IMPACT OF ENERGY USE AND POLICY ON THE STRUCTURE OF AGRICULTURE

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INTRODUCTION

The critical importance of energy in U.S. agriculture was forcefully brought to the attention of U.S. citizens in 1973 by the Arab oil embargo. This action was followed by natural gas delivery curtailments in 1975, 1976, and 1977. The disruption of oil supplies from Iran in 1979 contributed to shortages of diesel and gasoline supplies in the United States. Other oil-exporting countries also raised prices sharply. Sharply rising prices and increased uncertainty of fuel availability have significantly affected U.S. agriculture in recent years and will continue to be an important influence.

Energy has had a major but little noticed role in shaping the structure of agriculture. Prior to 1973, few people thought that the economy could be strained so severely by changes in the quantity and price of an input they had viewed as a small, rather stable part of U.S. agricultural production and transportation. The agricultural economy was developed using low-cost fossil fuel and the earnings were transferred to labor, capital and land. From 1960 through 1970, diesel fuel, gasoline, and natural gas were plentiful and inexpensive. During this period the price of gasoline increased only 40 percent while wage rates climbed 73 percent and machinery prices increased 46 percent. New and larger machines using gasoline and diesel fuel were brought into agriculture to offset the increasing cost of labor. This new equipment reduced the demand for labor and encouraged increases in farm size and declines in farm population and employment. Production shifted to geographic areas that, because of the amount of land involved and its quality, allowed large-scale mechanization and crop specialization. As a result, farm numbers and land in farms declined in the North-

In addition to being specialized in production, major areas have become more dependent on particular energy forms. Natural gas (primarily used for irrigation) ranks first as an energy source in the Southern Plains and Mountain States, accounting for 44 and 31 percent of the energy used in these areas, respectively (table 1). Gasoline accounts for over 50 percent of the total energy used in the Corn Belt, Lake States, and Northeast regions. Diesel fuel use ranks high in the Northern Plains, Delta States, and Southeast. Electricity, a primary source of energy for irrigation in the Pacific States, supplies nearly as much energy to agriculture as is consumed in diesel fuel. One-fourth of the irrigated land in the Nation relies on low-cost hydro power to supply water.

In each region, farmers have balanced their energy consumption with the availability and cost of fuel, choosing that with the lowest relative price. Regional energy use data strongly suggest that changes in the relative prices of fuels in the past few years may sharply shift the competitive position of major agricultural production regions. For example, higher natural gas prices are causing some producers in the High Plains to return to dryland farming as the cost of irrigation rises rapidly. Irrigation may also decline in the Northwest if prices of electricity rise sharply.

Data from the U.S. Department of Energy show that the average world price of crude oil on August 24, 1979 was $20.75 per barrel--up from $13.80 on January 1, 1979. In 1972 the price per barrel for imported crude oil was about $3.

In agriculture, higher fuel prices mean higher production costs. Direct energy in corn production cost $5.72 per acre in 1975 and represented 6.3 percent of variable production cost. In 1979, energy costs per acre averaged $11.10 and accounted for 10.6 percent of production costs (table 2). Energy as a percentage of wheat production costs rose from 10.4 percent in 1975 to 16.5 percent in 1979. For cotton, energy accounted for 5.9 percent in 1975 and 9 percent in 1979. Such cost increases can affect the income of marginal farmers dramatically and could hasten their departure from agriculture. However, because energy represents a small proportion of total costs for raw agricultural products, a 10-percent increase in energy cost raises total production costs by an estimated 0.6 percent. In the long run, higher energy costs in the farming and in marketing sectors will be translated into higher food prices. Even so, a 10-percent increase in energy cost would increase the consumer food bill an estimated 0.5 percent.

AGRICULTURAL DEMAND FOR ENERGY

The United States consumed 79 quads of energy in 1978 (a quadrillion is 10^{15} Btus.) Nearly half this energy was in the form of refined petroleum products. One-fourth came from natural gas, slightly less than 20 percent from coal, and 3 percent each from nuclear and hydropower.

