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Economics of Dieselhol

A Supplement to

Economics of Gasohol

Economic Report ER78-10

by

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Conclusion

From this analysis we conclude that dieselhol is not economically feasible, even if fuel consumption is assumed to be the same as for diesel fuel. Given that fuel consumption is higher with dieselhol than with diesel fuel, dieselhol becomes even less feasible economically.

ECONOMICS OF DIESELHOL^{1/}

by

M. Litterman, V. Eidman and H. Jensen*

Introduction

An earlier study at the University of Minnesota (1) dealt with the economic feasibility of gasohol. This report is a supplement to that study in which we analyze the economic feasibility of a 10 percent alcohol, 90 percent diesel fuel blend. For simplicity call this blend dieselhol. In this report we present the conclusions of a study done in the Department of Agricultural Engineering, University of Minnesota on the properties of alcohol diesel fuel blends. We then discuss the economic feasibility of dieselhol.

Properties of Alcohol-Diesel Blends

Alcohol can be blended with diesel fuel in various proportions. The larger the amount of alcohol in the blend the more pronounced are its effects. A study of the fuel effects using blends of up to 30 percent alcohol was done at the University of Minnesota (2). The study included a literature review and both laboratory and field experiments.

Alcohol-diesel fuel blends are less tolerant to water in the solution than gasoline-alcohol blends. At moderate temperatures (30-50°F) very small amounts of water will cause separation of the blend (2, p. 9). The study, therefore, recommends that any alcohol-diesel blend must be water free.

Fuel consumption increased when alcohol was mixed with diesel fuel. Two engines of different makes and engine sizes were used to test the effect of mixing alcohol with diesel fuel on fuel consumption. The amount of fuel consumed increased for all loads on both tractors as the alcohol content increased. The rate at which fuel consumption increased differed by load level and by tractor (Table 1).

Fuel consumption increases with alcohol-diesel are due to the lower BTU content of alcohol. This also explains the decreased power output of alcohol-diesel blends. The amount of power decrease varied by the tractor used, but in some cases, the decrease in power is directly related to the increased alcohol content (2, p. 23).

^{1/}The Economics of Dieselhol and the companion study of Economics of Gasohol, Economic Report 78-10, December 1978, were done at the request of and financed by the Minnesota Energy Agency.

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Table 1. Change in Fuel Consumption for Various Loads as Alcohol Content Increases From Zero to Ten Percent

<u>Load</u>	<u>Percent Change in Hours Run Per Gallon of Diesel Fuel as Alcohol Content is Increased From 0 to 10 Percent</u>
Ford Engine:	
1/4 load	-8.9
2/4 load	-4.0
3/4 and max load	-2.3
85% load	-4.4
John Deere Engine:	
1/4 load	-9.0
2/4 load	-6.1
max load	-.063
3/4 and 85% load	-3.9

Source: (2, p. 12, 22)

A desirable property of diesel fuel is that combustion occurs immediately after fuel is injected into the engine. When alcohol is added to the blend there is some delay in the time from when fuel is injected into the engine and when it fires. This delay increases as alcohol content increases. This leads to increased engine noise when alcohol content is higher than 10 percent.

Other problems exist with alcohol-diesel blends. Leakage occurs at various points of the fuel system. More bubbles are returned to the return fuel line with alcohol-diesel blends than with diesel fuel alone. This may lead to a less than continuous flow of fuel to the combustion chamber. Engine wear is greater with alcohol blends. Cylinder, piston and fuel injection system wear is likely to be increased, although tests were not lengthy enough to quantify the increased wear (2, p. 25).

The conclusion of this study is that a tractor using a 10 percent alcohol-90 percent diesel fuel blend performs very much like a tractor using straight diesel fuel, however fuel consumption increases with the blend. Blends having more than 10 percent alcohol perform poorly in comparison. Therefore, if alcohol is to be blended with diesel fuel, alcohol should make up no more than 10 percent of the total volume.

