of whom are highly dependent on natural gas to supply heat for cooking, canning, etc.

Conclusion

It appears that the United States energy shortage is real and will remain with us for some time. Its continued existence will force all sectors of the United States economy, including agriculture, to scrutinize their energy-use patterns. The agricultural production system is highly dependent on energy, particularly fossil fuel sources. Large-scale adjustments in agriculture's energy-use patterns could 1) have a devastating effect on production levels if fertilizer restrictions are focused on specific crops, regions, or farms, 2) contribute little to a reduction in total fuel consumption if field production operations, alone, were affected, and 3) prove very misleading if the energy requirements for transporting and processing agricultural commodities were overlooked.

Ken D. Duft
Extension Marketing Economist