The U.S. food and fiber system (including farm production, processing, marketing, and consumption) consumed about 6.4 quads of energy in 1978, about 8 percent of all energy used in the United States (tables 3 and 4).

Farm production costs of $98 billion in 1978 included approximately $6 billion for energy used directly in the production process. Another $1 billion was spent for energy in the production of fertilizer and pesticides.

About one-third of all energy used came from diesel fuel and fuel oil: slightly more came from gasoline. Electricity, LP gas, and natural gas supplied 8, 11 and 12 percent, respectively.

Direct Energy Use

Direct energy use in farm production amounts to 1.2 quads or about 1.5 percent of total U.S. energy consumption. When energy used in pesticides and fertilizer are included, total consumption approaches 2 quads or 2.6 percent of the U.S. total. Fertilizer alone accounts for more of the energy used in agriculture than any other direct farm operation. Irrigation uses more than any other production practice, one-fifth of the total direct energy in agriculture. Corn production alone accounts for about one-fourth of the total used directly while corn, wheat, cotton, and soybeans together consume over half. About 45 percent of the energy used in agriculture is concentrated in seven States--California, Illinois, Iowa, Kansas, Minnesota, Nebraska, and Texas. These States account for about the same proportion of cash receipts from farming.

Although agriculture uses only a small proportion of the total fuel consumed in this country, fossil fuels are a vital input in the production of food and fiber. Delays in planting or harvesting may mean that no crop is produced or that yields are seriously diminished. A farmer often must have one-third to one-half of his total fuel needs for a year's production in a span of a few days or weeks. During that period he would pay as high a price as necessary to get this fuel to plant or harvest a crop. Over the long, run, the farmer can respond to price changes and will look for ways to conserve energy and reduce production costs.

Table 4--Energy requirements in the food and fiber system, 1978

Sector	Gasoline	Diesel fuel	Fuel oil	LP gas	Natural gas	Coal	Electricity	Total Btu
	---Million gallons---				Billion cu. ft	Thousand short tons	Billion kWh	Quadrillion 1/
Agricultural inputs 2/	3,527	2,706	271	—	728.5	150	13.5	0.8
Agricultural production:								
Crops	2,833	2,327	286	1,017	134.9		21.9	1.0
Livestock	582	347	10	382	4.9	34.6	9.8	.2
Food processing	—	—	1,240	—	446.4	3,357.9	39.8	.9
Marketing and distribution:								
Supermarkets			24	—	20.3	—	40.9	.2
Transportation	411	3,303	—	—	—	—		.5
Preparation:								
Restaurants and cafeterias	—		714		645.0	—	75.9	1.0
Home-prepared meals	—				798.0	—	274.7	1.8
Total	7,353	8,683	2,545	1,399	2,778.0	3,542.5	476.5	6.4

— insignificant quantity used.

1/ One quadrillion (quad) is 10^{15} Btus.
2/ Includes farm machinery, livestock feeds, fertilizers, and pesticides.