Economic Feasibility of Dieselhol

Economic feasibility of gasohol was found to be dependent on many variables. The most critical of these variables are the cost of producing alcohol, the cost of grain and the price at which the distillers' dried grains and solubles by-product can be sold. In the gasohol study (1) we devised an equation to determine the price of gasohol. Since the cost of producing alcohol is independent of the fuel with which it is to be blended, a similar equation can be derived for dieselhol.

The cost of producing alcohol depends on the ownership costs, operating costs and the size of the plant. These costs were developed in the gasohol study for two plant sizes producing 17 and 34 million gallons of alcohol per year. The equation developed is repeated here.

$$(1) C_A = \frac{C_C}{2.7} + C_{OWN} + C_E + C_{FO} + C_O - (P_{DDGS}(.0005)(6.8))$$

Where

- C_A = Cost of alcohol (\$/gallon)
- C_C = Cost of corn (\$/bushel)
- C_{OWN} = Ownership costs of plant per gallon of alcohol basis
- C_E = Cost of electricity per gallon of alcohol basis

- C_{FO} = Cost of fuel oil per gallon of alcohol basis
- C_O = Other operating costs per gallon of alcohol basis
- P_{DDGS} = Price of DDGS (\$/ton)

This equation assumes 2.7 gallons of alcohol per bushel of corn and 6.8 pounds of DDGS per gallon of alcohol. Substituting estimated costs developed in the gasohol study into this equation gives:

$$(2) C_A = \frac{C_C + .186 + .0996 + .279 + .32 - (P_{DDGS}(.0005)(6.8))}{2.7}$$

for the 17 million gallon plant and

$$(3) C_A = \frac{C_C + .145 + .0996 + .279 + .21 - (P_{DDGS}(.0005)(6.8))}{2.7}$$

for the 34 million gallon plant.

When alcohol and diesel fuel are combined in a 1:9 ratio, equations (2) and (3) can be multiplied by .1 and added to the cost of .9 gallon of diesel fuel to obtain the cost per gallon of dieselhol given in (4) and (5). Notice that the estimates of C_{OWN} and C_O are summed in equations (4) and (5) below:

$$(4) C_{DH} = .9 P_D + .1 \left[\frac{C_C}{2.7} + C_E + C_{FO} + .506 - (P_{DDGS} (.0005)(6.8)) \right]$$

for the 17 million gallon plant and

$$(5) C_{DH} = .9 P_D + .1 \left[\frac{C_C}{2.7} + C_E + C_{FO} + .355 - (P_{DDGS} (.0005)(6.8)) \right]$$

for the 34 million gallon plant

Where

- P_D = Price of diesel fuel (\$/gallon)
- C_{DH} = Price of dieselhol (\$/gallon)

We can now vary the price of corn to determine at which point the cost of dieselhol equals that of diesel fuel. In this analysis, we assume that dieselhol is competitive with diesel fuel when their wholesale costs are equal even though fuel consumption is increased with dieselhol. We will address this point shortly.

With the price of diesel fuel at \$.53 per gallon and the cost of electricity and fuel oil as shown in equation (2), we can then vary the price of corn and DDGS to see at which point the cost of dieselhol equals the wholesale price of diesel fuel.^{2/} Figure 1 shows the cost of gasohol from a 17 million gallon plant when DDGS is \$120/ton, \$104/ton, \$60/ton and \$20/ton. As the price of DDGS decreases it furnishes a smaller feed credit, increasing the cost of dieselhol. Notice that dieselhol is more expensive than diesel fuel for all prices of corn when DDGS has a price of \$104 per ton or less. As the price of DDGS increases above \$104 per ton dieselhol costs less than diesel fuel only at very low corn prices.^{3/}

Figure 2 shows a similar picture for the 34 million gallon plant. The economies of size are evident, for each price of corn the cost of dieselhol is less than in Figure 1. In Figure 2, dieselhol costs more than diesel fuel for all corn prices, except when DDGS is above \$72 per ton. Even at a DDGS price of \$120 per ton, the price of corn must be less than \$1.00 for dieselhol to be competitive.

As in the gasohol study, let us assume that the price of diesel fuel doubles to \$1.06 per gallon wholesale. We again make the simplifying assumption that all other fuel prices double. The cost of dieselhol in this situation, for the two plant sizes are shown in Figures 3 and 4. Figure 3 shows that dieselhol is more expensive than diesel fuel for all prices of corn if the price of DDGS is no higher than \$60 per ton. In Figure 4 dieselhol costs more than diesel fuel for all corn prices except when DDGS is more than \$16 per ton. Note that even when DDGS is \$120 per ton, the price of corn that makes dieselhol competitive with diesel fuel is far below \$1.50 per bushel.

The dieselhol program, even at a national level, would be much smaller than a gasohol program, therefore the effect on the grain markets would be slight. This implies that the price of corn and thus DDGS are not likely to be affected much by a dieselhol program. At prices approximately what they are at this time; that is \$1.75/bu. corn and \$100/ton DDGS, dieselhol would cost \$.58 per gallon if the alcohol is produced in the larger plant. This is five cents more per gallon than the cost of diesel fuel.

These figures 1-4 show that dieselhol is more expensive than diesel fuel except at very low corn prices. This analysis is based on the assumption that fuel consumption is the same for both fuels. The engineering study (2) points out that this assumption is incorrect. This engineering study points out that fuel consumption varies with both load level and size of tractor engine used. However since only two tractors were tested, there is not information to accurately quantify increased fuel consumption with dieselhol. We proceed in this analysis, acknowledging this shortcoming.

In order to quantify increased fuel consumption we make the following assumptions. First, both tractors tested were smaller than those typically used, therefore we will only consider the larger John Deere engine in this

^{2/}The wholesale price of diesel fuel in late 1978 was \$.53/gallon according to Land O'Lakes data.

^{3/}These and following dieselhol figures are based on cost of production, zero profit margin.

Figure 1. Price of Dieselhol for Varying Prices of Corn in the 17 Million Gallon Alcohol Plant With the Wholesale Price of Diesel Fuel Set at \$.53 Per Gallon