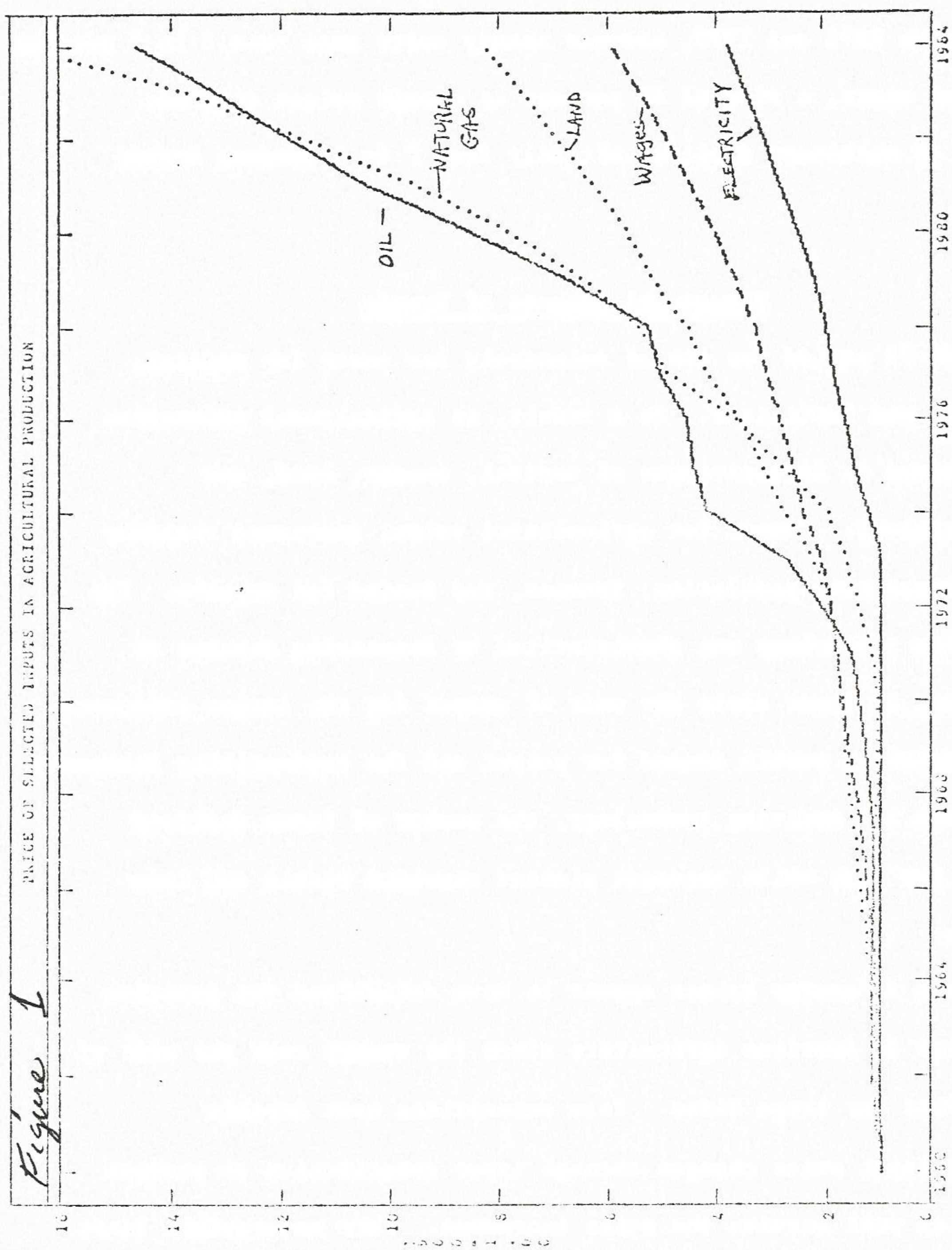

Figure 1

PRICE OF SELECTED INPUTS IN AGRICULTURAL PRODUCTION

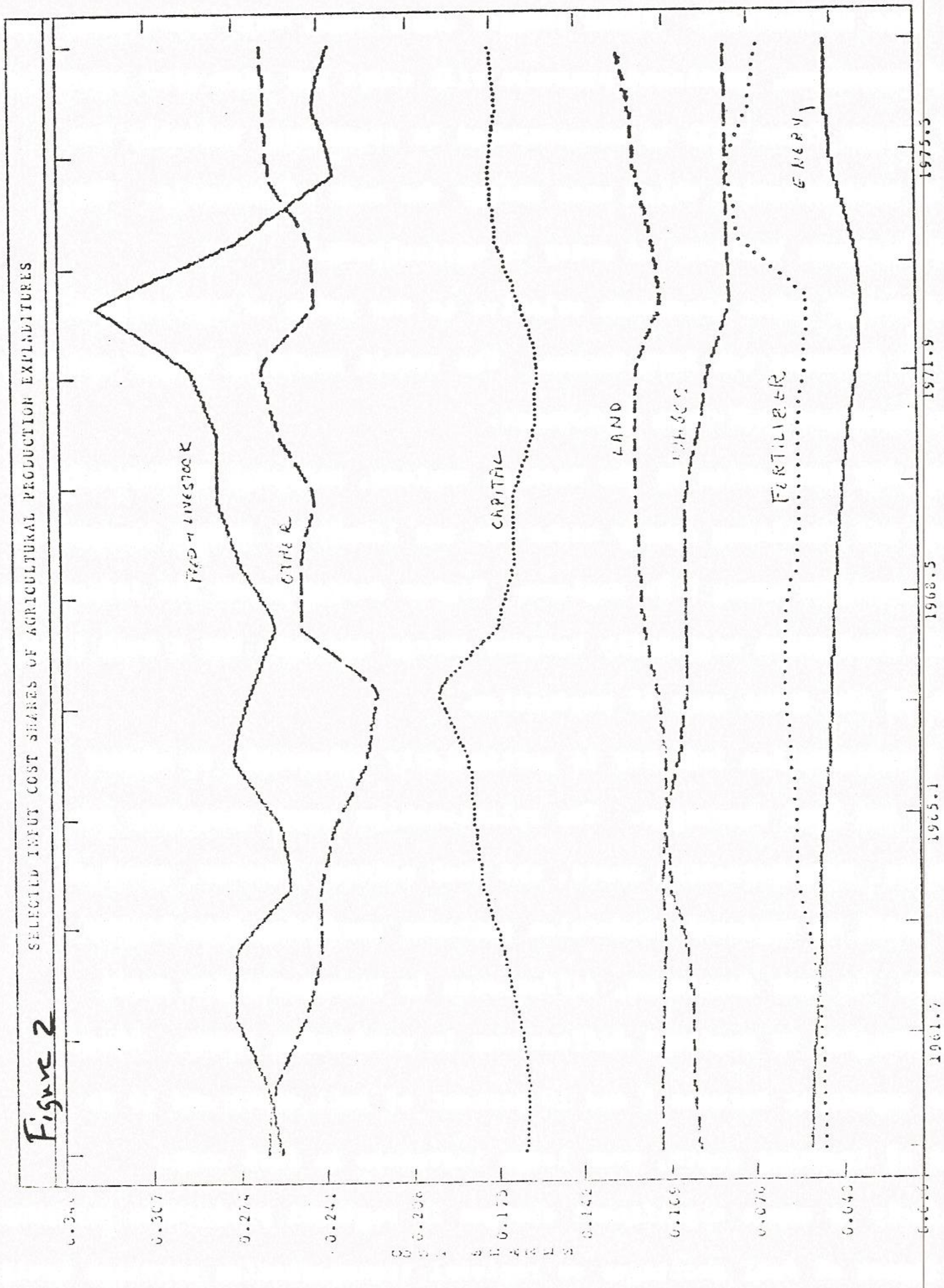
Figure 2
SELECTED INPUT COST SHARES OF AGRICULTURAL PRODUCTION EXPENDITURES
FEED + LIVESTOCK
OTHER
CAPITAL
LAND
LABOR
FERTILIZER
ENERGY
0.340
0.307
0.274
0.241
0.208
0.175
0.142
0.109
0.076
0.043
0.010
1961.7
1965.1
1968.5
1971.9
1975.3
YEARS 1960 TO 1977

there is no reason to expect allocation plans to explicitly favor some regions over others, it is unlikely that fuel shortages will affect regional production or consumption patterns.