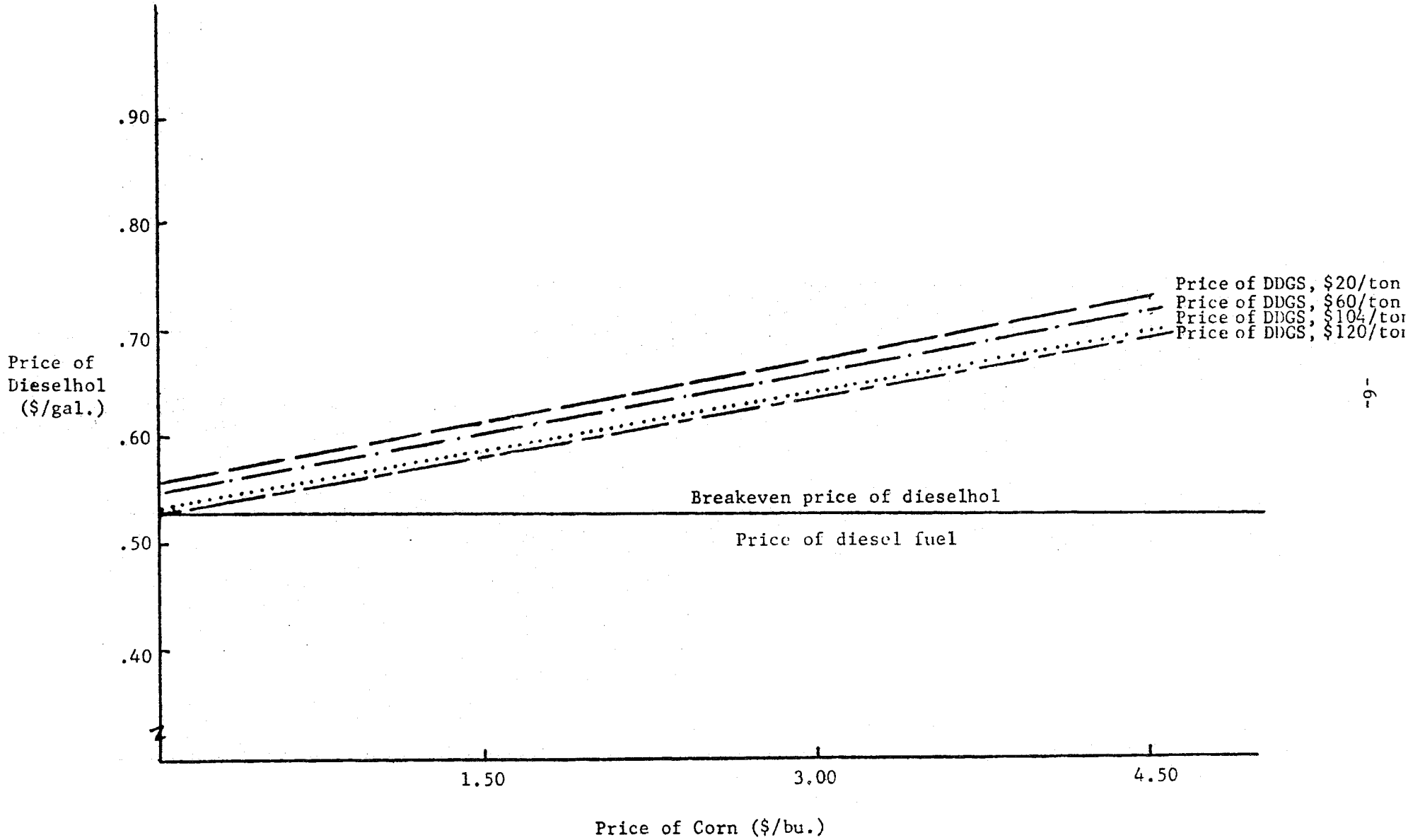


Figure 2. Price of Dieselhol for Varying Prices of Corn in the 34 Million Gallon Alcohol Plant With the Wholesale Price of Diesel Fuel Set at \$.53 Per Gallon

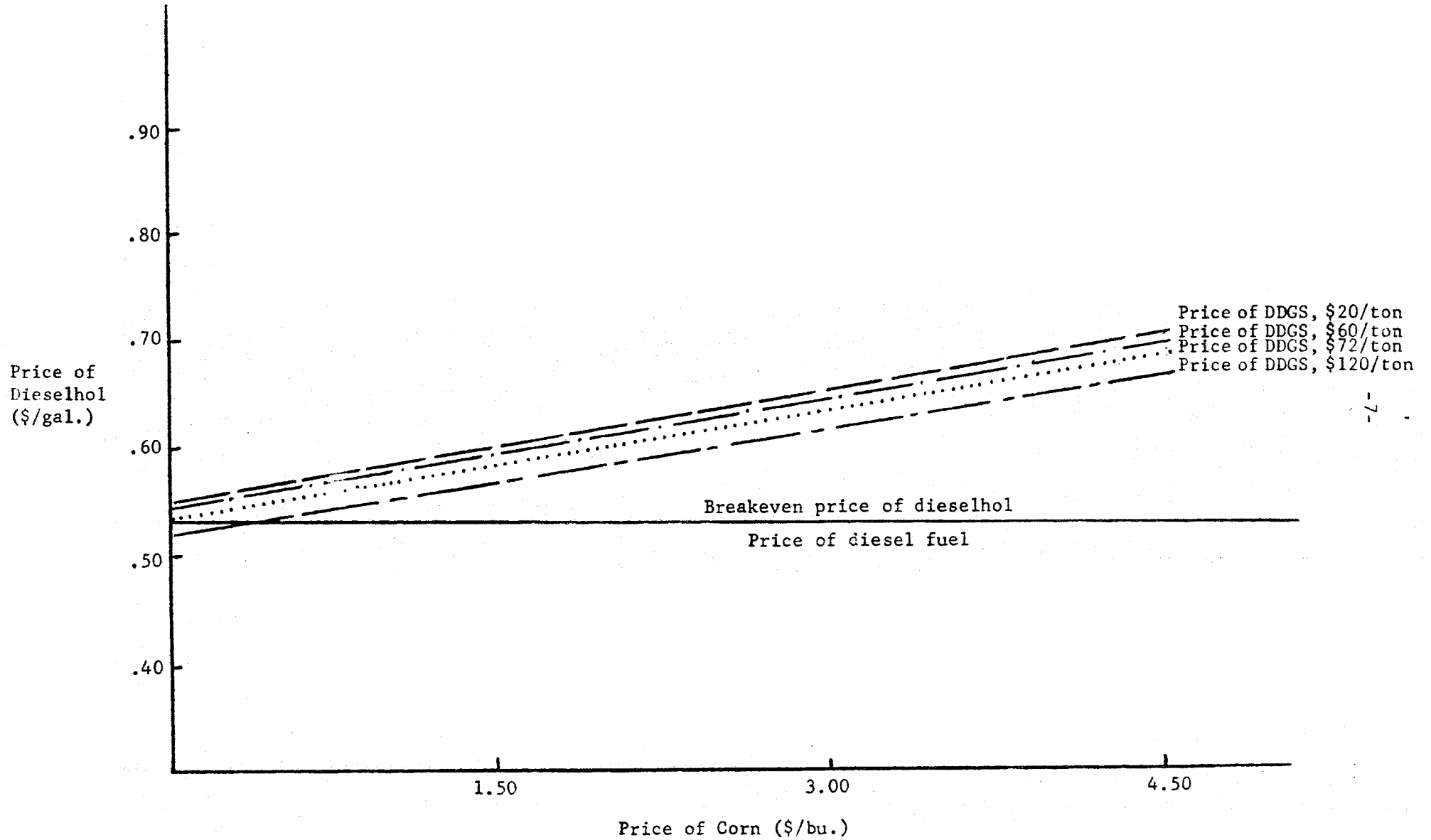


Figure 3. Price of Dieselhol for Varying Prices of Corn in the 17 Million Gallon Alcohol Plant With the Wholesale Price of Diesel Fuel Set at \$1.06 Per Gallon