ENERGY POLICY

Efforts to develop a comprehensive energy policy for this country have been underway since 1973 and a broad set of energy goals has evolved. The goals can be stated briefly as the desire to lessen our dependence on imported fuels through: (1) conservation of oil and natural gas, (2) the expansion of coal and oil shale development, and (3) conversion to renewable sources of energy such as solar and biomass.

For rural America and the food and fiber system, the primary goals in relation to energy, as currently stated, are these:

- To assure adequate supplies of energy to the food and fiber system and to rural America.
- To conserve fossil fuel, particularly petroleum and natural gas.
- To develop technology for production and use of renewable energy sources, such as direct solar energy, wind, and biomass.
- To shift to renewable energy where possible.
- To develop abundant resources such as coal and oil shale with minimum adverse impacts on agriculture and rural America.

These goals must be met with policies that will help maintain the abundance of the food production system while conserving energy and converting to new energy sources.

Rising energy prices mean higher costs of production and, at least in the early years of higher prices, lower net income. Some of the price impact may be offset by conservation efforts that will allow production of the same quantity with less fuel. Some of the effect may be passed through to the consumer or offset by improved technology that will reduce total energy requirements in agriculture.

A major policy debate concerns the priority of agriculture during periods of short supplies of fuel. Until recently, agriculture was entitled to 100 percent of its current operating needs. Currently, agriculture has priorities only for natural gas and LP gas. Gasoline is now allocated on a base year and diesel fuel is not allocated at all. Large farms that can afford to purchase and fill storage tanks are in a more favorable position with respect to fuel availability than are small farms that must rely on the local service station.

Fuel shortages can be expected to increase barriers to entry because fuel suppliers may give preferential treatment to established farm customers. The threat of fuel shortages also will encourage risk aversion by farmers investing in energy production technologies. Such technologies will require additional capital investment, thus favoring larger operations.

ENERGY CONSERVATION

Current national energy policy places a heavy emphasis on conservation of fuel and substitution of fossil fuel with renewable resources. Higher energy prices will compel farmers to conserve as much energy as is economically feasible and to search for alternative energy sources by:

- Changing the combination of inputs.
- Technological shifts which tend to make energy use more efficient.
- Increases in output resulting from more favorable weather conditions or other factors.
- Increasing returns to size (less energy used per unit of output as the size of a production unit increases).

Farmers have already adopted many conservation practices, such as, increased insulation in buildings; minimum tillage; and better management, such as closer regulation of ventilation in buildings, proper maintenance of tractors and other motor vehicles, and correct matching of tractor size to implement size. Some of the energy conservation efforts, of the livestock industry—that is, a reversal of the regional shift in cattle feeding over the past two decades.

Minimizing the economic problems does not address possible repercussions to the food and fiber system. Significant structural shifts of a large energy production program, however, would likely be inevitable as much of the potential energy production would involve collecting and processing various forms of biomass. Growing the biomass would in many cases compete directly with many of the livestock and crop products currently produced for human consumption. Each successive part of the complete worldwide food and fiber system would undergo a ripplelike effect resulting from the change introduced by a large energy production effort.

Energy production from agriculture will be influenced strongly by research efforts during the coming decades. If research indicates that small-size fermentors, anaerobic digestors, or other energy-producing devices are as cost efficient as larger ones, energy production and consumption will likely occur locally. If larger units produce energy less expensively or in the forms needed for the particular uses, rural agriculture will continue to be extremely dependent on outside sources for energy. With large-scale technology, farmers would produce and deliver products to an energy production site. They would then purchase fuel output and byproducts, such as dried distillers grains, and also residues for fertilizer use. The energy producers could be private individuals, corporations, or cooperatives. Agricultural cooperative type of ownership of such energy production facilities could enhance the position of farmers by allowing retention of control over energy inputs (including price and availability) for production purposes. Large-scale production

Biomass

Energy policies encouraging biomass production have been pursued because of the renewable, relatively large potential source of energy and the form of energy which could be readily used in current mechanized agriculture. Biomass production would have a major impact on cropland, fertilizer, machinery, and labor. Production of biomass in arid regions would compete for water supplies. Utilization of livestock waste and crop residues for energy could lower soil fertility. Small-scale biomass technology for farm use would increase farm labor requirements and divert farm resources from the production of food and fiber for human use.