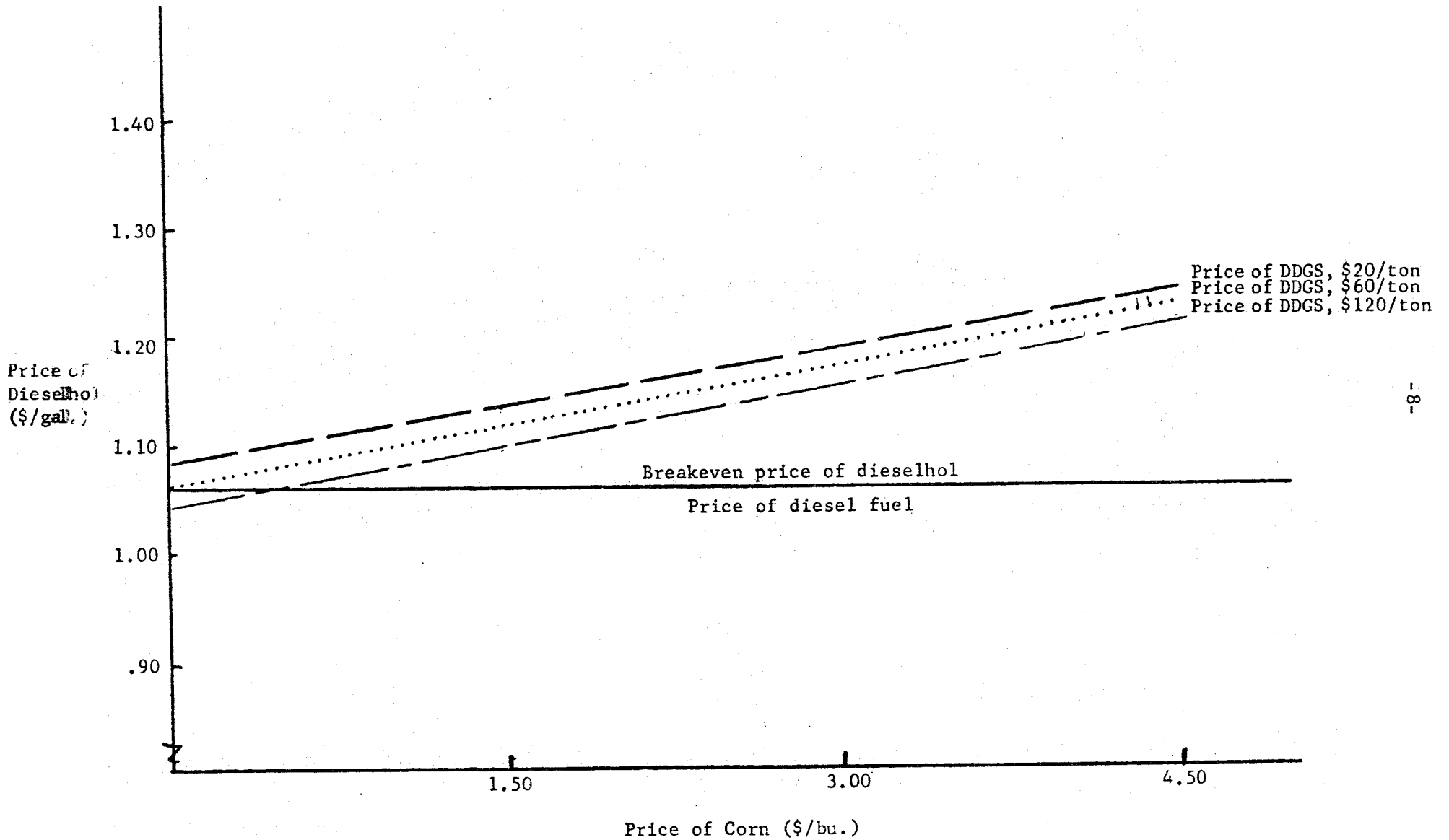
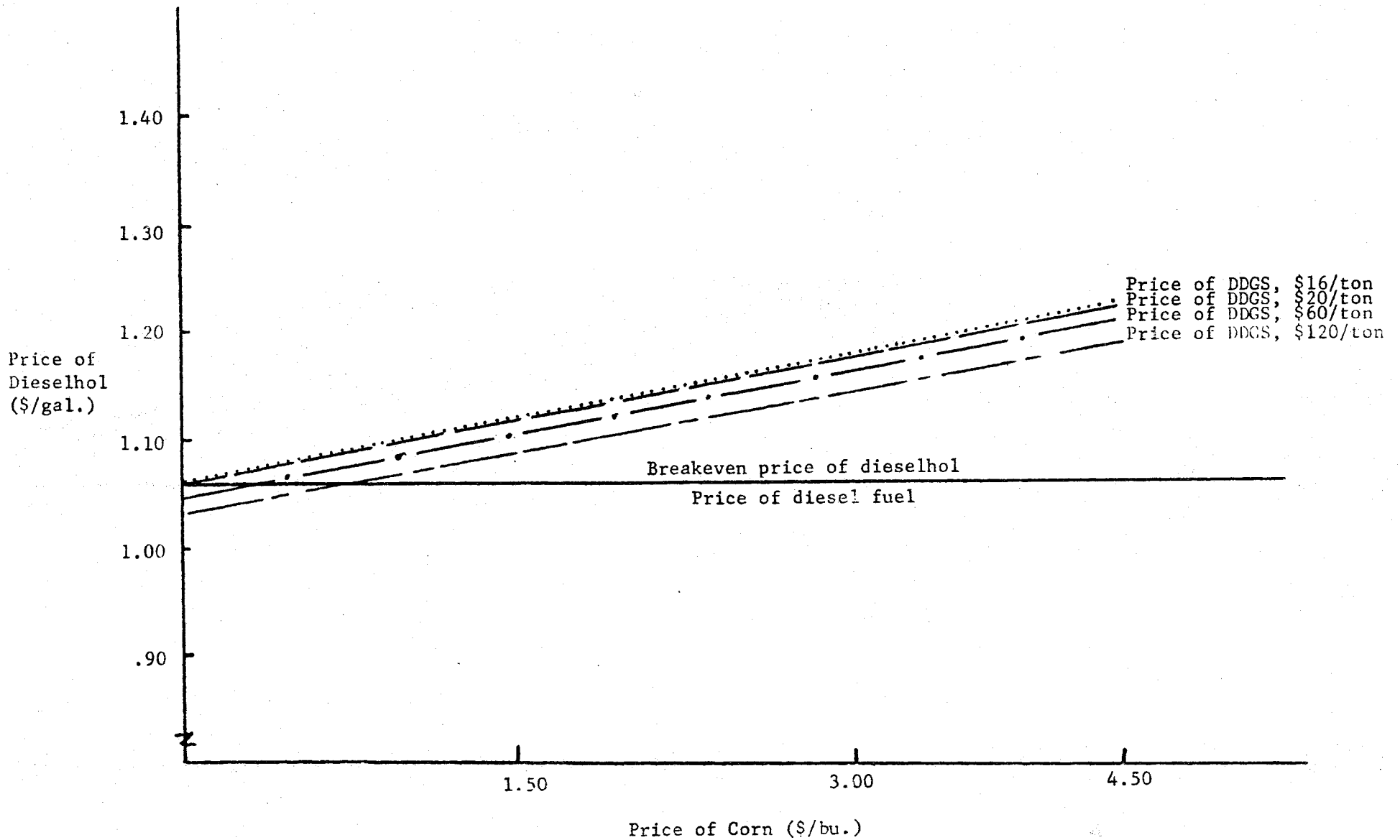


Figure 4. Price of Dieselhol for Varying Prices of Corn in the 34 Million Gallon Alcohol Plant With the Wholesale Price of Diesel Fuel Set at \$1.06 Per Gallon



analysis. Fuel consumption varies with load level which varies with farming operation. Therefore, we make the second simplifying assumption that the tractor is used at each of the five load levels equal amounts of time. This can be adjusted upward if the tractor is used more at lighter loads or downward if it is used more at maximum load.

The average fuel consumption increase for the John Deere engine using all five load rates equally is 4.6 percent. Using the previous example we can calculate the increased cost of increased fuel consumption (Table 2). With diesel fuel at \$.53/gallon, we found that the cost of dieselhol was \$.58/gallon in our example. However, to do the same amount of work as one gallon of diesel fuel, we must purchase 1.046 gallons of dieselhol costing \$.61. Similarly with the higher price of diesel fuel, at the same corn and DDGS prices, we must purchase \$1.15 worth of dieselhol to do the same amount of work as the \$1.06 gallon of diesel fuel.

Table 2. Cost of Dieselhol for Current and a Doubling of Wholesale Diesel and Other Fuel Prices

(1) Cost of Diesel Fuel (\$/gallon)	(2) Cost of Dieselhol (assuming equal fuel consumption) (\$/gallon)	(3) Cost of Dieselhol needed to do the same amount of work as one gallon of diesel fuel (1.046 x P _{DH})	(4) Difference in Costs: (3) - (1) (\$)
.53	.58	.61	.08
1.06	1.10	1.15	.09

Assumes: (1) Alcohol produced in the 34 million gallon per year plant
 (2) Price of corn is \$1.75/bushel
 (3) Price of DDGS is \$100/ton

Source: Table 1

References

- (1) Litterman, M., Eidman, V. and H. Jensen, Economics of Gasohol, Economic Report ER78-10, University of Minnesota, December 1978.
- (2) Strait, J., Boedicker, J.J. and K.C. Johansen, Diesel Oil and Ethanol Mixtures for Diesel Powered Farm Tractors, University of Minnesota, December 29, 1978.