Agriculture could achieve self-sufficient in energy by producing two quads of energy from alcohol produced from corn, which would require 90 million acres of 100 bushels per acre. (This assumes 85,000 Btu's per gallon of alcohol and 2.6 gallons per bushel). The acreage required is larger than the entire acreage planted to corn in 1979.

Regardless of the crops chosen or the methods used, a return to self-sufficiency in energy is likely to be very costly in terms of capital, labor, and other input requirements. And, increases in capital intensity suggest major pressures to increase farm size.

A major biomass production effort by agriculture could affect the environment significantly. Expanded areas of crop production will expose more land to soil erosion, which would make it a greater source of nonpoint water pollution. As the quality of land brought into production decreases, environmental impacts will become greater. Residues, which would be harvested for energy production, are normally left on the land to return nutrients to the soil and maintain organic matter content. Their presence reduces erosion, enhances water-holding capacity of the soil, and minimizes transport of nutrients, pesticides, and organic matter by runoff. Thus, a

Micro and Macro Impacts of Energy Production

The impacts of a large energy production effort on the structure of agriculture should be addressed at the farm level and at the national level.

At the individual farm level, two basic issues will determine the combination and size of enterprises each farmer will operate: the goal for net farm income over time and the degree of risk aversion desired. Other related issues that will influence farmers' decisions are: seasonal farm labor availability; quantity and type of energy which can be produced; additional capital expenditures; and age of individual farm operators.

If farmers want to minimize risk, energy production either on farms or in local areas would be an important consideration. This however, would require adequate seasonal labor and capital for investment in energy-producing equipment. In many cases these two inputs are already in short supply, especially seasonal labor. Farm structure could be affected by additional labor requirements, a change of crop mix, and changes within the input-supplying and product-marketing sectors.

The average age of farm operator could be important with respect to farm size changes, shifts in types of crops produced, and perhaps regional shifts in production of certain crops as a result of energy changes. If, on the average, farmers in a particular region are older, they are less likely to invest in alternative energy production technologies. This could make them less competitive with other producers and eventually force them out of business.

Perhaps even more important longrun considerations lie unanswered at the national level. The key issue is whether the agricultural resource base has the capacity and the flexibility under changing condi-

If larger energy production units are more economical, teams of specialists might form cooperative enterprises of much greater acreage. For example, one could specialize in maximizing the output of field and forage crops. An energy specialist could manage the operation of solar collectors, distillation units and methane digestion, as well as match the output with the uses. The livestock manager would design efficient ration mixes from the available feed and forage crops, as well as the energy-processing byproducts. If most of the farm's output is shipped for processing, a marketing specialist would have a key role in the success of the operation. Currently, an individual operator must have all these talents. If agriculture becomes an energy producer, the agricultural system could change, perhaps become vastly more complex, to the extent that an individual operator could no longer keep pace with all the technologies and physically perform the wide variety of operations at an economic level.

IMPACTS OF COAL AND OIL SHALE MINING

The mining of western coal and oil shale has direct impact on the land that is strip mined. In terms of overall agricultural structure or production, the impact is small. As coal mines are developed in the southern Corn Belt, the impact on farmland and production will be substantially greater. The impact on land depends on how the coal is utilized. If it is hauled by rail to eastern markets, the land impact is slight. If slurry pipelines are used, the impact on land is slight but the impact on water supplies would be large.

Steam generation and conversion to electricity at the mine mouth require more water than slurry pipelines. One estimate is that

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